Dietary intake of trace elements and minerals among adults in underprivileged communities of rural Rajasthan, India

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In developing countries, data on dietary intake of trace elements, and even major elements, is limited. The dietary intake of 1277 adults of underprivileged communities of rural Rajasthan was studied. Intake was assessed by the 24-h dietary recall method from which the average daily intake of macronutrients, some major elements, and trace elements was computed. The zinc intake was 69.7 and 49.7% of the recommended daily allowance in males and non-pregnant non-lactating females, respectively. The intakes of manganese and molybdenum were adequate when compared with the suggested daily intakes. Element intake during the physiological stress conditions of pregnancy and lactation was 42.4 and 53.0% for zinc, 36.5 and 29.8% for copper, and 21.0 and 23.1% for calcium, respectively. The intake of iron was less than 20 mg/day for all female subjects studied. No significant difference was observed in the trace element intake of subjects with different grades of malnutrition. Assessment of dietary intake may provide a useful indication of the possible status of major and trace elements among adult subjects.

Key words: underpriviledged communities, major elements, trace element intake, India, calcium, iron, zinc, copper, manganese, molybdenum.

Introduction

Data on the average daily dietary intake of trace elements is scarce, particularly from underpriviledged areas of the developing world. This is primarily because foods consumed vary widely over days and seasons.[1,2] However, the estimates of daily dietary trace elements, based on nutrient databases, have been found to be similar to those obtained from laboratory analysis studies of total diet.[3]

Large scale studies conducted in communities to assess nutrient intake are often based on multiple diet records or food frequency data because they are relatively inexpensive and fairly easy to administer, compared to collecting and analysing blood samples for trace elements.[2]

Jacques *et al.* compared the intake of 12 micronutrients as reported by the food frequency questionnaire method with the corresponding biochemical indicators of nutritional status in 139 subjects.[4] The correlation coefficients between the intake and biochemical measurements were more than 0.30 for carotenoids, vitamin D, vitamin E, vitamin B_{12}, folate and vitamin C for both sexes and carotene intake for females.

The present study was designed with the objective of assessing the dietary intake of trace elements among the free-living adult population of underprivileged communities of rural Rajasthan.

Materials and methods

The study was conducted in the state of Rajasthan. The percentage of the population which was low income group (LIG) in each district of the state was obtained from the Census of India, 1991.[5] The LIG population in the districts ranged from 14.6 to 29.6%. A list was prepared of districts with fewer than 20% and 20% and more of LIG population. One district from each of the two categories was selected randomly. In each district, all the villages within 20 km of the district headquarters were enlisted as well as a further three villages using the random sampling procedure. Three villages from each district were randomly selected for detailed study and a total of 1277 subjects (594 males and 683 females) were studied in detail.

A pretested questionnaire schedule was administered to elicit information on the socioeconomic status of the subjects. Home visits were undertaken and the dietary intake of each individual was assessed by trained nutritionists, using the 24-h recall method.[5] Standardized instruments were used to elicit the recall of raw foods used for cooking for the whole family, the volume of the cooked food and the volume of cooked food consumed by the index person. The raw foods were then calculated from the recall by using volumetric conversions. Food composition tables were used to calculate the nutrient intake of the subjects using this data.[6]

Anthropometric measurements (height and weight) were recorded using standard techniques and equipment.[7] The nutritional status of the subjects was assessed using the body mass index (BMI).[7]

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Table 1. Consumption of major food groups

Food groups	Mean intake ± SD (g) M (*n* = 594)	P (*n* = 106)	L (*n* = 146)	NPNL (*n* = 431)
Cereals	399 ± 205	310 ± 167	294 ± 157	280 ± 165
Pulses	36 ± 24	38 ± 34	40 ± 27	38 ± 30
Leafy vegetables	89 ± 47	110 ± 69	69 ± 39	90 ± 51
Other vegetables	80 ± 52	69 ± 44	69 ± 45	84 ± 54
Milk (mL)	57 ± 99	29 ± 45	31 ± 47	39 ± 58
Fruits	43 ± 39	51 ± 45	25 ± 18	39 ± 39
Meat	35 ± 37	—	58 ± 49	11 ± 19
Fats and oils	7 ± 3	6 ± 3	6 ± 4	7 ± 4
Sugar	9 ± 9	7 ± 6	7 ± 4	10 ± 4

M, Males; P, Pregnant women; L, Lactating women; NPNL, Non-pregnant non-lactating women.

Results

A total of 594 males and 683 females (including 106 pregnant, 146 lactating and 431 non-pregnant non-lactating (NPNL) women) were surveyed. The mean age of males was 33 ± 11 years and that of females was 32 ± 10 years (range 18–65). The socioeconomic data revealed that 91.5% of females and 61.2% of the males were illiterate.

The dietary intake of subjects was studied and it was found that cereals were the major contributors of nutrient and trace element intake. The mean consumption of cereals was 399 ± 205 g for males and 280 ± 165 g for NPNL females. The consumption of green leafy vegetables was highest among the pregnant women (110 ± 69 g) and lowest among the lactating women (69 ± 39 g). The consumption of meat, milk and fruits was found to be generally low (Table 1).

Further analysis of the dietary data revealed that the energy and protein intake of subjects was lower than the respective RDAs for age, sex and physiological status (Table 2).

The daily intake of trace elements (iron, manganese, copper, zinc, molybdenum along with calcium and magnesium) was computed (Tables 3, 4). For male subjects a deficit in the order of 12.9 and 13.7% was observed in the intake of zinc and iron. For NPNL females the deficit in the intake of iron, zinc, copper and calcium compared with RDA and suggested intakes was 43.3, 50.3, 9.1 and 42.5%, respectively.

The deficit in the consumption of elements, especially iron, zinc, and calcium, was higher among the pregnant and lactating women (i.e. 57.6 and 47% for iron, 63.5 and 70.8% for zinc, and 79.1 and 76.9% for calcium, respectively), compared with NPNL women (Table 4).

Table 3. Daily intake of trace elements and minerals by male subjects

Trace element and minerals	Suggested daily intake or RDA (mg/day)	Daily intake (mg/day)	(mg/10 MJ)	% subjects below RDA
Iron	28*	24.4	28.7	49.8
Copper	2.2	2.7	3.17	25.9
Manganese	5.5	9.6	11.3	0.3
Molybdenum	0.15–0.5	0.23	0.27	12.7
Zinc	15.5	10.8	12.7	75.4
Calcium	400**	323.4	380.4	66.9
Magnesium	350	641.5	754.7	5.4

* RDA; **trace element consumption more than suggested intake.

The intake of magnesium by NPNL and pregnant women, and that of copper by pregnant and lactating women was found to be comparable to the RDAs and suggested intakes.

The nutritional status of the subjects was assessed by calculating the body mass index (BMI) and the results showed that 52.6% of males and 63.8% of NPNL women were malnourished. No significant difference was found in the weight measurements of pregnant, lactating and NPNL women (i.e. 41.6 ± 4.0 kg, 42.2 ± 4.8 kg and 41.9 ± 4.4 kg, respectively). The dietary intake of macronutrients and trace elements by normal and malnourished subjects was also not found to be significantly different (Tables 5, 6).

Discussion

The importance of trace elements in human health and disease is widely recognized. Data on dietary trace elements status of the Indian population is scarce. Nutrient intake data of the free-living population is known to provide useful and valid information on micronutrient intake.[2,3]

In this study nutrient intake data of free-living underprivileged population of rural Rajasthan was collected. The diets of the subjects of poor communities are essentially based on cereals, which primarily contribute to the nutritive value of these diets. In this study the intake of minerals such as calcium was found to be low among females, while that of iron was low in both sexes.

Zinc deficiency is known to be prevalent among populations surviving on low incomes, inadequate protein intake and predominant use of cereal proteins. The suggested level of intake for the Indian population is 15 mg/day. In this study the diets of males and females were found to be zinc

Table 2. Nutrient intake of subjects as compared with recommended daily allowance

Subjects	Energy (kcal)* Intake*	RDA**	% below RDA	Protein (g) Intake*	RDA**	% below RDA
Males	2030 ± 1051 (8.5 ± 4.4)	2425	80.8	67.9 ± 36.0	60	49.3
Pregnant women	1457 ± 799 (6.0 ± 3.3)	2175	84.8	48.8 ± 28.2	65	81.9
Lactating women	1398 ± 692 (5.8 ± 2.9)	2425	94.5	46.6 ± 23.7	75	90.3
Non-pregnant non-lactating women	1469 ± 877 (6.1 ± 3.7)	1875	83.6	47.8 ± 29.6	50	62.9

*Mean ± SD (figures in parentheses denote energy in MJ); **RDA for sedentary activities (9).

Table 4. Dietary intake of trace elements and minerals among female subjects according to their physiological status

Trace elements	Non-pregnant non-lactating women				Pregnant women				Lactation			
	mg	Intake mg/10 MJ	SDI/ RDA	% deficit***	mg	Intake mg/10 MJ	SDI/ RDA	% deficit**	mg	Intake mg/10 MJ	SDI/ RDA	% deficit**
Iron	17.0	27.8	30*	43.3 (81.7)	16.1	26.8	38* (98)	57.6	1.9	27.4	30* (84.7)	47.0
Zinc	7.7	12.6	15.5	50.3 (91.3)	7.3	12.2	20	63.5 (96.2)	7.3	12.6	25	70.8 (97.9)
Copper	2.0	3.2	2.2	9.1 (56)	1.9	3.2	NK	—	1.9	3.3	NK	—
Calcium	230.0	377.0	400*	42.5 (82.2)	209.2	348.7	1000*	79.1 (99.3)	231.3	398.3	1000*	76.9 (99.3)
Magnesium	460.0	754.0	350	(24.1)	450.7	751.2	450	(47.6)	439.5	757.7	450	2.3 (53.1)

*RDA; **trace element consumption more than suggested daily intake; NK, not known; ***figures in parentheses denote percentage of subjects with intake below SDI/RDA.

Table 5. Dietary intake of male subjects in different grades of nutritional status

Nutritional status	Energy (kcal) (mean ± SD)	Protein (g) (mean ± SD)	Iron (mg) (mean ± SD)	Copper (mg) (mean ± SD)	Zinc (mg) (mean ± SD)	Calcium (mg) (mean ± SD)	Magnesium (mg) (mean ± SD)
Normal (*n* = 282)	1992 ± 967	67 ± 34	30.7 ± 19.6	3.52 ± 2.28	12.9 ± 6.9	395 ± 249	718 ± 359
CED							
Grade I (*n* = 184)	2017 ± 1076	67 ± 36	31.9 ± 22.1	3.8 ± 2.9	13.3 ± 8.3	447 ± 426	713 ± 371
Grade II (*n* = 77)	2224 ± 1229	75 ± 43	34.0 ± 25.0	3.82 ± 2.9	14.0 ± 8.9	501 ± 332	768 ± 413
Grade III (*n* = 51)	2026 ± 1125	68 ± 39	30.4 ± 19.3	3.6 ± 2.5	13.3 ± 7.9	397 ± 224	744 ± 430

CED, chronic energy efficient (i.e. BMI < 18.5); Grade 1, BMI = 17–18.4; Grade II, BMI = 16–17; Grade III, BMI = < 16.

Table 6. Dietary intake of female subjects (NPNL) in different grades of nutritional status

Nutritional status	Energy (kcal) (mean ± SD)	Protein (g) (mean ± SD)	Iron (mg) (mean ± SD)	Copper (mg) (mean ± SD)	Zinc (mg) (mean ± SD)	Calcium (mg) (mean ± SD)	Magnesium (mg) (mean ± SD)
Normal (*n* = 147)	1428 ± 594	46 ± 19	20.9 ± 11.6	2.51 ± 1.6	8.9 ± 3.9	278 ± 170	500 ± 198
CED							
Grade I (*n* = 234)	1516 ± 819	50 ± 28	21.2 ± 12.9	2.51 ± 1.6	9.5 ± 5.5	300 ± 188	531 ± 286
Grade II (*n* = 29)	1489 ± 1011	49 ± 34	21.4 ± 15.9	2.6 ± 2.0	9.6 ± 6.8	316 ± 202	527 ± 378
Grade III (*n* = 21)	1534 ± 1447	49 ± 49	22.6 ± 25.4	2.79 ± 3.43	10.0 ± 10.7	282 ± 259	520 ± 460

deficient. Sub-clinical deficiency of zinc in the Indian population has also been reported earlier.[8]

The dietary intake of copper was similar to the suggested dietary intake of 2.2 mg/day for the Indian adult.[6] Molybdenum and manganese intake by the population was also found to be adequate. The dietary intake of magnesium in this study was more than 400 mg per day. Diets based on cereals, pulses and vegetables are known to provide adequate magnesium.[9] Rao *et al.* have also reported adequate daily intake of magnesium and manganese by low income groups, with inadequate intake of copper and zinc.[10] The reduced content of trace elements in the diets of low income groups can be attributed to the reduced quantity of food consumed, as observed in the present study. Cereal-based low protein diets with inadequate vegetable, fruit and milk intake result in low element intakes.

Women in different physiological states had inadequate intake of zinc, iron and calcium. Dietary magnesium intake, however, was found to be comparable to the suggested intakes.[11]

Calcium intake by women in different physiological groups was much less than the recommended daily allowance. This is a concern as Indian women belonging to the low socio-economic groups are more susceptible to bone resorption and osteoporosis owing to repeated pregnancies and lactation.[12]

Dietary intake of iron was less than 20 mg/day among women in all groups. Ramachandran has also reported similar results.[13] The observed higher deficits in the intake of calcium, iron and zinc among pregnant and lactating women were mainly due to increased requirements during these physiological states and no concomitant increment in intake. This is also reflected in the low body weights of these women being similar to those of NPNL women.

The generally poor nutritional status, as evidenced by the high prevalence of malnutrition of the population studied, could be attributed to poor dietary intake of the subjects, although no significant difference was observed in macronutrient or trace element intake of subjects with different grades of malnutrition.

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印度 Rajasthan 農村下層社會成人的微量元素和無機鹽的進食水平

摘要

有關微量元素進食的數據不多，作者用1277位 Rajasthan 農村下層社會的成人爲對象，研究他們微量元素的進食情況。採用 24 小時回憶法計算每日平均宏觀營養素和微量元素的進食量。結果發現男性和非懷孕、非哺乳婦女鋅的進食分別爲每日推薦供給量 (RDA) 的 69.7% 和 49.7%。錳和鉬的進食是足夠的。懷孕和哺乳婦女微量元素的進食是：鋅分別爲 RDA 的 42.4% 和 53.0%，銅分別爲 RDA 的 36.5% 和 29.8%，鈣分別爲 RDA 的 21.0% 和 23.1%。所有女性鐵的進食每日少於 20 毫克，。在不同程度營養不良的對象中，其微量元素進食沒
有明顯差異。作者認爲微量元素進食的評估可提供成人微量元素營養狀況的有用數據。

In the absence of biochemical indicators for assessment of the trace element status, the assessment of dietary intake of trace elements may provide a useful approach among adults.

There is a need for similar studies with larger sample size and laboratory data to further substantiate the findings of this study.

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