Calcium Intake and Prevalence of Osteopenia among a Sample of Female College Students in Holly Makkah

Mervat Youssef

Clinical Nutrition Program, Faculty of Applied Medical Sciences, Umm Alqura University, Holly Makkah, KSA.
mervatqalon@gmail.com

Abstract: Introduction: Calcium is a major component of bone mineralization. Adequate dietary calcium intake in combination with maintaining a daily physical activity may contribute to healthy bones and play a role in practical prevention of osteoporosis. Osteoporosis is estimated to affect 200 million women worldwide. It is estimated that1 in 3 women over age 50 will experience osteoporotic fractures, as will 1 in 5 men aged over 50 worldwide. The risk of vertebral fractures can be doubled by a 10% loss of bone mass. The combined lifetime risk for hip, forearm and vertebral fractures coming to clinical attention is equivalent to the risk for cardiovascular disease. Osteoporosis presents a huge personal and economic burden. In Europe, the disability due to osteoporosis is greater than that caused by cancers. **Objectives:** The aim of the study was to estimate calcium intake, and assess the prevalence of osteopenia and osteoporosis among a sample of female college students. Explore the relationship between calcium intake and body weight, height, body mass index (BMI), and bone mineral density (BMD), as a pilot. **Methods:** A cross-sectional study was conducted among female students at Umm Alqura University in Holly Makkah. 267 female students, aged ≥17 years were included in the study. Dual Energy X-ray Absorptiometry (DXA) was used to assess (BMD) of 73 participants using World Health Organization (WHO) criteria. A 24-hour recall for two week days and one week end was administered to assess food intake for 3 days. The average intake for one day was used for data analysis. Analysis of calcium content of the food was estimated using Nutrisurvey 2007 software (Food and Agricultural Organization, FAO). **Results:** Age of the participants ranged between 17 and 25 years. The mean dietary calcium intake in this study was 559.34 ± 32.15 mg/day. 96.25% of studied sample consumed Ca below 1000 mg/day. 54.7% of the subjects consumed <550 mg/day. 58.9% of the studied ≥sample had normal BMD, 39.7% osteopenia, and 1.4% osteoporosis. Subjects who consumed calcium <550 mg/day had significantly higher body weight and BMI than ≥550mg/day (*p* values=0.040), and (0.008) respectively. **Conclusion:** Calcium intake was lower than the recommended daily intake in most of the female college students included in the study, with high prevalence of osteopenia.

[Mervat Youssef. **Calcium Intake and Prevalence of Osteopenia among a Sample of Female College Students in Holly Makkah.** *J Am Sci* 2015;11(3):99-105]. (ISSN: 1545-1003). http://www.jofamericanscience.org. 13

Key words: Calcium, intake, prevalence, osteopenia, osteoporosis, female, and college students.

1. Introduction:

Calcium is a mineral that is mostly present in bones and teeth. It is an integral part of bone structure. It plays an important role in blood clotting and neuromuscular function **(5).**

Adequate dietary calcium intake coupled with maintaining a daily physical activity, and increasing educational level, may contribute to healthy bones and play a role in practical prevention of osteoporosis **(**6**).**

In children and adolescents, studies have shown that supplementation with calcium, dairy calcium-enriched foods or milk enhanced the rate of bone mineral acquisition **(7-9).**

Calcium supplementation also has been shown to have a positive effect on (BMD) in postmenopausal women **(10).**

Osteoporosis is a disease characterized by decreased bone density and loss of bone micro architecture quality which in turn leads to an increased risk of fracture**.** It is the most common cause of fractures in the world **(11).**

Worldwide, osteoporosis causes more than 8.9 million fractures annually, resulting in an osteoporotic fracture every 3 seconds **(12).** Osteoporosis affects an estimated 75 million people in Europe, USA and Japan **(13).**1 in 3 women over age 50 will experience osteoporotic fractures, as will 1 in 5 men aged over 50 worldwide **(14-16).** Overall, 61% of osteoporotic fractures occur in women, with a female-to-male ratio of 1.6 **(12).**

Osteoporosis is estimated to affect 200 million women worldwide - approximately one-tenth of women aged 60, one-fifth of women aged 70, two-fifths of women aged 80 and two-thirds of women aged 90 **(17).** A 10% loss of bone mass in the vertebrae can double the risk of vertebral fractures, and similarly, a 10% loss of bone mass in the hip can result in a 2.5 times greater risk of hip fracture **(18).** By 2050, the worldwide incidence of hip fracture in men is projected to increase by 310% and 240% in women **(19).** The combined lifetime risk for hip, forearm and vertebral fractures coming to clinical

attention is around 40%, equivalent to the risk for cardiovascular disease **(20).**

Saudi Arabia, with a population of 1,461,401 persons aged 50 years or more, 8768 would suffer femoral fractures yearly at a cost of $1.14 billion **(21).**

Many risk factors are associated with osteoporotic fracture, including low peak bone mass, hormonal factors, the use of certain drugs such as glucocorticoids **(22-24),**cigarette smoking**(25-28)**, low physical activity and sedentary lifestyle**(29-32),** low intake of calcium and vitamin D**(5, 7-10, 33-38),** small body size**(39-42,43),** and a personal or a family history of fracture**(44-47).**All of these factors should be taken into account when assessing the risk of fracture and determining whether further treatment is required**(47).**

Childhood and adolescence are particularly valuable times to improve bone mass through exercise **(48-54).**

Studies showed that osteopenia and osteoporosis are more common amongst postmenopausal Saudi women and that bone densitometry should be employed in measuring the severity of bone loss **(55).**Bone mineral density using DXA is the standard diagnostic technique for osteoporosis but the cost is relatively high, and there is a shortage of DXA machines through most of the developing Asian countries **(56).**

The prevalence of osteoporosis for Saudi Arabian women aged 50–70 years was estimated to be approximately 23% **(57).**

Because of the severity of the problem, and because studies related to osteopenia and osteoporosis were mainly focused on postmenopausal women, this research aimed at looking at the problem in younger age, the college age, seeking for data to help in early prevention of osteopenia and osteoporosis.

2. Methods:

A cross-sectional study was conducted during the academic year 2013-14. The study included (267) female students, from different medical and applied medical science departments at Umm-Alqura University in Holly Makkah, Kingdom of Saudi Arabia (KSA).

Average daily calcium intake was estimated for a convenience sample of (267) students.

A 24-hour recall for two week days and one week end was administered to assess food intake for 3 days. The average intake per day was used for data analysis. Food intake data were collected by interview.

Questionnaires were administered to the students between regular class periods. Types and portion size of food consumed by each participant were analyzed for calcium content using Nutrisurvey 2007 software by FAO (Food and Agricultural Organization).

BMD for the whole body and spinal BMD were measured using DualEnergy X-ray Absorptiometry (DXA Scan, model 8743, manufacture Lunar, USA) for 73 of total participants.

The definition of Osteopenia and Osteoporosis according to The World Health Organization (WHO) criteria was adopted. Osteopenia is diagnosed by (-1 to -2.5 standard deviations), and osteoporosis (>-2.5 standard deviations) below mean BMD of 20 to 29 years old **(1,2,3).**

Body weight was measured using a calibrated portable scale while the subjects were wearing lightweight clothing and no shoes. Height was measured to the 0.5 cm using a stadiometer in bare foot, with the shoulders in relaxed position and arms hanging freely. BMI was determined by dividing weight in [kg] by height squared meter [m^2].

Data analysis:

Data collected were tabulated and statistical analysis was performed using the Statistical Package for Social Science (SPSS V 16) (SPSS Inc., Chicago, IL, USA.). Proportions were compared using chi-square test. Continuous variables were compared using independent sample t-test for two groups. Nutrisurvey software 2007 (FAO) was used to estimate calcium intake. Calcium Recommended Dietary Allowance for 2011were employed; 1300 mg/day for age 9 to 18 years, and 1000mg/day for 19 to 70years **(4).**In analysis of the anthropometric, and BMD data, subjects were stratified into two groups based on the daily calcium intake. Because the mean dietary calcium intake in this study was 559.34 mg/day, the figure (550) was used as a cutoff point. Subjects who consumed <550 mg/day represented the lower calcium intake, and those who consumed ≥550 mg/day represented the higher calcium intake group.

3. Results:

The sample consisted of 267 female students, 209 (78.3%) were >19 year, and 58 (21.7%) were 17 to19 years.

The mean dietary calcium intake in this study was 559.34 ± 32.15 mg/day. 96.25% of studied sample consumed calcium below (1000 mg/day). 26.59% of the sample had calcium intake between 200-<400, 34.83% between 400 - <600, 24.72% between 600 - <800, 10.11% between 800 - <1000, and 3.75% ≥ 1000 mg/day(Figure1).

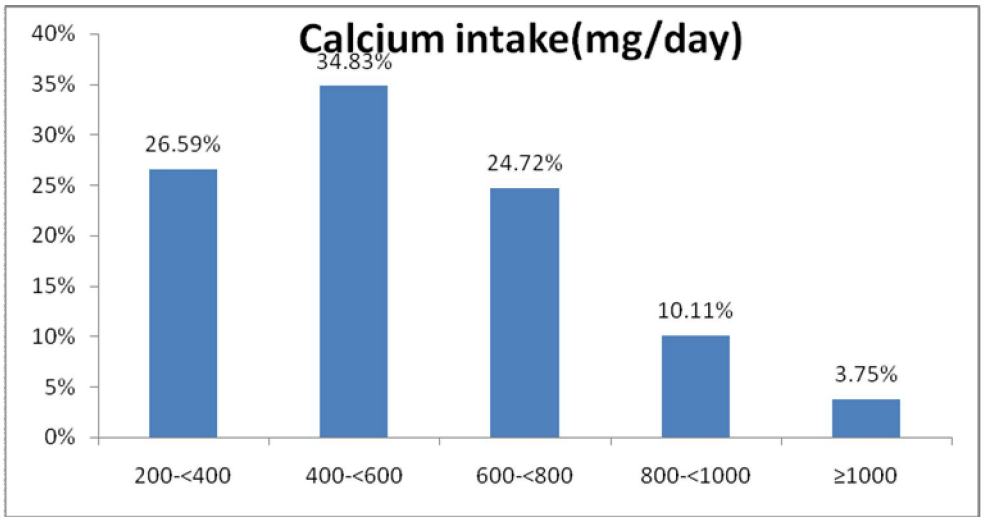

Figure (1): Daily Calcium intake

54.7% of the subjects consumed <550 mg/day. Out of the total sample of 267, only 73 subjects were assessed for BMD. Results indicate that 43 subjects (58.9%) of the sample had normal BMD, 29 (39.7%) osteopenia, and 1(1.4%) osteoporosis (Figure 2).

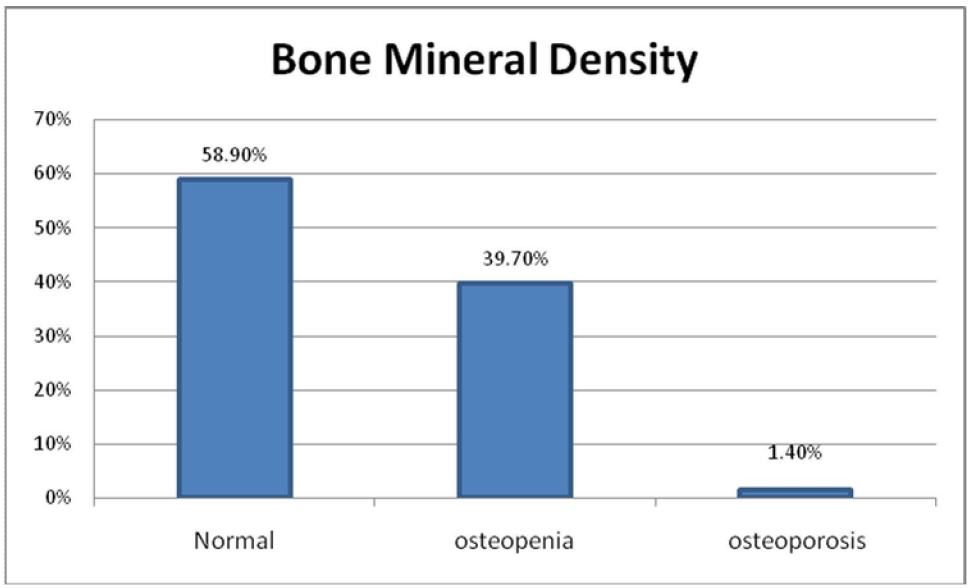

Fig (2): Bone Mineral Density

Subjects who consumed calcium <550 mg/day had significantly higher body weight and BMI than ≥550 mg/day (*p*values = 0.040), and (0.008) respectively. No statistical significant difference in height was found between the two groups ($p = 0.09$) (Table 1).

Table (1): Height, Weight and BMI by calcium intake

Measure**(Mean ± SD)**	Low Ca intake (< 550 mg/day)	Higher Ca intake (≥ 550 mg/day)	*P*
Height (cm)	157.13 ±6.03	157.39±5.18	0.090
Weight (kg)	54.80±12.71	52.27 ±10.20	0.040
BMI (kg/m^2)	22.09±4.76	21.11 ±3.81	0.008

(N=267)

A statistical significant difference (p = 0.044) in spinal BMD was detected between the low calcium and the higher calcium intake groups. The means for both total BMD and T-score for the higher calcium intake group were slightly higher than the low calcium intake group, which did not reach a statistical significant level (p = 0.110, 0.534) respectively (Table 2).

Table (2): BMD Measurements by calcium intake

Measure**(Mean ± SD)**	Low Ca intake (< 550 mg/day)	Higher Ca intake (≥ 550 mg/day)	*P*
Total (BMD)	1.04 ±0.12	1.06 ±0.06	0.110
(T-score)	0.82 ±1.03	0.90 ±2.06	0.534
(spinal BMD)	1.04±0.16	1.00 ±0.10	0.044

(N= 73)

4. Discussion:

Adequate levels of calcium intake can maximize the positive effect of physical activity on bone health during the growth period of children **(33).**

96.25% of the sample in this study consumed calcium below (1000 mg/day). This is in agreement with other studies. A study conducted on postmenopausal women in Jeddah found out that almost 60% of the total study population had lower calcium intake than the estimated average requirements whereas the whole population had vitamin D intake level below the estimated average requirements. The findings revealed the important role of dietary vitamin D and calcium in osteopenic patients and the likely requirement for supplementation of these nutrients in the Saudi population **(58).** Another study conducted in KSA showed that women of >40 years old, with low level of education, who did not drink diluted yogurt (laban) (which is a rich source of calcium) and had history of fractures were at high risk of low BMD **(59).**

Surveys indicate that teenage girls in the United States are less likely than teenage boys to get enough calcium. In fact, fewer than 10 percent of girls age 9 to 17 actually get the calcium they need each day **(60).**

Another study showed that only 15% of 9 to 13 years old females and ≤10% of females aged 14–18, 51–70, and ≥71 years met the adequate intake for calcium from diet alone(**61**).

Lactose intolerance has been shown to be associated with low bone mass and increased risk of fracture due to low milk (calcium) intake **(38).**

Low intake of calcium and vitamin D is associated with osteoporotic fracture **(5,7-10,33-38).**

Studies in children and adolescents have shown that supplementation with calcium, dairy calcium-enriched foods or milk enhances the rate of bone mineral acquisition **(7-9).**

Calcium and vitamin D supplementation reduces rates of bone loss and also fracture rates in older male and female adults, and the elderly **(35-37).** In institutionalized elderly women, this combined supplementation reduced hip fracture rates **(35).**

Adequate dietary calcium intake in combination with maintaining a daily physical activity may contribute to healthy bones and play a role in practical prevention of osteoporosis **(5).**

Lack of calcium is one of the main causes of osteoporosis in which the bones become extremely porous, are subject to fracture, and heal slowly, occurring especially in women **(61)**.

The prevalence of osteopenia and osteoporosis in this study is (39.7%), and (1.4%) respectively. Several studies were conducted in KSA to determine this prevalence. However, the results are different according to the age and association with other risk factors such as low peak bone mass, hormonal factors, the use of certain drugs, low intake of calcium and vitamin D, cigarette smoking, and low physical activity. The prevalence of osteoporosis for Saudi Arabian women aged 50–70 years was estimated to be approximately 23% **(57).**

Another study indicated that the prevalence of osteoporosis among a sample aged 20 to 79 years was found to be 44.5% in Saudi women when employing the manufacturer's reference (US/European reference) and 28.2% when employing the Saudi reference values **(62).**

A different study indicated that the prevalence of low bone mass (osteoporosis and osteopenia) in Saudi Arabia is 70.5% in men and women with an average age of 56 years. The prevalence of osteoporosis among women was 34% and in men 30.7% **(63).**

Only one candidate in the current study had osteopenia which is a small number that is difficult to make conclusions based on that.

BMD is influenced by several genetic and environmental factors. It has been suggested that genetic factors such as gender and race, may account for up to 75 percent of bone mass, and environmental factors such as diet and exercise habits account for the remaining 25 percent **(60).**

Results of this study indicate that current calcium intake has no significant effect on the total BMD or T-score. However, there is a significant difference in spinal BMD by calcium intake (p=0.044).

This is in agreement with a study by Mazess and Barden who evaluated the effects of age, calcium intake, smoking and physical activity on appendicular and axial (BMD) in a 2-years study of 200-300 healthy young women aged 20-39 years. They found that there was no cross-sectional change of BMD or longitudinal change with bone loss. There also was no association of calcium intake with BMD and/or with BMD changes. Current calcium intake was not a significant influence on BMD in this age group **(64).**

Studies indicate that variations in calcium intake early in life may account for a 5-10% difference in peak adult bone mass **(65).** In the same direction, **(66)** found that measures of lifetime physical activity and calcium intake were highly correlated and consistent factor for predicting BMD at all skeletal sites and current calcium intake predicted 6% of the variance in BMD.

Calcium is an essential nutrient for bone health. Calcium deficiencies in young people can account for a 5- to 10-percent difference in peak bone mass and can increase the risk for hip fracture later in life **(60)**.

Results of this study revealed a significant relationship between calcium intake and weight and BMI, but insignificant with height.

Recent human and animal studies indicated that a higher calcium intake was associated with reduced body fat or less gain of body fat over time. In a study of adipose cells in transgenic mice, high calcium, medium dairy, and high dairy diets reduced lipogenesis, stimulated lipolysis and reduced body fat accumulation at equivalent levels of energy intake **(67).**

In a randomized controlled clinical trial of reducing diets in adult outpatients, those maintained on a milk-based diet for 16 months had greater weight loss (7.0 *vs* 1.7 kg) than patients maintained on a conventional hypocaloric diet that was isocaloric to the milk-based diet. The investigators suggested that greater compliance with the novel milk-based diet contributed to the greater weight loss **(68).** However, the possible down regulation of lipogenesis and up-regulation of lipolysis with the milk-based diet *vs* the conventional hypocaloric diet is an alternate explanation for the greater weight loss.

Small body size is a risk factor that is associated with osteoporotic fracture**(39-43).**

Studies have provided evidence that weight in infancy is a determinant of bone mass in adulthood **(69-71).**

There is a need for further studies in the young ages to enable prevention of osteopenia and osteoporosis with their complications and huge financial and health burdens.

Saudi Arabia, with a population of 1,461,401 persons aged 50 years or more, 8768 would suffer femoral fractures yearly at a cost of $1.14 billion **(21).**

References:

1. WHO (1994), "Assessment of fracture risk and its application to screening for postmenopausal osteoporosis, report of a WHO Study Group World Health Organization technical report series. 843:1–129. Available from: http://www.who.int/chp/topics/Osteoporosis.pdf.
2. Kanis JA (1994). The diagnosis of osteoporosis. Journal of Bone and Mineral Research. 9: 1137–1141. Available from: http://www.who.int/chp/topics/Osteoporosis.pdf.
3. WHO (2003). Scientific Group on the Prevention and Management of Osteoporosis (2000: Geneva, Switzerland) (2003). Retrieved (05-31-2007). Available from Food and Nutrition Board, Institute of Medicine, National Academy of Sciences, (2010).
4. American Dietetic Association (2010). Calcium. Available from: http://www.med.umich.edu/pdf/ADA_Calcium.pdf.
5. A, Camdeviren H, Celik F, et al. (2005). Determination of osteoporosis risk factors using a multiple logistic regression model in postmenopausal Turkish women. Saudi Med J. Sep;26(9):1351-9.
6. Bonjour JP, Carrie AL, Ferrari S, et al. (1997) Calcium-enriched foods and bone mass growth in prepubertal girls: a randomized, double-blind, placebo-controlled trial. J Clin Invest 99:1287.
7. Cadogan J, Eastell R, Jones N, Barker ME (1997) Milk intake and bone mineral acquisition in adolescent girls: randomised, controlled intervention trial. Bmj 315:1255.
8. Johnston CC, Jr., Miller JZ, Slemenda CW, et al. (1992) Calcium supplementation and increases in bone mineral density in children. N Engl J Med 327:82.
9. Shea B, Wells G, Cranney A, et al. (2002) Meta-analyses of therapies for postmenopausal osteoporosis. VII. Meta-analysis of calcium supplementation for the prevention of postmenopausal osteoporosis. Endocr Rev 23:552.
10. World Health Organization (2003). The burden of musculoskeletal conditions at the start of the new millennium. WHO Technical Report Series 919, World Health Organization, Geneva.
11. Johnell O and Kanis JA (2006). An estimate of the worldwide prevalence and disability associated with osteoporotic fractures. Osteoporos Int 17:1726.
12. EFFO and NOF (1997). Who are candidates for prevention and treatment for osteoporosis? Osteoporos Int 7:1.

13. Melton LJ, 3rd, Atkinson EJ, O'Connor MK, et al. (1998). Bone density and fracture risk in men. J Bone Miner Res 13:1915.
14. Melton LJ, 3rd, Chrischilles EA, Cooper C, et al. (1992). Perspective. How many women have osteoporosis? J Bone Miner Res 7:1005.
15. Kanis JA, Johnell O, Oden A, et al. (2000). Long-term risk of osteoporotic fracture in Malmo. Osteoporos Int 11:669.
16. Kanis JA (2007). WHO Technical Report, University of Sheffield, UK: 66.
17. Klotzbuecher CM, Ross PD, Landsman PB, et al. (2000) Patients with prior fractures have an increased risk of future fractures: a summary of the literature and statistical synthesis. J Bone Miner Res 15:721.
18. Gullberg B, Johnell O, Kanis JA (1997). World-wide projections for hip fracture. Osteoporos Int 7:407.
19. Kanis JA (2002). Diagnosis of osteoporosis and assessment of fracture risk. Lancet 359:1929.
20. Bubshait D and Sadat-Ali M (2007) Economic implications of osteoporosis-related femoral fractures in Saudi Arabian society. Calcif Tissue Int 81:455.
21. Reid IR (1997) Glucocorticoid osteoporosis - mechanisms and management. Eur J Endocrinol 137:209.
22. Adachi JD (1997) Corticosteroid-induced osteoporosis. Am J Med Sci 313:41.
23. Kanis JA, Johansson H, Oden A, et al. (2004) A meta-analysis of prior corticosteroid use and fracture risk. J Bone Miner Res 19:893.
24. Nguyen TV, Kelly PJ, Sambrook PN, et al. (1994) Lifestyle factors and bone density in the elderly: implications for osteoporosis prevention. J Bone Miner Res 9:1339.
25. Ward KD and Klesges RC (2001) A meta-analysis of the effects of cigarette smoking on bone mineral density. Calcif Tissue Int 68:259.
26. Law MR and Hackshaw AK (1997) A meta-analysis of cigarette smoking, bone mineral density and risk of hip fracture: recognition of a major effect. BMJ 315:841.
27. Kanis JA, Johnell O, Oden A, et al. (2005) Smoking and fracture risk: a meta-analysis. Osteoporos Int 16:155.
28. Dargent-Molina P, Favier F, Grandjean H, et al. (1996) Fall-related factors and risk of hip fracture: the EPIDOS prospective study. Lancet 348:145.
29. Cummings SR, Nevitt MC, Browner WS, et al. (1995) Risk factors for hip fracture in white women. Study of Osteoporotic Fractures Research Group. N Engl J Med 332:767.
30. Nguyen TV, Sambrook PN, Eisman JA (1998) Bone loss, physical activity, and weight change in elderly women: the Dubbo Osteoporosis Epidemiology Study. J Bone Miner Res 13:1458.
31. Albrand G, Munoz F, Sornay-Rendu E, et al. (2003) Independent predictors of all osteoporosis-related fractures in healthy postmenopausal women: the OFELY study. Bone 32:78.
32. Specker B and Binkley T (2003) Randomized trial of physical activity and calcium supplementation on bone mineral content in 3- to 5-year-old children. J Bone Miner Res 18:885.
33. Shea B, Wells G, Cranney A, et al. (2002) Meta-analyses of therapies for postmenopausal osteoporosis. VII. Meta-analysis of calcium supplementation for the prevention of postmenopausal osteoporosis. Endocr Rev 23:552.
34. Chapuy MC, Arlot ME, Duboeuf F, et al. (1992) Vitamin D3 and calcium to prevent hip fractures in the elderly women. N Engl J Med 327:1637.
35. Chapuy MC, Pamphile R, Paris E, et al. (2002) Combined calcium and vitamin D3 supplementation in elderly women: confirmation of reversal of secondary hyperparathyroidism and hip fracture risk: the Decalyos II study. Osteoporos Int 13:257.
36. Dawson-Hughes B, Harris SS, Krall EA, Dallal GE (1997) Effect of calcium and vitamin D supplementation on bone density in men and women 65 years of age or older. N Engl J Med 337:670.
37. Obermayer-Pietsch BM, Bonelli CM, Walter DE, et al. (2004) Genetic predisposition for adult lactose intolerance and relation to diet, bone density, and bone fractures. J Bone Miner Res 19:42.
38. Ensrud KE, Cauley J, Lipschutz R, Cummings SR (1997) Weight change and fractures in older women. Study of Osteoporotic Fractures Research Group. Arch Intern Med 157:857.
39. Ensrud KE, Ewing SK, Stone KL, et al. (2003) Intentional and unintentional weight loss increase bone loss and hip fracture risk in older women. J Am Geriatr Soc 51:1740.
40. Farmer ME, Harris T, Madans JH, et al. (1989) Anthropometric indicators and hip fracture. The NHANES I epidemiologic follow-up study. J Am Geriatr Soc 37:9.
41. Bainbridge KE, Sowers M, Lin X, Harlow SD (2004) Risk factors for low bone mineral density and the 6-year rate of bone loss among premenopausal and perimenopausal women. Osteoporos Int 15:439.
42. De Laet C, Kanis JA, Oden A, et al. (2005) Body mass index as a predictor of fracture risk: a meta-analysis. Osteoporos Int 16:1330.
43. Pocock NA, Eisman JA, Hopper JL, et al. (1987) Genetic determinants of bone mass in adults. A twin study. J Clin Invest 80:706.
44. Seeman E, Hopper JL, Bach LA, et al. (1989) Reduced bone mass in daughters of women with osteoporosis. N Engl J Med 320:554.
45. Thijssen JH (2006) Gene polymorphisms involved in the regulation of bone quality. Gynecol Endocrinol 22:131.
46. L (2006 Feb). Epidemiology, etiology, and diagnosis of osteoporosis.Am J Obstet Gynecol.;194(2 Suppl):S3-11.
47. Bass S, Pearce G, Bradney M, et al. (1998) Exercise before puberty may confer residual benefits in bone density in adulthood: studies in active prepubertal and retired female gymnasts. J Bone Miner Res 13:500.
48. Bass SL, Saxon L, Daly RM, et al. (2002) The effect of mechanical loading on the size and shape of bone in pre-, peri-, and postpubertal girls: a study in tennis players. J Bone Miner Res 17:2274.

49. Kannus P, Haapasalo H, Sankelo M, et al. (1995) Effect of starting age of physical activity on bone mass in the dominant arm of tennis and squash players. Ann Intern Med 123:27.
50. Khan K, McKay HA, Haapasalo H, et al. (2000) Does childhood and adolescence provide a unique opportunity for exercise to strengthen the skeleton? J Sci Med Sport 3:150.
51. Janz KF, Burns TL, Levy SM, et al. (2004) Everyday activity predicts bone geometry in children: the iowa bone development study. Med Sci Sports Exerc 36:1124.
52. Forwood MR, Baxter-Jones AD, Beck TJ, et al. (2006) Physical activity and strength of the femoral neck during the adolescent growth spurt: a longitudinal analysis. Bone 38:576.
53. Linden C, Ahlborg HG, Besjakov J, et al. (2006). A school curriculum-based exercise program increases bone mineral accrual and bone size in prepubertal girls: two-year data from the pediatric osteoporosis prevention (POP) study. J Bone Miner Res 21:829.
54. El-Desouki MI (2003). Osteoporosis in postmenopausal Saudi women using dual x-ray bone densitometry. Saudi Med J. 24(9):953-6.
55. Mithal A, Dhingra V, Lau E, 2009. The Asian Audit. Epidemiology, costs and burden of osteoporosis in Asia. International Osteoporosis Foundation. http://www.iofbonehealth.org.
56. W, Mohammed Ahmed, Ayman Rifai et al. (2008). Exploring the Extent of Postmenopausal Osteoporosis Among Saudi Arabian Women Using Dynamic Simulation. Journal of Clinical Densitometry, volume 11, Issue 4, October–December, Pages 543–554
57. E, Sara Ghazi Qadi, Naseem Abdulmohi Alhujaili, et al.(2011). Effect of diet and lifestyle factors on bone health in postmenopausal women**.** Journal of Bone and Mineral Metabolism , November, Volume 29, Issue 6, pp 725-735.
58. A, Ambreen Kazi, Salwa Tayel, et al. (2014). Prevalence and factors associated with low bone mineral density in Saudi women: a community based survey. BMC Musculoskeletal Disorders 1; 15(1):5.
59. NIH (National Institutes of Health) (2012). Osteoporosis and Related Bone Diseases National Resource Center). Osteoporosis: Peak Bone Mass in Women. Available from: http://www.niams.nih.gov/Health_Info/Bone/Osteoporosis/bone_mass.pdf
60. Bailey RL, Dodd KW, Goldman JA, et al. (2010). Estimation of total usual calcium and vitamin D intakes in the United States. *J Nutr,* 140, 817-22.
61. Ardawi MS, Maimany AA, Bahksh TM, et al. (2005). Bone mineral density of the spine and femur in healthy Saudis. Osteoporos Int. 16; (1):43-55.
62. Mir Sadat-Ali, Ibrahim M. Al-Habdan, Haifa A Al-Turki, et al.(2012). An epidemiological analysis of the incidence of osteoporosis and osteoporosis-related fractures among the Saudi Arabian population. Ann Saudi Med; 32(6): 637-641.
63. Mazess RB, Barden HS. (1991). Bone density in premenopausal women: effects of age, dietary intake, physical activity, smoking, and birth-control pills. Am J Clin Nutr, 53, 132-42.
64. Heaney R, Matkovic V. (1995). Inadequate peak bone mass. In: Riggs L, Melton LJ, Editors. Osteoporosis: Etiology, diagnosis and management. 2nd Ed. Philadelphia: Lippincott-Raven Publishers; 115-131.
65. Wallace, L.S., J.E. Ballard, D. (2002). Lifetime physical activity and calcium intake related to bone density in young women. J Womens Health Gend Based Med, 11, 389 98.
66. Zemel MB, Shi H, Greer B, et al. (200). Regulation of adiposity by dietary calcium. FASEB J 14: 1132-1138.
67. Carruth BR. and Skinner JD. (2001). The role of dietary calcium and other nutrients in moderating body fat in preschool children. International Journal of Obesity, Volume 25, Number 4, Pages 559-566.
68. Cooper C, Cawley M, Bhalla A, et al. (1995) Childhood growth, physical activity, and peak bone mass in women. J Bone Miner Res 10:940.
69. Duppe H, Cooper C, Gardsell P, Johnell O (1997) The relationship between childhood growth, bone mass, and muscle strength in male and female adolescents. Calcif Tissue Int 60:405.
70. Cooper C, Fall C, Egger P, et al. (1997) Growth in infancy and bone mass in later life. Ann Rheum Dis 56:17.

3/4/2015