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Effect of traditional beer consumption on the iron status of a rural South African population

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Objective. To determine the effect of traditional beer consumption on the iron status of rural black subjects.

Design. A cross-sectional study was undertaken.

Setting. Dikgale field site and the surrounding villages in Limpopo Province, South Africa.

Subjects. Eight hundred and forty-four non-alcohol consumers (738 women and 106 men) and 280 alcohol consumers (163 women and 117 men) aged 30 years and above, participated in the study.

Outcome measures. Outcome measures included alcohol consumption, serum ferritin levels, percentage transferrin saturation, total iron-binding capacity, haemoglobin and C-reactive protein levels.

Results. Traditional beer fermented in either iron pots or plastic containers was found to have iron levels ranging from 15 mg/l to 67.8 mg/l and 6 mg/l to 17 mg/l, respectively. Iron status as measured by serum ferritin, serum iron, percentage transferrin saturation, and haemoglobin levels was significantly higher in alcohol consumers than in non-consumers, even after adjustment for age and C-reactive protein (CRP) levels. A high percentage of women (12.3%) and men (8.2%) consuming alcohol had iron overload.

Conclusion. This study showed that consumption of traditional beer in a non-urban population in Limpopo Province was associated with high levels of markers of iron status. Traditional beer consumption seemed to prevent iron deficiency in those at risk of developing such deficiency, but appeared to precipitate iron overload in those at risk of developing iron overload.

Beer drinking plays an important social role in rural Africa, and is the most commonly consumed beverage at most social events.[1,2] Beer drinking takes place at weddings and funerals, as a token of hospitality, during religious ceremonies, as a sign of change of status, and as a token of appreciation for work done.[1] Preparation and selling of traditional beer now represents a source of income in many households[3] in rural areas and has resulted in increased consumption of traditional beer. Traditional fermented beer is the most commonly consumed beverage at the Dikgale field site, with an average daily intake of about 1.3 litres.[4]

Traditional fermented beer prepared in iron pots is reported to contain high levels of bio-available iron ranging from 40 mg/l to 100 mg/l.[5,6] A study carried out in Zimbabwe,[7] showed that the consumption of traditional beer caused iron overload, while another study[8] in the same country showed that traditional beer improved iron status in women of child-bearing age.

In the preparation of traditional beer in the past, both the cooking and fermentation process took place in iron pots, hence the high iron content of the beer. Currently, while iron pots are still used for the initial cooking, plastic containers are often used during fermentation of the beer. Commercially prepared traditional beer containing no detectable iron is available in rural areas but is not consumed as frequently as traditionally fermented beer.[4] Both iron deficiency and iron overload have been reported to be a public health problem in rural areas of Limpopo Province in South Africa.[9,10]

We therefore decided to investigate whether the consumption of traditional beer had an effect on iron status in an adult rural black population.

Methods

Sample population and area

The study area was situated 50 km north-east of Polokwane, the capital city of Limpopo Province. The area was estimated to have 15 000 - 20 000 inhabitants, of whom approximately 5 000 were older than 30 years. The villages are typical rural settlements, with dwelling units consisting of a mix of shacks, traditional mud huts and conventional brick houses. Living conditions in the villages are of low standard, with an erratic water supply and poorly maintained roads. All inhabitants of this area belong to the Pedi group and are Northern Sotho-speaking.[11]

Permission for the study was sought from tribal chiefs, civic associations and village health committees. Letters explaining the objectives of the study were sent to all individual households, and written consent was obtained from all those who participated. Ethical approval was obtained from the Ethics Committee at the University of Limpopo.

Invitation letters describing the objectives of the study were sent to all households and surrounding schools. Pregnant women were excluded from the study. The response rate was 23%. This may be attributed to factors such as high rate of migrant labour and the HIV stigma, which makes people reluctant to donate blood. Complete iron status measures were therefore determined for 1 130 participants (225 men and 905 women). The study therefore included a high proportion of women. This may have been due to the fact that most men were migrant workers and as such may not have been available during blood collection, and/or because women are more concerned about health issues than men.

Of the 1 130 participants 901 women (99.5%) and 223 men (99.1) completed an alcohol consumption questionnaire. Anyone who reported consuming traditional beer on a daily basis was considered to be an alcohol consumer (163 women and 117 men), whereas those who did not consume beer or who occasionally consumed traditional beer were considered to be non-alcohol consumers (738 women and 106 men).

Blood sampling and assays

Blood was collected from each participant by peripheral venepuncture in silicone and EDTA-coated tubes. The samples were transported to the University of Limpopo laboratory for storage and analysis. Full blood count was performed immediately and serum and plasma were separated and stored at –80°C until use.

Haemoglobin (Hb) level was determined using the Sysmex K 1000 (Diamond Diagnostics, USA). Total serum ferritin level was determined using enzyme-linked immunoassay (ELISA) kits from Ramco Laboratories, using a Labsystem plate reader. Total serum iron, total iron-binding capacity (TIBC), gamma glutamyl aminotransferase (GGT) and C-reactive protein (CRP) levels were determined using Dimension EX 20 chemistry auto analyser (Du Pont, USA), using reagents from Dade Behring, USA. Total serum iron and TIBC analysis was carried out using methods recommended by the International Committee for Standardisation in Haematology.[12,13] Percentage transferrin saturation (%T) was calculated as follows: total serum iron/TIBC X 100.

In women, iron deficiency was diagnosed if a serum ferritin level < 12 µg/ml was obtained,[14] while in men iron deficiency was diagnosed if a serum ferritin level < 15 µg/ml was obtained.[14] In addition, the subjects were considered to be iron deficient if low serum iron levels and low percentage transferrin saturation were accompanied by normal or raised serum ferritin and raised CRP levels (> 12 mg/l).[10]

Iron overload was diagnosed in those with serum ferritin levels > 150 µg/l for women aged 20 - 44 years, > 200 µg/l for women aged 45 - 64 and men aged 20 - 24, > 300 µg/l for women aged 65 or older and men aged 25 - 64, and > 400 µg/l for men aged 65 and older, accompanied by percentage transferrin saturation > 50% for women and > 60% for men.[14]

Determination of iron content in traditional beer

Households fermenting and selling traditional beer in the study area were identified. Traditional beer samples were collected and methods of preparation documented. In preparing traditional beer, the ingredients are cooked in iron pots for about 3 hours. In some households the beer is fermented in the same iron pots, whereas in other households fermentation takes place in plastic drums. The samples were sent to the South African Bureau of Standards (SABS) for determination of iron content using atomic absorption spectrophotometry.

Statistical analysis

SPSS statistical computer software (version 11.0) was used for data analysis. Comparison of means between the two groups was performed using the Student's unpaired *t*-test. Comparison of means between several groups was performed using the one-way analysis of variance (ANOVA) test. Proportions were compared using the chi-square test at 95% confidence interval. Level of significance was considered when $p < 0.05$.

Results

According to the manufacturers, iron is not present in detectable levels in commercially prepared traditional

beer. The iron content of traditional beer fermented in iron containers (36.8 ± 22.9 mg/l) was significantly higher than that of beer fermented in plastic containers (11 ± 4.2 mg/l) (Table I).

Table II shows measures of iron status and other variables for those who admitted to currently consuming alcohol. Among women, the mean serum iron, ferritin, percentage transferrin saturation, haemoglobin and GGT levels were significantly higher in alcohol consumers than in non-alcohol consumers. Alcohol consumers were significantly older than non-consumers but after adjusting for age, all the parameters remained significantly higher in alcohol consumers. The findings were similar in men.

A significantly higher percentage of non-alcohol consumers were iron deficient than alcohol consumers (Table III), while a significant proportion of alcohol consumers had iron overload. Among alcohol consumers a higher percentage of women (12.3%) had iron overload compared with men (8.2%), although the difference was not significant ($p > 0.05$). We found that 91.3% of women and 90.9% of men with iron deficiency did not consume alcohol, while 65.5% of women and 75% of men with iron overload consumed alcohol.

It has also been reported that clinical presentation of iron overload occurs later in life (by age 40 - 60 years)[5] as the body requires enough time to accumulate iron. Table III shows the prevalence of iron deficiency and overload in women above 54 years and men above 49 years. The proportion of subjects with iron deficiency was significantly higher in non-alcohol consumers than in alcohol consumers, whereas the proportion of subjects with iron overload was significantly higher in

Table I. Iron content of tradional home-brewed beers consumed in the study area

Traditional beer	*N*	Mean ± SD (mg/l)	Range (mg/l)
Fermented in plastic containers	6	11 ± 4.2	6 - 17
Fermented in iron containers	10	36.8 ± 22.9*	15 - 67.8

*Significantly higher than in plastic containers (analysis of variance (ANOVA) $p = 0.02$)

Table II. Comparison of iron status measures between alcohol consumers and non-alcohol consumers

	Non-alcohol consumers (mean ± SD)	Alcohol consumers (mean ± SD)	Unpaired *t*-test *p*-value	Age and CRP-adjusted *p*-value
Women				
Number	738	163		
Age (yrs)	52.7 ± 13.9	60.3 ± 12.3	< 0.001	
Hb (g/dl)	13.2 ± 1.5	13.9 ± 1.2	< 0.001	< 0.001
Sercrum iron (mmol/l)	14.1 ± 6.4	17.8 ± 8.5	< 0.001	< 0.001
TIBC (mmol/l)	64.5 ± 14.8	60.8 ± 16.3	0.005	0.001
% T	23.6 ± 13.5	32.5 ± 22.0	< 0.001	< 0.001
Serum ferritin (µg/l)*	53.1 (5.3 - 340.5)	147.8 (14.6 - 2 071.0)	< 0.001	< 0.001
Log-ferritin	1.7 ± 0.71	2.2 ± 0.71	< 0.001	< 0.001
CRP (mg/l)	15.0 ± 14.6	24.8 ± 23.9	< 0.001	< 0.001
GGT (U/l)	29.0 ± 25.6	63.6 ± 99.6	< 0.001	< 0.001
Log-GGT	1.4 ± 0.3	1.6 ± 0.4	< 0.001	< 0.001
Men				
Number	106	117		
Age (yrs)	54.2 ± 13.7	52.7 ± 14.7	0.154	
Hb (g/dl)	14.6 ± 1.4	15.2 ± 1.8	0.011	< 0.001
Serum iron (mmol/l)	16.45 ± 6.4	20.44 ± 8.5	< 0.001	< 0.001
TIBC (mmol/l)	61.7 ± 12.8	58.3 ± 13.5	0.06	0.003
% T	28.2 ± 15.2	36.9 ± 17.8	< 0.001	< 0.001
Serum ferritin (µg/l)*	105.3 (15.3 - 1 016.0)	211.9 (23.3 - 2 362.7)	< 0.001	< 0.001
Log-ferritin	2.04 ± 0.2	2.41 ± 0.59	< 0.001	< 0.001
CRP (mg/l)	13.0 ± 13.9	15.7 ± 19.1	0.498	0.245
GGT (U/l)	70.9 ± 241.3	111.1 ± 262.0	0.24	0.071
Log-GGT	1.52 ± 0.41	1.73 ± 0.45	< 0.001	< 0.001

*Reported as median (95% confidence interval).
Hb = haemoglobin; TIBC = total iron-binding capacity; %T = percentage transferrin saturation; CRP = C-reactive protein; GGT = gammaglutamyl aminotransferase.

Table III. Comparison of the proportion of alcohol consumers and non-alcohol consumers in different iron status groups

	Non-consumers % (*N*)	Alcohol consumers % (*N*)	*p*-value
Total study population			
Women			
N	708	155	< 0.001
Iron deficient	25.1 (178)	11.0 (17)	
Normal iron status	73.4 (520)	76.8 (119)	
Iron overload	1.4 (10)	12.3 (19)	
Men			
N	99	110	< 0.001
Iron deficient	10.1 (10)	0.9 (1)	
Normal iron status	86.9 (86)	90.9 (100)	
Iron overload	3.0 (3)	8.2 (9)	
Men and women aged 50 or above and 55 years or above, respectively			
Women			
N	382	173	< 0.001
Iron deficient	14.9 (57)	2.9 (5)	
Normal iron status	83.9 (320)	82.7 (143)	
Iron overload	1.2 (5)	14.4 (25)	
Men			
N	58	78	
Iron deficient	6.9 (4)	0 (0)	< 0.001
Normal iron status	91.4 (53)	89.7 (70)	
Iron overload	1.7 (1)	10.3 (8)	

alcohol consumers than in non-alcohol consumers. In this age group, 92% of women and 100% of men with iron deficiency did not consume alcohol, while 83.3% of women and 88.9% of men with iron overload did consume alcohol.

It is has been shown extensively that iron deficiency is more common in women of childbearing age than in postmenopausal women.[15] To test the effect of alcohol consumption on iron status in this age group, iron status measures were compared between alcohol consumers and non-consumers in women aged 30 - 44 years (Table IV). As in the total population, iron status measures were significantly higher in alcohol consumers than in non-consumers. In this age group, 92.4% of subjects with iron deficiency did not consume alcohol and only 12% of subjects with iron overload consumed alcohol. Furthermore, significantly

Table IV. Comparison of iron status measures between women alcohol consumers and non-consumers aged betwen 30 and 44 years

	Non-alcohol consumers (mean ± SD)	Alcohol consumers (mean ± SD)	Age and CRP adjusted *p*-value
N	261	43	
Age (yrs)	36.9 ± 4.7	36.9 ± 4.8	0.971
Hb (g/dl)	13.2 ± 1.7	15.0 ± 2.3	< 0.001
Serum iron (mmol/l)	14.3 ± 7.3	18.4 ± 8.8	< 0.001
TIBC (mmol/l)	66.5 ± 15.1	65.5 ± 19.5	0.708
Transferrin saturation (%)	23.2 ± 13.7	30.4 ± 16.9	< 0.001
Serum ferritin (µg/l)*	37.7 (5.3 - 242.5)	106.8 (7.1 - 1 250.8)	< 0.001
Log-ferritin	1.54 ± 0.53	1.94 ± 0.83	< 0.001
CRP (mg/l)	11.5 ± 12.6	13.3 ± 16.1	< 0.001
GGT (U/l)	29.1 ± 25.5	105.2 ± 62.2	< 0.001
Log-GGT	1.3 ± 0.34	1.65 ± 0.38	< 0.001

*Reported as median (95% confidence interval).
Hb = haemoglobin; TIBC = total iron-binding capacity; CRP = C-reactive protein; GGT = gammaglutamyl aminotransferase.

Table V.	Comparison of proportion of alcohol consumers and non-alcohol consumers in different iron status groups in women aged 30 - 44 years		
	Non-consumers % (*N*)	**Alcohol consumers % (*N*)**	***p*-value**
Number	261	43	
Iron deficient	32.6 (85)	16.3 (7)	< 0.05
Normal iron status	64.8 (169)	81.4 (35)	
Iron overload	2.7 (7)	2.3 (1)	= 0.168

more non-alcohol consumers had iron deficiency than alcohol consumers, $p < 0.05$ (Table V). The proportion of subjects with iron overload was comparable in these women ($p = 0.168$).

Discussion

A dietary study of adult subjects living in the Dikgale field site indicated an adequate iron intake.[4] Our study shows that iron deficiency is still common in non-consumers of traditional beer (25% in women and 10% in men) despite adequate iron intake. The reason may be that most of the dietary iron is from plant sources,[4] and is therefore less bio-available. The same study showed that consumption of sorghum beer (traditionally fermented African beer) was common. In another study, 78% of alcohol consumers living in the study area consumed traditionally fermented beer.[16]

Our study shows that the iron content of traditionally fermented beer is high, even when plastic containers are used in the fermentation process, presumably because iron pots are used in the initial boiling which may take up to 3 hours. Use of iron pots in the preparation of food and sterilisation of water is still common in rural Africa.[17] Porridge cooked in iron pots collected from the study area had significantly higher iron content than porridge prepared in aluminium pots (0.13 ± 0.07 mg/g v. 0.0± mg/g).

The recommended daily iron intake is 18 mg in women aged 19 - 50 years or 8 mg in women above 50 years, and 8 mg in men.[18] The mean iron content of traditional beer fermented in iron pots is 36 mg/l, indicating that alcohol consumers get more than twice the recommended daily intake of iron when 1 litre of beer is consumed per day. Even beer fermented in plastic containers results in a high iron intake.

Ferritin and CRP levels have been reported to be increased in the presence of inflammation.[19] The mean CRP levels in alcohol and non-alcohol consumers were generally raised. The high CRP values may be attributed to the fact that infectious diseases (including HIV infections) are common in poor communities.[20] The present study also showed that alcohol consumers have higher iron status measures than non-consumers, suggesting that consumption of traditional beer may improve iron status. Even after adjustment for age and CRP, alcohol consumers continued to have higher iron status measures than non-alcohol consumers. Alcohol consumers are also less likely to be iron deficient. This is in agreement with a study on Zimbabwean women,[8] which showed that the consumption of traditionally fermented beer improved iron status in women of childbearing age.

Although both female (12.3%) and male (8.2%) alcohol consumers exhibited iron overload, not everyone consuming beer showed elevated iron parameters. It should also be borne in mind that dietary iron exposure is not the only factor contributing to the development of iron overload since genetic predisposition has also been reported to be a contributory factor.[21,22] Furthermore the degree of iron overload from consumption of traditional beer is related to the quantity and period of consumption of traditional beer.[5]

A limitation of this study is that indicators of quantity and lifetime consumption of alcohol were not determined, hence we could not assess the effect of quantity and long-term alcohol consumption on iron status. It has been reported to be difficult to obtain accurate information on alcohol consumption patterns. People tend to either overestimate or underestimate their intakes as their responses to alcohol consumption questionnaires do not correlate with biochemical markers of alcohol consumption.[23]

Another limitation of the study was that confounding factors such as hepatic diseases, parasitic infections and the use of oral contraceptives were not evaluated. It is, however, worth noting that parasitic infections are known to be absent in the study area,[24] and liver diseases are not listed as one of the major or minor causes of death in Limpopo Province.[25]

In elderly subjects, more than 80% of both men and women with iron overload consumed alcohol, and a higher proportion of alcohol consumers had iron overload compared with non-consumers, suggesting that in this age group the consumption of alcohol still prevents iron deficiency but increases the susceptibility to iron overload.

In women aged 30 - 44 years, consumption of traditional beer protected them from iron deficiency and did not lead to iron overload. In addition, most subjects with iron overload in this age group did not consume alcohol. It is worth noting that although in

a low percentage of subjects, iron overload occurred in those not consuming traditional beer. Consumption of non-alcoholic fermented products, mostly *mageu*, is common in black populations.[26] This may therefore have contributed to the presence of iron overload in non-alcohol consumers in this study.

The overall results of this study show that traditional beer consumption in rural areas has a protective as well as an adverse effect. Strategies to combat iron deficiency in developing countries include iron supplementation and food fortification.[15] The success of supplementation depends on compliance and cost, whereas food fortification is known to be effective but costly to both food producers and consumers. Alcohol consumption is being discouraged because of the effects of alcohol on the liver and other tissues. Traditional beer has been reported to have low alcohol content (3%),[5] and the present study shows that traditional beer consumption in a rural black population improved their iron status. We therefore suggest that consumption of food fermented in iron pots may be used as an alternative cost-effective intervention for controlling iron deficiency in high-risk population groups (women of childbearing age). Furthermore, Nemukula[16] showed that consumers of alcohol who lived in the present study area had better folate and vitamin B_{12} status owing to the high concentration of these vitamins in traditional beer. Because of the relationship between iron overload and hepatocellular cancer,[27] tuberculosis[28] and oesophageal cancer,[29] it is necessary to develop strategies to reduce iron overload. These may include advising against a high intake of traditional beer in the elderly.

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