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EFFECT OF AGE AND FRACTURES ON BONE LOSS AND CALCIUM NEEDS OF WOMEN 45 TO 85+ YEARS OF AGE

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ABSTRACT

The development of the convenient and inexpensive 5-2 phalanx photo-radiometric method with a reproducibility of +3% has permitted the undertaking of longitudinal studies of 10 to 20 years duration on the calcium needs of females and males of 30 to 85+ years of age. An on-going survey of 3,476 females and 1,541 males showed that a marked lower bone density on the left side prevailed in all right handed individuals. With, a startling decline in bone density with age in females compared to the small age differences in males.

Serial bone density measurements of 25 women, 40 to 64 years of age given calcium supplements for periods of 5 to 12 years revealed that counter-osteoporotic efficacy of supplementation depends in a large measure on age and degree of pre-existing bone loss. In some trials efficacy of calcium dosage was enhanced by the addition of micronutrient mixtures which simulated the USRDA pattern.

Determination of the effect of fractures on calcium needs of 8 females, 47-83 years of age, revealed that severe bilateral 5-2 phalanx bone loss ensued regardless of the fracture site. This loss persisted from one to three years despite increases in calcium and micronutrient supplementation. The degree of bilateral bone density effects of fractures appears to depend on the degree of hypokinesia caused by the accident. Disuse osteoporosis of hemiplegia was also found in 34 females and 27 males from 1 to 3 months after the onset of paralysis. Routine discharges of these patients precluded assessment of calcium needs to offset prevailing bone losses. Age associated bone losses and counter-osteoporotic efficacy of calcium supplementation was also investigated in "healthy normal" females in their 40th, 50th, 60th and 70th age decades with daily supplementation of 750 mg of calcium and 375 I.U. of vitamin D_2 for test periods of 10-12 years. Although the counter-osteoporotic efficacy of this supplement continued for some 12 years in the 40+ age group, it declined progressively with age in the 50+ and 60+ groups after 6 to 7 years of supplementation. The 70+ age group with initial subnormal

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2. The high phosphorus content of many weight-reducing regimens hinders utilization of the limited amounts of calcium for bone formation.

3. Existing subnormal bone density is further aggravated by the often uncompensated calcium needs of child-bearing-about 100,000 mg for the period of pregnancy.

4. Those women who breast-feed their infants require an additional 300 mg of calcium daily above their own needs of 800 mg per day during the breast-feeding period (2).

Table 1

CAUSES OF BONE LOSS

NUTRITIONAL	DISUSE ATROPHY	HORMONAL
Low calcium intake	Sedentary	Estrogen deficiency
High phosphorus intake	Life-style	Androgen deficiency
Protein poor diet	Fractures	Hyperparathyroidism
Vitamin D deficiency	Strokes	Adrenal hyperfunction

METHODS AND PROCEDURES

Determination of Bone Loss - One of the persistent obstacles in probing this insidious disease entity has been the lack of practical and quantitative methods for the detection of bone loss in pre- and postmenopausal women before the loss becomes a severe clinical problem. Invasive procedures such as measurements of serum and urine calcium levels or calcium balance determinations have proved not only inconvenient but also less than adequate for the detection of asymptomatic bone loss.

Until recently, early quantitative detection of osteoporosis was impossible. Conventional x-rays provide inadequate indications of bone health. Namely, bone density must decrease to at least 20% to 30% before the loss can be visualized. During the past decade, researchers have developed two nuclear techniques that measure bone mass by computerized tomography (the CAT scan) and dual photon absorptiometry (DPA). Unfortunately, this expensive equipment can be found only in major medical centers and teaching hospitals. The procedures are costly - between $150 and $400 or more per test and the results are qualitative rather than quantitative. The well known diagnostic shortcomings of conventional x-rays and the cost of the CAT and DPA methods led us to a search for practical, less costly and more precise means for the quantitative determination of bone status. After a long series of

regarding total food consumption during the proceeding 24 hours. Initial and all subsequent dietary records obtained from 1310 white "healthy normal" females (26-68 years) of the middle and upper socio-economic groups included information regarding age, body weight, height, occupation and concurrent medication. Tabular analyses of these data revealed that mean dietary caloric, protein and calcium intake of the participants were in good accord with those recorded in the Hanes 1971-74 report for females 25-74 years of age (5). Within the framework of the present investigation it is important to note that throughout the age span of our panel, average calcium intake was consistently 30-50% below the RDA value of 800 mg per day (6). The calcium deficit was, for the most part, associated with persistent failures of the women to consume adequate amounts of dairy products, and milk in particular. Suggestions to individuals with low bone densities to increase milk or dairy product consumption were in most instances met with reports of unpleasant gastrointestinal disturbances and fears of obesity. Under these circumstances daily calcium supplementation of their diet remained as the only recourse for overcoming the dietary deficiency. In this connection, it should be noted that a prolonged intake of diets high in phosphorus content can be expected to induce an electrolyte imbalance in body fluids which will in turn cause a compensatory release of bone calcium and therby negate serum calcium levels as an indicator of bone loss.

Calcium Supplements There are now dozens of calcium supplements in the market-place which vary greatly in amount of calcium per tablet and cost of $0.12-2.33 per 1000 mg of calcium. In these investigations we have employed a daily dose of 3 tablets of oystershell calcium carbonate which provides 750 mg of calcium and 375 I.U. of vitamin D_2 which with an average dietary calcium of 420 mg yields an intake of 1170 mg per day. Or, a daily dose of 4 tablets of calcium phosphate which provide 600 mg of calcium and vitamin-mineral mixture (600 mg Ca V.M.Mx) of approximately 100% RDA levels (Table 3). This supplement with an average of 420 mg of dietary calcium results in an intake of 1020 mg of calcium per day/ Calcium intake in excess of needs for maintenance of optimal bone density has been known to cause urinary tract stones in susceptible individuals who may not be aware of their metabolic defect. The application of the phalanx 5-2 method has overcome the too long existing shortcomings of the calcium balance method for the assessment of calcium needs. Apart from the technical advantages it is now possible to titrate with ease individual calcium requirements for the prevention of bone loss or the repair of fractures in pre- or postmenopausal women. The inclusion of vitamin D_2 is necessary to facilate calcium absorption. However, because vitamin D_2 can be toxic in large doses it is stressed that no one should take more than 600 to 800 I.U. per day without a

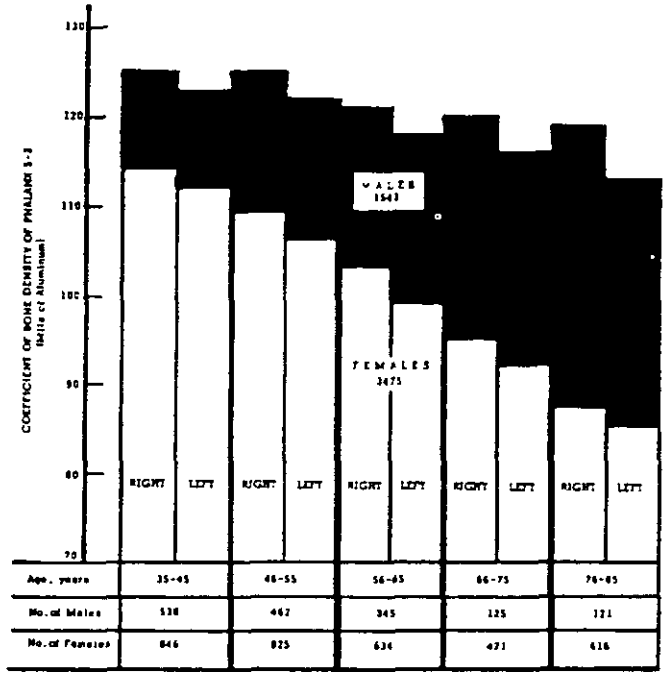

Figure 1. Effects of aging on bone density of the right and left sides of females and males from 35 to 85+ years.

loss. In a recent report Heaney (8) noted that most estimates of calcium requirements by calcium balance methods on elderly women are flawed because the data are based on short-term manipulation of calcium intake. Also, that the only way out of this dilemma is to perform very long-term balance studies with individuals on their own natural intake which have not been done, and may be too expensive ever to be done. Heaney concludes the acceptance of the concept of calcium supplements on the basis of balance data seems to have come about more because of its prima facie reasonableness than demonstrated efficacy and that really adequate data in the untreated state are still scant.

In an effort to overcome the above said problems of calcium balances we decided to document the relation of different levels of dietary calcium to the radiometric density of phalanx 5-2. To this end, we devised the protocol shown graphically in Figure 2. The dietary data of 4 healthy and

was undertaken with 21 right handed white females 40-65 years of age who were found to have subnormal bone densities. The experimental design and results of this study are assembled in Figure 3. Attention is called to the differences in the

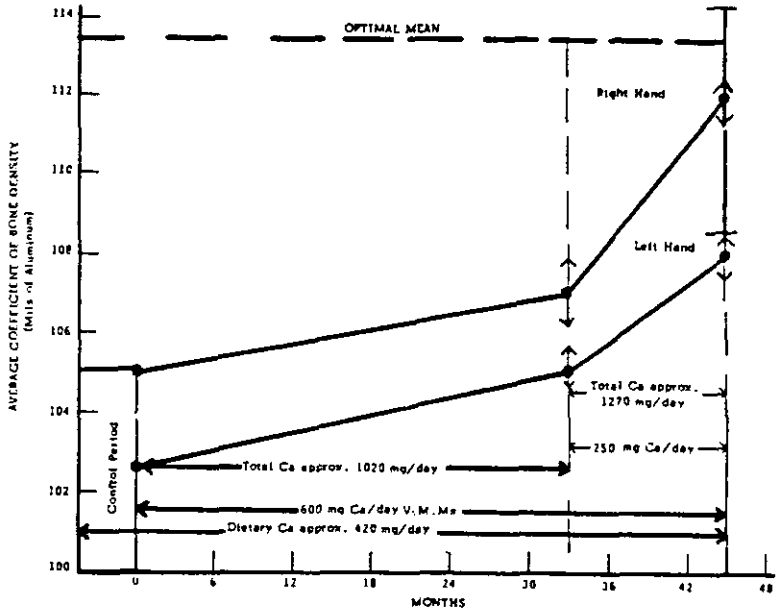

Figure 3. Average effect of dietary and supplemental calcium on 5-2 phalanx bone density of 21 pre- and postmenopausal women 40-65 years.

rate of improvement in bone density achieved with changes in daily calcium intakes of 420, 1020 and 1270 mg per day. The increase in bone density practically doubled with the change of 1020 to 1270 mg of calcium per day. Also, that the changes in rate and density were significantly greater on the right than the left side provides a clear illustration of the importance of stress factor effects on the metabolic rate of osseous tissues. These data also indicate the need of test periods longer than 10 months to induce bone density improvement with dietary and supplemental calcium intake of 1270 mg per day.

Although inadequate amounts of daily calcium intake appears to be a prime factor in the incidence of osteoporosis a number of other risk factors must be considered. It is now well known that race, family history, early menopause, excessive use of alcohol, smoking and high protein diets are known

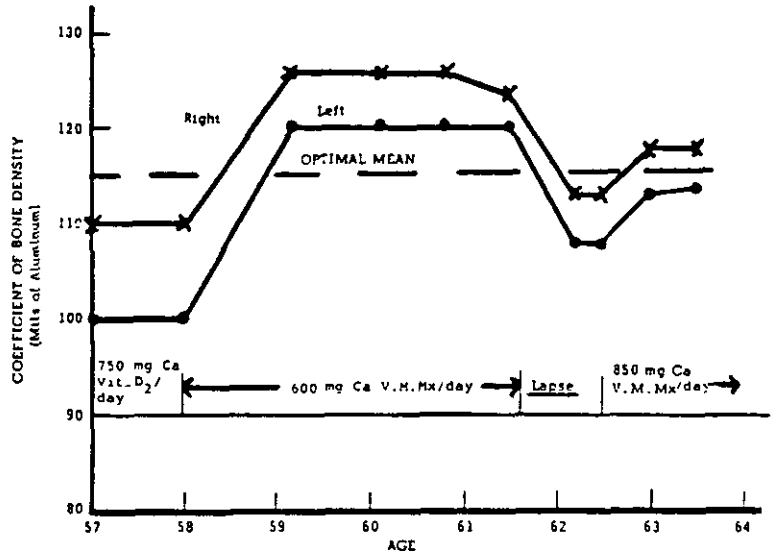

Figure 4. Regression of bilateral bone density improvement in a 57 year old female (A.D.) due to lapse in calcium supplementation.

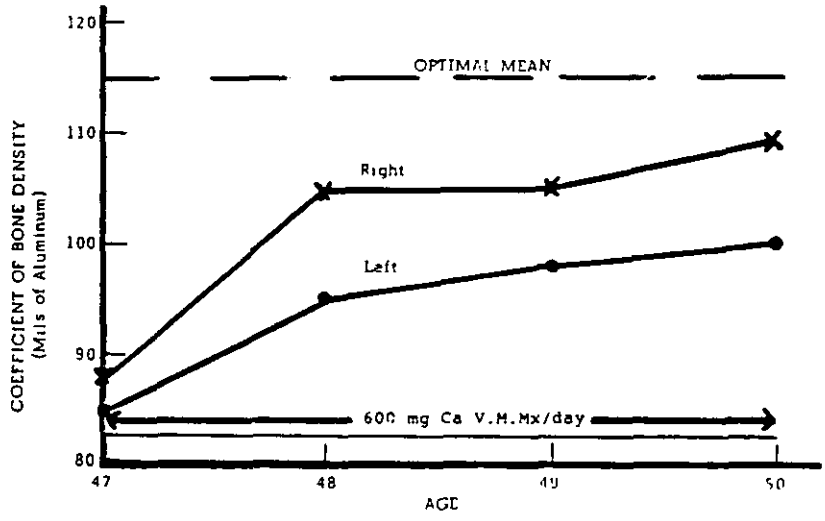

Figure 5. Improvement in right and left bone densities with calcium and vitamin-mineral mixture supplement in a 47 year old female (B.S.) with severe osteoporosis.

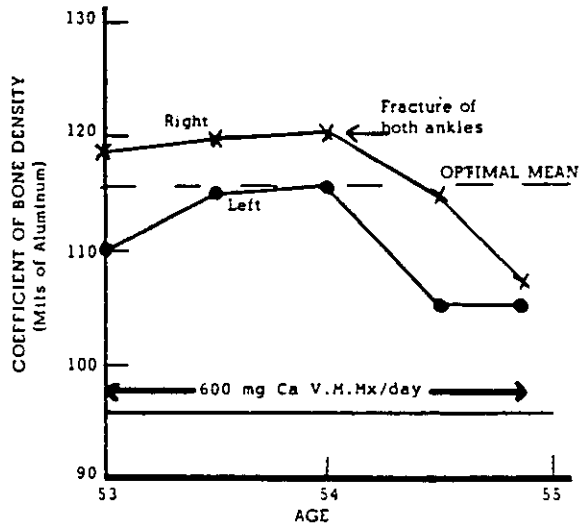

Figure 6. Bone loss induced immobilization associated with fracture of both ankles in female (O.R.) with age normal bone densities.

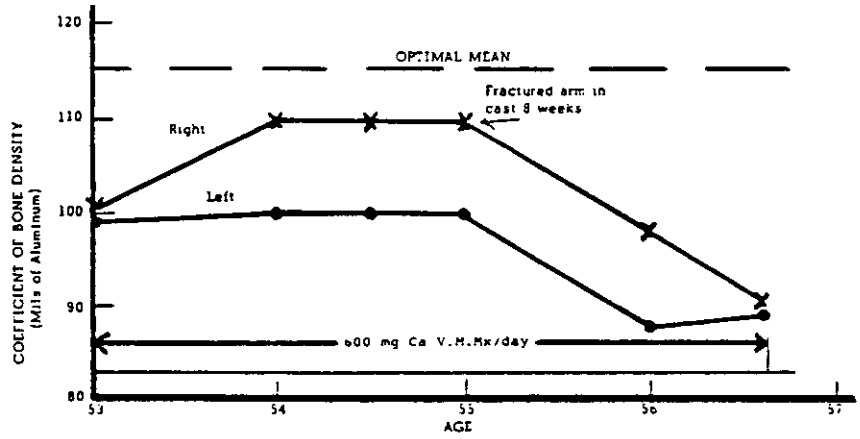

Figure 7. Loss of bilateral improvement in bone density in a 53 year old female (G.B.) due to reduced physical activity caused by fractured right arm in cast for 8 weeks.

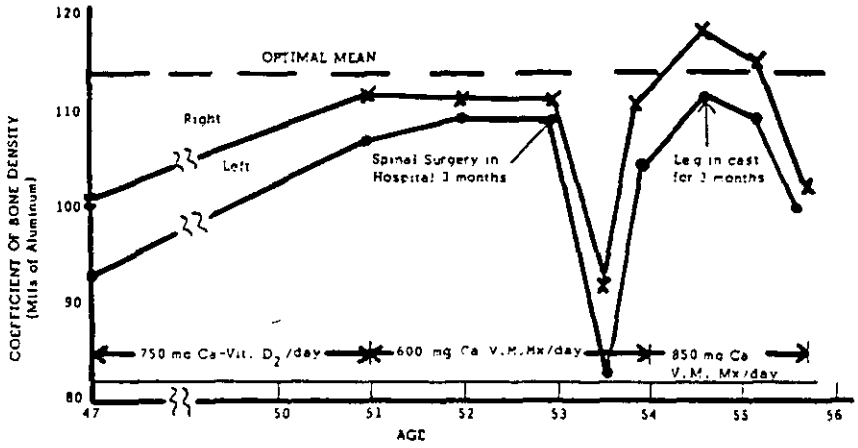

Figure 9. Marked improvement of bone density in a 47 year old female (S.R.) achieved with calcium-vitamin supplementation was lost during 3 months of recovery from spinal surgery. Subsequent improvement was lost agin during immobilization of left leg in cast for 3 months.

The sum total of these observations reveal that fractures of ankles, arm, spine and legs induce simultaneous and significant bone loss in left and right phalanges. Conversely, the return of phalanges 5-2 density to the norm reflects the return of the fractured and other skeletal areas to their norms as indicated by the densitometric data in Figure 9. It also appears that there is a need in post-fracture situations to augment the calcium content of supplements and/or to improve bioavailability with essential micronutrients. Last but not least, the sum total of our measurements provide convincing evidence that bone density changes of phalanges 5-2 mirror bone status of major skeletal structures.

Disuse Osteoporosis of Hemiplegia - The occurrence of a spontaneous fracture in the paralyzed leg of an elderly patient prompted Hodkinson and Brain (9) to study the incidence of localized osteoporosis in other patients with long-standing hemiplegia. Subsequently, investigations were undertaken of 14 elderly male and female patients (63-89 years) with spastic hemiplegia of at least 6 months duration resulting from cerebrovascular accidents. In 10 of the 14 patients there was a significant reduction in bone density on the hemiplegic side. Bone loss was associated with fractures in 4 patients. Goodman (10) found osteoporosis of the affected side in 15 patients approximately 9 weeks, on the average, after the onset of disability. In 3 patients, the presence of osteoporosis was detected as early as 2 to 4 weeks from the

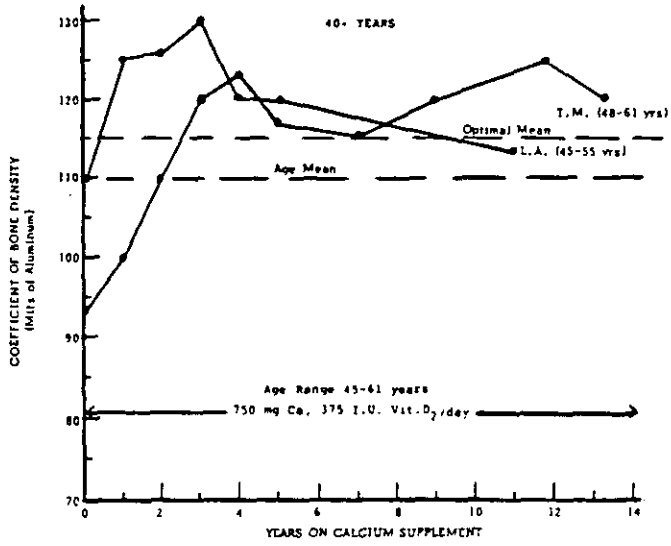

Figure 10. Marked and sustained bone density improvement with longitudinal calcium supplementation in females of 40+ years.

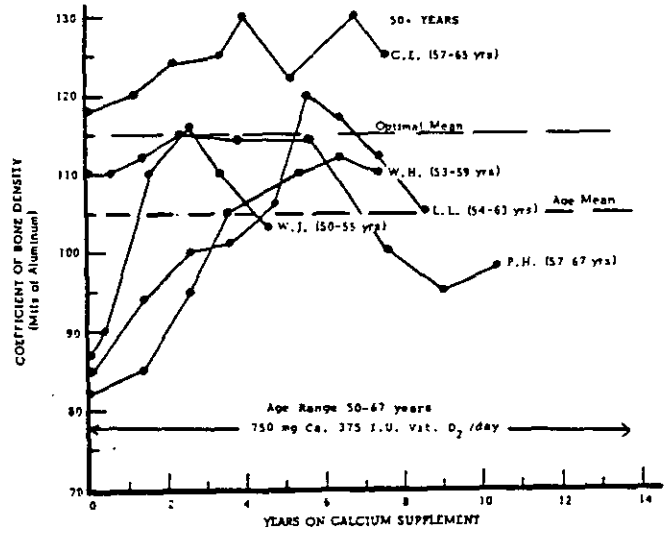

Figure 11. Variable improvement of bone density of females 50+ years with continuous calcium supplementation.

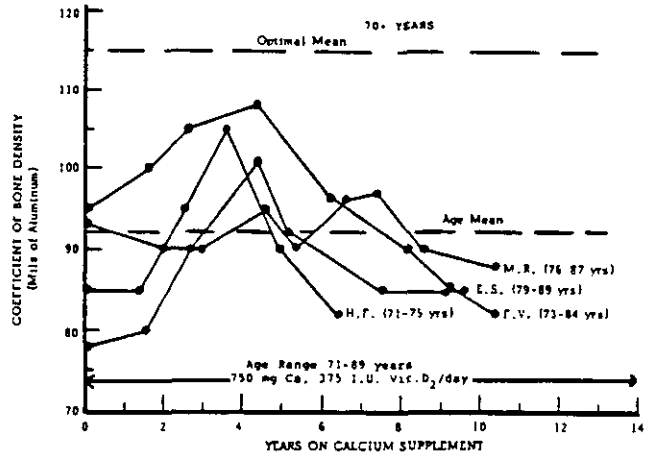

Figure 13. Limited and transient bone density accretion in females of 70+ years with initial subnormal bone status.

DISCUSSION

The now estimated growth of our 65+ population to some 40 million in the year 2000 will be accompanied by a high incidence of major health problems due to the interaction and decline of the life essential functions shown in Figure 14. Namely, as the heart beat weakens with age it pumps less blood and the circulation rate is reduced. The associated reduction in basal metabolism (the rate at which the resting body converts food to energy) and the decrease in physical activity lead to an endogenous waste of muscle and functions of vital organs. As a result of these events bone loss arises from a reduced vascular supply of calcium which is frequently augmented by an inadequate daily intake of dietary calcium.

The effect of calcium supplementation on bone density levels in females ranging in age from 40+ to 70+ years as shown in Figures 10-13 are summarized graphically in Figure 15. This summation shows that counter-osteoporotic efficacy of calcium supplementation declines steadily with each decade during test periods of 10-12 years. It should be noted, however, that the 40+ age group achieved and sustained optimal bone density levels - areas of minimal fracture risk during the 12 years of calcium supplementation of 750 mg per day. In contrast, the 50+ to 70+ age group attained modest or minor increases in bone density and remained in the areas

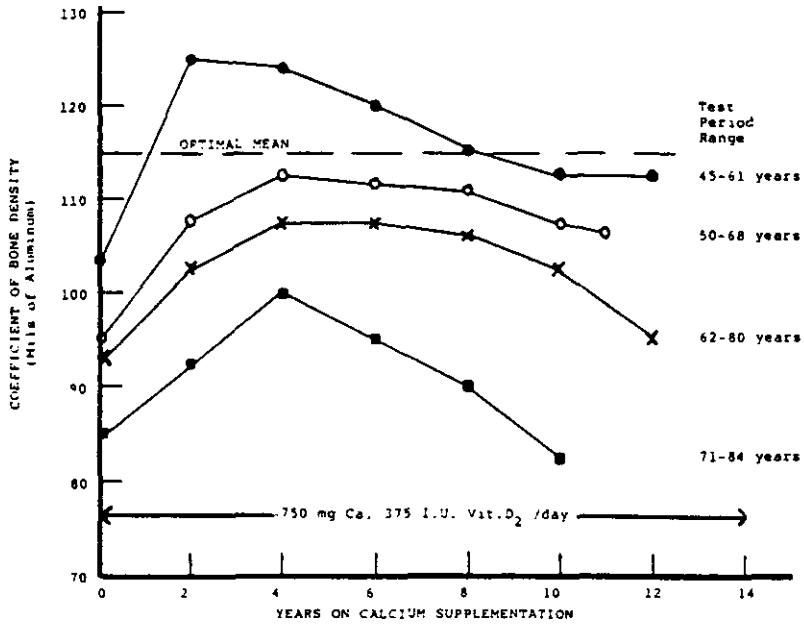

Figure 15. Comparison of bone density response to daily calcium supplements for test periods of 10-12 years in women of 40+ to 70+ years of age.

cium deposition equals calcium resorption, and in the elderly calcium resorption generally exceeds deposition. The process of bone mineralization and demineralization is under hormonal control. For example, PTH controls the resorption of calcium from bone. Although other vitamins do not appear to have specific functions in bone formation their need for over-all good nutrition is not clear. It is noteworthy, however, that we found an improved rate of bone density in subjects with severe bone loss given calcium supplements which contained a vitamin mineral mixture of approximately 100% RDA levels.

Sodium fluoride in dosages of 22-44 mg per day has been employed in conjunction with calcium supplements, but its usage remains experimental (13). Although fluoride appears to increase bone formation, concern has arisen regarding the structure of bone produced by this modality. Recent data have suggested an increased fracture incidence following long-term fluoride treatment, possibly due to the formation of fluorapatite rather than hydroxapatite bone crystals. High dosages of fluoride medications may contribute to the onset of peptic ulcers, hematemisis, fluorosis, adverse neurologic symptoms and a number of other untoward effects. Also, side effects of gastric and rheumatic symptoms preclude

Geriatric Soc. 15, 39 (1967).

10. Goodman, C.R. Osteoporosis as Early Complication of Hemiplegia. N.Y.S. J. Med. 71, 1943 (1971).

11. Albanese, A.A., Edelson, A.H., Lorenze, E.J., Woodhull, M.L. and Wein, E.H. Problems of Bone Health in the Elderly. N.Y.S.J. Med. 75, 326 (1975).

12. Albanese, A.A., Edelson, A.H., Lorenze, E.J., Wein, E.H. and McBean, L.D. Calcium Throughout the Life Cycle, National Dairy Council, Rosemont, IL (1978).

13. Riggs, B.L., Hodgson, S.F., Hoffman, D.L., Kelly, P.J., Johnson, K.A. and Taves, D. Treatment of Primary Osteoporosis with Fluoride and Calcium. J. Am. Med. Assoc. 243, 446 (1980).

14. Albanese, A.A., Edelson, A.H., Lorenze, E.J., Wein, E.H. and Carroll, L. Effects of Calcium Supplements and Estrogen Replacement Therapy on Bone Loss of Postmenopausal Women. Nutr. Repts. Intern. 24, 403 (1981).

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