Correlation of strength, BMI and limb girth to bone mineral density in young adults with different levels of physical activity

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Abstract. The aim of the study is to assess the association of strength and body mass index (BMI) to bone mineral density (BMD) in young adults with different levels of physical activity. Total of thirty young adults,, aged 25-30 years were recruited by advertising. Bone specific physical activity questionnaire (BPAQ) was used to measure the physical activity score. BMD of mid shaft tibia and distal radius of dominant limb was taken using ultrasound densitometry. Speed of sound (SOS) was measured for both the sites and Z-score was documented. Concentric quadriceps peak torque of dominant limb was measured in using an isokinetic dynamometer. Hand grip strength of dominant hand was measured using digital hand grip dynamometer. Bivariate correlation between both BMD sites and normalized quadriceps strength at 60)/sec, hand grip strength, BPAQ score, BMI, wrist circumference and bi-malleolar girth for different age groups were calculated using Pearson's coefficient of correlation. Physical activity and strength were found to be independent significant predicators of BMD, also BMI was found to be in positive correlation with bone health. Together these results clearly conclude that bone specific physical activity is an important determinant of BMD after and even before the peak bone mass attainment in young adults of different age groups. In the present study, we have only evaluated BMD of the radius and mid shaft tibia. This measure might be biased from the occupation or the amount of physical activity of a particular limb. Considering these facts we suggest that strength can be a good predictor of BMD at the time of peak bone mass attainment but not before that, on the contrary physical activity is significant predictor of BMD irrespective of age
Key words: *bone mass, hand grip strength, body mass index.*

Introduction

Bone status is influenced by variety of genetic (gender and race) and environmental (diet, life style and exercise habits) factors. Exercise is an important dynamic factor that imparts mechanical loading on a living bone tissue. The bone mineral density (BMD) accumulates during childhood and adolescence to peak in the mid-20s (1) or at some sites perhaps before 20 years of age. Physical exercise is any bodily activity that enhances or maintains physical fitness and overall health and wellness.

Physical exercise is important for maintaining physical fitness and can contribute positively to maintaining a healthy weight, building and maintaining healthy bone density, muscle strength, and joint mobility, promoting physiological well-being, reducing surgical risks, and strengthening the immune system. Physical activity has been shown to be associated with bone density (2, 3).

The best kind of exercise for bone health is weight-bearing exercise that works against gravity. Examples include walking, hiking, jogging, stair climbing, playing sports and dancing. Bone status is influenced by variety of genetic (gender and race) and environmental (diet, life style and exercise habits) factors. Exercise is an important dynamic factor that imparts mechanical loading on a living bone tissue. The bone is subject to constant alternation of loading during exercise. It adapts to this alternation by changing its mass and skeletal geometry (4).

If the bone is subject to one-sided loading, which leads to bending, it will change its structure by forming an osseous apposition on the concave side and by an increased resorption on the convex side of the bone. These observations have already been described by Wolff in 1892 and they are generally accepted as Wolf's law. It can be concluded that the bone reacts to loading by an increased bone formation (concave side of the bone) whereas a decrease of loading leads to a loss of bone mass (convex side). Thus the bone has to be exposed constantly to a minimum of loading in order to keep its mass and geometry. Mechanical loading is an essential component for maintenance of normal bone mineral density (BMD) and bone mineral content (BMC) (Lanyon, 1987 and Suominen, 1993) weight bearing activities induce mechanical loading and influences development and maintenance of positive bone health at all ages (5,6,7). Young et al (8) found that women in their seventies had an isometric quadriceps strength 35% below that of women in their twenties, and Harries et al (9) reported that maximal isokinetic quadriceps extensor strength was 30% lower in healthy women in their sixties compared to healthy women in their twenties Bone is subjected to different type of mechanical loading due to differential functional forces involved in different games. Further it is also known that bone responds differently under constant loading such as in marathon and weight lifters than under short term maximum strain as in sprinters and gymnast (7). As a result this study was undertaken to find out the association of strength and BMI to bone mineral density in young adults with different levels of physical activity.

Material and Methods

Subjects. Total of thirty young adults (15 males, 15 females) including men and women both, with mean age 27.5 years were recruited by advertising. None of the subject smoked, had any bone or muscle disease, or was using medication known to effect bone metabolism. Any individual, reported to be active sports person or had any recent knee surgery was excluded from the study. The subjects gave their written consent to participate in the study, which was approved by ethical committee of Guru Nanak Dev University, Amritsar, Punjab, India.

Physical Activity Assessment. Bone specific physical activity questionnaire, devised by B.K. Weeks and B.R. Beck was used to measure the physical activity score of individual of each age group.

BMD Measurement. BMD of mid shaft tibia and distal radius of right limb was taken using ultrasound densitometry. Accuracy and precision of this method has previously been discussed in detail by others (10). SOS was measured for both the sites and Z-score was documented. SOS is a function of both density and elasticity of the cortex (6); the higher the value of SOS, the stronger the bone. The Quantitative Ultrasound Densitometry (QUS) has shown good precision and moderate correlation with bone marrow density as measured by Dual Energy X-ray Absorptiometry (DEXA) at different sites.

Isokinetic Muscle Strength. Concentric quadriceps peak torque of right limb was measured in newton meters using an isokinetic dynamometer. The subject sat at a 90^0 hip angle with lever attached just above the ankle. The dynamometer axis of rotation was aligned with the knee joint and all the testing were done at angular speed of 60^0/sec. Each subject performed 3 sets of five maximal consecutive repetitions. The subjects were allowed to rest for 30 seconds between each set. The average peak torque was used in the correlation analysis.

Hand Grip Strength. Hand grip strength of right hand was measured using digital hand grip dynamometer. Average of 3 readings were documented and used for correlation analysis.

Statistical Analysis. The Pearson's product Moment Correlation Coefficient (r) method was used. The level of p= 0.01, 0.05 was considered significant.

Results

Table I shows the correlation in BPAQ score, BMD of both the limbs i.e. BMDL and BMDU and strength i.e. hand grip (hg) and peak torque of quadriceps (pt) in subjects of 25-30 yrs of age including both the genders. BPAQ score is in significant positive correlation with BMD of both the limbs at 0.01 level. Hg and pt shows significant positive correlation with BMD at the 0.05 level.

Table II shows the correlation in BPAQ score, BMD of both the limbs i.e. BMDL and BMDU and strength i.e. hand grip (hg) and peak torque of quadriceps (pt) in female subjects of 25-30 yrs of age. BPAQ score is in significant positive correlation with BMD of lower limb (BMDL) at 0.01 level whereas it was not significantly correlated with BMD of upper limb (BMDU).

Lower limb strength (pt) shows significant positive correlation with BMD at 0.01 level and upper limb strength (hg) shows positive correlation with BMD at 0.05 level.

Table III shows the correlation in bone specific physical activity (BPAQ) score, BMD of both the limbs (i.e. BMDL and BMDU) and strength, i.e. hand grip (hg) and peak torque of quadriceps(pt) in male subjects of 25-30 years of age.

BPAQ score is in significant positive correlation with BMD of lower limb (BMDL) and BMD of upper limb (BMDU) at 0.01 level.

Lower limb strength (pt) shows significant positive correlation with BMD at 0.01 level but upper limb strength (hg) doesn't shows significant correlation with BMD.

Table IV shows the bivariate correlation in wrist circumference (WC), bi-malleolar girt (BG) and BMD in subjects of 25-30 yrs of age including both genders. Wrist circumference (WC) shows significant positive correlation with BMD of upper limb (BMDU) at 0.01 level, whereas bi-malleolar girth (BG) doesn't shows significant correlation with BMD.

Table I. Correlation in BPAQ score, BMD of both the limbs and strength (both genders)

		BPAQ	BMDL	BMDU	hg	pt
Bpaq	Pearson Correlation	1	.820(**)	.556(**)	.124	.621(**)
	Sig. (2-tailed)		.000	.001	.513	.000
	N	30	30	30	30	30
Bmdl	Pearson Correlation	.820(**)	1	.182	-.167	.513(**)
	Sig. (2-tailed)	.000		.335	.376	.004
	N	30	30	30	30	30
bmdu	Pearson Correlation	.556(**)	.182	1	.305	.412(*)
	Sig. (2-tailed)	.001	.335		.101	.024
	N	30	30	30	30	30
Hg	Pearson Correlation	.124	-.167	.305	1	.368(*)
	Sig. (2-tailed)	.513	.376	.101		.045
	N	30	30	30	30	30
Pt	Pearson Correlation	.621(**)	.513(**)	.412(*)	.368(*)	1
	Sig. (2-tailed)	.000	.004	.024	.045	
	N	30	30	30	30	30

*** Correlation is significant at the 0.01 level (2-tailed); * Correlation is significant at the 0.05 level (2-tailed).*

Table II. Correlation in BPAQ score, BMD of both the limbs (female)

		BPAQ	BMDL	BMDU	hg	pt
Bpaq	Pearson Correlation	1	.930(**)	.479	.323	.754(**)
	Sig. (2-tailed)		.000	.083	.261	.002
	N	14	14	14	14	14
Bmdl	Pearson Correlation	.930(**)	1	.303	.197	.687(**)
	Sig. (2-tailed)	.000		.292	.499	.007
	N	14	14	14	14	14
Bmdu	Pearson Correlation	.479	.303	1	.536(*)	.269
	Sig. (2-tailed)	.083	.292		.048	.352
	N	14	14	14	14	14
Hg	Pearson Correlation	.323	.197	.536(*)	1	.199
	Sig. (2-tailed)	.261	.499	.048		.494
	N	14	14	14	14	14
Pt	Pearson Correlation	.754(**)	.687(**)	.269	.199	1
	Sig. (2-tailed)	.002	.007	.352	.494	
	N	14	14	14	14	14

*** Correlation is significant at the 0.01 level (2-tailed); * Correlation is significant at the 0.05 level (2-tailed)*

Table III. Correlation in BPAQ score, BMD of both the limbs (male)

		BPAQ	BMDL	BMDU	hg	pt
bpaq	Pearson Correlation	1	.973(**)	.756(**)	.425	.746(**)
	Sig. (2-tailed)		.000	.001	.114	.001
	N	15	15	15	15	15
bmdl	Pearson Correlation	.973(**)	1	.662(**)	.422	.721(**)
	Sig. (2-tailed)	.000		.007	.117	.002
	N	15	15	15	15	15
bmdu	Pearson Correlation	.756(**)	.662(**)	1	.447	.761(**)
	Sig. (2-tailed)	.001	.007		.095	.001
	N	15	15	15	15	15
hg	Pearson Correlation	.425	.422	.447	1	.346
	Sig. (2-tailed)	.114	.117	.095		.207
	N	15	15	15	15	15
pt	Pearson Correlation	.746(**)	.721(**)	.761(**)	.346	1
	Sig. (2-tailed)	.001	.002	.001	.207	
	N	15	15	15	15	15

*** Correlation is significant at the 0.01 level (2-tailed).*

Table IV. Correlation in wrist circumference (WC), bi-malleolar girt (BG) and BMD (both genders)

		BMDL	BMDU	WC	BG
Bmdl	Pearson Correlation	1	.414(*)	.460(*)	-.051
	Sig. (2-tailed)		.023	.011	.788
	N	30	30	30	30
Bmdu	Pearson Correlation	.414(*)	1	.476(**)	-.275
	Sig. (2-tailed)	.023		.008	.142
	N	30	30	30	30
Wc	Pearson Correlation	.460(*)	.476(**)	1	-.153
	Sig. (2-tailed)	.011	.008		.418
	N	30	30	30	30
Bg	Pearson Correlation	-.051	-.275	-.153	1
	Sig. (2-tailed)	.788	.142	.418	
	N	30	30	30	30

**Correlation is significant at the 0.05 level (2-tailed);*
***Correlation is significant at the 0.01 level (2-tailed).*

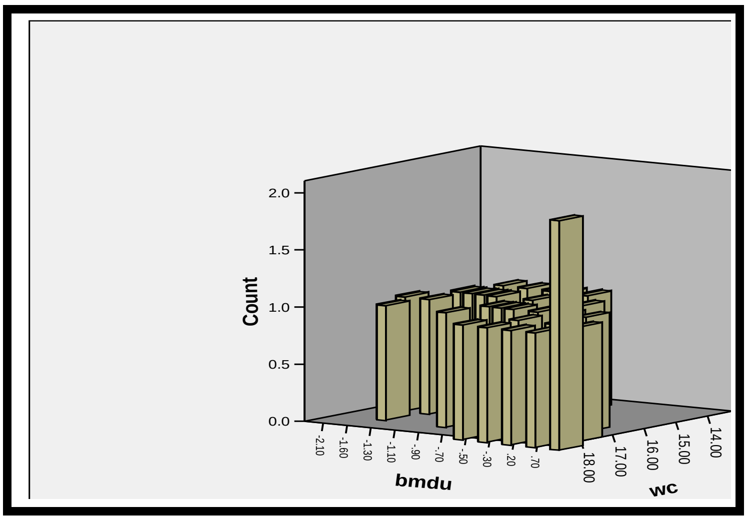

Figure 1. Illustrates 3d bar graph showing correlation in BMD of upper limb (BMDU) and wrist circumference (WC) in age group of 25-30 years

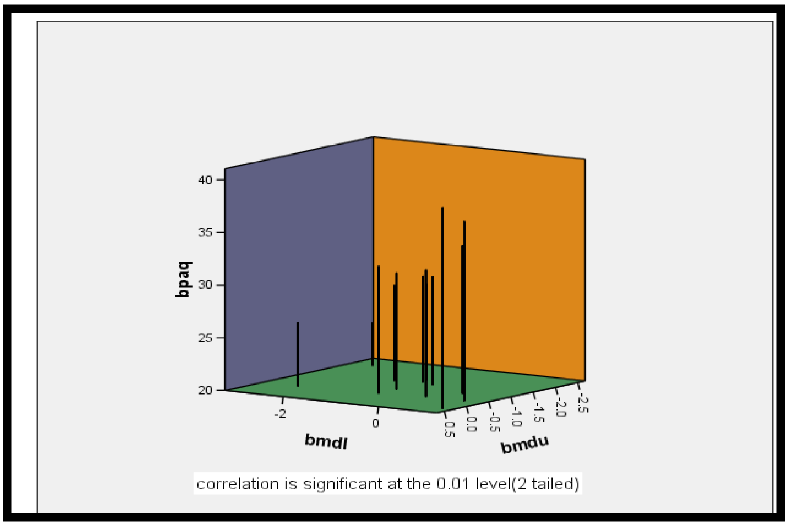

Figure 2. Illustrates 3d bar graph showing correlation in BPAQ score and BMD of both the limbs in age group of 25-30 years

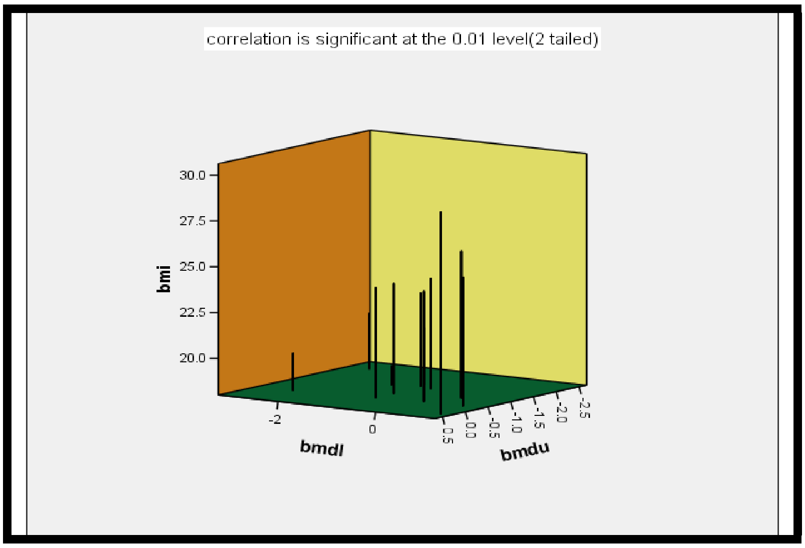

Figure 3. Illustrates 3d bar graph showing correlation in BMI and BMD of both the limbs in age group of 25-30 years

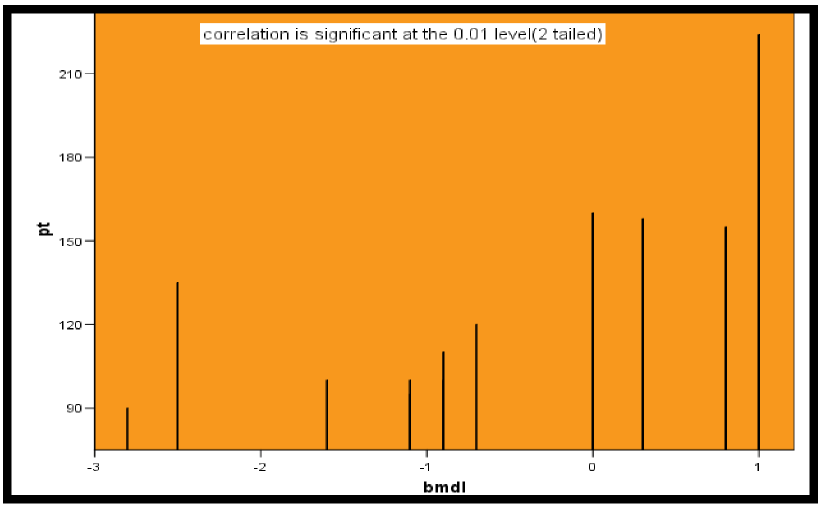

Figure 4. Illustrates bar graph showing correlation in strength of lower limb (pt) and BMD of lower limb (BMDL) in age group of 25-30 years

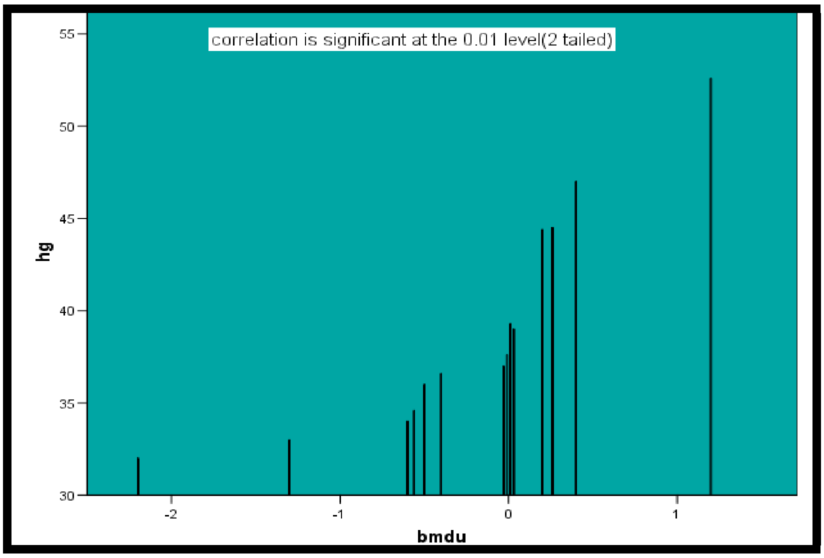

Figure 5. Illustrates bar graph showing correlation in strength of upper limb (hg) and BMD of upper limb (BMDU) in age group of 25-30 years

Discussion and Conclusions

Together these results clearly conclude that bone specific physical activity is an important determinant of BMD after and even before the peak bone mass attainment in young adults of different age groups. In the present study, we have only evaluated BMD of the radius and mid shaft tibia. This measure might be biased from the occupation or the amount of physical activity of a particular limb. Considering these facts we suggest that strength can be a good predictor of BMD at the time of peak bone mass attainment but not before that, on the contrary physical activity is significant predictor of BMD irrespective of age. Our study shows that peak bone mass is attained till third decade of life, thus making strength, physical activity and BMI much better predictor of BMD at this age, which is similar to the studies done on DEXA (6,8) which further proves ease of use, lower cost, and absence of radiation makes QUS a promising tool for evaluating BMD.

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