Thiamine deficiency in black male hostel-dwellers

The need for thiamine supplementation of sorghum beer

J. VAN DER WESTHUYZEN, R. E. DAVIS, G. C. ICKE, J. METZ

Summary

Some indices of nutrition have been examined in hostel- and non-hostel-dwelling groups of industrially employed black males. Hostel-dwellers in the large metropolitan areas have to prepare their own food and many are accustomed to excessive alcohol intake, especially of sorghum beer. In the two groups studied, blood levels of vitamin B12, folate, pyridoxal and albumin were similar, but erythrocyte thiamine levels were significantly lower in the hostel-dwellers. Although the proportion of subjects with elevated levels of γ-glutamyltranspeptidase, an index of alcoholic liver disease, was similar in the two groups, thiamine-deficient hostel-dwellers had a greater proportion of elevated values suggesting that thiamine deficiency was related to both inadequate diet and excessive alcohol consumption. Fortification of sorghum beer with thiamine might prevent or reduce thiamine deficiency in this group. The cost would not materially affect the price of the beer.

In the RSA, a large number of black men have to live in hostels in urban areas away from their families for varying periods. When food is provided by a control facility in the hostel, nutritional intake may be satisfactory. However, when hostel-dwellers have to provide and prepare their own food, nutritional deficiencies are likely to occur, especially when nutritional needs are increased by regular physical labour.

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be affected by alcohol (thiamine, pyridoxal, folate, vitamin B₁₂, albumin), and the results correlated with a marker of alcoholic liver disease, namely serum γ-glutamyltransferase (GGT) activity. A striking difference was revealed between thiamine nutrition in hostel-dwellers and a control group.

Subjects and methods

Industrially employed black men were selected randomly for inclusion in the study. Subjects living in hostels (the 'hostel group') were mainly migrant labourers; the control group resided in private homes in the townships. The 49 hostel-dwellers, aged 22 - 65 years (mean 38.4 years), were drawn from 24 different hostels in the PWV area. The 69 controls, who lived within the same area, were aged 18 - 65 years (mean 34.9 years).

Informed consent for blood donation was obtained from all subjects. Blood was drawn into a 5 ml Vacutainer tube containing EDTA anticoagulant and into a 10 ml plain tube for serum. The haematocrit was determined on the EDTA sample, after which the plasma and buffy coat were removed, and the packed erythrocytes stored at -30°C until analysed for thiamine and pyridoxal contents. The other biochemical estimations were carried out on serum.

Analytical methods

Serum folate and vitamin B₁₂ were determined with a commercial radio-assay kit (Simultrac — SNB Vitamin B₁₂ (57Co)/Folate (27H) kit; Becton Dickinson). Serum albumin and GGT were measured on the Abbott Series II Biochromatic Analyzer using commercial kits. The reagents and procedures for the serum albumin estimations were supplied in the Abbott BCG kit; and those for GGT in a new kit for automated analysis manufactured by Boehringer Mannheim.

Erythrocyte thiamine and pyridoxal estimations were performed at the Royal Perth Hospital, Western Australia, on frozen haemolysate which had been despatched by air. After thawing, the haemolysates were diluted 1:10 with buffer and heated at 95°C for 5 minutes at pH 4.6. The thiamine content was determined by automated microbiological assay using thiamine hydrochloride standards and a streptomycin-resistant mutant of Lactobacillus fermenti as the test organism. This organism responds to thiamine hydrochloride and its esters, and to free and bound forms of the vitamin. The limit of detection is 0.5 µg/l. Erythrocyte thiamine levels were measured because they reflect tissue concentrations of the vitamin.

Pyridoxal phosphate in blood was dephosphorylated with an acid phosphatase and assayed microbiologically, using L. casei as the test organism. Growth of L. casei is stimulated only by pyridoxal (the major form present in blood) and the organism is unable to utilise pyridoxine or pyridoxamine.

Statistical methods

Data are presented as means ± 1 SD. Differences between groups were determined by means of Student's t-test (two-tailed). The level of significance chosen was P < 0.05. Reference ranges are those determined in healthy subjects, usually laboratory workers.

Results

Results of the tests carried out on samples from hostel-dwelling and control groups are summarised in Table I. There were no statistically significant differences between the two groups with respect to mean serum vitamin B₁₂, folate, GGT, albumin or erythrocyte pyridoxal concentrations. However, the mean erythrocyte thiamine concentration of the hostel group was significantly lower (P < 0.001) than that of the control group.

Few or no subnormal values were observed for any of the nutritional indices measured (Table II) with the exception of erythrocyte thiamine concentration. Some 51.2% of the subjects in

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### TABLE I. SOME INDICES OF NUTRITION AND LIVER DISEASE IN 49 HOSTEL-DWELLERS AND 69 CONTROL SUBJECTS

<table>
<thead>
<tr>
<th></th>
<th>Hostel-dwellers</th>
<th>Controls</th>
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</thead>
<tbody>
<tr>
<td>Erythrocyte thiamine (µg/l)</td>
<td>51.5 ± 11.0 (26 - 75)</td>
<td>64.5 ± 12.1 (32 - 86)*</td>
</tr>
<tr>
<td>Erythrocyte pyridoxal (nmol/l)</td>
<td>61.9 ± 25.1 (12.5 - 119)</td>
<td>61.4 ± 21.8 (17.5 - 113.5)</td>
</tr>
<tr>
<td>Serum vitamin B₁₂ (ng/l)</td>
<td>648 ± 235 (190 - 1600)</td>
<td>660 ± 272 (223 - 1500)</td>
</tr>
<tr>
<td>Serum folate (µg/l)</td>
<td>4.3 ± 1.8 (1.0 - 9.0)</td>
<td>4.5 ± 2.0 (1.9 - 11.5)</td>
</tr>
<tr>
<td>Serum GGT (U/l)*</td>
<td>46.6 ± 73.7 (9 - 497)</td>
<td>43.2 ± 41.7 (4 - 287)</td>
</tr>
<tr>
<td>Serum albumin (g/l)</td>
<td>38.9 ± 2.5 (32 - 44)</td>
<td>39.6 ± 2.6 (33 - 45)</td>
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*Significantly different from control group, P < 0.001.

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### TABLE II. PERCENTAGE OF ABNORMAL VALUES FOR SOME INDICES OF NUTRITION AND LIVER DISEASE IN HOSTEL-DWELLING AND CONTROL SUBJECTS

<table>
<thead>
<tr>
<th></th>
<th>Hostel-dwellers</th>
<th>Controls</th>
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</thead>
<tbody>
<tr>
<td>Erythrocyte thiamine</td>
<td>Below Above</td>
<td>Below Above</td>
</tr>
<tr>
<td>50 - 106 µg/l</td>
<td>51,2 NR</td>
<td>11,7 NR</td>
</tr>
<tr>
<td>Erythrocyte pyridoxal</td>
<td>7,3 NR</td>
<td>3,3 NR</td>
</tr>
<tr>
<td>20 - 96 nmol/l*</td>
<td>0 12,2</td>
<td>0 13,2</td>
</tr>
<tr>
<td>Serum folate</td>
<td>2 - 13 µg/l</td>
<td>4,1 NR</td>
</tr>
<tr>
<td>Selenium vitamin B₁₂</td>
<td>10 - 50 U/l</td>
<td>18,4 NR</td>
</tr>
<tr>
<td>160 - 900 ng/l</td>
<td>0 NR</td>
<td>0 NR</td>
</tr>
</tbody>
</table>

*Age-specific reference ranges used: 20 - 29 years 26 - 96 nmol/l; 30 - 39 years 25 - 85 nmol/l; 40 - 49 years 25 - 66 nmol/l; 50 - 58 years 25 - 35 nmol/l; 60+ years 20 - 50 nmol/l serum. (Reference ranges for erythrocyte pyridoxal not available.)

NR = not relevant.
Thiamine deficiency may result from deficient dietary intake of the vitamin, and is commonly associated with excessive alcohol intake. In hostel-dwellers, it is difficult to separate the proportion of the thiamine deficiency due to poor diet alone from that linked with the effects of excessive alcohol intake. There is evidence that hostel-dwellers are accustomed to a high intake of traditional (sorghum) beer. McCabe in a recent review wrote: 'There are official beerhalls in every township which sell only African beer (of low alcohol content). These are situated mainly near the hostels where the migrant labour force lives (an estimated one-tenth of the township population) and these halls are patronised almost solely by the hostel-dwellers... It is interesting to note that the beerhall beer does not produce the picture of alcoholism as do the stronger brews.' In seeking to find that proportion of the thiamine deficiency which is due to alcoholism, one should look for other stigmata of alcoholism in this group. Serum levels of GGT, the most widely used biochemical test for assessing alcohol abuse, are elevated in some three-quarters of alcoholics and heavy drinkers, even in the absence of clinical evidence of hepatic disease, and independent of recent exacerbation of drinking. Alcohol intake and GGT activity are correlated, even at levels of alcohol consumption lower than those regarded as excessive. In the present study, GGT levels were elevated in about one-fifth of the subjects investigated, but there was no significant difference in the frequency of elevated values between hostel-dwellers and controls. However, when GGT levels in hostel-dwellers with low thiamine concentrations were compared with those with normal thiamine concentrations, the mean value for GGT was almost treble that in the thiamine-deficient group (Fig. 1). In addition, the mean value for GGT in subjects with subnormal thiamine levels was 64.3 U/l, almost twice that of the mean of 34.2 U/l in the thiamine-replete hostel-dwellers. This difference was not statistically significant due to the wide range of observations in the thiamine-deficient group. The mean age of the thiamine-deficient hostel-dwellers was also higher than in the thiamine-replete hostel-dwellers (P < 0.05).

Discussion

There is little published information on the dietary habits of black hostel-dwelling men. Facilities for the preparation of their own food are limited, and their diet therefore consists primarily of carbohydrate-rich foods purchased from local stores. These foods include the traditional maize meal (eaten as porridge), supplemented by bread, some milk and occasionally small amounts of meat and green vegetables. In urban black households bread is progressively replacing maize meal as the staple foodstuff. A recent poll showed that 90% of urban black households consume bread daily, and 9% consume milk daily (The Star, 7 June 1985). It is of interest that the thiamine intake for relatively well-off urban black household-dwellers has been calculated to be 1.8 mg, only slightly above the recommended daily allowance of 1.2 - 1.4 mg.

In spite of the apparent poor diet of the hostel group, few were deficient in protein, vitamin B12, pyridoxal and folate, and the mean values for these nutrients were not significantly lower than in controls. However, there is a striking incidence of low erythrocyte thiamine values in the hostel-dwellers. Thiamine deficiency may result from deficient dietary intake of the vitamin, and is commonly associated with excessive alcohol intake. In the hostel-dwellers, it is difficult to separate the proportion of the thiamine deficiency due to poor diet alone from that linked with the effects of excessive alcohol intake. There is evidence that hostel-dwellers are accustomed to a high intake of traditional (sorghum) beer. McCabe in a recent review wrote: 'There are official beerhalls in every township which sell only African beer (of low alcohol content). These are situated mainly near the hostels where the migrant labour force lives (an estimated one-tenth of the township population) and these halls are patronised almost solely by the hostel-dwellers... It is interesting to note that the beerhall beer does not produce the picture of alcoholism as do the stronger brews.' In seeking to find that proportion of the thiamine deficiency which is due to alcoholism, one should look for other stigmata of alcoholism in this group. Serum levels of GGT, the most widely used biochemical test for assessing alcohol abuse, are elevated in some three-quarters of alcoholics and heavy drinkers, even in the absence of clinical evidence of hepatic disease, and independent of recent exacerbation of drinking. Alcohol intake and GGT activity are correlated, even at levels of alcohol consumption lower than those regarded as excessive. In the present study, GGT levels were elevated in about one-fifth of the subjects investigated, but there was no significant difference in the frequency of elevated values between hostel-dwellers and controls. However, when GGT levels in hostel-dwellers with low thiamine concentrations were compared with those with normal thiamine concentrations, the mean value for GGT was almost treble that in the thiamine-deficient group. Thus using GGT as an index, it would seem that excessive alcohol intake plays a significant role in the aetiology of the thiamine deficiency demonstrated in hostel-dwellers. Deficiencies of pyridoxal and folate are common findings in

<table>
<thead>
<tr>
<th>TABLE III. COMPARISON OF RESULTS IN 20 HOSTEL-DWELLERS WITH NORMAL LEVELS AND 21 WITH DEFICIENT LEVELS OF THIAMINE</th>
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<tbody>
<tr>
<td>Normal (50 - 105 µg/l)</td>
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<td>Abnormal values (%)</td>
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<thead>
<tr>
<th>Age (yrs)</th>
<th>Below</th>
<th>Above</th>
<th>Below</th>
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<tbody>
<tr>
<td>Mean ± SD</td>
<td></td>
<td></td>
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</tr>
<tr>
<td>35.8 ± 10.1</td>
<td>NR</td>
<td>NR</td>
<td>42.9 ± 12.4</td>
<td>NR</td>
</tr>
<tr>
<td>60.5 ± 8.3</td>
<td>—</td>
<td>—</td>
<td>43.1 ± 5.4*</td>
<td>—</td>
</tr>
<tr>
<td>70.5 ± 28.8</td>
<td>5.0</td>
<td>NR</td>
<td>53.7 ± 18.9*</td>
<td>9.5</td>
</tr>
<tr>
<td>637 ± 296</td>
<td>1.0</td>
<td>10.0</td>
<td>673 ± 189</td>
<td>0</td>
</tr>
<tr>
<td>3.9 ± 1.8</td>
<td>5.0</td>
<td>NR</td>
<td>4.3 ± 1.7</td>
<td>4.8</td>
</tr>
<tr>
<td>34.2 ± 17.5</td>
<td>NR</td>
<td>10.0</td>
<td>64.3 ± 110.0</td>
<td>NR</td>
</tr>
<tr>
<td>38.8 ± 1.7</td>
<td>0</td>
<td>NR</td>
<td>39.4 ± 2.8</td>
<td>0</td>
</tr>
</tbody>
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NR = not relevant.
*Significantly different from hostel group with normal thiamine values (P < 0.05).
**Significantly different (P < 0.001).
alcoholics, but were present in only a few of the subjects in the present study. However, the highest incidence of deficiency of pyridoxal was in hostel-dwellers with low thiamine levels.

There is evidence that thiamine deficiency plays a significant role in the cardiomyopathy common in urban black males; hence the high incidence of deficiency in this population indicates that corrective action is necessary. The social conditions under which the hostel-dwellers live are difficult to modify in the short term, and as long as they are required to prepare their own food and consumption of sorghum beer continues, it is unlikely that their thiamine nutrition can be improved significantly unless a practical solution is found, and the most practical measure would appear to be fortification of sorghum beer with thiamine.

The general principles of food fortification have been enumerated by a joint FAO/WHO Expert Committee on Nutrition and, in the local context, in a CSIR Research Report on food enrichment in the RSA. Fortification is a public health measure aimed at improving or maintaining the nutrient intake of a population or segment of it (the target group) to meet an established need.16 In a fortification programme, certain criteria need to be met. Firstly, the nutrient needs and the target groups must be defined, and when there is clinical evidence of deficiency disease, improvements in the diet must be considered. As discussed above, there is a need for thiamine to be added to the diet of habitual consumers of sorghum beer, which would include the target group of hostel-dwellers. Enrichment has advantages over reliance on other (natural) foods as a means of improving the diet.17

The second set of criteria in food fortification involves the selection of a vehicle and the appropriate level of fortification. The clear vehicle of choice is sorghum beer, consumption of which amounts to 1 billion litres a year.18 Thus the chosen vehicle is regularly consumed in sufficient quantities by those whose diet is in need of enrichment.

A recommendation to fortify alcoholic beverages with thiamine is not new, and has been proposed to prevent encephalopathy in alcohol abusers.19-21 The thiamine concentration of sorghum beer sold on the Witwatersrand averages 0.33 mg/l; however, more than 95% of this is in the cellular fraction of the beer and is not generally available for absorption.22 With concentrations of added thiamine hydrochloride in excess of 2.5 mg/l vitamin uptake by the cells is less than 30%. At this level of fortification appreciable amounts of thiamine hydrochloride are absorbed in spite of the presence in the beer of alcohol and live yeast cells.23 The addition of 3 mg thiamine hydrochloride per litre would supply about 2 mg of absorbable thiamine and thus meet the recommended daily allowance in beer consumers. However, the recommended level of fortification is likely to be low concentrations is frequently impaired in alcoholics,24 supplementation at these levels is unlikely to be effective in treating the thiamine deficiency of alcoholics. The minimum effective dose for this purpose would be at least 30 mg thiamine hydrochloride (89 μmol/d).25

The third set of criteria in food fortification involves the technological factors. Since the process of sorghum beer brewing has been examined in detail by the CSIR, the stage at which the vitamin should be added in processing beer may easily be established, and since the level of fortification proposed is relatively low (3 mg/l beer), the addition of milligram amounts of the nutrient should not present undue technical difficulties. Since beer is a fluid, mixing in of the added nutrient would be achieved easily, in contrast with the situation with solid foods such as maize meal. Preliminary results suggest that the fortification of sorghum beer with thiamine has no influence on the appearance, taste or physical characteristics of the product.

Thiamine is a vehicle of choice for humans unless administered parenterally in a dose many thousands of times that required for optimal nutrition.26

The fourth set of criteria involves economic considerations. The capital costs of fortification equipment are negligible in relation to the beer-making industry's annual turnover of R250 million.16 At the present cost of the vitamin, fortification would add 0.03 cent to the price of a litre of beer, a small expense for the expected benefit to the consumer through improved health of the target group, leading to increased labour productivity and decreased demands on medical services.

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REFERENCES