Short Communication

A study of calcium intake and sources of calcium in adolescent boys and girls from two socioeconomic strata, in Pune, India

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Adequate intake of calcium is important for skeletal growth. Low calcium intake during childhood and adolescence may lead to decreased bone mass accrual thereby increasing the risk of osteoporotic fractures. Our aim was to study dietary calcium intake and sources of calcium in adolescents from lower and upper economic strata in Pune, India. We hypothesized that children from lower economic strata would have lower intakes of calcium, which would predominantly be derived from non-dairy sources. Two hundred male and female adolescents, from lower and upper economic stratum were studied. Semiquantitative food frequency questionnaire was used to evaluate intakes of calcium, phosphorus, oxalic acid, phytin, energy and protein. The median calcium intake was significantly different in all four groups, with maximum intake in the upper economic strata boys (893 mg, 689-1295) and lowest intake in lower economic strata girls (506 mg, 380-674). The median calcium intake in lower economic strata boys was 767 mg (585-1043) and that in upper economic strata girls was 764 mg (541-959). The main source of calcium was dairy products in upper economic strata adolescents while it was dark green leafy vegetables in lower economic strata adolescents. The median calcium intake was much lower in lower economic strata than in the upper economic strata both in boys and girls. Girls from both groups had less access to dairy products as compared to boys. Measures need to be taken to rectify low calcium intake in lower economic strata adolescents and to address gender inequality in distribution of dairy products in India.

Key Words: calcium, adolescent, sources, FFQ, Indian

INTRODUCTION

Osteoporosis is a systemic disorder characterised by low bone mass and micro-architectural deterioration of bone tissue with a consequent increase in bone fragility and susceptibility to fracture.[1] Osteoporosis is highly prevalent in India and reports suggest that osteoporotic fractures occur 10-20 years earlier in Indians compared to Caucasians.[2] Bone mass during later life is a function of peak bone mass acquired during adulthood and adolescence, and subsequent age related bone loss.[3] In women, 95% of peak bone mass is achieved by the end of the second decade while, 90% of peak bone mass in boys is achieved by the age of 20 years.[4] Calcium (Ca) is an essential nutrient in bone hyroxyapatite and an adequate dietary intake of calcium during childhood and adolescence is important for mineralisation.

Dietary intake of Ca is known to be low in underprivileged children and adults in India.[5,6] Moreover, dietary Ca is largely derived from low Ca-dense non dairy sources. Dark green leafy vegetables (DGLV) and cereals are the staple food of majority of Indian adolescents, thus, their diets are rich in oxalic acid and phytins, which also reduce the bioavailability of calcium.[7-9] Furthermore, discrimination against girls in India is well-documented and intra-familial distribution of food shows significant male preference.[10]

To inform public health policy for Ca supplementation, it is crucial to know the current state of Ca intake in adolescents. Thus, our aim was to study the dietary Ca intake and sources of Ca in adolescents from lower and upper socio economic strata in Pune and to study the gender differences in Ca intake.

MATERIALS AND METHODS

A cross sectional study was carried out on a pragmatic sample of 400 students (mean age 14.5 years (SD: 0.7),

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200 boys, 200 girls) studying in grade 9, in Pune, Maharashtra, India from January to March 2007. The study was approved by the Institutional Ethics Committee and written informed consent was obtained prior to the study. Initially, 5 state-run schools and 5 private schools were approached; of these an approval was obtained from the Principals of 3 state-run schools and 2 private schools. The subjects from the state-run school came from lower socio economic (LES) with an average monthly per capita income of 750 Indian Rupees (approximately UK£ 9.5, US$15, €10.5). The subjects from the private schools came from affluent areas of the city (i.e. areas with high land prices).[11] The principals of the private schools did not grant permission to enquire about the average monthly income of the families however, the minimum annual fee of the private schools was 20000 Indian Rupees (UK£257, US$ 424.5, €287) (Indian per capita income 2007-2008, Rs 2021/ month).[12] One hundred boys and 100 girls were randomly selected from the state-run and private schools (total 400).

Standing height and weight were measured and z scores were calculated for height, weight and body mass index (BMI) using local standards.[13]

A food frequency questionnaire (FFQ) developed for estimation of calcium intake was modified for our circumstances and was self administered.[14] We decided to use a semiquantitative FFQ as youth have been reported to have limited ability to estimate portion sizes accurately.[14] Fifty one day diet recalls were taken from subjects similar to the study group, from both socio economic strata and sexes to prepare the list of foods in the FFQ.

The nutritionist then made a list of food items that were commonly eaten and were important nutrient sources, using published food composition tables for Indian foods.[15] The final food list in the FFQ consisted of 150 food items under twelve categories: cereals, legumes, dairy, DGLV, roots and tubers, other vegetables, fruits, nuts, poultry, fish, meat and oils and sugar based. Each food item had a 6-point-scale ranging from daily, alternate day, weekly, fortnightly, monthly to never consumed. Subjects were asked how often on average they had consumed each food item during the past year, the frequency of consumption and amount in terms of household or common measures such as 1 slice, 1 tablespoon (15 ml), or 1 cup (250 ml), representing 1 standard serve for each food. Thus, the questionnaire asked about diet in the previous 12 months.The FFQ was field tested on 25 individuals before it was administered to the study subjects.

Data from the FFQ were used to compute daily food consumption. In case of reversal items in one category, a weighted frequency was computed (example: instead of eating unleavened wheat pancake if the subject consumed leavened rice flour pan cakes for a meal, then he would not consume unleavened wheat pancakes that day. Thus, for that day, we have subtracted unleavened wheat pancakes intake from the total wheat intake to compute wheat intake for that child). Weights of the portion units were decided on the basis of average weight of each food item for that portion size collected from different households representing the sample. Intake of calcium (Ca), phosphorus, oxalic acid, phytin, energy and protein were calculated.[15] Contribution of dairy products to the overall Ca intake was estimated. Amount of absorbable Ca (amount of Ca absorbed from total Ca consumed) in the diet was estimated. Ten percent calcium was considered to be absorbed from the non-dairy sources and 30% from dairy sources.[16]

Repeatability of the FFQ was tested by re-administering the FFQ to a random sample of 64 children after one week as per the permission granted by the schools principals. An interview was conducted to assure that the students did not remember what they had answered the first time that the FFQ was administered. The response to both the FFQs agreed well with respect to consumption of foods and computed intakes of Ca and other nutrients (Intra class correlation coefficient ranged from 0.81 to 0.98 for different nutrient and food intakes).

Statistical methods

Data are presented as median with 25th and 75th percentiles. Group difference was also tested by adjusting for other co-variables using Student's t-test. Statistical associations were adjusted for possible confounders as necessary using ANCOVA. All analyses were performed using SPSS version 11.5, Chicago, USA. *P*-value less than 0.05 were considered statistically significant.

RESULTS

Comparison of age and anthropometric characteristics of the study population are presented in Table 1. Table 2 shows comparison of intakes of Ca, phosphorous, oxalic acid, phytin, energy and protein, between adolescent boys and girls of both socio economic strata.

Calcium

There was a significant difference in the median Ca intake among the four groups (p = 0.001) with the highest found in upper economic strata (UES) boys and the low-

Table 1. Comparison of age and anthropometric characteristics of the study population boys and girls of both strata Data presented as median (25th and 75th percentiles)

Parameter	Boys			Girls		
	UES (n=100)	LES (n=100)	p	UES (n=100)	LES (n=100)	p
Age (yrs)	14.1 (13.8-14.5)	14.4 (13.8-15.2)	0.003	14.7 (14.4-14.9)	14.5 (14.0-15.1)	0.251
Height (cm)	162 (157-168)	155 (147-161)	0.001	157 (153-160)	151 (147-156)	0.001
Height z Score	0.5 (0.09-1.2)	-0.9 (-1.5--0.03)	0.001	0.5 (-0.3-0.9)	-0.6 (-1.1-0.2)	0.001
Weight (kg)	48.5 (41.0-55.0)	36 (32.0-42.5)	0.001	46.0 (41.0-53.8)	39.0 (35.2-42.0)	0.001
Weight z Score	0.2 (-0.4-1.1)	-1.1 (-1.6--0.5)	0.001	-0.03 (-0.6-0.7)	-0.9 (-1.3--0.4)	0.001
BMI (kg/m^2)	18.1 (15.4-18.5)	15.2 (14.2-16.9)	0.001	18.9 (17.3-21.8)	17.0 (15.4-18.6)	0.001
BMI z Score	0.2 (-0.4-1.1)	-1.2 (-1.6--0.6)	0.001	-0.3 (-0.8-0.7)	-0.8 (-1.3--0.3)	0.001

UES: Upper Economic Strata; LES: Lower Economic Strata

Table 2. Comparison of daily dietary parameters between adolescent boys and girls of both strata. Data presented as median (25th and 75th percentiles)

Parameter	Boys				Girls			
	UES (n=100)	LES (n=100)	*p*1	*p*2	UES (n=100)	LES (n=100)	*p*1	*p*2
Energy, kcal	1909 (1390-2263)	1814 (1561-2199)	0.805	0.899	1465 (1230-1809)	1178 (1064-1527)	0.001	0.001
Protein, g	60.6 (45.3-83.3)	64.7 (51.1-78.9)	0.362	0.292	46.3 (37.3-60.9)	41.6 (34.4-54.2)	0.008	0.008
Calcium, mg	893 (689-1295)	767 (585-1043)	0.003	0.005	764 (541-959)	506 (380-674)	0.001	0.001
Phosphorous, mg	1372 (1053-1816)	1409 (1117-1709)	0.517	0.664	1114 (864-1406)	857 (731-1096)	0.001	0.001
Oxalic acid, mg	193 (116-309)	169 (102-354)	0.359	0.312	168 (115-209)	133 (87-197)	0.151	0.123
Phytin, mg	266 (183-356)	440 (356-486)	0.001	0.001	201 (169-251)	278 (231-357)	0.001	0.001

*p*1: significance by independent t test, *p*2: Adjusted for age and sex as appropriate by ANCOVA.

est in lower economic strata (LES) girls. As per Indian Recommended Daily Allowance (RDA) (600mg/ day)[17] boys from both socio economic strata and girls from the UES had median intakes of Ca above the RDA (149% and 128% in UES and LES boys and 127% in UES girls, respectively) whereas, the median intake was 84% of the RDA in the LES girls. Sixty-six percent of LES girls consumed less than Indian RDA.[17]

Contribution of dairy products to the overall Ca intake was the highest in the UES boys (271 mg, 219-382) and the lowest in LES girls (43 mg, 14-66). Median dairy Ca intake in LES boys was 180 mg (74-217) and in UES girls was 223 mg (134-377). Thus, the main source of Ca in the diets of UES adolescents was dairy products while in that of LES it was DGLV (Figure 1).

Estimated amount of absorbable Ca in the UES boys' diet was 148 mg (111-199), in LES boys it was 107 mg (77-148), in the UES girl's diets it was 123 mg (86-166), while it was 62 mg (46-78) in the LES girls' diet. Total Ca intake and Ca intake from dairy products was significantly lower in girls of both strata when compared to boys of the respective strata (p = 0.001 for both).

Phosphorous

There was no significant difference in the phosphorus intake of the UES and LES boys (p = 0.517) whereas a significant difference was observed between UES and LES girls (p = 0.001) (Table 2). Phosphorus intake was more than the RDA (600 mg/day) in all the four groups.[17]

Calcium to Phosphorus (Ca: P) ratio

Ca: P ratio was less than 1 in all the four groups. The median Ca: P ratio was 0.7 in UES boys and girls and 0.5 in LES boys and girls.

Oxalic acid

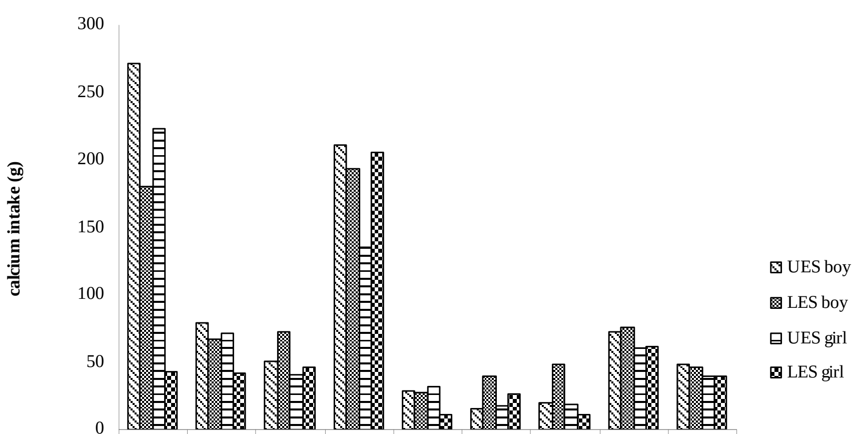
As shown in Table 2, there was no significant difference in the oxalic acid intakes in the boys and girls of the two socio economic strata.

Phytin

There was a significant difference between the phytin intakes among the UES and LES boys and girls (p = 0.001 for all) (Table 2). The highest intake of phytin was found in LES boys and the lowest intake was found in UES girls. The intake of phytin was more amongst LES adolescents as their diets were predominantly cereal and pulse based.

DISCUSSION

In our cross-sectional study comparing upper and lower



	Dairy	Cereals	Pulses	DGLV	Fruits	Meat	Nuts	Veges	Tubers
UES boy	271.3	78.6	50.8	210.7	28.9	15.5	19.9	72.7	48.9
LES boy	180	66.5	72.6	193.8	27.1	39.7	47.9	76	46.6
UES girl	222.8	71.4	40.6	134.8	31.9	17.4	18.7	60.3	39.1
LES girl	43.4	41.6	46.4	205.2	10.9	26.1	10.9	62	39.9

Figure 1. Sources of calcium intake in adolescent boys and girls from upper and lower socio economic strata.

socio economic strata adolescent boys and girls from Pune, India, we found that in both gender groups, median dietary Ca intake of adolescents from the LES was significantly lower than that of adolescents from the UES. Total median Ca intake and Ca intake from dairy products was significantly lower in girls of both strata when compared to boys of the respective stratum. The contribution of dairy products to overall Ca intake was highest in the UES boys and lowest in LES girls. The main source of Ca in the diet of UES adolescents was dairy products, while in the LES adolescents it was DGLV.

In a study on 6-17 year old girls from Delhi, India, Marwah *et al.* have reported a Ca intake of 480 mg/day in LES girls whereas it was 707 mg/day in UES girls, while the phytin intake was 98 mg and 80 mg in the two groups respectively.[18] In a similar study from Delhi, Puri *et al.* have reported a Ca intake of 454 mg/day in LES girls and 685 mg/day in UES girls with a phytin intake of 105 and 85.6 mg/day respectively.[19] The Ca intake in both these studies is in line with the intake in our study group, however, phytin intake was much lower in the Delhi girls as compared to our study group This was possibly because our girls had a much higher intake of cereals and pulses which are a major source of phytin. Vatanparast *et al*. have reported that between 9 and 18 years, boys accrue 199 g bone mineral content (BMC) per year, equivalent to 175 mg Ca per day while girls accrue 138 g BMC per year, equalling 122 mg Ca per day. Thus, they have estimated that from age 14-18 years, the mean Ca requirements would be relatively stable at 1000 mg/day for girls and 1200 mg/day for boys.[20] Absorbable calcium intake was thus, way below the minimum recommended absorbable calcium intake of about 330-400 mg in all the 4 groups.[21]

The median estimated amount of absorbable Ca in the UES boys' diet was the highest in the study groups, while, as expected, it was lowest in the LES girls. Low absorbable Ca in LES adolescents, particularly girls, who were smaller and lighter than their more affluent peers, indicates that habitual low intake of calories and protein are likely to have had an impact on their growth.

In a study on LES girls from Pune with sub-optimal dietary intake of Ca, protein and calories it was seen that the girls were shorter and lighter than their age matched South Asian UK counterparts. Pune girls also had low bone mass for projected bone area in comparison to the UK Asian girls.[22] It is thus likely that the habitual intake of foods with low calcium density may have a long term impact on their skeletal health.

The dietary Ca:P ratio in all four study groups was less than 1 with phosphorous being higher than the RDA in all four groups. Our results are in line with other studies where the Ca:P ratio in Asian youth in the US was 0.6, whereas it was 0.8 in white Caucasian youth.[23] In experimental studies, high phosphorus intake has been shown to cause secondary hyperparathyroidism. [24.25] An increase in parathyroid hormone PTH levels may lead to skeletal demineralisation and increased synthesis of 1,25-dihydroxyvitamin D, which in-turn is known to degrade 25-hydroxyvitamin D to inactive 24,25-dihydroxyvitamin D, thereby depleting body stores of vitamin D. This may further have adverse effect on bone health.[26]

There is considerable evidence that distribution of resources is unequal within the family in many developing countries, particularly in Asia.[27] Such an unequal distribution of goods usually takes the form of a bias against females. While staple food items (i.e., rice, lentil soup, bread, etc.) are distributed fairly equally, side dishes usually containing a higher proportion of micronutrients (i.e., meat and yogurt) are preferentially allocated to boys and men.[28] In a study on 400 households from Punjab in India, Das Gupta found consistent differentials in milk and fat allocation between boys and girls, although caloric intake was roughly similar between the two. While adolescent girls and boys had roughly similar calorie intakes, the former were given more cereals while the latter had more milk and fats with their cereal.[29]

This study has a number of shortcomings. FFQ was self administered wherein the children answered the frequency of food consumption themselves with help from the nutritionists. It is possible that the children may not have recalled exactly what they ate and may not have been able to quantify their intake. However, we found good agreement in the estimated intake of Ca in a subset of 64 adolescents (32 from LES) to whom the FFQ was administered a week later (Data not shown). We were not granted permission by UES school principals to enquire about the monthly income of the students.

In summary, we found that adolescent boys and girls from LES had lower intake of Ca compared with their counterparts from UES, and it was more likely to be derived from non-dairy products with high oxalic acid and phytin content, which impair gastrointestinal absorption. In both socio economic groups, boys had higher intake of dairy based foods than girls. Educational measures are needed to increase intake of Ca rich foods in adolescents from LES and tackle engrained gender discrimination when it comes to distribution of dairy products within families.

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AUTHOR DISCLOSURES

None declared.

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印度 Pune 兩個社經層級的青春期男女生的鈣質攝取量及其來源

適當的鈣攝取量對於骨骼生長是重要的。在兒童及青少年，鈣質攝取量過低將會導致骨質自然累積減少，因此增加了日後骨質疏鬆症的危險性。我們的目的為研究在印度 Pune 地區，較低及較高經濟層級的青少年，其飲食鈣質攝取量及來源。我們假設，來自較低經濟層級的兒童有較低的鈣質攝取量，而其主要來源為非乳製品。各兩百名青春期男生與女生，來自較低及較高的經濟層級，參與這個研究。使用半定量食物頻率問卷評估鈣質、磷、草酸、植酸鹽、熱量及蛋白質的攝取量。四組的鈣質攝取量中位數有顯著性差異，最高的攝取量為來自較高經濟層級的男孩(893 mg，689-1295)，最低的攝取量則來自較低經濟層級的女孩(506 mg，380-674)。較低經濟層級的男孩鈣質攝取量中位數是 767 mg (585-1043)，較高經濟層級的女孩是 764 mg (541-959)。在較高經濟層級的青少年主要的鈣質來源是乳類製品，較低經濟層級的青少年是深綠色蔬菜。低經濟層級的男女青少年比起較高經濟層級，均有較低的鈣質攝取量。女生比男生較難攝取到乳類製品。必須採取對策修正在印度較低經濟層級的青少年低鈣質攝取量的現象，以及重視乳類製品的可獲性在性別上的差異。

關鍵字：鈣質、青少年、來源、食物頻率問卷、印度人