Dietary Iron and Anaemia in an Indian Community in Natal

F. G. H. MAYET, M.D. UNIV. NATAL, Senior Lecturer, E. B. ADAMS, M.D. UNIV. RAND, F.R.C.P. LOND., Professor of Medicine, T. MOODLEY, M.B. CH.B. UNIV. NATAL, Wellcome Research Fellow, E. E. KLEBER, B.SC., Scientific Assistant AND S. K. COOPER, Senior Medical Technologist, MRC Nutritional Anaemia Research Group, Department of Medicine, University of Natal, Durban

SUMMARY

Because of the high incidence of iron-deficiency anaemia among Indians in Natal, in comparison with Bantu, a dietary and haematological survey was carried out in the Durban metropolitan area. For this purpose the homes of 397 Indian families were visited at random. The mean iron intake per head per day was 11.5 mg, but it was less than 8 mg in almost 20% of the families. Iron-deficiency anaemia was common, but did not appear to be related to the total-iron intake; there were as many anaemic subjects in the under 8 mg per head per day group as there were among those taking more than 14 mg per day. High dietary phytate and low calcium content appear to be important contributory causes.

In striking contrast to the situation among Bantu patients in the wards of King Edward VIII Hospital, in whom iron-deficiency anaemia is infrequently found (because of high dietary iron), patients of Indian descent commonly suffer from this type of anaemia. Analysis of the records of 1 medical unit over a 16-year period, corrected for the higher proportion of Bantu patients admitted to the hospital, showed that Indians with iron-deficiency anaemia outnumbered Bantu by 20:1. Often the cause of their anaemia is not clear. It therefore seemed worth while to re-examine the relationship between dietary iron intake and iron-deficiency anaemia.

In this article we report the main findings related to iron intake and anaemia from a random dietary and haematological survey of the Indian population of the Durban metropolitan area. The survey was based on cluster samples and involved home visits to 397 families from whom details of the family food intake over a 7-day period were obtained using the food list method. Venous blood was taken from all available subjects over the age of 10 years, capillary blood being sampled in children under this age.

DIETARY IRON

Diets were analysed from food tables. Table I sets out the relevant dietary constituents in 391 families; the records of 6 were unsatisfactory. Mean values for calorie and calcium intake fall short of normal requirements. Protein intake and the phosphorus and carbohydrate content were normal. The mean iron-intake of 11.5 mg per head per day is a somewhat low normal level, 10 - 18 mg per day being generally accepted in Western countries. Although 11.5 mg is probably adequate, it should be noted that the diets of 70 families (18%) contained less than 8 mg per head per day (see Table II).

**TABLE I. DIETARY CONTENT OF 391 FAMILIES**

<table>
<thead>
<tr>
<th>Component</th>
<th>Mean/head/day (and range)</th>
<th>Normal requirements</th>
</tr>
</thead>
<tbody>
<tr>
<td>Fe (mg)</td>
<td>11.5 (4.9 - 42.7)</td>
<td>Geigy tables 10 - 18</td>
</tr>
<tr>
<td></td>
<td></td>
<td>S.A. food tables</td>
</tr>
<tr>
<td>Protein (g)</td>
<td>68 (29 - 271)</td>
<td>45 - 65 60 - 70</td>
</tr>
<tr>
<td>Ca (mg)</td>
<td>451 (114 - 2 120)</td>
<td>800 - 1 400</td>
</tr>
<tr>
<td>P (mg)</td>
<td>988 (338 - 3 987)</td>
<td>800 - 1 400</td>
</tr>
<tr>
<td>Carbohydrate (g)</td>
<td>268 (93 - 936)</td>
<td>1 745 1 700 - 3 000</td>
</tr>
<tr>
<td>Calories (kal)</td>
<td>1 745 (625 - 6 767)</td>
<td>2 100 - 4 500</td>
</tr>
</tbody>
</table>

HAEMATOLOGICAL RESULTS

By using standard methods, estimations of haemoglobin and the packed cell volume were done on all available subjects. Plasma iron was measured by the method of Bothwell and Maller and a radioactive $^{59}$Fe method was used for the unsaturated iron-binding capacity from which the total iron-binding capacity and the percentage saturation were calculated. Microbiological assays were...
performed for estimating serum folate and serum vitamin B\textsubscript{12} levels.
The results are summarized in Tables III and IV. The high incidence of anaemia is illustrated in Fig. 1.

**TABLE III. HAEMATOLOGICAL RESULTS**

<table>
<thead>
<tr>
<th>Hb</th>
<th>F</th>
<th>M</th>
<th>MCHC</th>
<th>saturation</th>
</tr>
</thead>
<tbody>
<tr>
<td>Mean</td>
<td>12.4</td>
<td>13.3</td>
<td>31.6</td>
<td>23.4</td>
</tr>
<tr>
<td>Range</td>
<td>4.2 - 17.5</td>
<td>5.0 - 20.1</td>
<td>20.5 - 40.0</td>
<td>1 - 100</td>
</tr>
<tr>
<td>No. of subjects</td>
<td>1 610</td>
<td>888</td>
<td>2 435</td>
<td>2 225</td>
</tr>
</tbody>
</table>

**TABLE IV. SERUM FOLATE AND VITAMIN B\textsubscript{12} LEVELS**

<table>
<thead>
<tr>
<th>Folate</th>
<th>Vitamin B\textsubscript{12}</th>
</tr>
</thead>
<tbody>
<tr>
<td>Mean</td>
<td>10.6</td>
</tr>
<tr>
<td>Range</td>
<td>1.5 - 40.0</td>
</tr>
<tr>
<td>2.0% under</td>
<td>1.0% under</td>
</tr>
<tr>
<td>3.0 ng/ml</td>
<td>100 pg/ml</td>
</tr>
<tr>
<td>No. of subjects</td>
<td>2 025</td>
</tr>
</tbody>
</table>

**RELATIONSHIP BETWEEN DIETARY IRON AND ANAEMIA**

When 10 mg was taken as the lower limit of the normal range, no significant differences could be shown between the mean values of subjects with low daily dietary iron intake and those whose intake was normal as regards the proportions who were anaemic (haemoglobin less than 11.0 g per 100 ml), exhibited hypochromia (mean corpuscular haemoglobin concentration under 30%) or had plasma iron patterns with saturation levels of 16% or less (see Table V).

It might be argued that differences between the groups might not emerge in such a comparison since the daily iron intakes in the majority were clustered around the mean value of 11.5 mg and that the cut-off point at 10 mg was too close to the mean. Moreover, the majority of subjects were females in whom menstrual losses and pregnancies, likely to be equal in the 2 groups, might further obscure the influence of dietary iron on the results. A different form of analysis was therefore carried out, which compared, in adult males only, those whose daily iron intakes were below 8 mg with those in whom the intake was above 14 mg per day. The results are set out in Table VI in which it will be noted that haemoglobin levels below 11.0 g/100 ml and above 12.5 g/100 ml, were used to separate anaemic from non-anaemic subjects. Again no real differences were seen.
DIETARY IRON (ADULT MALES ONLY)

From these comparisons it can be concluded that low total daily iron intake, as judged from food tables, is not the cause of the high incidence of iron-deficiency anaemia in the Indian population of the Durban metropolitan area.

**TABLE V. DIETARY IRON INTAKE AND IRON-DEFICIENCY ANAEMIA**

<table>
<thead>
<tr>
<th>IRON DEFICIENCY ANAEMIA</th>
<th>Low intake</th>
<th>Normal intake</th>
</tr>
</thead>
<tbody>
<tr>
<td>(&lt;10 mg/day)</td>
<td>(1%)</td>
<td>(1%)</td>
</tr>
<tr>
<td>Hb &lt;11.0 g/100 ml</td>
<td>15.5</td>
<td>15.9</td>
</tr>
<tr>
<td>Hyprochromia</td>
<td>16.6</td>
<td>19.1</td>
</tr>
<tr>
<td>(MCHC &lt;30%)</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Fe saturation</td>
<td>27.0</td>
<td>28.7</td>
</tr>
<tr>
<td>15% and less</td>
<td></td>
<td></td>
</tr>
</tbody>
</table>

**TABLE VI. DIETARY IRON INTAKE AND IRON-DEFICIENCY ANAEMIA**

<table>
<thead>
<tr>
<th>Iron intake</th>
<th>&lt;11.0</th>
<th>&gt;12.5</th>
</tr>
</thead>
<tbody>
<tr>
<td>% saturation</td>
<td>16 and less</td>
<td></td>
</tr>
<tr>
<td>&gt;14 mg</td>
<td>16.9</td>
<td>51.0</td>
</tr>
<tr>
<td>&lt;8 mg</td>
<td>15.0</td>
<td>50.5</td>
</tr>
</tbody>
</table>

**DIETARY SOURCES OF IRON AND THE INCIDENCE OF ANAEMIA**

The diet of each adult male was analysed with regard to the source of iron from 2 main categories—meat, fish, and dairy products comprising one, and legumes and cereals the other. This was done since legumes and cereals, containing a high concentration of phytic acid, were observed to be an important source of the dietary iron. Each category was arbitrarily subdivided into 3 groups: high, medium, and low, according to the iron content. The high and low groups were then tabulated as 4 possible combinations of level of protein iron with level of legume/cereal iron, and for each combination the incidence of iron-deficiency anaemia was calculated. The result is set out in Table VII.

Diet rich in protein iron are clearly associated with much less anaemia than those in which protein sources of iron are poor; and in the low protein category there was more anaemia when legumes and cereal sources were judged to be high, than when these were low. The fact that there was less anaemia (14%) in the low-protein iron and low-legume/cereal iron combination than in the low-protein/high cereal combinations (22%), may be due to the high phytate content of the legumes and cereals.

**DISCUSSION**

The design of this survey and the analysis of the results are open to several criticisms. The food list method is at best only a rough approximation of food intake. More important, iron intake was estimated for each family unit and assumed to be equally distributed between its members. Haematological investigations, on the other hand, were perforce done on individual subjects. Possible correlations were therefore between iron intake based on the mean for the family, and individual haematological findings. Another limitation of the survey lies in the fact that only some three-quarters of the population whose food was listed was available for blood sampling, largely due to the absence from home of adult males during the day.

The results confirm the high incidence of iron-deficiency anaemia among people of Indian origin in the metropolitan area of Durban, but show no direct relationship between the daily iron intake (on a quantitative basis) and the occurrence of iron-deficiency anaemia.

In relation to the incidence of this type of anaemia in various communities, qualitative considerations appear to be more important than the total dietary iron intake, particularly with regard to calcium, phosphorus and phytate content. The interrelationships are complex. Two studies of particular note are those of Hussain and Patwardhan, and Apte and Venkatchalam from the Nutrition Research Laboratories, Hyderabad. In metabolic experiments on 4 healthy adult males, the former workers showed that a mean positive iron balance of 2.48 mg was reduced to 0.17 mg on a constant daily iron intake (21-23 mg) when the phytate content of the diet was increased from 8% to 40%. Apte and Venkatchalam's work demonstrates how increasing the calcium content of the diet counteracts the adverse effect on iron absorption caused by excess dietary phytate: a negative iron balance on an iron intake of 16.6 mg per day when the calcium intake was 400 mg, changed to a delicate positive balance on 1000 mg calcium and increased to a good positive balance at 1500 mg, phytate in the cereal diet remaining constant at 40%.

The results of the present study can in part be explained by these experimental findings. Table I shows that the mean daily calcium in the diet (451 mg) is little more than half normal requirements, although the phosphorus content is well within the normal range. In Table VII, iron-deficiency anaemia is seen to occur much more frequently (22%) in subjects living on diets with a high content of legumes and cereals, but poor in meat, fish, and dairy products (presumably low protein-iron/high phytate), than it does (14%) among those with poor diets.
as regards both of these categories (low-protein iron/low
phytate). The assumption made here is that the high
phytic acid content of the former diet renders the small
amount of protein iron unavailable for absorption, and
this results in the high incidence of iron deficiency.

This work was supported by grants from the South African
Medical Research Council and the Wellcome Trust.

REFERENCES
in the Indian and the African in Durban. M.D. Thesis, University of
Natal, Durban.

Changes in \(^3\)H-Oestradiol Distribution in Rat
Tissues During Growth and After Prolonged
Oestrogen Deprivation

C. J. BEARDWOOD, PH.D. UNIV. LOND., Senior Lecturer AND S. S. BUCCIMAZZA, B.SC. (HONS.) UNIV. CAPE
TOWN, Demonstrator, Department of Physiology and Medical Biochemistry, University of Cape Town

SUMMARY

Tissues from the hypothalamus, pituitary, uterus, and
ovaries of the rat, were compared with cerebral cortex and
blood serum for their ability to bind radioactive
oestradiol. Most of the hormone was bound by the uterus
and ovaries, then by the pituitary, pre-optic area of the
brain, arcuate region, anterior hypothalamus, and posterior
hypothalamus.

Gradually increased binding of the hormone by these
tissues was evident during development from 7 to 240
days of age. The brain areas began binding significant
amounts of hormone from the age of 19 days. The wean-
ing rat, in contrast to the neonate, rapidly converts
oestradiol to oestriol. In the latter, oestradiol is converted
mostly to oestrone.

Prolonged deprivation of endogenous oestrogen gave
rise to reduced binding of the steroid by brain and
pituitary tissues in adult rats. The significance of oestro-
gen-binding by brain and pituitary cells, is discussed in
relation to ovulation control.


The action of oestrogen at the cellular level is very likely
mediated by means of a complex cytoplasmic/nuclear
carrier system which was first described for the uterus by
Jensen and Jacobson\(^1\) in 1962. Subsequent studies have
shown that similar carrier systems function in all the
oestrogen target tissues, namely, vagina,\(^1\) ovaries,\(^2\) anterior
pituitary,\(^3\) and brain,\(^4\) although there is evidence that the
carrier proteins in the anterior pituitary and hypothalamus
are different from those in the uterus.\(^5\) Little attention has
been paid to the ovarian receptor mechanism, while
possible changes in the oestrogen-binding system during
growth of the various target tissues, have been investi-
gated to a limited extent.\(^6,7\)

Our experiments, although directed mainly towards the
study of oestradiol-binding mechanisms of the brain and
pituitary, also describe the \emph{in vivo} interaction of this
steroid with the other target tissues. Attention is paid to
changes in the oestrogen-complexing mechanism from the
neonatal age onwards. Evidence is also presented for an
alteration in the ability of brain and pituitary tissue to
bind oestrogen, after prolonged absence of an endogenous
supply of oestrogen.

\(^*\)Date received: 18 February 1972.