Impact Evaluation of Calcium and Vitamin D Supplementation and Physical Activity on Bone Health Status of Elderly Population of Urban Vadodara

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Abstract: *Background*: Osteoporosis is a global public health problem affecting the ageing population and influenced by poor nutrition, lack of physical activities, and absence of supplementation on time.

Objectives: To study the impact of Calcium and vitamin D supplementation along with weight bearing exercises on bone health status of elderly.

Methods: 30 elderly males and 20 elderly females having poor BMD and poor serum vitamin D were supplemented with 1000 mg calcium and 500 IU vitamin D/ day along with weight bearing exercises for a period of 3 months, along with that 60000 IU vitamin D_3/week for 2 months were given to 30 males only. Serum calcium, Vitamin D, BMD, dietary calcium intake, frequency of vitamin D rich food intake, anthropometry etc. were measured at the baseline as well as after the intervention.

Results: Mean BMD T-scores (-1.1 to -2.5: osteopenia; >-2.5: osteoporosis) of the elderly males and females were significantly ($p \leq 0.001$) decreased after the intervention depicting improvement (baseline:-2.34±0.50, final:-1.86±0.61). 26.7% reduction in osteoporotic cases among males and 50 % among women was achieved. Mean serum calcium (baseline: 9.38±0.63, final: 9.46±0.61) and vitamin D level (baseline: 23.76±13.17, final: 35.48±14.84) was increased significantly ($p \leq 0.05$). 60% males and 70% females achieved vitamin D sufficiency level after the intervention. Mean physical endurance (Grip strength, standing balance, walking speed and rise from chair) scores were significantly increased in both males and females. Locomotor problems were reduced among 6.7% males and 40% females after regular weight bearing exercise and supplementation.

Conclusion: Calcium and vitamin D supplementation with daily weight bearing exercise has a preventive and curative effect on BMD and it maintains the serum calcium and vitamin D levels. Long term and high dose supplementation needs further investigation.

Keywords: Elderly, BMD, Calcium, Vitamin D, Physical Activity.

INTRODUCTION

Osteoporosis is a global health problem affecting 200 million elderly worldwide and socioeconomic burdens in developed and developing countries to the affluent and non affluent societies [1, 2]. Scientific reports suggest 20% women and 15% men are suffering from osteoporosis in India [3]. In India the number of osteoporosis patients is approximately 26 million (2003 figures) with the numbers projected to increase to 36 million by 2013 [4]. In a hospital in New Delhi 141 were reported having osteoporosis among 421 patients with hip fractures [5]. Both men and women experience a progressive loss of bone mass with age. For women there is a further acceleration of bone mass loss of 20% to 30% occurring 3 to 6 years after menopause. There are various factors implicated in bone loss. Non- nutritional factors like physical activity, genetic disposition etc. and nutritional factors like dietary calcium and vitamin D intake and supplementation of the same determine bone health during all stages of growth and ageing, therefore needs to be considered in the risk assessment of osteoporosis. Diet, physical activity, may have influence along with genetics on bone mass; but they can be modified during the active life time [6]. Old age brings a halt to the active lifestyle practices and may experience difficulties in mobility. Physical inactivity is accountable for decline of bone mass and as the major risk factor for osteoporotic fractures among elderly [7]. The incidence of fracture is very high among Indian geriatric population. Specific and sensitive tools for diagnosis and monitoring the therapeutic efficacy are more or less established but need to be refined [8]. Weight bearing exercises along with 1000 mg/day calcium intake showed beneficial impact on bone mass [9]. Supplementation of Calcium and vitamin D to older adults over three- years abridged bone loss in femoral neck, spine and reduced non-vertebral fractures as well [10]. Oral vitamin D is considered to maintain normal 25(OH) D concentrations in blood and to convene the calcium requirements but it is a more difficult issue as calcium intake among Indians is very low. Mega dose

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of 60,000 IU vitamin D is considered as safe and beneficial to treat hypovitaminosis D and poor BMD in all age groups [11]. In a population-based cohort study 1896 women and 829 men aged 25 years and older were examined for serum 25-hydroxyvitamin D and PTH for a period of 10-years and it showed that vitamin D supplement intake increased by 317 (95% confidence interval [CI] 277 to 359) IU/day in women and by 193 (135 to 252) IU/day in men. Serum 25(OH) D increased by 9.3 (7.3 to 11.4) nmol/L in women and by 3.5 (0.6 to 6.4) nmol/L in men. Lower PTH levels were associated with younger age and higher 25(OH) D levels in both women and men [12]. Due to unexplored silent growing epidemic proportions of osteoporosis in the country and the available literature on bone health status of elderly indicated investigation in BMD and calcium and vitamin D supplementation along with physical activity. Prevention of the diseases and associated fractures is essential for good health, quality of life, and independent ageing [13].

METHODOLOGY

Sample Size

30 males and 20 females having osteopenia or osteoporosis as well as serum vitamin D insufficiency or deficiency were purposively selected for intervention.

Sampling Technique

Purposive sampling.

Study Setting

Urban Vadodara city.

Supplementation

30 elderly males and 20 elderly females with poor BMD and either VDI or VDD were supplemented 60000 IU vitamin D_3/ week for 2 months as serum vitamin D storage sufficiency, followed by 1000 mg calcium carbonate and 500 IU vitamin D_3 / day as a maintenance dose along with routine weight bearing exercises for a period of three months. Two tablets containing 500 mg calcium carbonate and 250 IU vitamin D_3 was supplemented along with or after the meal. Looking at the baseline mean serum vitamin D level of selected female subjects i. e. 32.75$\pm$15.94 ng/dl, mega dose of vitamin D (60000 IU) was not given to avoid toxicity. Subjects were followed up in every 15 days to check the compliance and reinforcement of the physical activity and exercise.

Data Collection

Data on anthropometric measurements, morbidity status, physical activity, and BMD and serum vitamin D was collected at the baseline. Information education and communication tools in form of Booklet, brochures and posters were developed to counsel the subjects for daily physical activity and weight bearing exercises. Physical endurance (grip strength, rise from chair, standing balance and walking speed) was tested at the baseline and after the intervention and subjects were counseled for three months to see the improvement.

Tools and Techniques

BMD

BMD camps were organized in senior citizen associations, health clubs, rotary clubs, lions clubs, hospitals, gyms, physiotherapy centers, haveli, mahila mandals etc. in all the five zones of urban Vadodara. Ultra sound based BMD machine was used for BMD assessment and done under the constant supervision of orthopaedician.

Normal: < -1.0, Osteopenia: -1.0 to -2.49, Osteoporosis: <-2.5

Serum Vitamin D and Calcium

Blood sample were collected to assess serum vitamin D and calcium status at the baseline as well as after the supplementation to see the impact of Ca and vitamin D supplementation, using CLIA technique.

Serum 25 (OH) D Levels [14]

20 - <30.0 ng/ml: Vitamin D Insufficiency.

<20 ng/ml: Vitamin D Deficient (VDD)

VDD: 10.0−<20.0 ng/ml: Mild (Lips P, 2001).

5.0−<10.0 ng/ml: Moderate

<5.0 ng/ml: Severe

Serum Calcium Level [15]

<9 mg/dl: Deficiency

9-11 mg/dl: Normal

Anthropometric Measurements

Weight, height, BMI, WHR (standardized bathroom scale, height meter and measuring tape were used) were taken using standard tools and techniques. BMI category used: BMI limit for Indians (Asia Pacific).

Less than 18.4 – Underweight

18.5 - 22.9 - Normal

23 - 24.9 - Overweight

More than 25 – Obese

Physical Endurance Test [16]

1) Hand grip strength: Dynamometer

2) Standing Balance: 10 second each: Side by side (SS); Semi-tandem (ST); Tandem (T)

3) Walking speed: 8 ft/ 2.4 M walking

4) Rises from chair: 5 sitting down and standing up from the chair within given time.

Statistical Analysis

Appropriate statistical tests such as mean, SD, paired t-test, student's t-test were used and statistical tools like SPSS/PC+ were used for analysis of the collected data.

RESULTS AND DISCUSSION

Mean BMD of the subjects was compared with the WHO standard. Anthropometric measurements like height, weight; BMI, waist-hip ratio etc. were expressed in terms of mean ± SD.

Mean BMD of the elderly was significantly improved after calcium and vitamin D supplementation and daily exercise for a period of three months. Significant ($p \leq 0.001$) reduction in post interventional BMD T-scores in both male and female was observed (Table **1**). The pattern in reduction in BMD T-scores indicated that male achieved rapid improvement compared to the females of the same age i.e. -1.8±0.7 in males and 2.01±0.44 in females. A study by Bass in 1998 documented that adult gymnasts had higher BMD than age-matched sedentary controls [17]. Another study by Moayyeri in 2008 suggested that moderate-to-vigorous physical activity is associated with reduced hip fracture risk of 45% (95% CI, 31-56%) and 38% (95% CI, 31-44%), respectively, among men and women [18].

Prevalence of osteopenia as well as osteoporosis was reduced after the supplementation and daily exercise period. 26.7 percent reduction in osteoporotic male and 50 percent in female was achieved (Figure **1**). In a study an improvement in bone density was noted among healthy older men in response to a calcium and vitamin D supplement, whereas placebo-treated men lost bone [19]. A study on Ca supplementation in postmenopausal women for one to

Table 1: Change in Mean BMD T-Scores of Elderly Males and Females after the Supplementation

Mean BMD	Gender				t-value
	Male (n=30)*		Female (n=20)**		
BMD	Pre intervention	Post intervention	Pre intervention	Post intervention	4.93*
Normal: < -1.0 Osteopenia: -1.0 to -2.49 Osteoporosis: <-2.5	-2.3±0.5	-1.8±0.7	2.57±0.45	2.01±0.44	7.01**

Significant at $p \leq 0.001$.

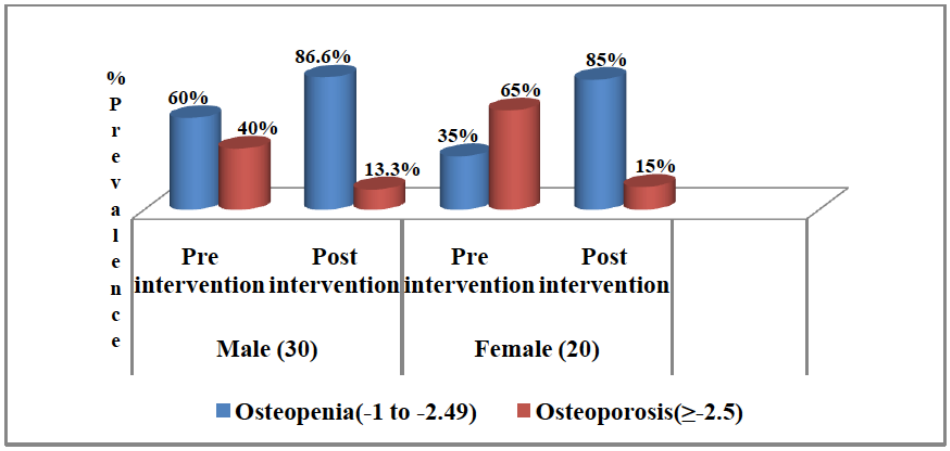

Figure 1: Change in bone health status of elderly subjects after the supplementation.

Table 2: Mean Anthropometric Measurements of Elderly Males and Females

Sr. No.	Indices	Age groups				
		Pre intervention (N=50)		Post intervention (N=50)		t-value
		Males (n=30)	Females (n=20)	Males (n=30)	Females (n=20)	
1.	Weight (Kg)*	66.66±17.7	66.12±12.62	67.53±18.3	66.36±12.32	*0.5 (male) 0.6 (female)
2.	Height (cm)	161.86±8.9	154.21±8.69	161.86±8.9	154.21±8.69	
3.	BMI(kg/m^2)**	25.25±5.05	27.73±4.65	25.66±5.83	27.82±4.41	** 0.6 (male) 0.5 (female)

two years duration have shown that calcium can reduce the rate of bone loss to some extent [20]. Combined supplementation with Ca and vitamin D for 1·5–3 years have shown impressive reductions in hip-fracture incidence in elderly women (mean age 84 years) [21, 22]. Another meta-analysis of Ca supplementation trials reviled that Ca supplementation reduces bone loss [23].

There was no significant change in anthropometric measurements of the subjects after the supplementation. Calcium and vitamin D had no impact on weight and BMI of the subjects (Table **2**). Moreover, daily prescribed routine exercise might have beneficial effect on anthropometric parameters. At the baseline females with higher BMI had poor BMD, indicated higher BMI as a risk factor for poor BMD. Thus, it gave an indication for further investigation on long term effect of daily exercise along with supplementation for relevant and significant documentation.

After the supplementation no significant change was observed in percentage of elderly males and females laying in different BMI categories compared to the base line. A study supported the same: maintenance of body mass index of not less than 19 kg/m2 is recommended for prevention of osteoporosis [13].

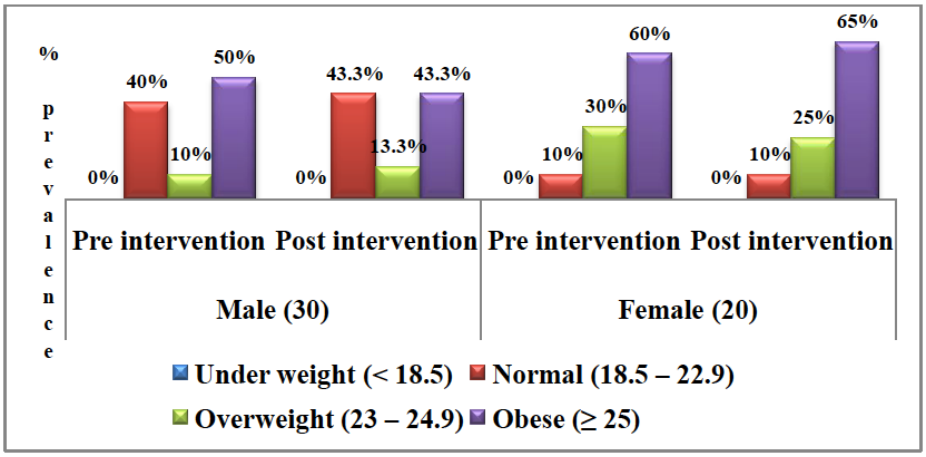

Figure 2: Change in BMI status before and after intervention.

Table 3: Mean Serum Calcium Levels among the Elderly before and after Intervention

Mean	Gender				t-value
	Male (n=30)*		Female (n=20)**		
Serum calcium (mg/dl)	Pre intervention	Post intervention	Pre intervention	Post intervention	2.56 *
	9.68±0.38	9.75±0.38	8.92±0.66	9.02±0.64	2.25 **
Serum vitamin D (ng/dl)	17.75±5.81	32.75±13.3	32.75±15.94	39.58±21.13	6.10 * 6.60**

(Serum vitamin D: VDI: 20 - <30.0 ng/ml, Mild VDD: 10.0–<20.0 ng/ml).
Serum calcium level Significant at p≤0.05.
Serum vitamin D level significant at p≤0.001.

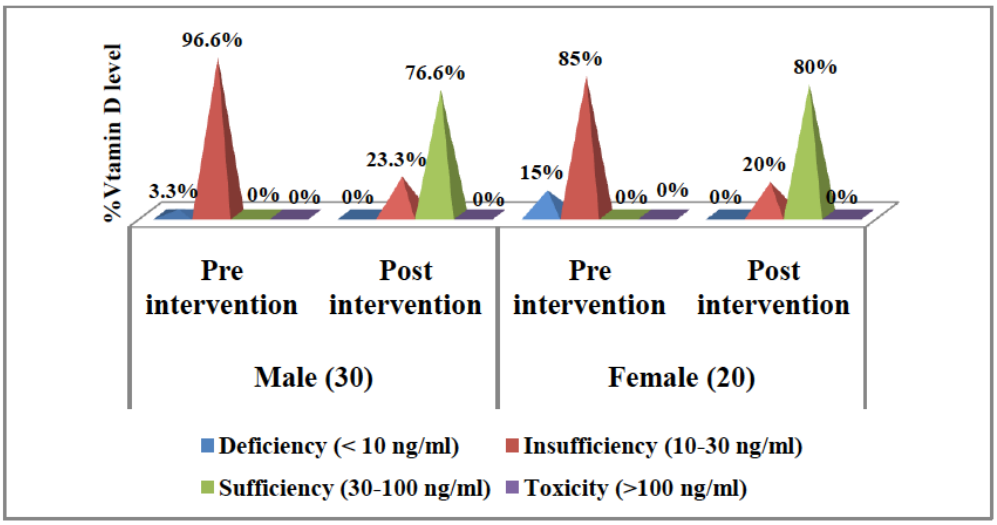

Figure 3: Percentage of elderly showing Vitamin D levels before and after intervention.

Significant (p≤0.05) increase in mean serum calcium level was observed after calcium and vitamin D supplementation among both male and female but the response was greater among males compared to females. Similarly, the serum vitamin D level was also increased significantly (p≤0.001). At the baseline serum vitamin D level was greater among females compared to males thus mega dose of vitamin D (60000 IU) was not given to them to avoid toxicity but the increase in serum vitamin D level of male subjects (mega dose was given) compared to females indicated mega dose has a positive impact on serum vitamin D level (Table **3**). In several studies Calcium supplementation had been shown to have a positive effect on bone mineral density in postmenopausal women [22]. Daily 500 mg of calcium and 700 IU of vitamin D supplementation along with the usual diet in 101 post-menopausal women and 86 men of 65 years and above had been shown reduction in rate of loss of BMD [18].

At the baseline 96.6% males and 55% females were laying under vitamin D insufficiency level and 3.3% males under deficiency level but after the intervention 100% male and female was shifted to sufficiency level. A study from North India reported requirement of 60,000-120,000 IU per month to achieve vitamin D level of > 30ng/ml [24]. Another study reported increase in vitamin D level to normal after 8 weeks supplementation with 60,000 IU/ week [25]. Both these studies highlighted the need of regular supplementation of at least 2000 IU/day vitamin D supplementation to maintain normal vitamin D levels.

Daily weight bearing exercise along with supplementation for three months was able to improve physical endurance of both males and females. Mean grip strength and walking speed of female was significantly (p ≤ 0.05) improved. Mean standing balance of male (p≤0.01) and female (p ≤ 0.01) was improved compared to the baseline performance.

Table 4: Mean Values of Physical Endurance of Elderly Males and Females

Physical endurance	Gender					t-value
	Male (n=30)		t-value	Female (n=20)		
	Pre intervention	Post intervention		Pre intervention	Post intervention	
Grip strength score	15.83±4.8	18.03±5.34	7.0	1.6±0.50	1.8±0.52	2.17 ***
Standing balance score	3±0.64	3.35±0.67	3.19*	3±0.64	3.35±0.67	6.60 ****
Walking speed score	4.59±1.8	4.99±1.17	3.05**	2.2±0.69	2.45±0.68	2.51 ***
Rise from chair score	13.19±3.38	14.19±3.38	4.75	2.5±0.88	2.65±0.98	1

Significant at *p≤0.01, **p≤0.001, ***p ≤ 0.05, ****p ≤ 0.01.

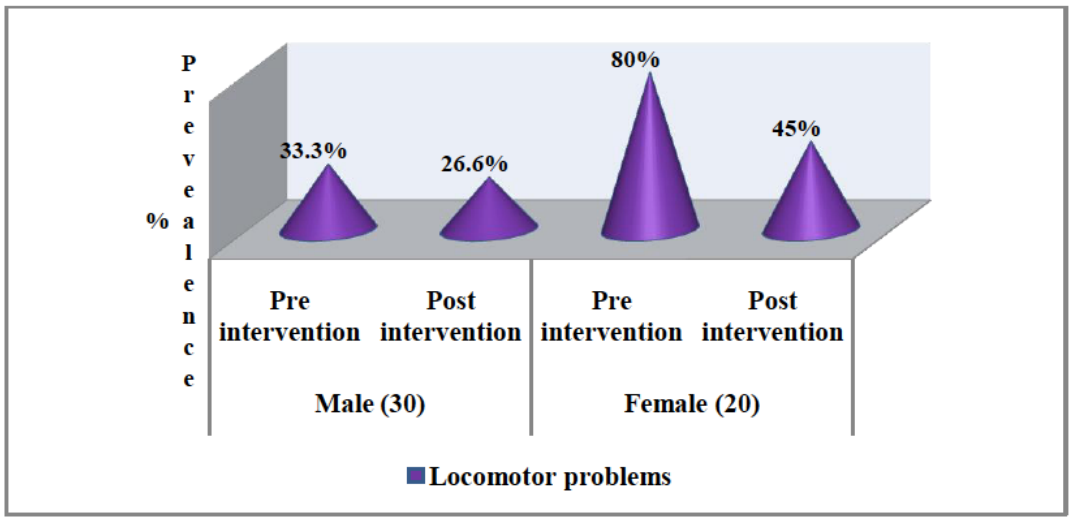

Figure 4: Prevalence of locomotor problems among the elderly after the intervention.

There is no age bar for exercise and getting its benefits and evidence showed that low body weight and excessive dieting is associated with low bone mineral status and increased fracture risk [26, 27]. In a study 72% Pakistani women lead a sedentary lifestyle and documented with high prevalence of osteopenia and osteoporosis [28, 29].

Locomotor problems were reduced among males (6.7%) but more among females (40%) after daily exercise and supplementation. In a study risk of falling is suggested to be generally reduced among physically active people with a potential increased risk in the most active and inactive people. Positive effects of physical activity on BMD and bone quality are of a questionable magnitude for reduction of fracture risk [18].

CONCLUSIONS

Daily calcium and vitamin D supplementation along with weight bearing exercise had a beneficial effect not only on BMD but also it increases and maintains serum calcium and vitamin D level among elderly. Mega dose of vitamin D is necessary prior to daily calcium and vitamin D doses to increase serum vitamin D and BMD. Thought the change was not statistically significant but daily weight bearing exercise was able to reduce locomotor problem like joint pain. The same might give statistically significant improvement in long term supplementation. Encouraging active life style at all ages is therefore a top priority to prevent osteoporosis. Thus, calcium and vitamin D supplementation along with daily weight bearing exercises can be used as a preventive as well as curative strategy for poor BMD. No side effect was reported by the subjects. In spite of adequate dietary calcium intake by the study population prevalence of poor BMD and serum vitamin D deficiency was very high. Pure vegetarian diet as a staple, infrequent intake of vitamin D rich food sources may be a hidden influence behind it. Population groups in many developing countries have a much lower calcium intake of about 500 mg. After examining the evidence for nutritional status of Ca of the Indian population, experts suggest an upward revision of calcium RDA [30]. Vitamin D deficiency in various subgroups of Indian population is highly prevalent, in spite of the abundant sunlight availability.

RECOMMENDATIONS AND FUTURE SCOPES

Long term impact evaluation of calcium and vitamin D supplementation as well as daily weight bearing exercise needs to be taken under further investigation. Impact of high dose of calcium and vitamin D should be analyzed. Bone health care specific Nutrition Health Education as a tool to modify life style should be evaluated with special consideration to dietary modification, exercise, sun exposure etc.

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