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The effect of iron-deficiency anaemia on two indices of nutritional status, prealbumin and transferrin

By F. DELPEUCH, A. CORNU and P. CHEVALIER

Nutrition Research Unit, National Office for Scientific and Technical Research, PO Box 193, Yaoundé, Cameroon, W. Africa

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1. Serum prealbumin, transferrin and iron concentrations were measured in ninety-two north Cameroonian children under 5 years of age. The results were grouped according to the blood haemoglobin concentration range in order to show the interactions of anaemia with prealbumin and transferrin concentrations.

2. Transferrin concentration showed a significant negative correlation with serum Fe and percentage saturation of transferrin values. Prealbumin concentration showed a significant direct correlation with haemoglobin but did not correlate with either serum Fe or percentage saturation of transferrin.

3. It is concluded that in regions where Fe-deficiency anaemia is endemic transferrin concentration may be of little value in determining nutritional status. On the contrary, prealbumin seems to be more useful.

Recently there has been a growing interest in biochemical indicators of protein–energy malnutrition (PEM). The search has been particularly directed towards an index which allows early detection of PEM (Whitehead, 1967; Rutishauser & Whitehead, 1969). Since the liver is one of the organs first affected by PEM, special attention has been given to serum proteins of hepatic origin. Thus, transferrin (MacFarlane *et al.* 1969; Gabr *et al.* 1971; Reeds & Laditan, 1976) and prealbumin (Ingenbleek *et al.* 1972; N'Diaye *et al.* 1977) have been proposed as indices of the severity of PEM as well as indices for field assessment of nutritional status. In severe kwashiorkor prealbumin concentrations (Ingenbleek *et al.* 1972) as well as transferrin (Reeds & Laditan, 1976) may decrease to 18% of the normal level. A recent study has also shown that prealbumin and transferrin are useful criteria for assessing PEM in surgical patients (Young & Hill, 1978).

However, PEM is very often associated with other diseases such as infections or mineral deficiencies. One can assume that these diseases may also lead to modifications in the metabolism of serum proteins and therefore influence their effectiveness as indicators of nutritional status. Thus, previous studies indicate that Fe-deficiency anaemia could lead to increased transferrin synthesis (Morton & Tavill, 1977) and increased serum transferrin concentrations (Mosawe & Rwabwogo-Atenyi, 1973). In view of the fact that prealbumin and transferrin may be more and more used for early detection of undernutrition it seems timely to assess the influence of other diseases than PEM on serum prealbumin and transferrin concentrations.

In Cameroon a national nutrition survey has revealed that Fe-deficiency anaemia and chronic PEM are among the most wide-spread diseases in children under 5 years of age. In most cases these diseases are interrelated. The purpose of this paper is to investigate the interaction between Fe-deficiency anaemia and prealbumin and transferrin concentrations.

SUBJECTS AND METHODS

This study was carried out in the dry season (March 1978) and involved ninety-two children from villages around Tokombéré in the northern province of Cameroon: in this area, the staple diet is mainly whole sorghum (*Sorghum vulgare*). Fe-deficiency represents the most important cause of anaemia in the region and is probably due to poor intestinal absorption of food Fe.

Table 1. *Mean values of age, weight-for-height and height-for-age, serum iron, prealbumin and transferrin concentrations, and percentage saturation of transferrin for north Cameroonian children grouped according to their blood haemoglobin concentrations*

(Mean values with their standard errors)

Group*...	1		2		3		Statistical significance of difference: P		
No. of children...	26		45		21				
	Mean	SE	Mean	SE	Mean	SE	1 v. 2	1 v. 3	2 v. 3
Age (months)	32·8	2·3	27·8	1·5	27·6	2·5	NS	NS	NS
Weight-for-height (%)†	90·6	1·6	91·8	1·1	91·4	1·9	NS	NS	NS
Height-for-age (%)†	93·8	0·6	92·8	0·7	91·0	0·9	NS	< 0·05	NS
Fe (μmol/l)	11·7	1·1	7·7	0·5	7·8	1·0	< 0·001	< 0·01	NS
Transferrin (mg/l)	3513	86	3952	95	3907	175	< 0·05	< 0·05	NS
Percentage saturation of transferrin	15·8	1·5	9·5	0·6	9·8	1·3	< 0·001	< 0·01	NS
Prealbumin (mg/l)	125	6	114	5	97	7	NS	< 0·01	< 0·05

NS, Not significant (P > 0·05).

* Blood haemoglobin concentration range (g/l): group 1 > 100, group 2 80–99, group 3 < 80; mean ± SE: group 1 109 ± 1, group 2 90 ± 1, group 3 74 ± 1.

† Percentage of expected values taken from the Harvard standards (Stuart & Stevenson, 1959), as given by Jelliffe (1966).

Body-weight and height were measured. Weight-for-height and height-for-age were calculated as percentages of the expected values taken from the Harvard standards (Stuart & Stevenson, 1959) as given by Jelliffe (1966).

Blood samples were collected from fasting children by venous puncture in the femoral vein.

Informed consent was obtained from the parents and the study was approved by the paediatric service of the Tokombéré hospital.

Whole-blood haemoglobin values were determined by the cyanmethaemoglobin method of Drabkin modified by Van Kampen & Zijlstra (1961). Serum Fe concentrations were measured by the orthophenantrolin method (Fortune & Mellow, 1938). Serum prealbumin and transferrin concentrations were determined by radial immunodiffusion. Percentage saturation of transferrin values were calculated as follows: (serum Fe/total Fe-binding capacity) × 100. Since blood haemoglobin concentration is commonly a basis for the diagnosis of anaemia (WHO, 1968; Derman *et al.* 1978), the ninety-two children were divided into three groups according to their blood haemoglobin concentration.

Differences between mean values and the significance of correlation coefficients were assessed by the Student's *t* test (Snedecor & Cochran, 1957).

RESULTS

The ninety-two children were classified into groups according to their blood haemoglobin concentration range (group 1 had the highest value and group 3 the lowest value, Table 1). While not having very high mean values for haemoglobin, serum Fe and percentage saturation of transferrin, group 1 may be considered as a control group for the children of the region studied.

The children of groups 2 and 3 had significantly lower values for serum Fe and percentage saturation of transferrin than the children of group 1. For groups 2 and 3 the mean values for serum Fe (less than 8 μmol/l) and percentage saturation of transferrin (below 10%) could be considered as abnormal and typical of Fe-deficiency anaemia.

Table 2. *Correlation coefficients for prealbumin and transferrin* v. *haemoglobin, serum iron and percentage saturation of transferrin for ninety-two north Cameroonian children under 5 years of age*†

	Prealbumin	Transferrin
Haemoglobin	0·3069***	−0·2314*
Serum Fe	0·1144	−0·2969**
Percentage saturation of transferrin	0·0938	−0·5626***

* $P < 0·05$, ** $P < 0·01$, *** $P < 0·005$.
† For details, see Table 1.

Transferrin concentrations for groups 2 and 3 were significantly higher than those for group 1.

There were no differences in the mean values for serum Fe, percentage saturation of transferrin and transferrin between groups 2 and 3 despite the fact that haemoglobin concentrations for group 3 were less than those for group 2.

Significant decreases in the prealbumin concentration were found only between group 3 and groups 1 and 2. Values given in Table 1 suggested that the lowest values of haemoglobin were associated with low values of prealbumin.

When the children of the three groups were considered together (Table 2) the level of prealbumin did not correlate with either the level of serum Fe or the percentage saturation of transferrin. On the contrary, there was a highly significant correlation between prealbumin and haemoglobin. This correlation was still significant when the level of Fe was kept constant (partial r 0·29, $P < 0·01$). The serum transferrin concentration was negatively correlated with haemoglobin as well as with serum Fe and the percentage saturation of transferrin. However, correlation between haemoglobin and transferrin was no longer significant when serum Fe was kept constant (partial r 0·11, $P > 0·05$).

DISCUSSION

The results of the present study suggest that in areas of endemic Fe-deficiency anaemia the use of transferrin concentration as an indicator of nutritional status should be undertaken with extreme caution.

Our results and those reported by Mosawe & Rwabwogo-Atenyi (1973) show that anaemia tends to increase serum transferrin concentrations.

Even in the group with the highest values of haemoglobin and serum Fe, mean transferrin concentration was much higher than that reported by Neumann *et al.* (1975) for a control group of Ghanaian children (3107 mg/l). The mean value of percentage saturation of transferrin of the group 1 (15·8 %) was below the limit of normal values (16 %) considered by Bainton & Finch (1964) and Derman *et al.* (1978). This could indicate a propensity for Fe deficiency in north Cameroonian children.

However, the results of another study carried out on children with kwaskiorkor do not show any significant correlations between transferrin levels and haemoglobin or serum Fe values (Gabr *et al.* 1971).

These results may be explained by the fact that in the instance of kwaskiorkor the marked decrease in transferrin level minimizes the augmentation due to Fe deficiency. In addition one can also assume that impaired liver function does not allow an increase in the transferrin synthesis. On the contrary, in moderate forms of malnutrition the liver function and transferrin concentration are only slightly depressed. Thus, with an infant suffering simultaneously from moderate PEM and anaemia, the decrease in transferrin due to malnutrition is masked by the increase due to a lack of Fe. When compared to the normal value found by Neumann *et al.* (1975) for transferrin concentration, the increase reported in the present study as a result of Fe deficiency (+27%) is much more important than the decrease caused by moderate PEM (− 14%, Neumann *et al.* 1975; − 18%, Reeds & Laditan, 1976). Consequently it would seem appropriate to do a complete check for anaemia in children when transferrin is used as an indicator in field assessment of nutritional status.

The mean value for prealbumin concentration found in the present study for group 1 children was approximately that found in healthy children from Egypt (145·0 mg/l, Smith *et al.* 1973) and from Thailand (129·0 mg/l, Schelp *et al.* 1976).

Since prealbumin did not correlate significantly with either serum Fe or percentage saturation of transferrin our study shows that prealbumin concentrations do not seem to be affected by Fe-deficiency anaemia.

However, the significant relationship between prealbumin and haemoglobin suggests a metabolic alteration with a common origin which leads to a simultaneous decrease in these two variables. One could suspect the existence of protein or amino acids deficiencies. The effects of such deficiencies on the haemoglobin synthesis and on the appearance of hypochromia has already been demonstrated (Aschkenasy, 1971). Moreover, children with kwashiorkor have prealbumin levels lower than that of children with marasmus (Ingenbleek *et al.* 1975). This could also indicate a specific effect of protein deficiencies. Children of group 3 did not seem to be particularly affected by acute PEM (mean weight-for-height 91·4% of the standard value, not different from that of group 1). However, the significant decrease in the mean height-for-age suggests a chronic moderate PEM characterized by reduced levels of haemoglobin and prealbumin.

In conclusion it can be suggested that in regions with endemic Fe-deficiency anaemia, while transferrin may be of little value, prealbumin could be a valuable index of nutritional status.

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