Original Research Article

Anthropometric Parameters and Bone Health Status in Young Adults of District Gurdaspur, Punjab

Dr. Manjula Uppal[1], Karamjeet Kaur[2]

[1]Associate Professor and HOD, Department of Zoology, S.L. Bawa DAV College, Batala, India.
[2]Project Fellow, Department of Zoology, S.L.Bawa DAV College, Batala, India.

Corresponding Author: Karamjeet Kaur

ABSTRACT

With increase in life span and longevity, maintenance of healthy bones and skeletal structure might help to escape associated morbidity and economic burden occurring because of bone fragility and fractures during old age. To ensure a healthy bone structure the younger population is needed to be assessed for a timely intervention to improve the bone health to avoid the associated morbidities later in life.

Objective: Keeping this in view, the present survey was designed to study anthropometric parameters and bone health status of young adults since it is the time when peak bone mass is attained.

Method: The survey was carried out on 1000 college-going boys and girls in the age range of 16-23 years using quantitative ultrasound bone densitometer.

Result: Male subjects displayed better skeletal health as well as a higher mean t-score value in all age groups and significantly so in age group 16-17 yrs, 22-23yrs, and in overall data. Mean z-score was significantly different in all the age groups. Male subjects (57.1%) were in a significantly better state of bone health than girls (48.7%). Maximum cases of normal bone health were present in age group 20-21yrs with 89% of males and 83% of females which thereafter decreased to 87.5% in males and 57.1% in females in age group 22-23yrs. In all, 37.8% of male subjects had osteopenia and 5.1% had osteoporosis compared to 44.9% and 6.4% respectively in females.

Discussion: Weight, BMI, WC, HC, WHtR affected bone health in studied young females and was observed to have negative correlation in studied young females.

Key words: Weight, BMI, WC, HC, WHtR, Osteoporosis, Osteopenia.

INTRODUCTION

Osteoporosis is characterized by low bone mass and micro-architectural deterioration of bone tissue leading to enhanced bone fragility, thus increasing susceptibility to fracture. These changes are initially silent and can progress gradually until a low trauma fracture occurs. [1] Bone health is important for overall health and quality of life and is dependent on bone mass, bone architecture and body mechanics. [2] Optimal bone health status is crucial to prevent osteoporosis, which is a disease characterized by low bone mass and bone micro-architectural deterioration, leading to bone fragility and an increased risk of fracture. [3] 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. [4] Life expectancy in India is on the rise and average age of an Indian had shown an increase by almost ten years in the past two decades. [5] India is a young country as nineteen percent of its population is in the age group 15-24 years and today every fifth

person in India is an adolescent (10-19 years, app. 253.2 million) and every third, a young person (10-24 years,~231.9million) - a factor associated with demographic and social flux. [6] The demographic shift towards younger population and rising level of longevity could prove to be crucial factors which could lead to an increase in population vulnerable to osteoporosis and associated implications. Childhood, adolescent and early adulthood are the times when there could be a significant increase in peak bone mass. [7] The present attempt was undertaken to assess the anthropometric parameters bone health in adolescent and young-adults as it has been reported that weight and BMI could be used to screen risk of developing osteoporosis and its related complication.[26,28]

METHODOLOGY

The study was conducted on 1000 individuals in age range of 16-23 years (mean age: 19.35±2.27 yrs.) attending local educational institutes in the township of Batala belonging to urban and rural areas of near and far vicinity in the year 2016-17. Six hundred and thirteen urban (male: 229; female:384) and three hundred and eighty seven rural (male: 165; female: 222) apparently healthy subjects were taken as study group after having obtained a written consent. The exclusion criteria included chronic or any other infectious ailment. Standard methodology of was implied to measure height, weight, waist circumference and hip circumference. [8] 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. [9]

Normal Bone Mass - t-score > -1
Osteopenia - t-score between -1 and -2.5
Osteoporosis - t-score < -2.5

Statistical analysis: Statistical analysis was performed using standard descriptive statistical tests with the help of SPSS software through chi-square, Anova and Pearson's correlation coefficient.

RESULTS

A significant difference in mean height measurement of male and female individuals was indicated through t-value in various age groups (Table 1). A consistent increase in weight is seen in both the sexes. Maximum weight gain was in age group 20-21yrs. in boys (64.440±10.240kg) and age group 22-23yrs. in girls (54.951±10.35kg) with a significant difference in all the age groups. As discernable from Table 1, waist circumference was significantly higher in all age groups with boys having higher girth measurements. In total data the mean waist circumference for boys (71.931±9.903cm) and girls (63.957±9.358 cm) was significantly different (f=156.50; p<0.000). Maximum increase in hip circumference was by the time subjects were in their age group 20-21yrs. (Table 1). There was a significant difference for this measurement in different age groups.

Mean value of BMI in male and female subjects (Table 2) was in close approximation in age groups 18-19yrs and 22-23 yrs while in the rest of two age groups it differed significantly amongst gender. Urban and rural peers also had their BMI almost in the same range.WHR (Table 2), was different significantly amongst male and female individuals in age group 16-17yrs. and 20-21yrs. as well in overall data (f=7.102; p<0.008). Waist to height ratio (Table 2) was again to the highest level in age group 20-21 in both boys (0.444±0.049) and girls (0.417±0.060) and no significant difference existed in age groups 18-19yrs and 22-23 yrs.

Table 1: Anthropometric measurements of college going males and females.

Anthropometric variables					
Age grps.(yrs.)		Height	Weight	W.C.	H.C.
		Mean ±S.D.	Mean ±S.D.	Mean ±S.D.	Mean ±S.D.
16-17	Male	169.906±5.975	61.602±11.507	70.536±9.661	88.483±10.493
	Female	156.210±5.776	48.801±8.912	62.049±8.372	82.727±7.351
	t/(p)-value	18.455;(0.000)	9.945;(0.000)	7.470;(0.000)	5.101;(0.000)
18-19	Male	169.496±8.040	62.260±11.367	71.700±9.494	89.168±8.851
	Female	155.871±6.441	49.757±9.725	64.031±9.461	84.184±10.872
	t/(p)-value	16.051;(0.000)	10.054;(0.000)	6.778;(0.000)	4.127;(0.000)
20-21	Male	169.143±6.729	64.440±10.240	75.152±8.461	90.436±7.786
	Female	155.137±5.857	50.270±8.892	64.757±9.127	85.474±9.208
	t/(p)-value	16.437;(0.000)	10.942;(0.000)	8.478;(0.000)	4.125;(0.000)
22-23	Male	167.940±8.857	63.068±12.070	70.972±11.525	87.618±11.131
	Female	158.464±6.120	54.951±10.535	64.848±10.138	82.495±11.594
	t/(p)-value	9.471;(0.000)	5.265;(0.000)	4.140;(0.000)	3.225;(0.000)
Total	Male	169.226±7.418	62.686±11.337	71.931±9.903	88.917±9.662
	Female	156.399±6.185	50.925±9.817	63.957±9.358	83.758±10.022
	f /(p)-value	875.609;(0.000)	302.869;(0.000)	165.501;(0.000)	65.088;(0.000)

Table 2: Anthropometric variables and indices of college going males and females.

		Anthropometric indices		
Age grps.(yrs)		BMI	WHR	WHtR
		Mean ±S.D.	Mean ±S.D.	Mean± S.D.
16-17	Male	21.366±3.988	0.802±0.115	0.415±0.059
	Female	19.993±3.403	0.750±0.086	0.397±0.052
	t/(p)-value	2.948;(0.004)	4.069;(0.000)	2.613;(0.010)
18-19	Male	21.632±3.397	0.804±0.066	0.423±0.055
	Female	20.463±3.732	0.797±0.437	0.410±0.058
	t/(p)-value	2.719;(0.007)	0.173;(0.863)	1.848;(0.066)
20-21	Male	22.503±3.154	0.831±0.060	0.444±0.049
	Female	20.902±3.652	0.760±0.107	0.417±0.060
	t/(p)-value	3.336;(0.001)	5.450;(0.000)	3.420;(0.001)
22-23	Male	22.282±3.521	0.811±0.093	0.422±0.064
	Female	21.869±3.994	0.790±0.093	0.409±0.064
	t/(p)-value	0.775;(0.439)	1.649;(0.101)	1.432;(0.153)
Total	Male	21.868±3.574	0.811±0.088	0.425±0.058
	Female	20.804±3.760	0.776±0.248	0.409±0.059
	f/(p)-value	19.851;(0.000)	7.102;(0.008)	18.097;(0.000)

Table 3: t- score and z-score values of college going males and females.

Age grps.(Yrs.)		T-score	Z-score
		Mean ±S.D.	Mean ±S.D.
16-17	Male	0.632±0.984	- -
	Female	-0.385±0.805	
	t/(p)-value	3.979; (0.000)	
18-19	Male	-0.036±0.844	- -
	Female	-0.184±0.883	
	t/(p)-value	1.430; (0.154)	
20-21	Male	0.026±0.8801	-0.043±0.852
	Female	-0.194±0.949	-0.028±0.881
	t/(p)-value	1.781; (0.076)	1.979; (0.049)
22-23	Male	-0.051±0.870	-0.058±0.933
	Female	-0.713±0.812	-0.770±0.780
	t/(p)-value	5.726; (0.000)	6.119 ;(0.000)
Total	Male	0.002±0.882	-0.051±0.890
	Female	-0.360±0.890	-0.526±0.866
	f/(p)-value	40.071;(0.000)	30.752;(0.000)

Mean t-score (Table 3) was high in male subjects in all the age groups and significantly so in age group 16-17yrs. (Male: 0.063±0.984; Female: -0.385±0.0805) and 22-23yr. (Male: -0.051±0.870; Female: -0.713±0.812) as well as in overall data (Male: 0.002±0.882;

Female: -0.360±0.0890). A significant difference in mean and standard deviation of z-score between male and female individuals was present in all age groups.

DISCUSSION

As anticipated, boys were taller, heavier and had higher circumferences and indices (Table 1 & 2) compared to girls in likelihood to the other reported studies. [10] Male individuals had high mean t-score values (Table 3) in all the age groups while significantly higher in age group 16-17 yrs. and 22-23yrs. as well as in overall data. Mean z-score values were also significantly higher in males compared to females in all age groups as well as total data. Adolescence, characterized by the changes in height, weight and body composition, is a crucial period for bone mineral accrual. [11] Approximately forty percent of peak bone

mass is accumulated during adolescence which protects against post menopausal osteoporosis. [12] Therefore optimizing peak bone mass in early adulthood is thought to reduce the risk of osteoporosis by offsetting bone losses later in life. [13] In studied population of young adults, an improvement in bone health was discernable (Table 4) with increase in age and maximum cases of normal bone health were present in age group 20-21yrs with 89% of males and 83% of females which thereafter decreased to 87.5% in males and 57.1% in females in age group 22-23yrs.

Table 4: Number and percentage distribution of college going boys and girls w.r.t. Bone Mineral Density (BMD).

BMD	Male						Female						χ^2	p-value
	Normal		Osteopenia		Osteoporosis		Normal		Osteopenia		Osteoporosis			
	N	%	N	%	N	%	N	%	N	%	N	%		
16-17	37	32.2	68	59.1	10	8.7	22	16.1	100	73.0	15	10.9	9.057	0.011*
18-19	45	38.5	63	53.8	9	7.7	67	38.3	87	49.7	21	12.0	1.500	0.472
20-21	73	89.0	8	9.8	1	1.2	122	83.0	23	15.6	2	1.4	1.582	0.453
22-23	70	87.5	10	12.5	0	0.0	84	57.1	62	42.2	1	0.7	21.967	0.000*
Total	225	57.1	149	37.8	20	5.1	295	48.7	272	44.9	39	6.4	6.841	0.033

An investigation does suggest that ninety-five percent of peak bone density is achieved by 17 yearsinfemalesand2-3years later for males. In the present study 37.8percent and5.1percent of boys were osteopenic and osteoporotic in comparison to 44.9 percent and 6.4 percent of girls respectively. [14] Similar studies by Mishra depicted twenty-three percent and fifteen percent of osteopenia and osteoporosis, respectively, in females of age group 25-39yearswhereasseventy percent of osteopenia casesingirlsbelow25years of age. [15-17] The current work revealed that in the population undertaken for study only 52.9percent of youngster's were normal for BMD while 41.3 percent and 5.8 percent were osteopenic and osteoporotic, respectively.

Presence of about forty six percent of young adults with impaired BMD could be an alarming feature for any society and might prove to be an indicator of bone fragility having greater probability to get fractured in later part of life. In a study to screen bone status of adults over 20 years utilizing calcaneal quantitative ultrasound as a diagnostic tool yielded the prevalence of 41.4% and 33.33% of osteopenia among women and men respectively and 12.85% and 3.7% of osteoporosis respectively. [18]

A correlation of anthropometric variables and indices with t/z-score (Table 5 & 6) indicated that in male subjects weight (r=-0.121; p<0.017) was negatively correlated with T-score.

Table 5: Correlation coefficient value "r" of anthropometric variable with t-score in college – going males and females.

Age grps.(yrs.)		Height	weight	BMI	W.C.	H.C.	WHR	WHtR
16-17	Male	-0.076	-0.157	-0.125	-0.185*	-0.192*	0.004	-0.155
	(p-value)	(0.422)	(0.095)	(0.183)	(0.048)	(0.040)	(0.970)	(0.099)
	Female	-0.136	0.112	0.182*	0.113	0.194*	-0.033	0.153
	(p-value)	(0.113)	(0.191)	(.033)	(0.189)	(0.023)	(0.701)	(0.074)
18-19	Male	-0.079	-0.160	-0.131	-0.003	-0.067	0.062	0.022
	(p-value)	(0.398)	(0.084)	(0.158)	(0.972)	(0.473)	(0.504)	(0.814)
	Female	0.021	0.041	0.040	-0.026	0.107	-0.090	-0.031
	(p-value)	(0.782)	(0.590)	(0.600)	(0.736)	(0.158)	(0.235)	(0.686)
20-21	Male	-0.056	-0.032	0.002	0.029	0.009	0.015	0.051
	(p-value)	(0.619)	(0.772)	(0.987)	(0.796)	(0.938)	(0.897)	(0.650)
	Female	-0.227**	-0.095	0.008	0.061	0.002	0.046	0.120
	(p-value)	(0.006)	(0.253)	(0.925)	(0.460)	(0.976)	(0.578)	(0.147)
22-23	Male	-0.125	-0.082	-0.032	-0.116	-0.045	-0.121	-0.098
	(p-value)	(0.271)	(0.468)	(0.780)	(0.305)	(0.694)	(0.287)	(0.388)
	Female	-.019	0.100	0.107	0.145	0.134	0.015	0.150
	(p-value)	(0.820)	(0.229)	(0.198)	(0.080)	(0.106)	(0.854)	(0.070)
Total	Male	-0.079	-0.121*	-0.089	-0.081	-0.092	-0.008	-0.059
	(p-value)	0.161	0.017	0.079	0.109	0.067	0.869	0.246
	Female	-0.125**	-0.014	0.042	0.060	0.120**	-0.044	0.095*
	(p-value)	0.002	0.729	0.305	0.143	0.003	0.279	0.019

**. Correlation is significant at the 0.01 level, *. Correlation is significant at the 0.05 level .

Table 6: Correlation coefficient value "r" of anthropometric variable with z-score in college going males and females.

Age grps.(yrs.)		Height	weight	BMI	W.C.	H.C.	WHR	WHtR
16-17	Male	-	-	-	-	-	-	-
	Female	-	-	-	-	-	-	-
18-19	Male	-	-	-	-	-	-	-
	Female	-	-	-	-	-	-	-
20-21	Male	0-.076	-0.052	-0.009	0.016	-0.018	0.028	0.045
		(0.497)	(0.644)	(0.936)	(0.884)	(0.875)	(0.803)	(0.688)
	Female	-0.243**	-0.116	-0.007	0.069	-0.007	0.060	0.131
	(p-value)	(0.003)	(0.161)	(0.934)	(0.407)	(0.936)	(0.470)	(0.112)
22-23	Male	-0.142	-0.110	-0.056	-0.140	-0.061	-0.140	-0.118
	(p-value)	(0.208)	(0.333)	(0.622)	(0.215)	(0.591)	(0.216)	(0.297)
	Female	0.009	0.105	0.102	0.130	0.118	0.015	0.130
	(p-value)	(0.911)	(0.205)	(0.219)	(0.115)	(0.154)	(0.860)	(0.117)
Total	Male	-0.113	-0.083	-0.034	-0.073	-0.042	-0.074	-0.047
	(p-value)	(0.151)	(0.292)	(0.665)	(0.359)	(0.597)	(0.352)	(0.554)
	Female	-0.188**	-0.069	0.009	0.093	0.095	-0.003	0.144*
	(p-value)	(0.001)	(0.239)	(0.884)	(0.110)	(0.103)	(0.957)	(0.014)

**. Correlation is significant at the 0.01 level .
*. Correlation is significant at the 0.05 level .

In females height was negatively correlated with t-score (r=-0.125; p<0.002) and Z-score (r=-0.188; p<0.001) while HC was positively correlated with t-score (0.0120; p<0.003) and WtHR with t-score (r=0.095; p<0.091) as well as z-score (r=-0.144; p<0.014). However, a positive correlation of BMD with weight was reported while in similarity to the present study a correlation of height and physical activity with osteoporotic index was indicated and a high prevalence of osteoporosis in low stature adults was reported. [19-21] In likelihood to the present study a statistically significant correlation between bone mineral density and height, weight W.C, H.C, WHR and body mass index in Iranian population. [22,23] Age, nutrition, height and weight were reported to be significantly associated at peripheral sites. [24] Weight, height, BMI, physical activity, diet and calcium- phosphorus ratio were yet again positively correlated with bone health. [25,26] The predictor of bone status among adolescent boys were age, body mass index (BMI), height attained (z-score) and maternal T-score and for girls were BMI, age at menarche, paternal T-score and Z-score. Stunted adolescents suffered from low bone mass density and low stature adults suffered a high prevalence of osteoporosis. [21] Weight and BMI can be used as to screen those at risk of developing osteoporosis and its related complication. [27] Body mass index, physical activity, low calcium consumption, and abnormal life style have role in bone mineral density and prognosis of osteoporosis in young adults. [28]

Boys had better anthropometric variables and bone health compared to the girls. In studied females, weight, WC, HC, BMI and WHtR had a significant negative correlation with t-score while height could be positively correlated, and WHtR was negatively correlated with z-score. Osteopenia (males: 37.8%; females: 44.9%) and osteoporosis (males: 5.1%; females: 6.4%) were significantly much pronounced in females.

CONCLUSION

The current study reveals that in young population of district Gurdaspur, Punjab more than forty percent of males (osteopenia : 37.8%; osteoporosis : 5.1%) and fifty percent of females (Osteopenia : 44.9; osteoporosis :6.4%) suffered from impaired bone health and anthropometric variables like weight, BMI, WC, HC, WHtR were seen to have a negative correlation with bone health in young girls.

REFERENCES

1. Lane NE. Epidemiology, etiology and diagnosis of osteoporosis. Amer. J. Obstet. Gynecol 2006;194: S3-11.
2. Heaney RP. Dairy and bone health.*J Am Coll Nutr* 2009 ;28:82S-90S.
3. Weaver CM, Gordon CM, Janz K.F, Kalwant H.J, Lappe J.M, R.Lewis, M.O karma,Wallace T.C, Zemel B.S . The National Osteoporosis Foundation's position statement on peak bone mass development and lifestyle factors: a systematic review and implementation recommendations. *OsteoporosInt* 2016;27:1 281-1386.
4. Rizzoli R, Bonjour J-P, Ferrari SL.Osteoporosis, genetics, and hormones. J Mol Endocr 2001;26:79-94.
5. WHO (World Health Organization) 2016. WHO | India. From<www.who.int>country>ind> (Retrieved on 3 November 2016).
6. Chandramouli C 2011. Adolescents and Youth in India. Highlights from Census 2011. Registrar General and Census Commissioner, India. www.censusindia. gov.in. (Retrieved on 3 November 2016).
7. AAOS (American Academy of Orthopaedic Surgeons) 2012. Orthoinfo.aaos. org/topic.cfm? Topic a00127.
8. Weiner JS, Lourie JA 1981. Practical Human Biology. New York: Academic Press Inc.
9. WHO 2004. Scientific Group on the Assessment of Osteoporosis at Primary Health Care Level. Summary Meeting Report. Brussels, Belgium.
10. Arbi A, Nabulsi M, Maalouf J, Choucair M, Khalife H, Veith R, FuleihanGE.Bone mineral density by age, gender, pubertal stages, and socioeconomic status in healthy Lebanese children and adolescents. Bone 2004;35:1169-1179.
11. Kun Z, Greenfield H, Xueqin D, Fraser DR. Improvement of bone health in childhood and adolescence. Nutr Res Rev. 2000;14:119-52.
12. Matkovic V, Jelic T, Wardlaw GM, Ilich JZ, Goel PK, Wright JK, Andon MB, Smith KT, Heaney RP. Timing of peak bone mass in Caucasian females and its implication for the prevention of osteoporosis. Inference from a cross-sectional model. J Clin Invest 1994 Feb;93(2):799-808.
13. Marwaha RK, Puri S, Tandon N, Dhir S, Agarwal N, Bhadra K, Saini N. Effect of sports training and nutrition on bone mineral density in young Indian healthy females. Ind J Med Res 2011;134: 307-313
14. Marcus R 2001 Role of exercise in preventing and treating osteoporosis. Osteoporo. 27: 131-141.
15. Mishra AK, Gajjar K, Patel K. Association between body mass index and bone mineral density among healthy women in India. Int. J. Med. Res. Hlth. Sci. 2016;4:156-160
16. Soomro RR, Ahmed SI, Khan M et al. comparing the effects of osteoporosis prevention exercise protocol(OPEP) versus walking in the prevention of osteoporosis in younger females.Pak J Med Sci 2015; 31 . www.jpms.com.pk
17. Soomro RR, Ahmed SI, Khan M. Frequency of osteopenia and associated risk factors among young female students. J. Pak. Med. Assoc. 2017. http://www.jpma.org.pk/full_article_text.php p? Article_ id= 8111 (Retrieved on 8 March 2017).
18. Silvanus V, Ghosal K, Behera A, Subramanian P. Screening for osteopenia and osteoporosis in an urban community in India. Nepal Med Coll J. 2012; 14: 247-250.
19. Wilkin LD, Jackson MC, Sims TD, Haddock BL (2010) Racial/Ethnic differences in bone mineral density of young adults. Int J Exerc Sci. 3:197-205
20. Kim J Jung M Hong Y Park J Choi B .Physical activity in adolescence has a positive effect on bone mineral density in young men. J Prev Med Pub Hlth 2013;46: 89-95. doi: 10.3961/ipmph.2013.46.2.89. From < http://www.ncbi.nlm.nih.gov/pmc/artcles/P MC3615384/ > (Retrieved on 6 September 2017).
21. Ibrahim SA, Samy MA, Matter MK, Saleh AOL. Bone mineral density in Egyptian adolescents and adults with short stature: results of national survey. East Medita. Hlth. J.2011; 17: 687-693.
22. AghaeiMeybodiHR, Hemmat-abadi M, Heshmat R, RezaeiHomami M, Madani S, Ebrahimi M, Adibi H, and Larijani[B]Association between Anthropometric Measures and Bone Mineral Density: Population-Based Study. Iran J Public Health 2011; 40(2): 18–24.Published online 2011 Jun 30.

23. Soltani A, Larijani B, Khashayar P, Rezaei Hemami M, Fakhari S. Acta Med Iran. The relationship between anthropometric parameters and bone mineral density in an Iranian referral population. 2014;52(7):505-10.

24. Marwaha RK and SripathyG.Vitamin D & bone mineral density of healthy school children in north India. Ind J Med Res 2008;127: 239-244.

25. Naseem N .Bone mineral density measured by ultrasound among resident doctors of Multan and their correlation with common risk factors. JSOGP 2013;3: 170-174.

26. Martinaityte I, Jorde R, Emaus N, Eggen AE, JoakimsenRM, Kamycheva E. Bone Mineral Density is associated with Vitamin D Related rs6013897 and Estrogen Receptor Polymorphism rs4870044: The TromsØ

Study. PLoS One 2017;12(3): e0173045. Doi: 10.1371/journal.pone.0173045. From <http:// www.ncbi.nlm.nih.gov/pubmed / 28253304 > (Retrieved on 18 January 2018).

27. Alghadir A.H., S Gabr S.A., Al-EisaE. Physical activity and lifestyle effects on bone mineral density among young adults: sociodemographic and biochemical analysis. J Phys Ther Sci 2015 Jul; 27(7): 2261–2270.Published online 2015 Jul 22. doi: 10.1589/jpts.27.2261

28. Annamalai R and Shankar Lal J. Correlation of anthropometric measurements with bone mineral density in south Indian population International Journal of Orthopaedics Sciences 2018; 4(1): 221-224. DOI: https://doi.org/10.22271/ortho.2018.v4.i1d.31

******