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Role of physical activity in addition to calcium and vitamin D supplementation in the prevention of osteoporosis in postmenopausal women: an Indian scenario

Mahesh Kumar Talele*, Deo Rishi Tripathi and Amod Sharma

Department of Physical Medicine and Rehabilitation, Dr. Ram Manohar Lohia Hospital, Baba Kharak Singh Marg, New Delhi-110001 India

Abstract: *Background:* Inadequate physical activity and dietary intake of calcium and vitamin D and other lifestyle factors contribute to the high prevalence of osteoporosis among elderly women. *Objective:* To find out the relation of Z score of the hip, and femoral neck using dual-energy x ray absorptiometry (DEXA) in healthy postmenopausal women with respect to duration since menopause, duration and type of physical activity and vitamin D3 level. *Patients and methods:* A 12 months cross sectional study. We screened elderly postmenopausal women (age >50 yrs) without any co-morbidities (subjects N=67) on OPD basis for bone mineral density (using DEXA scan of 3 sites spine, hip and neck of femur and total body). On BMD basis, the subjects were then classified into 2 groups A and B. Group A (N=23) included osteoporotic subjects (BMD T<-2.5) and Group B (N=34) included osteopenic/normal subjects (BMD T>-2.5). Detailed present and past history of diet (calcium content), physical activity levels (using duration and type of activity as per GPPAQ general practice physical activity questionnaire) and laboratory tests (serum calcium , serum phosphorus , vitamin D3 levels), we identified relative effects of each of them on bone mineral density (age matched Z scores). Bone mineral density (age matched Z scores) was measured by dual-energy x-ray absorptiometry every twelve months. *Results:* The correlation between physical activity, calcium, vitamin D3 levels and bone mineral density was determined by regression analysis. The strongest association was found between stair climbing and walking speed and duration of weight bearing activities and hip (femur) bone mineral densities. Approximately 95% of participants had insufficient serum 25-hydroxy vitamin D. Mean physical activity duration was 17.6 minutes/day. *Conclusion:* The positive association between stair climbing and walking speed and duration of weight bearing activities and hip (femur) cortical bone measures in postmenopausal women may indicate a lifestyle factor in addition to calcium and vitamin D3 supplementation that can help prevent bone loss. Given the significantly greater hours per week of weight bearing physical activity done by subjects, duration is an important determinant of the effect physical activity has on bone.

Keywords: General Practice Physical Activity Questionnaire; bone mineral density

Introduction

Osteoporosis is a condition resulting in an increased risk of skeletal fractures due to a reduction in the density of bone tissue (Consensus 1991). It has been defined more explicitly as a disease characterized by low bone mass, micro-architectural deterioration of bone tissue leading to increased bone fragility and consequent increase in fracture risk (Consensus 1993). The most common clinical manifestations of osteoporosis are fractures of the hip, vertebrae or wrist. According to the World Health Organization (WHO), approximately 30% of postmenopausal females have osteoporosis (Kanis 1994, WHO 1994). The value of exercise as an intervention for the prevention of postmenopausal bone loss is a controversial subject (Kanis 1994).

The high prevalence of osteoporosis fractures in postmenopausal women means prevention of this disease is important. Activities that seem to have the most substantial effect on skeletal mass are those that include 1) high-impact, rapid, forceful loading (e.g., jumping, running, gymnastics, volleyball); 2) changing, diverse, or novel loading angles and force magnitudes over time (e.g., ball sports, gymnastics); 3) weight-bearing, high forces (e.g., dancing, weight lifting); and 4) direct impact on the bone of interest (e.g., dominant arm of tennis players) [1].

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Nonimpact activities such as swimming and cycling (although the torso experiences some weight-bearing forces when using a traditional racing bicycle) typically do not a have an osteogenic effect on bone density [2], but they may be beneficial for bone strength [3].

NICE Public Health Intervention Guidance published in March 2006 [4] recommended that primary care practitioners should take the opportunity, whenever possible, to identify inactive adults and advice them to aim for 30 minutes of moderate activity on 5 days of the week (or more). Practitioners should use their judgement to determine when this would be inappropriate (for example, because of medical conditions or personal circumstances). They should use a validated tool, such as the Department of Health's general practitioner physical activity questionnaire (GPPAQ), to identify inactive individuals. The GPPAQ has good face validity and good construct validity is repeatable criterion validity predicts all-cause and cardiovascular mortality in men and women.

The combination of work and leisure time physical activity into a single index are more consistently associated with mortality than either components used alone [5].

Objectives: The purpose of this study was to find out the relation of duration since menopause, duration and type of physical activity, vitamin D3 and its association to Z score of the hip, and femoral neck using dual-energy x-ray absorptiometry (DEXA).

Material and Methods

Research Design: This study examines the baseline cross-sectional relationship between duration since menopause, duration and type of physical activity, vitamin D3 and its association to cortical BMD Z score of the hip, and femoral neck using dual-energy x-ray absorptiometry (DEXA).

Subject Screening, Selection, and Characteristics: We enrolled all healthy, postmenopausal women with symptoms of osteoporosis women (N = 67; mean age: 53.8 yr) (45–80 yr of age) as part of a cross-sectional study in the rehabilitation department of Dr Ram Manohar Lohia Hospital New Delhi. All subjects were given dietary advice and asked to practice regular physical activity including exercises along with rich diet supplemented with 500 mg of calcium plus 700 IU of vitamin D (cholecalciferol) per day. Written informed consent was obtained from all patients.

Inclusion criteria:

- All healthy women who went through a natural menopause, were ≤80 yr of age

Exclusion criteria:

- Any previous history of bone disease, renal disease, urinary stones, cardiovascular disease, diabetes mellitus, respiratory disease, parathyroid disease, thyroid or liver disease.
- Any chronic medications, such as cholesterol-lowering or antihypertensive medications, or hormonal therapy.
- Women with evidence of previous or existing spinal fractures

Data Collection:

History--present and past history of menstruation, diet (calcium content), diseases and medications.

Anthropometric measurements–height, weight

Laboratory tests--serum calcium, serum phosphorus, serum alkaline phosphatase vitamin D3 levels, serum proteins, lipid profile, thyroid profile.

Bone densitometry-hip, femur and spine T, Z score.

Subjects were then classified into 2 groups A and B. Group A (N=23) included osteoporotic subjects (BMD T<-2.5) and Group B (N=44) included osteopenic /normal subjects (BMD T>-2.5).

Physical activity assessment: Physical activity during the past few months was assessed using a General Practice Physical Activity Questionnaire.

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Name: ..... Date: .....

1. Please tell us the type and amount of physical activity involved in your work. Please tick one box that is closest to your present work from the following five possibilities:

a	I am not in employment (e.g. retired, retired for health reasons, unemployed, full-time carer etc.)	
b	I spend most of my time at work sitting (such as in an office)	
c	I spend most of my time at work standing or walking. However, my work does not require much intense physical effort (e.g. shop assistant, hairdresser, security guard, child minder, etc.)	
d	My work involves definite physical effort including handling of heavy objects and use of tools (e.g. plumber, electrician, carpenter, cleaner, hospital nurse, gardener, postal delivery workers etc.)	
E	My work involves vigorous physical activity including handling of very heavy objects (e.g. scaffolder, construction worker, refuse collector, etc.)	

2. During the *last week*, how many hours did you spend on each of the following activities?

	Please answer whether you are in employment or not	**None**	**<1 hr**	**1 hr -3hr**	**>3 hr**
a	Physical exercise such as swimming, jogging, aerobics, football, tennis, gym workout etc.				
b	Cycling, including cycling to work and during leisure time				
c	Walking, including walking to work, shopping, for pleasure etc.				
d	Housework/Childcare				
e	Gardening/DIY				

3. How would you describe your usual walking pace? Please mark one box only.

Slow pace (i.e. < 3 mph)		Steady average pace	
Brisk pace		Fast pace (i.e. > 4mph)	

Statistical Analyses: Data ananysis included multiple linear regression (for continuous measures of activity) and analysis of variance (for categorical measures), using windows excel, with measurements at BMD hip being used as separate dependable variables. Variables considered to be established risk factors for osteoporosis were treated as confounding variables and adjusted for in the analysis. These were age at scan, height, weight, years since menopause.

Results

A total of 67 women were recruited. the mean age was 57 years(SD 3.8 years) and their mean height was 156 cm(SD 6.1 cm) and their mean weight was 55.2kg (SD 8.4 kg). The women were a median of 10.5 years of menopause.

I] *Femoral Z score with Duration of menopause:* The Z score was relatively higher in younger women and the score decreases with the age of the patient. Statistically femoral Z score was negatively correlated to the duration of menopause in both osteoporotic and osteopenic /normal patients. Bone mass rapidly deteriorates with advancing age as shown by negative value of regression coefficient. This is due to the physical inactivity with advancing age.

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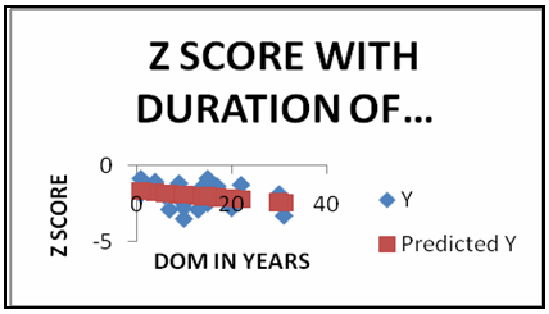
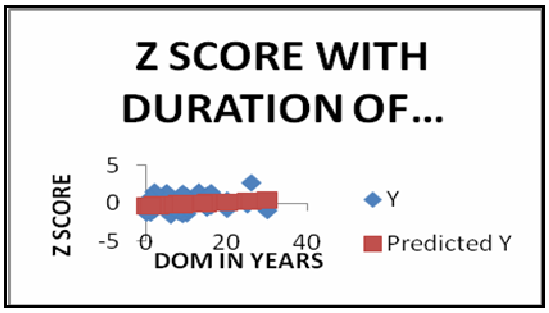


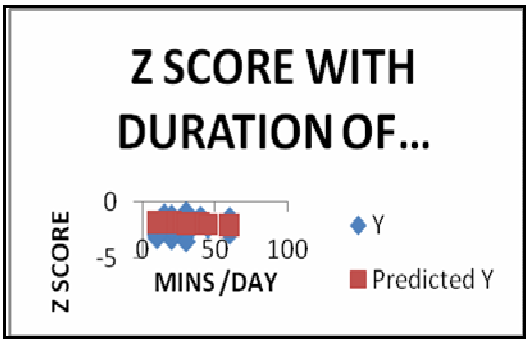
Osteoporotic group A



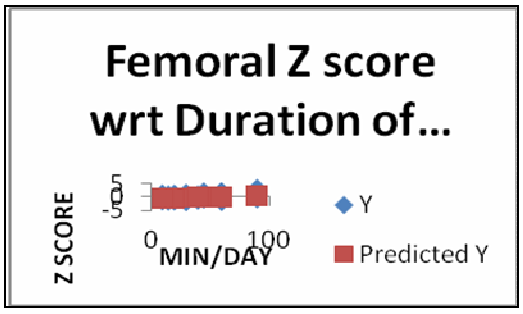
Osteopenic/ normal group B

Comparison of Femoral Z score in group A and B with Duration of menopause.

II] *Femoral Z score with duration of physical activity(mainly walking):* The femoral Z score was relatively higher in women with > 40 mins of daily weight bearing physical activity and the score was lower in women with <40 mins of daily weight bearing physical activity. Statistically z score was positively correlated to the duration of weight bearing physical activity in both osteoporotic and osteopenic/normal patients. The Odd's ratio risk of low DEXA femoral bone t-score and z-score due to low physical activity is 7.9091 (1.6028 to 39.0274) times of normal risk. The Odd's ratio risk of low DEXA at spinal bone t-score and z-score due to low physical activity is 14.6250(2.9348to 72.8808) times of normal risk.



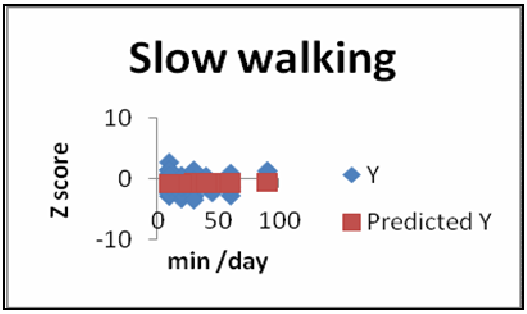
Osteoporotic group A

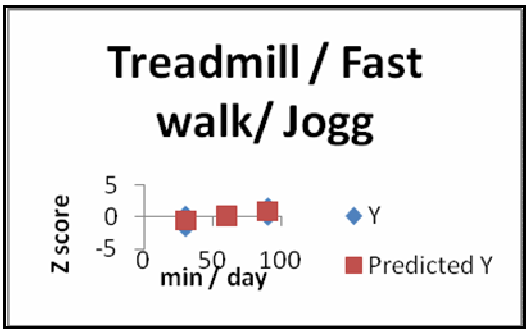


Osteopenic/ normal group B

Comparison of Femoral Z score in group A and B with Duration of Physical Activity (walking).

III] *Femoral Z score with pace of walking*: The femoral Z score was relatively higher in women with > 4 miles/hr of walking and the score was lower in women with <4 miles/hr of daily weight bearing physical activity. Statistically z score was positively correlated to the pace of walking in patients.





Comparison of Femoral Z score with Pace of Walking.

IV] *Femoral Z score with vitamin D*: The vit. D levels were in the lower range of normal in both groups. Statistically femoral Z score was unrelated to the vit. D levels in patients. Most postmenopausal women showed substantial loss of DEXA femoral bone t-and z-score

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because of low dietary calcium intake and low serum 25 (OH) cholecalciferol levels.

- The Odd's ratio risk of low DEXA at femoral bone t-score and z-score due to low calcium diet is 1.4091 (0.4323 to 4.5930) times of normal risk. The Odd's ratio risk of low DEXA at spinal bone t-score and z-score due to low calcium diet is 2.5333(0.7583 to8.4629times of normal risk.
- The Odd's ratio risk of low DEXA femoral bone t-score and z-score due to low serum 25 (OH) cholecalcIferol levels is 1.0413 (0.2470 to 4.3903) times of normal risk. The Odd's ratio risk of low DEXA at spinal bone t-score and z-score due to low serum 25 (OH) cholecalciferol is 1.3333(0.3083 to5.7655) times of normal risk.

Table-1: Odd's ratio risk of osteoporosis for variables

Variables		Osteoporosis (n=23)		Osteopenia (n=30)		Normal (n=14)	Femoral OR	Spinal OR
		Femoral	Spinal	Femoral	Spinal			
Diet	Veg	15	17	16	21	7	1.4091 (0.4323 to 4.5930)	2.5333 (0.7583 to 8.4629
	Non-Veg	8	6	14	9	7		
S.25(OH) Cholcalciferol	25(OH)cholecalciferol insufficient (<30ng/dl)	17	18	25	26	11	1.0413 (0.2470 to 4.3903)	1.3333 (0.3083 to 5.7655)
	25(OH)cholecalciferol sufficient (30-90ng/dl)	6	5	5	4	3		
Physical Activity	Inactivity <30 mins slow walk	16	19	13	18	2	7.9091 (1.6028 to 39.027)	14.6250 (2.9348 to 72.8808)
	Mod active >45 min	4	3	15	10	7		
	Active > 45 mins brisk walk	1	1	2	2	5		

Table-2: Correlation of variables to z-score

Z Sore In Relation To		Regression Coefficient	*SE*	*t Stat*	*P-value*
Vitamin D		-0.15787	0.3858	-0.40913	0.6837
Duration of Menopause	Osteoporosis	-0.32863	0.248775	-1.321	0.193653
	Osteopenia/ Normal	-2.61611	1.189008	-2.20024	0.038587
Duration of Physical Activity/ Walking	Osteoporosis	-1.80494	0.307606	-5.86769	0.0006
	Osteopenia/ Normal	-0.62556	0.257408	-2.43022	0.019442
Speed of Walking	Fast Walkers	-1.24118	0.48204	-2.57484	0.036748
Stair Climbing	Stair Climbers	-3.3175	-3.3175	-2.43362	0.04097

Discussion

In the present study, we sought to determine which physical activity was most strongly associated with BMD femoral neck. Hours per week of physical activity were significantly different between osteopenic and osteoporotic, which most likely influenced the significant differences in the z score femur measures between osteoporotic and osteopenic women. This suggests that hours per day of physical activity may play a beneficial role in building or maintaining cortical bone properties at the femur. On average, the osteoporotic women reported 3.6 $h \cdot wk^{-1}$ of activity, whereas the osteopenic women reported an average of 5.1 $h \cdot wk^{-1}$. Lorentzon et al. [3] have suggested that 4 $h \cdot wk^{-1}$ of physical activity is the threshold required to induce a positive bone response, below which no effect will be

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observed. On average, the osteoporotic subjects were below this threshold, whereas the osteopenic subjects were above it. In fact, more than half of osteopenic subjects participated in physical activities for four or more hours per week, whereas fewer than 40% of osteoporotic subjects did the same. This supports the theory that a threshold level of activity may need to be reached for leisure physical activity to exert a positive effect on bone.

Walking was described in detail and it is of interest that reported walking speed rather than the duration was significant at the trochanter. Furthermore in brisk walkers the frequency and duration of walking over a mile at a time were associated with increased BMD at hip sites. These results are consistent with current views that mechanical strain is an important influence on bone [6] and are compatible with work by Kerr et al. [7] who showed a site-specific response of bone to resistance loading at the trochanter but not the femoral neck. Studies of hip joint loading during walking [8-9] have also reported substantial increases in hip joint forces associated with increased walking speeds, suggesting a mechanism for our finding. Another study of walking [10] found that duration was significantly associated with BMD at the spine and total body, only when comparing women walking less than one mile per week with those walking more than 7.5 miles per week. A study of more active women [11] found weak associations between walking duration and BMD in the spine and hip, walking was strongly related to other activities which could have confounded the results. A prospective study of fractures [11] found that participation in regular weight bearing activity, which was mainly walking, reduces fracture risk over one year, however fracture risk is influenced by factors which reduce the incidence of falls as well as by BMD.

Randomized controlled trials of extra walking in healthy post-menopausal women have either failed to provide evidence that improves bone density at the hip or spine [12] or at best have provided tentative evidence [13]. One study found that walking at 7.2 km per h (comparable to race walking) increased BMD at the spine after 7 months whereas brisk walking at 6.2 km per h had no effect [14]; normal walking speeds are about 4.8km per h [15].

We also found that regular sufficient vitamin D3 and calcium dietary intake reduces the risk of osteoporosis overtime. Adequate calcium intake of 800*mg/day and 1,000 to 1,500** mg/day and sufficient vitamin D intake are fundamental to all prevention and treatment programs for postmenopausal osteoporosis. *RDA = recommended dietary allowance. Divided doses are advised. Consensus Development Conference (mg)**. All milks (skim, 1%, 2%, and whole) have the same calcium content. Breads and cereals, unless fortified with calcium, are relatively low sources of calcium but still contribute substantially to calcium intake because these foods constitute such a large part of the diet. Vitamin D plays a major role in calcium absorption, bone health, muscle performance, balance and risk of falling. NOF recommends an intake of 800 to 1,000 international units (IU) of vitamin D per day for adults age 50 and older. This intake will bring the average adult's serum 25(OH) D concentration to the desired level of 30 ng/ml (75 nmol/L) or higher. Chief dietary sources of vitamin D include vitamin D-fortified milk (400 IU per quart, although certain products such as soy milk are not supplemented with vitamin D) and cereals (40 to 50 IU per serving), egg yolks, salt-water fish and liver. Some calcium supplements and most multivitamin tablets also contain vitamin D.

Many elderly patients are at high risk for vitamin D deficiency, including patients with malabsorption (e.g., celiac disease) and chronic renal insufficiency, housebound patients, chronically ill patients and others with limited sun exposure. Serum 25(OH)D levels should be measured in patients at risk of deficiency and vitamin D supplemented in amounts sufficient to bring the serum 25(OH)D level to 30 ng/ml (75 nmol/L) or higher. Many patients, including those with malabsorption, will need more. The safe upper limit for vitamin D intake for the general adult population was set at 2,000 IU per day in 199719; recent evidence indicates that higher intakes are safe and that some elderly patients will need at least this amount to maintain optimal 25(OH) D levels [16]. Calcium and vitamin D supplementation is recommended whenever dietary intake is inadequate or

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restricted to less than the recommended amount. Supplementation should also be prescribed as part of any prevention or treatment program when needed to ensure sufficient daily calcium intake. Calcium (0.5-2 g/day) and vitamin D (400 IU/day) supplementation can reduce the rate of bone loss in older women (>5 years postmenopausal). Fracture reduction efficacy of calcium and vitamin D supplementation, administered independently, has been demonstrated in women older than 75 years of age [17].

Conclusion

In conclusion, considering the bone mineral densities of females with both high and low physical activity levels, a statistically significant difference between females with high physical activity levels and those with low physical activity levels in terms of BMD neck, T score neck and Z score neck values is found. There is a relation between BMD and physical activity level, t-score and physical activity level, and z-score and physical activity level of females with high physical activity levels. It is found that females with high activity levels have higher bone values. Brisk walking and climbing stairs are practical lifestyle changes which can be recommended for incorporation into daily activity. The use of posters to promote stair climbing as opposed to using escalaters have been shown to be effective [18].

It is found that females with high dietary calcium intake and higher serum 25 (OH) cholecalciferol levels and high activity levels have higher bone mass values.

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*All correspondences to: Dr. Mahesh Kumar Talele, Senior Resident, Department of Physical Medicine and Rehabilitation, Dr. Ram Manohar Lohia Hospital, Baba Kharak Singh Marg, New Delhi-110001 India. E-mail: maheshtalele8283@gmail.com

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