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Research Paper :

Role of dietary intake and calcium supplementation on serum calcium levels and bone mineral density of osteoporotic women

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ABSTRACT

One hundred twenty women of 45-55 years of age belonging to middle income group were selected on the basis of their Bone Mineral Density (BMD). They were equally divided into two groups of 60 each. Assessment of nutritional status was done by dietary survey before and after the study period. Dietary survey revealed that among the subjects of group I, daily intake of milk and milk products, roots and tubers, GLVs, other vegetables and fruits increased significantly whereas the intake of sugar and jaggery and fats and oils decreased significantly after NC. Among the subjects of group II, intake of other vegetables and fruits increased and of sugar and jaggery and fats and oils decreased significantly. In group I, there was significant increase in the intake of beta - carotene, niacin, vitamin c, iron, calcium and phosphorus after NC. In group II the intake of protein, niacin and iron increased significantly. The serum calcium level of subjects of group I and II improved significantly. The t-score of the BMD value also increased significantly. The subjects were classified as osteopenic and osteoporotic on the basis of their t-scores. 66.7% and 33.3% of the subjects of group I and II, respectively were osteopenic and the rest were osteoporotic. But after NC the percentage of osteopenic subjects increased to 80 per cent in group I and 82 per cent in group II and the percentage of osteoporotic subjects decreased from 33.3 to 20 per cent in group I and 46.7 to 18.3 per cent in group II. Intake of calcium was positively and significantly ($p<0.05$) correlated with BMD. On the other hand protein intake had negative and non – significant correlation with BMD of the subjects.

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Calcium is a major cation of bone-mineral. Its rate of deposition is highest in new born infant, decreasing to a very low level till the time people have stopped growing. The rate of calcium removal from skeleton tends to parallel the calcium deposition rate.

In the adult skeleton, most metabolic activity occurs by the process of bone 'remodeling' or bone turnover. This metabolic activity serves to maintain the structure and homeostatic functions of the skeleton.

In the long term, a change in bone mineral content reflects an imbalance between the processes of bone formation and resorption. Incomplete refilling of resorption cavities will result in a net loss of bone, and overfilling of these cavities will result in a net gain of bone.

After the age of 35-45 years, bone calcium mass decreases, gradually in men and abruptly in women for about a decade after their menopause. Menopause is a reproductive milestone in a woman's life. It brings a woman acutely face to face with reality of ageing when menstrual activity decreases and eventually ceases and body decreases production of female hormones-estrogen and progesterone. The term comes from the Greek words- 'Mena' and 'Paus' meaning 'Month' and 'Pause' (Susan, 2001). The menopause accelerates age related bone loss.

Post menopausal osteoporosis is a very common problem characterized by low bone mass micro architectural deterioration of bone tissue leading to enhanced bone fragility and consequently increasing the fracture risk among elderly people (Dempster and Lindsay, 1993). However, osteoporosis is the sub-clinical or symptomless condition and becomes clinically evident only when a person suffers a fracture. Women have a greater bone loss than men especially after the onset of menopause due to hormonal changes and reduced absorption efficiency of calcium. Added to the uncontrollable factors such as age, sex and menopause, several controllable factors also affect osteoporosis which can be classified under different categories like physiological (menarche, early menopause, multiparity), lifestyle (inactivity and excessive exercise), nutritional (prolonged low calcium intake, high animal protein), medical factors (degenerative diseases as anorexia nervosa, diabetes, alterations in gastrointestinal functions etc.) and drugs (thyroid replacement drugs, glucorticoid drugs, anticonvulsant drugs etc.) (Deepti *et al.,* 2006).

The mechanism leading to net bone loss are osteoclastic overactivity and/or osteoblastic underactivity. It has been shown that estrogen replacement and bone calcium supplementation prevent bone loss (Sanjay and Rohankar, 1999).

The intake of calcium and protein rich foods during childhood and adolescence is an important contributor to peak bone mass. They are also crucial for maintenance of bone mass and prevention of bone loss in adults. Despite benefits of protein to bone health, dietary protein has been shown to increase urinary calcium resulting from an increase in bone-resorption. Excess dietary proteins, whether from animal or plant sources may be deterimental to bone health, but nutrients such as calcium, potassium, phosphorus and vitamin D can influence the effects of protein.

As women go through menopause, their metabolism slows down, their vitamin requirements increase but calorie requirements decrease. So, the diet should be modified by including more of whole and fresh foods rich in vitamins but fewer in calories. The menopausal women should reduce intake of sugar and fat as low fat diet helps to adjust smoothly with decline in production of estrogen in body. Complex carbohydrates should be preferred to simple carbohydrates as they are digested more slowly than simple carbohydrates, which enter blood stream directly from digestive tract. Intake of coffee, caffeine products and carbonated drinks should also be restricted as they increase urinary loss of calcium and decrease bone mass. Hence, a good balanced diet along with supportive nutritional supplements, stress management and routine exercise help women in better management of menopause.

Therefore, the present investigation was undertaken with the following specific, to study the impact of dietary intake and calcium supplementation on bone mineral density of menopausal women and to assess the impact of protein intake on calcium and bone-homeostasis.

METHODOLOGY

The present study was undertaken to study the impact of dietary intake and calcium supplementation on serum calcium levels and bone mineral density of osteoporotic women. A sample of 120 post-menopausal women between the age group of 45-55 years belonging to middle income group were selected. The subjects were divided into two groups equally. The subjects from the first group were given nutrition counseling whereas the second group was advised calcium supplementation by the doctor.

Interview-cum-questionnaire method was used for collecting general information of the subjects. Information regarding their age, occupation, marital status, family type, educational level, occupation and educational level of spouse, family and per capita income was recorded. The assessment of nutritional status of the subjects was done by dietary survey and biochemical investigation of blood before and after NC. The dietary survey was conducted for 3 consecutive days using 24 hours recall method. For calculating daily nutrient intake of each subject, 'MSU nutriguide software' (Song *et al.*, 1992) was used. Serum calcium was analyzed and bone mineral density was measured using OCPC method(Gitelman, 1967) and Dual Energy X-Ray Absorptiometry, respectively.

Nutrition education was imparted to the subjects of group I twice a month, for a period of four months. On the basis of their dietary pattern, they were given knowledge about the sources of calcium and how to include those in their daily diet. A daily dose of 1000mg calcium supplement was recommended to the respondents of group II for a period of four months by the physician. A sub-sample consisting of 30 respondents having serum calcium levels less than 9mg/dl were selected from each group. The effect of dietary calcium intake and calcium supplementation after four months was seen by analyzing their serum calcium. The data collected were statistically analyzed using mean, standard error, students' t-test and Karl Pearson's coefficient of correlation (r).

FINDINGS AND DISCUSSION

Data (Table 1) revealed that the mean age of the respondents was 49.5 years with majority between the age-group of 45-55 years.

Most of the women were married and belonged to nuclear families, having family members upto four. The subjects and their spouses were well-educated, that is, 68.33 per cent of the subjects in group I and 66.67 per cent of the subjects in group II were graduates. Whereas 58.33 per cent of the spouses of the subjects of group I and 48.33 per cent of group II were graduates. Majority of the respondents of group I (66.67%) and II (60%) were housewives. In group I, 45 per cent of spouses of respondents were in service and 51.67 per cent were in business whereas in group II an opposite trend was recorded, that is, 55 per cent were in service and 41.67 per cent had their business. Most of the subjects from group I (73.33%) group II (88.83%) had monthly family income in the range of Rs. 10,000 to Rs. 20,000. Mean per capita income of the subjects of group I and II was Rs. 4915 and Rs. 4374 per month, respectively.

Majority of the subjects in group I (36.67%) and group II (38.33 %) were vegetarian, followed by non-

Table 1 : General information of the subjects

Age (years)	Group – I (n = 60)		Group – II (n = 60)	
	No. of respondents	%	No. of respondents	%
45-50	38	63.33	28	46.67
51-55	22	36.67	32	53.33
Educational level				
Under graduate	9	15	7	11.67
Graduate	41	68.33	40	66.67
Post-graduate	10	16.67	13	21.67
Educational level of spouse				
Under Graduate	8	13.33	17	28.33
Graduate	35	58.33	29	48.33
Post-graduate	15	25	15	25
Marital status				
Unmarried	2	3.33	1	1.67
Married	58	96.67	58	96.67
Divorcee	--	--	1	1.67
Family type				
Nuclear	44	73.33	46	76.67
Joint	7	11.67	6	10
Extended	9	15	8	13.33
Occupation				
House wife	40	66.67	36	60
Service	18	30	22	36.67
Business	2	3.33	2	3.33
Occupation of spouse				
Service	27	45	33	55
Business	31	51.67	25	41.67
Family Income (Rs.)				
10000-20000	44	73.33	53	88.33
20001-30000	16	26.67	7	11.67
Per capita income (Rs.)				
< 4500	34	56.67	38	63.3
4501 – 6500	18	30	18	30
> 6500	8	13.33	4	6.67

Table 2 : Food habits of the respondents

Food habits	Group – I (n = 60)		Group – II (n = 60)	
	No. of respondents	%	No. of respondents	%
Vegetarian	22	36.67	23	38.33
Non-vegetarian	21	35	21	35
Ovatarian	17	28.33	16	26.67

Table 3 : Information regarding health status of the subjects

Health condition	N=120	%
Lactose intolerance	2	1.67
Hypertension	16	13.33
Cervical problems	2	1.67
Diabetes Mellitus Type 2	15	12.5
Low blood pressure	15	12.5
Arthritis	2	1.67
Hysterectomy	3	2.5
Hypothyroidism	8	6.67
Calculii	5	4.17
Hypercholesrolemia	2	1.67
Diabetes mellitus + Thyroid	3	2.5
Diabetes mellitus + Hypertension	5	4.17

vegetarian and ovatarian (Table 2). Though almost all women were non vegetarian, but the consumption of non-vegetarian food was negligible. Vegetarian diet is considered better as reported by Virginia (1996) that vegetarian women lost less bone mass, reducing the risk of osteoporosis and generally they consumed much less saturated fat thus reducing the risk of obesity and arthritis.

The most common health problem observed among the respondents was hypertension (13.33%) followed by diabetes mellitus and low blood pressure (12.5% each) (Table 3). Multiple health problems like diabetes mellitus type 2 + hypertension and diabetes mellitus + hypothyroidism were also recorded among the subjects.

Nutrition education resulted in significant changes in food intake of the subjects (Table 4). Among the subjects of group I, the intake of milk and milk products increased significantly ($P<0.05$) from 250 to 295g. The intake of roots and tubers (58 to 81g), GLVs (19 to 49g), other vegetables (34 to 59g) and fruits (53 to 102g) increased significantly ($P<0.01$) whereas the intake of sugar and fats and oils decreased significantly ($p<0.01$) from 21 to 17g and 30 to 18g, respectively in respondents of group I. Among the subjects of group II the intake of other vegetables (27 to 51g) and fruits (40 to 90g) increased and of sugar (29 to 20g) and fats and oils (28 to 24g) decreased significantly at 1% and 5% level of significance, respectively. Subsequently there was a significant decrease ($P<0.01$) in the intake of energy from 2244 to 2132 Kcal and total fat from 125 to 74g (Table 6). Hence, the per cent energy contribution from carbohydrates increased from 48 to 52 per cent and from fats decreased from 43 to 37 per cent which was still higher than the recommendations. There was significant increase in the intake of beta-carotene, niacin, vitamin c, iron, calcium and phosphorus after NC. In group II, the intake of protein, niacin and iron increased significantly ($P<0.01$). However, the intake of proteins, beta-carotene and iron was less than the RDAs in subjects of both the groups.

The biochemical assessment of the subjects revealed that the serum calcium level of subjects of group I

Table 4 : Average daily food intake by the subjects before and after NC and calcium supplementation

Food groups (g)	Group I			Group II		
	Before	After	t-value	Before	After	t-value
Cereals	247 ± 17.37	266.3 ± 9.4	-1.43	260 ± 10.41	258 ± 10.25	0.19
Pulses	43.3 ± 1.41	42.7 ± 1.49	0.36	43.83 ± 1.44	43.3 ± 1.5	-0.26
Milk and milk products	249.6 ± 5.97	295 ± 10.93	-2.33**	208.9 ± 6.54	227.1 ± 8.74	-1.72
Roots and tuber	57.6 ± 5.97	81.3 ± 1.85	-7.49*	53.5 ± 1.88	49.8 ± 2.28	1.85
GLV	18.8 ± 0.95	49.32 ± 2.49	- 12.18*	18.7 ± 0.84	19.75 ± 1.13	-0.77
Other vegetables	34.47 ± 2.23	58.9 ± 2.69	-7.27*	27.28 ± 1.66	51.02 ± 2.45	-10.14*
Fruits	53.1 ± 2.57	101.5 ± 4.82	-8.27*	39.82 ± 2.03	90.18 ± 6.46	8.44*
Sugar and jaggery	20.9 ± 0.99	17.2 ± 0.62	3.43*	29.3 ± 1.54	20.1 ± 0.78	4.99*
Fats and oils	30.2 ± 0.73	18.5 ± 0.43	6.59*	28.15 ± 0.72	24.1 ± 0.41	2.31**

* and ** indicate significance of values at P = 0.01 and 0.05, respectively

Table 5 : Change in the per cent adequacy of food intake after NC and calcium supplementation

Food group	Group I		Group II		Suggested intake[1] g / day
	Before	After	Before	After	
Cereals	82.33	88.77	86.67	89.33	300
Pulses	72.17	71.17	73.05	72.17	60
Milk and milk products	83.2	98.33	69.63	75.7	300
Roots and tubers	57.6	81.3	53.5	49.8	100
GLV	18.8	49.32	18.7	19.75	100
Other vegetables	34.47	58.9	27.28	51.02	100
Fruits	53.1	101.5	38.82	90.18	100
Sugar and jaggery	104.5	86	146.5	100.5	20
Fats and oils	151	92.5	142.5	120.5	20

[1]ICMR (2000)

Table 6 : Average daily nutrient intake by the subjects before and after NC and calcium supplementation

Nutrient	Group I			Group II			
	Before	After	t-value	Before	After	t-value	RDA1
Energy (Kcal)	2244.42 ± 22.1	2132.33 ± 13.38	4.58*	1946.53 ± 72.52	2073.23 ± 16.06	-1.68	1875
Protien (g)	48.18 ± 1.08	49.05 ± 2.34	-0.36	42.53 ± 1.47	43.67 ± 3.23	0.87	50
Total fat (g)	125.12 ± 5.12	74.12 ± 2.46	8.89*	93.47 ± 5.11	84.8 ± 2.45	1.59	42
Beta-carotene (mcg)	880.02 ± 80.43	1183 ± 52.07	-3.55*	1024.64 ± 101.01	1035.42 ± 93.34	-0.08	2400
Thiamine (mg)	1.26 ± 0.26	1.883 ± 0.07	1.42	1.7 ± 0.4	1.87 ± 0.07	-1.09	0.9
Riboflavin (mg)	1.14 ± 0.06	1.11 ± 0.07	0.32	0.92 ± 0.06	1.2 ± 0.08	-0.22	1.1
Niacin (mg)	5.12 ± 0.98	22.2 ± 1.10	-6.44*	10.45 ± 0.86	18.28 ± 1.1	-5.79*	12
Vitamin C (mg)	85.92 ± 11.62	98.92 ± 9.8	-2.47**	81.75 ± 76.72	90.78 ± 7.72	-1.19	40
Iron (mg)	16.73 ± 0.99	21.92 ± 0.99	-3.67*	14.22 ± 0.78	19.58 ± 0.85	-4.57*	30
Calcium (mg)	618.28 ± 24.16	967.93 ± 33.85	-8.12*	592.23 ± 30.85	692.5 ± 43.86 +1000supplement	-1.9	1000
Phosphorus (mg)	861.58 ± 36.99	688.32 ± 54.76	2.49**	866.42 ± 37.38	1066.17 ± 56.9	0.004	1000

* and ** indicate significance of values at P = 0.01 and 0.05, respectively
[1] ICMR (2000)

improved significantly (P<0.01) but was close to the minimum value of the normal range of 9-11mg/dl (Table 7). In the subjects of group II the values of serum calcium level increased from 7.9 to 9.5mg/dl and were within the standard range. The t-score of the BMD value increased from -2.2 to -2.01 in subjects of group I and -2.3 to -1.8 in group II. The increase was significant at 5 per cent level in group I and at 1 per cent level in group II. The subjects were classified as osteopenics and osteoporotic on the basis of their t-scores (Table 8). Majority of the

Table 7 : Serum calcium and bone mineral density of the respondents

	Group-1			Group-II			
	Before	After	t- value	Before	After	t-value	Standards
Serum Ca (mg/dl) (n=30)	7.82 ± 0.11	8.99 ± 0.16	-6.48*	7.91 ± 0.12	9.49 ± 0.31	-8.38*	9-10
BMD (T-score) n=60)	-2.2 ± 0.11	-2.01 ± 0.01	-2.48**	-2.27 ± 0.07	-1.77 ± 0.06	-4.78*	>-1.

* and ** indicate significance of values at P = 0.01 and 0.05, respectively

Table 8 : Classification of subjects according to T-scores

Diagnosis	T-score	Group-I		Group-II	
		Before	After	Before	After
Osteopenia	-1 to -2.5	40 (66.67)	48 (80)	32 (53.33)	49 (81.67)
Osteoporosis	<-2.5	20 (33.33)	12 (20)	28 (46.67)	11 (18.33)

Figures in parentheses represent percentages

subjects of group I and II, that is, 66.67 per cent and 53.33 per cent, respectively were osteopenic and 33.33 per cent and 46.67 per cent subjects of group I and II, respectively were osteoporotic. But after NC the per centage of osteopenic subjects increased to 80 per cent in group I and after calcium supplementation the percentage of osteopenics increased to 82 per cent and there was a corresponding decrease in osteoporotic subjects.

Data in Table 9 reveals the correlation of dietary calcium and protein intake with BMD of the subjects. Intake of calcium was positively and significantly ($p<0.05$) correlated with BMD. On the other hand, protein intake

Table 9 : Correlation of BMD with dietary protein and calcium intake

Nutrient	Group I BMD	Group II BMD
Calcium	0.25**	0.28**
Protein	-0.12	-0.05

** indicates significance of value at P = 0.01

had negative and non – significant correlation with BMD of the subjects. Menopause is associated with fall in . . . . . (Wishart *et al.*, 2000). Therefore, an increase in calcium intake through diet or supplements is suggested. But according to Wolf *et al.* (2000), calcium absorption is inversely associated with total calcium intake.

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