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Reduced Levels of Some Iron Parameters of Protein Energy Malnourished Children in Calabar, Nigeria

Naomi Ernest [1], Patience Akpan [2], Emmanuel Uko [2]

1.Department of Haematology, University of Calabar Teaching Hospital, Calabar, Cross-River State, Nigeria.

2.Department of Medical Laboratory Science, Haematology Unit, University of Calabar, P.O. box 1115, Calabar, Cross-River State, Nigeria.

* E-mail of the corresponding author: apu0520@yahoo.com

Abstract

Hunger and malnutrition are among the most devastating problems dominating the health of the world's poorest nations. This research was carried out to assess iron related parameters of protein energy malnourished children in Calabar. One hundred (100) malnourished children within the ages of 1-10 years and admitted in the Paediatric clinic of University of Calabar Teaching Hospital, Calabar were enrolled for this study. Fifty (50) apparently healthy children of similar age were used as controls. Assays were performed using standard methods. The mean values of haemoglobin, packed cell volume and serum ferritin obtained from protein energy malnourished (PEM) children were significantly lower ($P<0.05$) when compared to values for control subjects. Conversely, the serum iron and transferrin saturation of the test group were significantly higher ($P<0.05$) than that of the controls. Serum ferritin level of the protein energy malnourished children who were 6-10 years of age was significantly lower ($P<0.05$) than their counterparts who were 1-5 years old. Iron parameters were observed to be the same irrespective of the type of PEM. The body mass index (BMI) of the control was higher than that of the test group. The iron stores of protein energy malnourished children has been observed to be significantly reduced ($P<0.05$) when compared with apparently healthy children. Poor diet and the low socio-economic status of the parents are implicated.

Key words: Protein energy malnutrition, iron, kwashiorkor, marasmus

1. Introduction

Nutrition is a fundamental need for health and in all stages of development in humans (WHO, 2000). Growth and development is being threatened by the growing surge of malnutrition in our society especially in children aged between one and ten years. The World Health Organization (WHO) defines malnutrition as the cellular imbalance between the supply of nutrients and energy and the body's demand for them to ensure growth maintenance and specific function (WHO, 2003). Hunger and malnutrition remain among the most devastating problems facing majority of the poor and needy in resource poor countries in the world and thus continue to dominate the health problems in these nations (WHO, 2000). Commonly referred to as "the silent emergency", malnutrition is said to be an accomplice in at least half of the 10.9 million child deaths each year in developing countries. Sadly, of all the various forms of malnutrition, protein energy malnutrition (PEM) is considered the most lethal (WHO, 2000) and infants are its targeted victims. A study on the nutritional status of Nigerian children revealed that 52% of child deaths are attributed to PEM making it the single greatest cause of infant mortality (Abdullahi *et al*., 2001). PEM covers a range of deficiency states from mild to severe and is defined as a range of pathological conditions arising from coincident lack in varying proportions of protein and calories occurring most frequently in infants or young children. The clinical disorders present either as kwashiorkor (insufficient high quality proteins) or marasmus (deficiency of calories). A combination of both is known as marasmic-kwashiorkor (Petason and Watson, 2004). Iron is a universal co-factor for mitochondrial energy generation and supports the growth and differentiation of all cell types. The regulation of systemic iron is through the proteins transferrin (iron mobilization) and ferritin (iron sequestration) (Ruskins and Connors, 1994). Maintenance of total body iron is dependent on absorption of ingested iron by the intestinal mucosa. Iron absorption is a very complex process that is influenced by the body iron store, its rate of utilization and the availability of transport proteins. This study was aimed at providing information on the iron status of protein energy malnourished children in Calabar, Nigeria.

1.1 Materials and methods

A total of one hundred children between the ages of one to ten (1-10) years diagnosed with various forms of protein energy malnutrition and admitted at the Paediatric clinic of University of Calabar Teaching Hospital, Calabar, Nigeria were enrolled in this study. Of these, forty three (43) were males while fifty seven (57) were

females. Fifty apparently healthy children of similar age consisting of twenty nine (29) males and twenty one (21) females, selected from Madonna Montessori Nursery and Primary school, Calabar served as control subjects. The study was approved by the ethical committee of the University of Calabar Teaching Hospital (UCTH). Informed consent and a standard questionnaire on medical and social history were administered to the parents of each subject. The protein energy malnourished children who were less than a year old or older than 10 years and had other clinical complications were excluded from the study.
Five milliliters (5ml) of venous blood was collected aseptically into two sample containers. Two (2) ml of blood was delivered into dipotassium ethylene diamine tetra acetic acid (K_2EDTA) container to a final concentration of 2mg/ml for the estimation of haemoglobin and packed cell volume while the remaining 3ml was delivered into sterile iron-free screw-cap bottles and allowed to clot within one hour at room temperature, then centrifuged at 3,000 rpm for 10 minutes and the serum separated into iron-free containers and stored at -20^{o}C until the analysis was performed. Haemoglobin (Hb) was estimated using Cyanmethaemoglobin method while packed cell volume (PCV) was measured using the microhaematocrit method (Dacie and Lewis, 2001). Serum iron (SI) and total iron binding capacity (TIBC) were measured colorimetrically using kits purchased from Audit Diagnostics, Ireland. Serum ferritin (SF) determination was based on a solid phase enzyme-linked immunosorbent assay (ELISA). Transferrin saturation (TS) was derived by calculation from serum iron and total iron binding capacity. The body mass index (BMI) of the test and control subjects was also determined. The data generated from this study were subjected to student t-test analysis and one-way analysis of variance. A two tailed P-value of < 0.05 was considered indicative of a statistically significant difference.

1.1.1 Results

This research work examined iron-related parameters of one hundred protein energy malnourished children in Calabar aged between one to ten years as compared to fifty apparently healthy control subjects of similar age.

The tests performed were haemoglobin (Hb) concentration, packed cell volume (PCV), serum iron (SI), total iron binding capacity (TIBC), serum ferritin (SF) and transferrin saturation (TS). As shown in table 1, the mean values obtained for haemoglobin, packed cell volume and serum ferritin of PEM children were 8.70±1.10g/dl, 0.26±0.04L/L and 15.10±13.45ng/ml respectively and these values were significantly lower (P<0.05) when compared to values obtained for control subjects (11.00±0.90g/dl, 0.33±0.02L/L, 53.50±30.13ng/ml). Conversely, the serum iron and transferrin saturation of the test group (14.00±3.90µmol/L, 25.70±8.30%) were significantly higher (P<0.05) than that of the controls (9.80±2.32µmol/L, 15.90±4.76%). There was no change (P>0.05) in the total iron binding capacity with PEM subjects and controls having values of 55.80±8.30µmol/L and 62.80±8.90µmol/L respectively. Table 2 shows the influence of age on the parameters measured for PEM children and controls. The study population was grouped into ages 1-5 and 6-10 years. Serum ferritin level of the 1-5 years group (24.02±32.35ng/ml) was significantly higher (P<0.05) than the 6-10 years group (13.88±8.41ng/ml) for the test subjects. Similarly, the values for the control subjects were 64.48±28.30ng/ml and 45.39±28.40ng/ml for the 1-5 and 6-10 years group respectively. Other parameters were not influenced by age. Table 3 shows that iron parameters are the same irrespective of the type of PEM. The body mass index (BMI) of the control (20.91±3.10) was higher than that of the test group (18.39±3.27) though not significantly. A comparison of the weight and height of PEM children and control subjects is presented in Figures 1 and 2.

1.1.2 Discussion

Protein energy malnutrition is one of the most serious problems encountered in early childhood. It is implicated in childhood mortality and morbidity. This study was designed to investigate and evaluate some iron related parameters of protein energy malnourished children in Calabar. It was observed that the haemoglobin, packed cell volume and serum ferritin (8.70±1.10g/dl, 0.26±0.04L/L and 15.10±13.45ng/ml) of protein energy malnourished children were significantly lower (P<0.05) than values obtained for control subjects (11.00±0.90g/dl, 0.33±0.02L/L, 53.50±30.13ng/ml). This finding is in accordance with the report of previous studies (Reeds and Laditan, 1996; Emeribe, *et al.* 1994; Usanga, 1990; Taiwo, *et al.* 1992). These low values could be attributed to poor diet due to low socio-economic status of the parents. It was observed from the administered questionnaire that these children were from very poor background, not well breast-fed or abandoned. The significant reduction in haemoglobin and packed cell volume in this study could be explained by the fact that synthesis of haemoglobin is impaired in protein-depletion conditions. Indirect evidence that protein deficiency is the cause of anemia in PEM was shown by Allen and Dean (1993). However, it has been shown that an erythropoietic adaptation rather than anaemia occurs in children with PEM as a consequence of a reduction in lean body mass, as measured indirectly by urinary creatinine excretion. According to Viteri and

Alvarado (1970), total circulating haemoglobin is reduced in proportion to the degree of depletion of the lean body mass. Conversely, mild to moderate anaemia (Hb of about 10g/dl) had earlier been reported to be more commonly associated with PEM in Zimbabwe (Nkrumah, *et al*. 1988); Uganda (Allen and Dean, 1993) and South Africa (Macdougall, *et al*. 1999). Serum ferritin was found to be significantly lower ($p<0.05$) in protein energy malnourished children than in the control group. Low SF level in malnourished children defines the onset of iron deficiency and denotes complete exhaustion of iron stores (Ramdath & Goklien, 1989). The lack of iron has been reported by several workers to be the main cause of anaemia in malnutrition. Iron deficiency in relation to PEM, impairs normal motor and mental development in children (Pollit, 1995). In contrast serum iron and transferrin saturation (14.00±3.90μmol/L, 25.70±8.30%) of protein energy malnourished children were significantly higher ($p<0.05$) than in the control group (9.80±2.32μmol/L, 15.90±4.76%). This is in accordance with work done by Taiwo, *et al* (1992) in Ile-Ife, western Nigeria. This significant increase in SI and TS may be due to the fact that transferrin which is responsible for transport of free iron to storage sites is lacking due to the deficiency in protein. This results in a high level of unbound iron in the serum. Cook and Skikne (2005) reported that serum iron is not enough to measure iron stores and anaemia. In contrast, Sa'iah, *et al* (2007) reported a decrease in serum iron in PEM. This could be attributed to the fact that the malnourished children in their study suffered from severe trichuriasis which was a significant contributor to anaemia and iron deficiency in that population. According to Mclaren, *et al* (1986), increased transferrin saturation in protein energy malnourished children may be due to the bone marrow presenting normal or elevated iron deposits. Transferrin saturation may also play a key role in infection resistance during period of physiological low concentration of immunoglobulins in growing children (Dallman, 1987).

When the age of protein energy malnourished children was considered in relation to iron (table 2), the serum ferritin was significantly different ($p<0.05$) for the two age groups. This implies that body iron stores decreases with age. This is in agreement with previous findings (Abdulkader and Ataur, 1992). This study has shown no significant differences ($p>0.05$) in mean values of all analyzed iron related parameters between the PEM types (table 3) and agrees with previous report (Saad, 1974). The low level of haemoglobin and PCV in relation to PEM groups could be attributed to an adaptation to decreased body mass. The haematological alterations in PEM must be viewed as a dynamic phenomenon of balance between body composition and the erythron (Viteri, *et al*.1998).

Comparing the weights and heights in relation to the ages of protein energy malnourished children with the control group (figures 1 & 2), it was observed that there was a stunt in the growth of those children who were malnourished. This reflects the cumulative effect of under nutrition. This Anthropometry measurement is in accordance with the World Health Organization standard as it relates to PEM.

This study has shown that a statistical difference exists between the iron levels of protein energy malnourished children when compared with apparently healthy children. Due to the significant decrease in the iron related parameters of malnourished children in this part of the world, it is recommended that haemoglobin concentration, packed cell volume and serum ferritin should be part of the routine tests for children reporting to hospitals for any ailment. Also, early hospital attendance when PEM related symptom is noticed is recommended. Improvement in societal infrastructure, better maternal education and nutrition, provision of adequate child welfare clinics, and proper child welfare which should include balanced and adequate dieting will contribute significantly to reduce the incidence of protein energy malnutrition and its effects.

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Table 1

Iron related parameters of protein energy malnourished children and control subjects

	PEM patients (N=100)	Control subjects (N=50)	P-value
HB (g/dL)	8.70±1.10	11.00±0.90	<0.05
PCV (L/L)	0.26±0.04	0.33±0.02	<0.05
SF (ng/ml)	15.10±13.45	53.50±30.13	<0.05
SI (µmol/L)	14.00±3.90	9.80±2.32	<0.05
TIBC (µmol/L)	55.80±8.30	62.80±8.90	>0.05
T/S (%)	25.70±8.30	15.90±4.76	<0.05

Table 2
Iron related parameters of PEM children and controls based on age

	PEM patients (N=100)		Control subjects (N=50)		P-value
AGES (years)	1-5 (n=75)	6-10 (n=25)	1-5 (n=28)	6-10 (n=22)	
HB (g/dL)	8.70±1.10	8.50±1.30	11.10±1.00	11.10±1.00	>0.05
PCV (L/L)	0.27±0.03	0.26±0.04	0.33±0.02	0.32±0.02	>0.05
SF (ng/ml)	24.02±32.35	13.88±8.41	64.48±28.30	45.39±28.40	<0.05
SI (µmol/L)	13.84±3.70	14.55±4.40	10.19±2.60	9.17±1.60	>0.05
TIBC(µmol/L)	55.03±8.40	57.69±7.50	62.32±8.10	62.61±9.20	>0.05
T/S (%)	25.53±7.80	26.08±9.60	17.13±5.30	15.03±3.80	>0.05

Table 3
Iron related parameters of children based on types of PEM

	Marasmic kwashiokor (<60% with oedema) (n=13)	Underweight kwashiokor (60 -80% oedema) (n=62)	Marasmus (<60% without oedema) (n=25)	P-value
HB(g/dL)	8.50±0.09	8.60±1.30	8.80±0.80	>0.05
PCV(L/L)	0.26±0.03	0.26±0.04	0.27±0.02	>0.05
SF(ng/ml)	13.01±8.66	16.56±11.62	17.15±21.89	>0.05
SI(µmol/L)	13.90±4.50	14.30±3.90	12.90±3.00	>0.05
TIBC (µmol/L)	55.90±10.50	55.60±7.60	56.60±8.60	>0.05
T/S (%)	26.10±10.80	26.30±8.10	23.90±6.80	>0.05

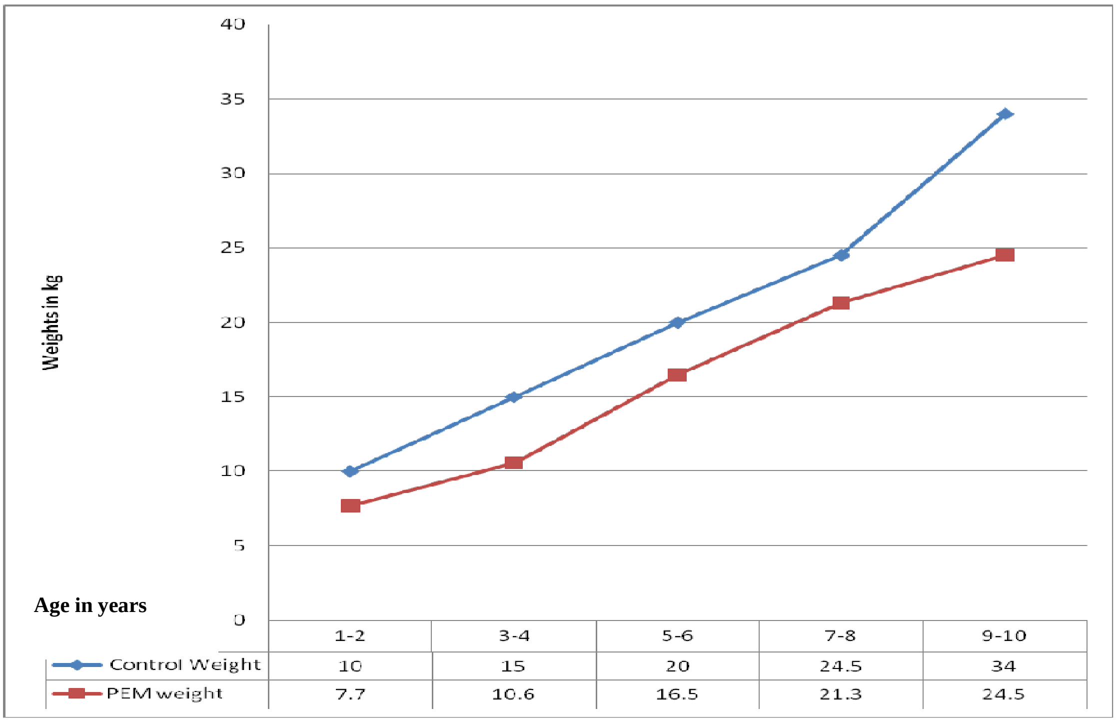

Figure 1 Weight and age of control children compared with PEM children

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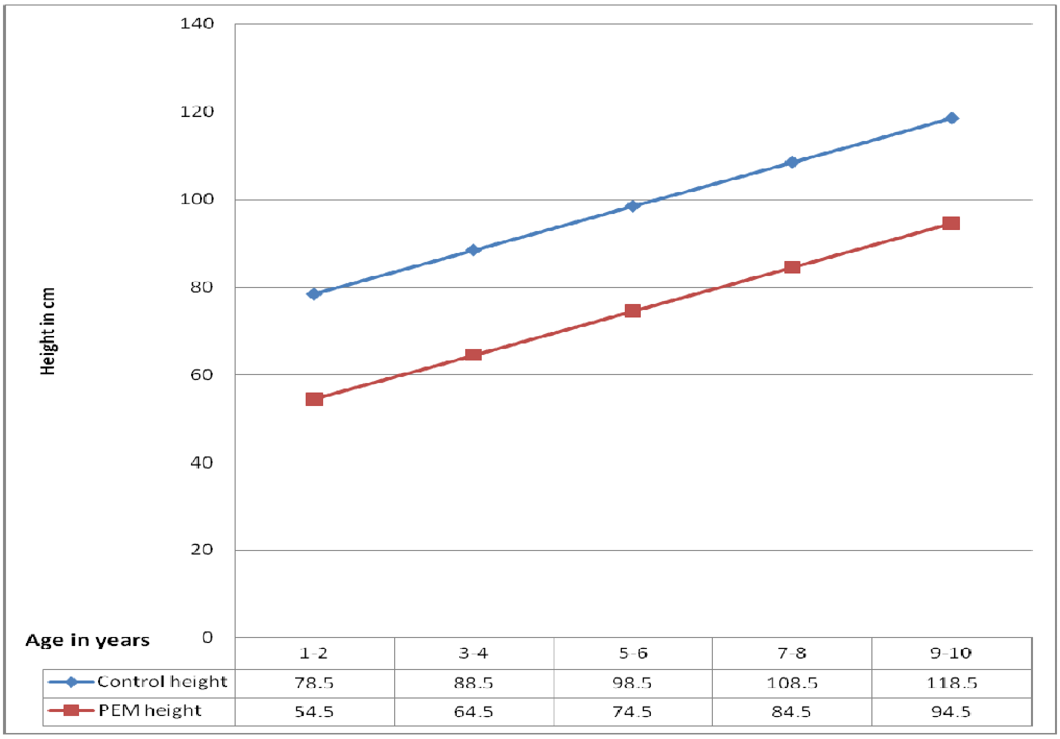

Age in years	1-2	3-4	5-6	7-8	9-10
Control height	78.5	88.5	98.5	108.5	118.5
PEM height	54.5	64.5	74.5	84.5	94.5

Figure 2 Height and age of control children compared with PEM children