Anthropologist 28(3): 166-172 (2017)
DOI: 10.31901/24566802.2017/28.03.04

Assessment of Bone Mineral Density Using Calcaneal Ultrasound Bone Densitometer in College-Going Boys and Girls of District Gurdaspur, Punjab

Manjula Uppal and Rupinder Kaur

S. L. Bawa D.A.V. College, Batala 143505, Distt. Gurdaspur, Punjab, India
E-mail: slbdavc@yahoo.com

KEYWORDS BMI. Menstruation. Osteopenia. Osteoporosis. Young Adults

ABSTRACT Attainment of high bone mineral density in younger age is essential for the maintenance of healthy bones in later years of life to escape the morbidity and economic burden associated with it. The present study was carried out to assess the bone mineral state of 300 young adults in age group 16-23 years using calcaneus quantitative ultrasound bone densitometer. Normal bone mineral density was prevalent in 59.3 percent of urban and 58.2 percent of rural subjects. The subjects consuming non-vegetarian diet (64.8%) were slightly better for their bone density compared to those who consumed vegetarian food (62.9%). Moderately active subjects (34.9%) had lesser number of osteopenia cases in comparison to the ones with low level (38.1%) of physical activity. Maximum number of osteopenia cases were observed in underweight (42.9%) and obese II (50%) categories in boys as well as girls (47.8% and 50% respectively). Female subjects with regular menstrual flow were significantly better for their bone density than the ones who had irregular periods. A marked and significant improvement in bone density was observed in both boys and girls with increase in age. However, 7.1 percent of boys and 23.1 percent of girls in age group 22-23 years were found to be osteopenic.

INTRODUCTION

Bone mineral density is a measure of bone mineral per volume of bone and is an indirect indicator of osteoporosis and bone fracture. Osteoporosis is a systematic skeletal disease characterized by low bone mass and micro-architectural deterioration of bone tissue, with a consequent increase in bone fragility and susceptibility to fracture. These changes are initially silent and can progress silently until a low trauma fracture occurs (Loud et al. 2005). At any given age, bone mass results from the amount of bone acquired during growth, and the attainment of a higher peak bone density in growing years has an important role in the prevention of osteoporosis later in life (Rizzoli et al. 2001). As per the WHO data published in 2015, life expectancy in India is 68.3 years which showed an increase by almost 10 years in the past two decades while children born in the year 2015 were expected on an average to live up to 70 years (WHO 2016). Globally, life expectancy at birth is projected to rise from 70 years in 2010-2015 to 77 years in 2045-2050 and to 83 years in 2095-2100, and Asia is projected to gain about 13-14 life years by the end of century (UN 2016). With increasing longevity of Indian population, it is now being realized that, as in West, osteoporotic fractures are a major cause of morbidity and mortality in elderly, and estimations suggest that twenty percent of women and ten to fifteen percent of men would be osteoporotic by 2015 (Nordin 1966; Gupta et al. 1967). If the lower bone density is shown to confer a greater risk of fracture, this risk of fracture is expected to increase up to 50 million (Malhotra and Mithal 2008). India is considered to be a young country with nineteen percent of its population in the age group 15-24 years, and today every fifth person in India is an adolescent (10-19 years, ~253.2 million) and every third, a young person (10-24 years, ~231.9 million) (Chandramouli 2011) – a factor associated with demographic and social flux. With changes in lifestyle patterns, mineral-deficient diet and physical inactivity, there is a

Address for correspondence:
Dr. Manjula Uppal
SL Bawa DAV College, Batala 143505,
District Gurdaspur, Punjab, India
Phone: 09815747374 (M),
Fax: 01871-240800,
E-mail: manjula_uppal@yahoo.com

predisposition of impending risk factors for low bone mineral density in young adults (Arasheben 2011; Mishra et al. 2016; Solmi et al. 2016; Soomro et al. 2017). As life expectancy intends to rise, this could prove to be a foreground for osteoporosis having its associated debilitating effects and economic burden. Therefore, in the present study, an attempt has been made to investigate the level of bone mineral density in young adults who are the future strength and potential of the country.

METHODOLOGY

The data was collected in 2016 from the students attending local colleges in the township of Batala, having their niche in urban areas and various villages of near and far vicinity, and even from the deeper rural pockets. A sample of 300 healthy students (144 boys and 156 girls) in the age range of 16-23 years, hailing from urban (103 boys and 118 girls) and rural (41 boys and 38 girls) background, belonging mostly to middle socio-economic status, was undertaken for the study (Table 1). Exclusion criteria included chronic or infectious ailments. The subjects were enquired about their dietary habits with regard to the intake of vegetarian and non vegetarian food. Physical activity of the study group was assessed by referring to WHO global physical activity questionnaire (GPHQ). Using standard methodology of Weiner and Lourie (1981), height and weight measurements were taken to calculate body mass index (BMI) as per the WHO criteria (WHO 2000). Bone mineral density (BMD) was measured in right calcaneum with bone densitometer (Furno's CM-200 light ultrasound bone densitometer; Furuno Electric Co. Ltd., Japan) in terms of T-score and Z-score. T-score is expressed as the number of standard deviation relative to standard speed of sound value of the young age group whereas Z-score is the number of standard deviation with respect to the standard speed of sound value of the matched age group. According to WHO definition (WHO 2004),

Normal Bone Mass	– T-score	$\geq$-1
Osteopenia	– T-score	Between -1 and -2.5
Osteoporosis	– T-score	$\leq$-2.5

RESULTS

Table 2 shows dispersion of data for bone mineral density as per the socio-demographic features, indicating that 59.3 percent of urban

Table 1: Number and percentage distribution of college-going boys and girls

Sex	*Area of distribution*					
	Urban		*Rural*		*Total*	
	N	*%*	*N*	*%*	*N*	*%*
Boys	103	71.5	41	28.5	144	48.0
Girls	118	75.6	38	24.4	156	52.0
Total	221	73.7	79	26.3	300	100.0

Table 2: Number and percentage distribution of college-going boys and girls for their bone mineral density (BMD) with respect to various socio-demographic features

Variables		*Bone Mineral Density (BMD)*								χ^2-*value*
		Normal		*Osteopenia*		*Osteoporosis*		*Total*		
		N	*%*	*N*	*%*	*N*	*%*	*N*	*%*	
Area	Urban	131	59.3	79	35.8	11	5.0	221	73.7	0.2660
	Rural	46	58.2	30	38.0	03	3.8	79	26.3	
Food Habits	Vegetarian	144	62.9	67	29.3	18	7.9	229	76.3	0.4009
	Non-Veg	46	64.8	21	29.6	04	5.6	71	23.7	
Physical Activity	Low	113	58.3	74	38.1	07	3.6	194	64.7	0.4576
	Moderate	64	60.4	37	34.9	05	4.7	106	35.3	
Sex	Male	93	64.6	46	31.9	05	3.5	144	48.0	3.5689
	Female	84	53.9	65	41.7	07	4.5	156	52.0	

individuals had normal level of bone density compared to 58.2 percent of rural subjects who had thirty-eight percent of individuals with osteopenia while 35.8 percent being so in urban group. Percentage of osteoporosis was comparable at 5.0 and 3.8, respectively, for urban and rural youngsters. Young adults, who consumed non-vegetarian food, were better in the percentage representation of normal bone mineral at 64.8 percent in comparison to 62.9 percent in vegetarian individuals. Higher percentage of vegetarians (7.9%) was in osteoporotic state compared to non-vegetarians (5.6%). Normal bone mineral density was more pronounced in moderately active subjects (60.4%) than the ones with low level of physical activity (58.3%). The cases of osteopenia were 34.9 percent in the former and 38.1 percent in the latter category. Boys (normal, 64.6%; osteopenia, 31.9% and osteoporosis, 3.5%) were analyzed to be in a better state of bone health rather than the girls (normal, 53.9%; osteopenia, 41.5% and osteoporosis, 4.5%). No statistical significance could be established in BMD in relation to BMI (Table 3). However, in the underweight category, 47.8 percent of girls and 42.9 percent of boys were observed to have osteopenia, 57.1 percent of boys and 45.7 percent of girls had normal BMD, and osteoporosis was to the level of 6.5 percent in girls. Improvement in nutritional status indicated a rise in percent prevalence of normal BMD, as 65.4 percent of boys and 54.8 percent of girls were found to be normal for their BMD with respect to normal BMI. In overweight category, seventy-two percent of boys and 62.5 percent of girls were normal for their BMD while obese I state showed 60.9 percent of boys and 64.7 percent of girls to be normal for BMD, and 34.8 percent of boys and 35.3 percent of girls to be osteopenic. Obese II category had fifty percent cases with normal mineral density and osteopenia, respectively, for both boys and girls. Based upon chi square values (Table 4), girls with regular menstrual flow were analyzed to be significantly better for their

Table 3: Number and percentage distribution of college-going boys and girls for their bone mineral density (BMD) with respect to body mass index (BMI) categories

Body Mass Index(BMI)	*Bone Mineral Density (BMD)*								χ^2-*value*
	Normal		*Osteopenia*		*Osteoporosis*		*Total*		
	N	*%*	*N*	*%*	*N*	*%*	*N*	*%*	
				Boys					
Underweight	08	57.1	06	42.9	–	–	14	9.7	2.7648
Normal	51	65.4	24	30.8	03	3.9	78	54.2	
Overweight	18	72.0	06	24.0	01	4.0	25	17.4	
Obese-1	14	60.9	08	34.8	01	4.4	23	16.0	
Obese-2	02	50.0	02	50.0	–	–	04	2.8	
Total	93	64.6	46	31.9	05	3.5	144	100	
				Girls					
Underweight	21	45.7	22	47.8	03	6.5	46	29.5	4.2197
Normal	40	54.8	29	39.7	04	5.5	73	46.8	
Overweight	10	62.5	06	37.5	–	–	16	10.3	
Obese-I	11	64.7	06	35.3	–	–	17	10.9	
Obese-II	02	50.0	02	50.0	–	–	04	2.6	
Total	84	53.9	65	41.7	07	4.5	156	100	

Table 4: Number and percentage distribution of college-going girls for their bone mineral density (BMD) with respect to menstruation history

Variables		*Bone Mineral Density (BMD)*								χ^2-*value*
		Normal		*Osteopenia*		*Osteoporosis*		*Total*		
		N	*%*	*N*	*%*	*N*	*%*	*N*	*%*	
Menstruation	Regular	65	56.5	47	40.9	03	2.6	115	73.7	8.9721*
	Irregular	17	41.5	18	43.9	06	14.6	41	26.3	

*significant at $p<0.01$

bone density (normal, 56.5%; osteopenia, 40.9% and osteoporosis, 2.6%) compared to those who had irregular menstruation (41.5%, 43.9% and 14.6%, respectively).

As displayed in Table 5, a significant improvement in BMD was observed in both boys and girls with an increase in age. Least number of cases of osteopenia in boys (7.1 percent) was in age group 22-23 while in girls (17.9%) it was in age group 20-21 which thereafter increased to twenty-three percent in age group 22-23 years.

DISCUSSION

Although there was not much of a difference in the level of bone mineral density as per the area of distribution, osteopenia was a little more pronounced in rural subjects (38%) compared to their urban peers (35.8%). A similar study on urban population in age group of 20-39 years reported 27.8 percent individuals to be osteopenic and 8.3 percent to be osteoprotic (Silvanus et al. 2012).

Most of the youngsters studied had a sedentary lifestyle with a spending of more than 3-4 hours in front of television and mobile phones. Though there was not any significant difference in bone mineral density (BMD), it was observed that even a slight increase in physical activity could increase the bone mineral density, as the percentage of osteopenia was higher in subjects who had a sedentary lifestyle and low level of physical activity compared to moderately active individuals (38.1%/34.9%). Likewise, a study on young Indian adults by Tandon et al. (2003) indicated that with regular physical exercise, young individuals intend to have normal bone mineral values. A meta-analysis of bone mineral density in collegiate female athletes, carried out by Arasheben et al. (2011), too revealed a greater BMD in female patients who compete at increasingly intense athletic levels, with elite athletes having higher BMD than other patients who are either active or not. Marwaha et al. (2011) also reported that sports training and nutrition played a significant impact on bone mineral density in sports women of 18-21 years in comparison to sedentary control group which is in agreement with the present study. Ermin et al. (2012) reported weight-bearing exercises to be critical in increasing BMD. Similarly, low physical activity and sedentary lifestyle have been assessed as a risk factors which are significantly associated with low mineral density resulting in osteopenia and osteoporosis (Javed et al. 2015; Sridevi and Ragi 2016).

More of the non-vegetarian individuals were normal for their BMD (64.8%/62.9%) and percentage of osteoporotic cases was higher in vegetarian group (7.9%/5.6%). There was not a significant difference between these diet patterns, as the frequency and quality of non-vegetarian food intake were quite low. Parallel to the present study, vegetarian diet has been related to affect bone mineral density in a number of other studies on elderly females (Gandhi and Shukla 2005; Dutta et al. 2015) which is considered to be deficient in mineral content (Chiu et

Table 5: Number and percentage distribution of college-going boys and girls for their bone mineral density (BMD) with respect to various age groups

Body Mass Index(BMI)	*Bone Mineral Density (BMD)*								χ^2-*value*
	Normal		*Osteopenia*		*Osteoporosis*		*Total*		
	N	*%*	*N*	*%*	*N*	*%*	*N*	*%*	
Boys									
16 – 17	11	39.3	17	60.7	–	–	28	19.5	
18 – 19	21	43.8	23	47.9	04	8.3	48	33.3	
20 – 21	48	88.9	05	9.3	01	1.9	54	37.5	40.2879*
22 – 23	13	92.9	01	7.1	–	–	14	9.7	
Total	93	64.6	46	31.9	05	3.5	144	100	
Girls									
16 – 17	04	14.8	21	77.8	02	7.4	27	17.3	
18 – 19	24	40.0	31	51.7	05	8.3	60	38.5	
20 – 21	46	82.1	10	17.9	–	–	56	35.9	43.5721*
22 – 23	10	76.9	03	23.1	–	–	13	8.3	
Total	84	53.9	65	41.7	07	4.5	156	100	

*significant at $p<0.01$

al. 1997; Barr et al. 1998; Lau et al. 1998). Similar to the present findings, the studies carried out on younger age group by Wang et al. (2008) and Langsetmo et al. (2010) showed no significant relation between type of diet and BMD while Burckhardt (2016) advocated that vegetarian diet contains low acid load and is correlated with lower bone resorption and higher BMD. Physical inactivity and diet quality were considered to be risk factors associated with poor bone health (Mishra et al. 2016; Solmi et al. 2016; Zhang et al. 2016; Soomro et al. 2017).

The state of bone health, in the present study, was observed to be more precarious in girls, where 46.2 percent of subjects suffered from unhealthy bone state compared to boys (35.4%). A healthy bone state in boys (64.6%) in comparison to girls (53.9%) might be attributed to their larger and heavier bone skeleton as well as a physically active life pattern. Moreover, a discriminatory behaviour towards girls and preferential feeding for boys, right from the childhood, could add to a better bone health in boys. Silvanus et al. (2012), in a study on community with average age 44.3 years, yielded a prevalence of 41.4 percent and 33.3 percent of osteopenia, and 12.8 percent and 3.7 percent of osteoporosis among women and men, respectively, which is in conformation to the present study. The present study is also in consistence with the findings of Kruger et al. (2013) which shows a high degree of poor bone health in both men and women of Asian countries.

Chi-square did not display any significant difference (Table 3) in bone mineral density with respect to body mass index (BMI). Bone health was noticed to improve with increase in BMI favouring boys in overweight (normal BMD, 72% and osteopenia, 24%) and girls in obese I categories (normal BMD, 64.7% and osteopenia, 35.3%) in the present work. Silambuselvi and Murugu (2016) reflected a significant association between BMI and BMD and observed that BMI is an important determinant of BMD in Indian females. Comparable to the present study, high BMI has also been shown (Shatrugan et al. 2005; Reddy et al. 2009; Jain et al. 2013) to have a protective effect against bone loss. However, a longitudinal study by Lloyd et al. (2016) between body composition and bone mineral density among older adults indicated that high body mass might not be protective for bone loss over the time. The present study revealed that girls with regular menstrual flow were significantly better for their bone density compared to those who had irregularity with their menstruation (χ^2=8.9721). Akin to the carried out study, Yannakoulia et al. (2004) too reported a significantly lower BMD in subjects who encountered menstrual problems during adolescence. In the present investigation, female subjects with irregularity of menstruation had 43.9 percent cases of osteopenia and 14.6 percent of osteoporosis in comparison to the ones with normal menstruation (40.9% and 2.6% of osteopenia and osteoporosis, respectively). Jauregui-Lobera et al. (2016) indicated a marked improvement in bone density in patients of anorexia nervosa (Osteopenia: 22.9%, Osteoporosis: 74.3%) when they recovered for their normal weight and regular menses (osteopenia: 20% and osteoporosis: 60%).

Bone mineral density increased significantly with advancement in age (Table 5) and both boys (χ^2=40.2879) as well as girls (χ^2=43.5721) showed an increase in percent number of normal bone density, and a reduced frequency of osteopenia and osteoporosis. This could be because of the fact that youngsters intend to achieve their peak bone mass in early twenties. It was recommended that peak bone mass is a predictor of future risk of osteoporosis and fracture. The opinion regarding this varies as per different studies, but most of the research reports suggested it to be between 20-30 years of age (Rizzoli et al. 2007), while two Indian studies recommended it between 26-30 years (Kadam et al. 2009; Marwaha et al. 2009). An investigation by Marcus (2001) does suggest that ninety-five percent of peak bone density is achieved by 17 years in females and 2-3 years later for males. In the present study, compared to 31.9 percent and 3.5 percent of boys to be osteopenic and osteoporotic, 41.7 percent and 4.5 percent of girls suffered from these conditions. Similar studies by Mishra et al. (2016) depicted twenty-three percent and fifteen percent of osteopenia and osteoporosis, respectively, in females of age group 25-39 years whereas Soomro et al. (2015, 2017) indicated seventy percent of osteopenia cases in girls below 25 years of age. The current work revealed that fifty-nine percent of the population was normal for BMD while 33.7 percent and 4.3 percent were osteopenic and osteoporotic, respectively, which is quite a high percentage. As about thirty-eight percent of young

adults suffered from impaired BMD, it appears to be an alarming factor and it might be a layout for fragile bones with a greater chance to get fractured in later part of life.

CONCLUSION

The study carried out on young adults pointed out towards a better bone status in the subjects having non-vegetarian and physically active mode of life. Both underweight and obese I conditions act as negative factors whereas normal and overweight BMI state in boys and overweight and obese II state in girls had a positive impact on BMD. A better bone health was recognized in girls who had normal menstrual cycle. A significant improvement of bone density with age indicated that peek bone density might get achieved in early twenties.

RECOMMENDATIONS

Osteoporosis is not only a biological health problem but also has its social ramification as well as economic costs and consequences. It may turn out to be a larger problem with increasing level of age expectancy, sedentary lifestyle and exposure to fast food. Making youngsters aware of this situation and providing them guidance for healthy lifestyle would curb down osteopenia, a ground reality for forthcoming age-related disease. Therefore, bone density management programmes should be established within health care community centers as well as educational institutes.

ACKNOWLEDGEMENT

The financial aid provided by University Grants Commission, New Delhi (India) for the major research project [MRP-MAJOR-ANTH-2013-42372, No - 43-36/2014(SR)] is highly acknowledged.

REFERENCES

Arasheben A, Barzee KA, Morley CP 2011. A Meta-analysis of Bone Mineral Density in Collegiate Female Athletes. J Am Board Fam Med, 24: 728-734. Doi: 10.3122/jabfm.2011. 06.100289.10. From <http://www.jabfm.org/ content/ 24/6/728.full> (Retrieved on 5 December 2016).

Barr SJ, Prior JC, Janelle KC, Lentle BC 1998. Spinal bone mineral density in premenopausal vegetarian and non-vegetarian women: Cross-sectional and prospective comparison. *J Am Diet Assoc*, 98: 760-765.

Burckhardt P 2016. The role of low acid load in vegetarian diet on bone health: A narrative review. *Swiss Med Wkly*, 146: w14277.

Chandramouli C 2011. Adolescents and Youth in India. Highlights from Census 2011. Registrar General and Census Commissioner, India. From <www. censusindia. gov.in> (Retrieved on 3 November 2016).

Chiu JF, Lan SJ, Yang CY, Wang PW, Yao WJ, Su LH et al. 1997. Long term vegetarian diet and bone mineral density in postmenopausal Taiwanese women. *Calc Tiss Int*, 60: 245-249.

Dutta N, Saikia AM, Saikia AM, Das AK 2015. Status of bone mineral density in adult population using calcaneal ultrasound bone densitometer: A study from Assam, India. *Int J Appl Basic Med Res*, 4: 150-158.

Ermin K, Owens S, Owens S, Ford MA, Bass M 2012. Bone Mineral Density of Adolescent Tennis Players and Non-tennis Players. J Osteopor, P. 5, Article ID 423910. From <http://dx.doi.org/10.1155/2012/423910> (Retrieved on 12 May 016).

Gandhi AB, Shukla AK 2005. Evaluation of BMD of women above 40 years of age. *J Obstet Gynecol India*, 55: 265-267.

Gupta AK, Samuel KC, Kurian PM, Rallan RC 1967. Preliminary study of the incidence and aetiology of femoral neck fracture in Indians. *Ind J Med Res*, 55: 1341-1348.

Jain V, Agarwal BK, Varshney A, Biswas SS 2013. Prediction of bone mineral density by age, body mass index and menopausal status in middle socioeconomic status women of urban Kolar region of Bihar. *J Dental Med Sci*, 12: 17-21.

Jauregui-Lobera I, Bolanos-Rios P, Sabate J 2016. Bone mineral density in anorexia nervosa: Only weight and menses recovery? *Endocrinol Nutr*, 63: 458-465. Doi: 10.1.16/j endowing. 2016.06.006.

Javed Z, Imam SF, Imam N, Saba K, Bukhari MH 2015. Bone mineral density and diet of teachers of College of Home Economics at Lahore. *Pak J Med Sci*, 31: 970-974.

Kadam N, Khadilkar A, Chiplonkar S, Khadilkar V, Mughal Z 2009. Variation in lumbar spine bone mineral content by age and gender in apparently healthy Indians. *J Bone Metabol*, 27: 705-712.

Kruger MC, Todd JM, Schollum LM, Kuhn-Sherlock B, McLean DW, Wylie K 2013. Bone Health Comparison in Seven Asian Countries using Calcaneal Ultrasound. BMC Musculoskel Disord, 14: 81. Doi: 10.1186/1471-2474-1481. From <http://www.ncbi.nlm.nih.gov/pubmed/ 23497143> (Retrieved on 15 July 2016).

Langsetmo L, Poliquin S, Hanley DA, Prior JC, Barr S, Anastassiades T et al. 2010. Dietary patterns in Canadian men and women ages 25 and older: Relationship to demographics, body mass index and bone mineral density. *BMC Musculoskel Disord*, 11: 20. Doi: 10.1186/1471-2474-11-20.

Lau EM, Kwok T, Woo J, Ho SC 1998. Bone mineral density in Chinese elderly female vegetarians, vegans, lactovegetarians and omnivores. *Eur J Clin Nutr*, 52: 60-64.

Lloyd JT, Alley DE, Hochberg MC, Waldstein SR, Harris TB, Kritchevsky SB et al. 2016. Change in bone mineral density over time by body mass index in the

health ABC study. *Osteopor Int*, 27: 2109-2116. Doi: 10.1007/s00198-016-3506-x.
Loud KJ, Gordon CM, Micheli LJ, Field AE 2005. Correlates of stress fractures among pre-adolescent and adolescent girls. *Pediatrics*, 115: 399-400.
Malhotra N, Mithal A 2008. Osteoporosis in India. *Ind J Med Res*, 127: 263-268.
Marcus R 2001. Role of exercise in preventing and treating osteoporosis. *Osteoporosis*, 27: 131-141.
Marwaha RK, Puri S, Tandon N, Dhir S, Agarwal N, Bhadra K, Saini N 2011. Effect of sports training and nutrition on bone mineral density in young Indian healthy females. *Ind J Med Res*, 134: 307-313.
Marwaha RK, Tandon N, Shiraprusad C, Kanwar R, Mani K, Aggarwal R et al. 2009. Peak bone density of physically active healthy Indian men with adequate nutrition and no known constraints to bone mineralization. *J Clin Densit*, 12: 314-321.
Mishra AK, Gajjar K, Patel K 2016. Association between body mass index and bone mineral density among healthy women in India. *Int J Med Res Hlth Sci*, 4: 156-160.
Nordin BEC 1966. International patterns of osteoporosis. *Clin Orthop*, 45: 17-30.
Reddy GA, Kulkarni B, Shatrugna V, Redy PTR, Nagella B, Kumar PA, Rani KU 2009. Bone mass of overweight affluent Indian youth and its sex-specific association with body composition. *Arch Osteopor*, 4: 31-39.
Rizzoli R, Bonjour J, Chevalley T 2007. Dietary protein intakes and bone growth. *Int Cong Ser*, 1297: 50-59.
Rizzoli R, Bonjour JP, Ferrari SL 2001. Osteoporosis, genetics, and hormones. *J Mol Endocrinol*, 26: 79-94.
Shatrugan V, Kulkarni B, Kumar PA, Rani KU, Balakrishna N 2005. Bone status of Indian women from a low-income group and its relationship to the nutritional status. *Osteoporosis International*, 16: 1827-1835.
Silambuselvi K, Murugu VV 2016. Association between body mass index and bone mineral density among rural and urban post-menopausal women. *Int J Pharm Clin Res*, 8: 239-242.
Silvanus V, Ghosal K, Behera A, Subramanian P 2012. Screening for osteopenia and osteoporosis in an urban community in India. *Nepal Med Coll J*, 14: 247-250.
Solmi M, Veronese N, Correll CU, Favaro A, Santonastaso P, Vancampfort D, Luchini C, De Hert M, Stubbs B 2016. Bone mineral density, osteoporosis and fracture among people with eating disorders: A systematic review and meta analysis. *Acta Psychiatr Scand*, 133: 341-351.
Soomro RR, Ahmed SI, Khan M 2017. Frequency of Osteopenia and Associated Risk Factors among Young Female Students. J Pak Med Assoc. From <http://www.jpma.org.pk/full_article_text.php? article_ id= 8111> (Retrieved on 8 March 2017).
Soomro RR, Ahmed SI, Khan M, Ali SS 2015. Comparing the effects of osteoporosis prevention exercise protocol (OPEC) versus walking in the prevention of osteoporosis in younger females. *Pak J Med Sci*, 31: 336-340.
Sridevi A, Ragi V 2016. Management of osteoporosis in women - A prevalence and interventional study. *Int Arch Integ Med*, 3: 140-145.
Tandon N, Marwaha RK, Kalra S, Gupta N, Dudha A, Kochupillai N 2003. Bone mineral parameters in healthy young Indian adults with optimal vitamin D availability. Nat Med J India, 16: 208-302. From <http://www.nmji.in/archives/volume%2016-20october%202003/ original%20article/Bone_mieral_ parameter.html> (Retrieved on 22 December 2015).
UN (United Nations) 2016. World Population Prospects. The 2015 Revision. From <https://esa.un.org>publiations>files> (Retrieved on 3 November 2016).
Wang YF, Chiu JS, Chuang MH, Chiu JE, Lin CL 2008. Bone mineral density of vegetarian and non-vegetarian adults in Taiwan. *Asia Pac J Clin Nutr*, 17: 101-106.
Weiner JS, Lourie JA 1981. *Practical Human Biology*. New York: Academic Press Inc.
WHO (World Health Organization) 2000. *The Asia-Pacific Perspective: Redefining Obesity and Its Treatment*. Australia: International Diabetes Institute, Health Communications.
WHO (World Health Organization) 2016. WHO | India. From <www.who.int>country>ind> (Retrieved on 3 November 2016).
WHO Scientific Group on the Assessment of Osteoporosis at Primary Health Care Level 2004. *Summary Meeting Report*. Brussels, Belgium.
Yannakoulia M, Keramopoulos A, Matalas A 2004. Bone mineral density in young active females: The case of dancers. *Int J Sport Nutr Exer Metabol*, 14: 279-291.
Zhang J, Jameson K, Sayer AA, Robinson S, Cooper C, Dennison E 2016. Accumulation of risk factors associated with poor bone health in older adults. *Arch Osteoporosis*, 11: 3. Doi 10.1007/s11657-015-0250-3.

Paper received for publication on January 2017
Paper accepted for publication on April 2017