Original Article:

Patterns of dietary calcium intake in south Indian rural, urban and metropolitan city subjects

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ABSTRACT

Background: Adequate dietary calcium intake favours bone mineral accrual. Sparse published data are available on dietary calcium intake of metropolitan city population from south India.

Methods: We recorded the dietary intake of calcium and phytates of 524 healthy subjects from Bengaluru, a metropolitan city, by recalling the diet consumed in the previous 5 to 7 days and compared it with dietary intake of calcium of 325 healthy subjects from rural areas around Tirupati, and 508 healthy subjects from urban Tirupati.

Results: The dietary calcium intake of the Tirupati rural subjects was the least compared to that of the urban and metropolitan city subjects. In the metropolitan and urban groups the diet was high in calories, milk, milk products and vegetables compared to rural subjects. Dietary calcium intake was significantly lower ($p<0.0001$) in the rural subjects compared to the urban and metropolitan city subjects. The dietary phytate were significantly different in both the rural, urban as well as the metropolitan city groups ($p<0.0001$). The dietary phytate/calcium ratio was significantly higher in rural subjects compared to urban and metropolitan city group ($p<0.0001$).

Conclusions: Improving the quality of diet by reducing the phytate and enriching/supplementing with calcium will be of benefit for maintaining bone health.

Key words: *Dietary calcium, Vitamin D, Fortification of foods, Rural, Urban, Metropolitan city*

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INTRODUCTION

Nutrition plays a vital role in bone homeostasis. Adequate dietary calcium intake during childhood and pubertal growth spurt, favours bone mineral accrual. Serum 25 hydroxy vitamin D [25(OH)D] levels greater than 30 ng/mL are required for optimum intestinal absorption of calcium from the gut. Daily dietary calcium intake of 1 to 1.5 g along with adequate [25(OH)D] levels helps to maintain bone mineral mass attained at the end of growth period and to prevent deleterious skeletal effects.[1,2] Low dietary calcium along with low 25 OHD levels is associated with secondary hyper- parathyroidism (SHPT). SHPT mobilizes mineral and matrix from skeleton and has adverse calcium metabolism, osteoblastic activity, matrix ossification, bone mineral density (BMD) and bone remodelling.

Low dietary calcium intake and subclinical vitamin D deficiency are important risk factors for osteoporosis and fractures due to long standing SHPT and consequent increased bone turnover. Vitamin D and calcium supplementation normalizes SHPT,[3] reduces bone remodelling and prevents further bone loss and fractures.[3-6] Hence, it is important to document dietary calcium and 25(OH)D status in subjects with bone disease, since vitamin D and calcium supplementation improves their BMD and prevents further deterioration and fractures.

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Previously we have documented low dietary calcium intake of rural and urban population in south India.[7] There are no data available in literature on the dietary calcium intake of metropolitan city subjects in south India. Hence the present study was designed.

MATERIAL AND METHODS

We studied the dietary calcium intake of subjects resding in 524 asymptomatic healthy subjects in the metropolitan city of Bengaluru, Karnataka state, in South India. The data collection methodology was similar to that described in detail in our previous publication.[7] The dietary intake of calcium and phytates were documented by recalling the diet consumed in the previous 5 to 7 days. The dietary pattern was documented by the same observers as in our previous study.[7] The validity and repeatability of the documentation was rechecked at random by one of the authors during the period of the study. There was no significant error in the documentation of dietary history. From the raw weights, the calcium and phytate intakes were calculated using the published food composition table detailing the nutritive value of Indian foods.[8-10]

Statistical methods

Descriptive results are presented as mean ± standard error of mean (SEM). One-way analysis of variance (ANOVA) was used to compare various dietary parameters documented in the present study with data obtained from asymptomatic healthy rural subjects from areas around Tirupati (n = 325) and urban subjects from Tirupati (n = 508), Andhra Pradesh.[7] If a significant difference was found, a multiple comparison test was performed using least significant difference (LSD) posthoc test to analyze the differences between the study groups. A $p\text{-value}<0.05$ was considered significant. Statistical analysis was performed using SPSS package (version-10) SPSS Inc., Chicago, USA statistical software.

RESULTS

In rural subjects, diet consisted of approximately 1700 KJ/day. Of the total energy, carbohydrates provided 75% of the intake,

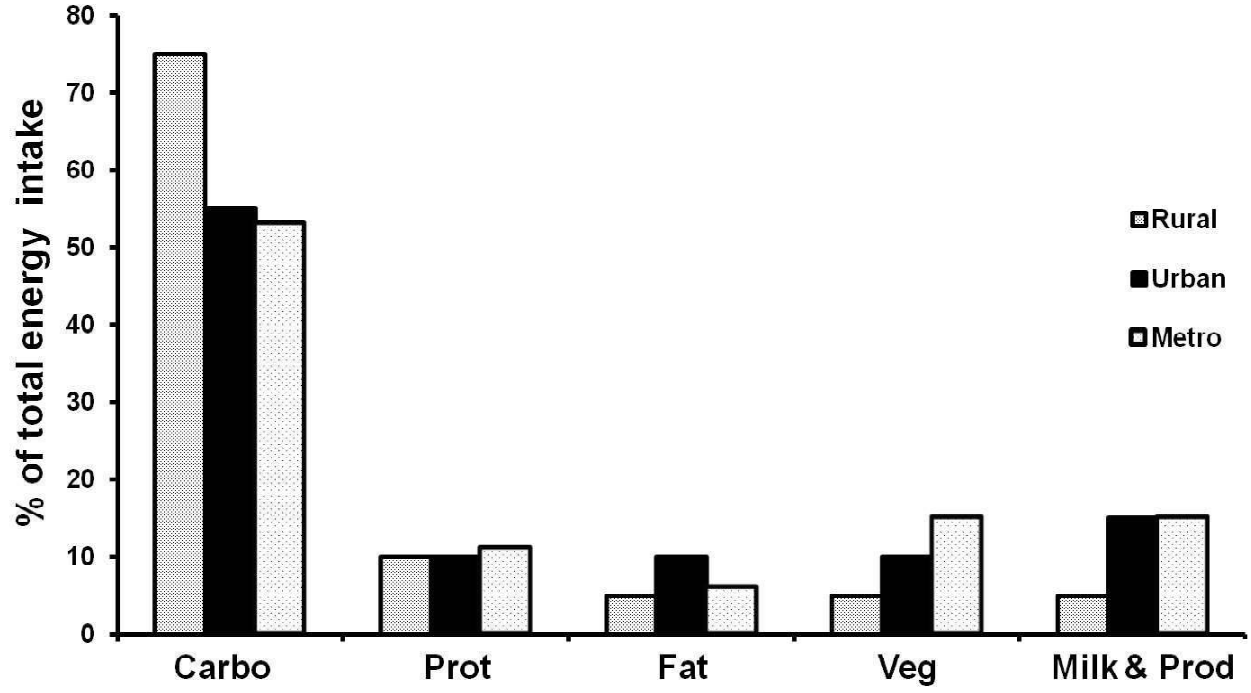

Figure 1: Dietary pattern (% of total energy intake)of rural, urban and metropolitan city subjects
Carbo = carbohydrates; Prot = ptoteins; Veg = vegetables; Milk & prod = milk and milk products

proteins 10%, fat 5%, vegetables 5%, and milk and milk products 5% (Figure 1). The carbohydrate source was from cereals with rice in 60% and ragi *(Eleusine Coracana)* provided 40%. Drumstick leaves, brinjals and tomatoes were the vegetable sources. Animal sources of protein were consumed once fortnightly. The diet in urban subjects consisted of approximately 2200 KJ/day. Carbohydrates constituted 55% of the total energy intake, proteins 10% and fat 10%. Vegetables contributed 10% to total energy intake and milk and milk products contributed to about 15% (Figure 1).

The carbohydrate source was primarily from cereals with rice providing 50% of total carbohydrates, wheat 25% and ragi 25%. Vegetable sources included amaranth leaves, cauliflower, carrots, ladies fingers, other seasonal vegetables and tubers. Animal sources of protein were consumed once a week. The diet in metropolitan city subjects consisted of 2200 KJ/day approximately. Carbohydrates provided 53% of the total energy intake, proteins 11% and fat 6%. Vegetables contributed 16% to total energy intake and milk and milk products (cheese and *panneer*) contributed 14% (Figure 1).The carbohydrate source was primarily from cereals with rice providing 50% of total carbohydrates and the remaining by wheat. Vegetable sources were similar to urban subjects. In addition access to vegetables like broccoli, peas, and other rarer vegetables was often. Animal sources of protein were consumed twice a week. There was no other source of calcium or any other mineral in all three groups.

The mean ± SEM of dietary calcium, phytate and dietary phytate/calcium ratio, of the rural, urban and metropolitan city population is described in Table 1. The daily dietary calcium intake (mean ± SEM mg/day) were low in rural (269 ± 2); urban (308 ± 5) and metropolitan city (526 ± 8) subjects compared to that of recommended daily/dietary allowance (RDA) issued for the Indian population by the Indian

Table 1: Dietary patterns of rural, urban and metropolitan city populations of south India

Variable	Rural* (n=325)	Urban* (n=508)	Metropolitan city* (n=524)
Age (yrs)	40 ± 0.9†	47 ± 0.6†	43 ± 0.7†
Calcium (mg/day)	269 ± 2 ‡	308 ± 2.3‡	526 ± 8‡
Phytates (mg/day)	199 ± 1.6‡	155.8 ±1.5‡	238 ± 4‡
Phytates/calcium	0.75 ± 0.01‡	0.51 ± 0‡	0.51 ± 0.01

Data are presented as mean ± standard error of mean; *data from *reference 7*; †p<0.01 compared to daily RDA of ICMR;[11] ‡p<0.0001 compared to daily RDA of ICMR[11]
RDA = recommended daily allowance; ICMR = Indian Council of Medical Research

Table 2: Daily recommended dietary allowances of calcium (mg/day) in India and USA

Category	India[11]	USA[12]
Infants		
Infants 0 - 6 months	500	500
Infants 6 -12 months	500	750
Children		
1 - 9 years	600	800
10 - 15 years	800	1200 - 1300
16 - 18 years	800	1200 - 1300
Men	600	800 - 1000
Women	600	800 - 1000
Pregnant and lactating mothers	1200	1200 - 1300

Table 3: Vitamin D status of south Indian population

Study	Location	No. studied	Study population	Age (years)	25(OH)D (ng/nmol)
Harinarayan *et al*[13]	Tirupati	191	Tirupati Rural*	44 ± 1.0	21 ± 0.5
		125	Tirupati Urban*	45.5 ± 1.0	13.5 ± 0.6
Harinarayan *et al*[14]	Tirupati	134	Urban men*	47 ± 1.5	18.5 ± 0.8
		109	Rural men*	45 ± 1.4	23.7 ± 0.8
		807	Urban women*	46 ± 0.4	15.5 ± 0.3
		96	Rural women*	41 ± 1.4	19 ± 0.9
		30	Urban children male*	11 ± 1	15.6 ± 1.2
		34	Rural children male*	12 ± 0.7	17 ± 1.3
		39	Urban children female*	13.5 ± 0.6	18.5 ± 1.7
		36	Rural children female*	12.6 ± 0.5	19 ± 1.6
Harinarayan *et al*[15]	Tirupati	164	Post-menopausal†	54 ± 8	14.6 ± 7
Harinarayan *et al*[16]	Tirupati	55	Women in reproductive age group*	37.5 ± 0.9	15.7 ± 1.4
			Post-menopausal*	53.3 ± 0.7	17.7 ± 0.9
Harinarayan *et al*[17]	Bengaluru	150	Males*	50 ± 1.4	12.7 ± 0.6
		606	Females*	51 ± 0.6	13.7 ± 0.4

* data are presented as mean ± standard error of mean

† data are presented as mean ± standard deviation

Council of Medical Research (ICMR). These differences were statistically significant ($p<0.0001$). Dietary calcium intake was significantly lower ($p<0.0001$) in the rural subjects compared to the urban and metropolitan city subjects. The dietary phytate were significantly different in both the three groups studied ($p<0.0001$). The dietary phytate/ calcium ratio was significantly higher in rural subjects compared to urban and metropolitan city group ($p<0.0001$). There was no significant difference between the urban and metropolitan city group (Table1). The daily recommended dietary allowance (RDA) of calcium in India[11] and USA[12] is shown in Table 2. Vitamin D status documented in published studies[13-17] from south India by the authors group is shown in Table 3.

DISCUSSION

In the metropolitan city and urban group the diet was high in calories, milk, milk products and vegetables intake compared to rural subject. The major cereal consumed was rice, rather than ragi and wheat, which has lower phytate levels. The consumption of ragi was the least in metropolitan city subjects. Sweets containing milk and its products were substituted for carbohydrate portion in urban and metropolitan city subjects. The intake of cheese and panner was high in the metropolitan city subject. The dietary calcium intake by the Tirupati rural subjects was the least compared to that of the urban and metropolitan city subjects (Table 1). Intake of Ragi (rich in phytates) retards the absorption of calcium from the gut. Phytates has inositol hexaphosphate, which chelates calcium in the gut. In the rural subjects the daily consumption of milk and milk products was only 5% of their total energy intake. This is far less compared to the urban and metropolitan city population who consume 10% and 14% of milk and milk products of their daily energy intake. In the rural subjects other source of calcium was from leafy vegetables (especially drumstick leaves), while the urban and metropolitan city subjects had access to other milk products like, milk sweets, cheese and panner. Nevertheless, the dietary calcium intakes the rural, urban and samples were much lower than the RDA for calcium as per the ICMR guidelines

(Table 2). There is no dietary source of vitamin D in diets of these three groups of subjects studied. These data highlight the high prevalence of inadequate dietary calcium intake across the three groups compared to the RDA. To the best of our knowledge, there are no population-based studies from India comparing rural, urban and metropolitan city populations with their dietary calcium intake.

In first generation normal Asian Indian immigrants in USA, the dietary intake of calcium was found to be less than the dietary reference intake recommended for a normal person as per the guidelines of the USA.[18] The recently revised RDA for calcium in India recommended by the Indian Council of Medical Research (ICMR) is lower than the recently revised recommendations by the USA and Canada (Table 2).[11,12]

There are studies which have shown that the calculated values of the nutrients are higher than analytical values.[19] Hence in the background of high phytates in the diet, subjects with a calculated low dietary intake of calcium as in our study may be more calcium deficient than the dietary intake data. This data becomes more significant in the background of high phytate / calcium ratio associated with low 25 (OH) D levels.

We observed the 25(OH)D to be 17 ± 1.3 ng/mL (mean ± SEM).[20] In the rural subjects the 25(OH)D levels were around 21 to 23 ng/mL, in the urban subjects it was around 17 to 19 ng/mL and in the metro- politan city subjects 12 to 14 ng/mL.[20,21] At serum 25(OH)D levels of > 30 ng/dL the calcium absorption form the gut is at its maximum.[20,21] At low serum 25(OH)D concentration the calcium absorption from the gut is reduced. This is further amplified by low dietary calcium intake with high calcium/ phytate ratio. The consequence of these interactions is SHPT which mobilizes mineral (calcium) and matrix from the skeleton. This leads to apparently normal serum calcium levels at the expense of erosion of the bone. In the post menopausal women and the elderly this leads to increased risk of fractures. Thus, low vitamin D impairs dietary calcium absorption and adversely affects bone mineralization. This may be incorrectly seen as low BMD measurements.

Bone integrity and bone metabolism depends on appropriate vitamin D and calcium status of an individual. Low dietary calcium and vitamin D of an individual affects calcium metabolism, osteoblastic activity, matrix ossification, BMD, and bone remodelling. There are reports of very low dietary intakes of calcium (<300 mg/day) in patients with osteomalacia.[22,23] 25(OH)D deficiency in diet is the earliest step in the evolution of osteomalacia. Low dietary calcium intake influences the progression and evolution (duration) of the disease. There are also documented reports to show that vitamin D and calcium supplementation is able to prevent hip fracture in elderly by normalizing the SHPT, reduc- ing bone modelling and stopping bone loss.[3,5,6,24,26] Improving the quality of diet by reducing the phytate and enriching / supplementing with calcium will be of benefit for maintaining bone health. More multicentre studies need to be undertaken to document this problem in different parts of India.

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