RESEARCH REVIEW JOURNALS
Volume-03
Issue-09
September-2018

ISSN: 2455-3085 (Online)
RESEARCH REVIEW International Journal of Multidisciplinary
www.rrjournals.com [UGC Listed Journal]

Association between Bone Mineral Density and Physical Function of Indian Women

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ARTICLE DETAILS

Article History
Published Online: 07 September 2018

Keywords
Bone Mineral Density, Physiological, Physical functioning and women

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ABSTRACT

The purpose of this study to observe the difference in physiological and physical functioning parameters among the groups, to classify the predictor variables and to observe the independent and group effect of physiological and fitness variables on BMD. Total 34 Indian women were divided into three age groups Older (N = 11), Middle (N = 10) and Younger adult women (N = 13). Force Vital Capacity was measured through Spirometer. OSTA score was used to predict the BMD risk factors. BMD of the distal radius site measured through Quantity Ultrasound. Physical functioning test included grip strength, isometric back strength, balance, proprioceptive ability and gait velocity. For statistical analysis, One-Way ANOVA followed by Independent sample t-test, Factor Analysis and linear regression were computed. There were considerable correlation between Bone Mineral Density and the selected factors. It was concluded from this study that with progressing age BMD and physiological, physical functioning parameters gradually decline. Factor effect was more significantly predict the bone health status of all age group of women than the independent effect of the parameters. OSTA Index and velocity of gait independently predict the bone health status of all age group of women. BMD improved by the improvement of selective considerable factors.

1. Introduction

In a poor country like India, where most people live under the poverty line, it is very difficult to test the BMD for a huge amount of money, the current investigation tried to solve this problem indirectly through examining some physical functioning test. After reviewing different research works, a concept was developed that as soon as the BMD decreased, strength, balance, proprioceptive abilities were decreased rapidly. Which severely affect the functional movement. Health and Physical fitness measurements can easily perform at low cost and do not require specialized equipment. Thus, they can used effectively to identify young and olderly adult individuals with low bone mass without the need of bone mass measurement. Decline in physical function can lead to physical inactivity in the olderly and reduced the total loading in bones. Health and Physical fitness measurements were considered a screening tool for low bone mass, investigating the association between bone mass and physical function not only help to prevent falls and fracture but may also promote screening among olderly individuals with low bone mass. (Minematsu et al., 2017).

The purpose of this present study to observe the difference in physiological and physical functioning parameters among the groups, to classify the predictor variables according to interrelationship and to observe the independent and group effect of physiological and fitness variables on BMD.

2. Methodology

2.1 Subjects

Investigator invited total 146 women of different age group from the city of Kalyani, WB through the help of some local renounce person and instructors of the Department of Physical Education, University of Kalyani. 82 women willing to participate in this programme from there 70 women were screened according to age group and health status. But during the day of measurement 21 women were absent, 3 women were not participated due to injury, 3 women for sickness, 9 women lost their interest. Finally, 34 women completed this programme. The subjects were divided into three age groups Older adult (N = 11, 58.909), Middle-aged adult (N = 10, 44.700) and Younger adult women (N = 13, 35.231). The oral informed consent obtained from the subjects and the Institutional research committee approved the study. Selected subjects belong to lower socioeconomical status, which was predicted through their approximate monthly family income.

2.2 Personal data

Age was evaluated through the date of birth; weight and height were measured with minimal cloth and without shoes.

2.3 Physiological parameters

Force Vital Capacity (FVC) was measured through Spirometer (Spirolab III, Ver 4.4) including Winspiro PRO Software on line PC connection with icon interface. Osteoporosis Self-Assessment Tool for Asians (OI) score was used to predict the BMD risk factors based on age and weight (Koh et al., 2001). BMD of the distal radius site measured through Quantity Ultrasound Technology (Sunlight Miniomni Maclure software). And obtained SD of T score was used for analysis.

2.4 Physical function test

Handgrip strength (DGS), Isometric Back strength (IB), Standing on One Foot (SOF), Standing on One Foot with eye Close (SOFC) and 10 m gait speed (MS6) were measured. All physical performance test was measured twice and mean value was use for analysis. Investigator measured the tests to assess the strength, balance, proprioception level and gait movement with BMD of the subjects

2.4.1 Isometric grip strength (DGS)

Dominant handgrip strength with 90^0 flexion with standing position was measured by grip dynamometer (Karkkainen et al., 2009, Roberts et al., 2011, Minematsu et al., 2017; Kitamura et al., 2011; Lindsey et al., 2005; NHANES, 2011 and Sias and Mohammad, 2014).

2.4.2 Isometric back strength (IB)

The subjects were asked to stand upright with shoulder width apart on the base of the dynamometer, palm and finger face downward or outward as far as possible in front of the thigh. Then bend forward and grasp the bar, pull as hard as possible with bending the knee (Wood, 2008; IMI, 2014).

2.4.3 Standing on One Foot (SOF)

The subjects were asked to perform one leg (dominant) stand test for 30 Sec. The hand should be placed on the waist, weight bearing foot movement should not be allowed, the spine should be erect, head erect and vision forward. Through this test investigator measured the Static balance (Karkkainen et al., 2009, Lindsey et al., 2005).

2.4.4 Standing on One Foot with eye Close (SOFC)

The subjects were asked to stand barefoot on a hard floor and close the eyes for 30 sec. Then bend the knee and lift the foot approximately 6 inches from the floor. The hand should be placed on the waist, weight bearing foot movement should not be allowed, spine and should be erect. During any movement timer was stopped the watch. Through this test investigator measured the Proprioceptive ability.

2.4.5 10 m gait (MS6)

Walk without assistance for 10 meters with time measured for the intermediate 6 meters, with the command 'Ready Set Go' subject started to walk normal comfortable speed with wearing regular footwear. Time taken by stopwatch when the toes of the leading foot crosses the 2 meter mark and stop timing when the toes of the leading foot crosses the 8 meter mark. Through this test investigator measured the Velocity of gait (Ghosal and Bandyopadhyay, 2018).

2.5 Statistical analysis

All the statistical analyses were performed by using SPSS, version 21.0 on windows 10.0 and significant level considered 0.05. At first the descriptive statistics was (mean and SD) computed for simpler interpretation of the data. Shapiro-Wilk test and Kolmogorov – Smirnov test were computed to determine the sample data has been drawn from normally distributed population or not, and Levine's Test was computed for homogeneity test to determine the equal distribution of single categorical variables of the groups. And found satisfactory results except for the SOF and SOFC test because there was a floor and ceiling effect, cut off time and different age group included in this study. One-way Analysis of Variance was performed to determine the difference among the groups. Independent sample t-test was computed to find difference between the groups. Cronbach alpha used to measure internal consistency or reliability. Kaiser- Meyer- Olkin (KMO) index measure the sampling adequacy. And Bartlett's sphericity test (BTS) were used to assess how adequately the sample size. Exploratory Factor Analysis was conducted to assess the properties of measures in terms of testing the validity to identify adequate fit of scale items. This analysis provides the researcher with a clear understanding of which variables may act in concert and how many variables may actually be expected to have an impact in the analysis. Factor extraction through the process of Principal Component Analysis, and the extraction of the principal factors was performed after Varimax orthogonal rotation. OLS Multiple regression analysis (Ordinary Least Square) used to examine the independent effects of parameters and factors on the BMD with assumption of multicollinearity and autocorrelation.

3. Results

Table 1
Characteristics of all selected parameters

Vr.	Older Adult	Middle aged adult	Younger adult
Age (Yr.)	58.909 ±6.363	44.700 ±2.669	35.231 ±2.774
Height (cm)	150.091 ±3.270	152.900 ±4.725	152.731 ±4.438
Weight (Kg)	55.364 ±6.185	62.600 ±6.883	62.308 ±11.390
FVC (lit)	1.559 ±0.423	2.043 ±0.252	2.022 ±0.193
BMD (T)	-2.782 ±0.252	-2.140 ±0.320	-1.400 ±0.400
OI	-0.709 ±1.688	3.580 ±1.632	5.415 ±2.060
DGS (Kg)	19.364 ±7.963	24.450 ±5.644	31.942 ±6.597
IB (Kg)	23.477 ±4.300	30.800 ±4.014	29.974 ±8.250
SOF (Sec)	7.692 ±11.282	21.892 ±5.943	22.569 ±10.584
SOFC (Sec)	2.183 ±2.293	2.416 ±2.202	3.922 ±1.381
MS6 (m/s)	0.948 ±0.088	0.842 ±0.135	0.773 ±0.082

Table 2
Comparison of physiological and physical function among the group

Vr.	ANOVA F (df = 2,31)		Independent sample t-test OA & MA (df = 19)		OA & YA (df = 22)		MA & YA (df = 21)	
FVC	9.18	P< 0.01	3.14	P< 0.01	3.55	P< 0.01	0.22	P> 0.05
BMD	51.03	P< 0.01	5.13	P< 0.01	9.90	P< 0.01	4.78	P< 0.01
OI	34.51	P< 0.01	5.91	P< 0.01	7.87	P< 0.01	2.31	P< 0.05
DGS	10.35	P< 0.01	1.67	P> 0.05	4.24	P< 0.01	2.87	P< 0.01
IB	4.78	P< 0.05	4.02	P< 0.01	2.35	P< 0.05	0.29	P> 0.05
SOF	8.37	P< 0.01	3.99	P< 0.01	3.33	P< 0.01	0.18	P> 0.05
SOFC	2.81	P> 0.05	0.24	P> 0.05	2.29	P< 0.05	2.01	P> 0.05
MS6	8.84	P< 0.01	2.16	P< 0.05	5.03	P< 0.01	1.52	P> 0.05

OA - Older adult, MA - Middle-aged adult, YA - Younger adult, df - degree of freedom.

Table 2 revealed the One Way ANOVA and Independent sample t-test result of the variables among the groups. All the ANOVA shows significant result, only SRC didn't shown significant difference. All the variables shown significant difference between OA and YA groups. OA and MA shown significant difference in all variables except DGS and SOFC. Only BMD, OI and DGS shown significant difference between MA and YA age group and remaining variables shown insignificant results.

Table 3
Cronbach's Alpha, KMO, and Bartlett test value of the data

Cronbach's Alpha = 0.665	**Cronbach's Alpha based on standardized items = 0.718**	
Kaiser-Meyer-Olikin measure of sampling adequacy	0.828	
Bartlett's test of sphericity	Approx. Chi-square	101.969
	df	28
	P	0.01

Table 4
Factor Analysis Statistics of the data

Vr.	Communalities	Loading	
		Physiological function	**Physical function**
FVC	0.556	0.563	
BMD	0.717	0.786	
OI	0.737	0.810	
IB	0.371		0.540
SOF	0.689		0.756
SOFC	0.759		0.870
MS6	0.707	0.841	
DGS	0.654		0.747
Eigen Value		4.043	1.147
% of Variance		**35.049**	**29.832**

Table 5
Multiple Regression Analysis between BMD and Factors

Model	Unstandardized Coefficients		*t*	*P*	Collinearity statistics
	B	***S. E***			***VIF***
Constant	-2.065	0.063	-32.598	0.01	
Physiological function	0.529	0.064	8.229	0.01	1.00
Physical function	0.211	0.064	3.287	0.01	1.00
***R* = 0.847**	***R Square*** = 0.717		***Adjusted R Sq***. = 0.699		***S. E. of the estimate*** = 0.37
***Durbin-Watson* = 1.56**			***F-stat* = 39.256 (P = 0.01)**		

Table 6
Multiple Regression Analysis between dependent and independent variables

Model	Unstandardized coefficients		*t*	*P*	Collinearity statistics
	B	*Std. Er.*			*VIF*
(Constant)	-1.403	1.01	-1.387	0.177	
FVC	0.262	0.283	0.926	0.363	1.70
OI	0.094	0.036	2.622	0.014	2.04
IB	-0.008	0.014	-0.569	0.562	1.45
SOF	-0.005	0.01	-0.492	0.627	2.05
SOFC	0.056	0.05	1.128	0.270	1.67
MS6	-1.734	0.77	-2.231	0.035	1.45
DGS	0.008	0.013	0.587	0.562	1.92
R = 0.796	**R Square =** 0.634		**Adjusted R Sq. =** 0.535		**S.E. of the estimate =** 0.46
***Durbin-Watson* = 1.158**			***F-stat* = 6.42 (*P* = 0.01)**		

The Cronbach's alpha (0.665) was accepted, reasonable and adequate level for the whole scale. Kaiser-Meyer-Olikin measure of sampling adequacy index 0.828, which came under good category because it was near to one. Bartlett's test of sphericity was 101.969, which was significant at 0.01 level. Which verifies that there was no cross correlation among variables and that all diagonal correlations were zero. Which indicated that the data were suitable for factor analysis.

The Exploratory Factory Analysis (EFA) revealed that 2 out of 8 factors had Eigen value greater than 1. The first factor explained 35.049% of variation and second factor explained 29.832% of variation in the variables in FA. Selected 2-factor total explained 64.88% of the total variation of the variables in FA, which was satisfactory. The communalities value for variables were good because it was more than 0.35. Factor 1 considered as physiological function and factor 2 considered as physical function. The values of factors loading higher than 0.5 level. Greater the loading was more the variable pure measured of factor. There was no negative correlation found in any factor.

Linear regression was calculated to predict the BMD based on the two factors. From Table 5 significant regression equation was found (df = 2, 31 F = 39.256, P < 0.01). Which was good to explained the Dependent Variable (DV). R of this factor regression was 0.847, which was close to positive 1 and values indicated stronger relationship. The values of R^2 of the factors was 0.717, it was positive and close to 1, which indicated that the model was a good fit. Also said that the model containing the factors can explain 71.7% variation of BMD. Adjusted R^2 of factors was 0.699, which was more closely reflect the goodness of fit of the model. Also said that more precisely 69.9% of variables of BMD closely related to the factors. The value of Durbin Watson test was 1.56, which was close to 2, and not violate the assumption of independency. VIF value of two factors of present study was ranged in 1 which indicated that there was no multicollinearity among the group and data was reliable. It was mentioned that higher the VIF value less reliable the regression result. After the confirmation for the model fit, want to know the relative importance of each factor in predicting BMD. The unstandardized beta coefficients were considered for the analysis. The predicted value of this study was -2.065 (SE = 0.063) which was highly significant (t = -32.598, P < 0.01). The regression equation written as, the participant predicted BMD = {-2.065 + 0.529** (Physiological function) + 0.211** (Physical function)}. When the variables measured in-group or factors. The coefficient for Physiological function was 0.529 (SE = 0.064), so for every unit increase in Physiological function, 0.529 unit increase in BMD was predicted, holding all other variables constant. The same way the coefficient for Physical function was 0.211 (SE = 0.064), so for every unit increase in Physical function, 0.211 unit increase in BMD was predicted, holding all other variables constant. The value of Physiological function (t = 8.229, P < 0.01) and Physical function (t = 3.287, P < 0.01) were significant evidence to suggest that both the grouping factor was not zero (P < 0.01) (Hair et al., 2010; Field 2000).

Table 6 revealed the Multiple Linear regression to predict the BMD based on all the variables. And significant regression equation was found (df = 7, 26 F = 6.42, P < 0.01). R of this variables regression was 0.796, and values indicated stronger relationship. The values of R^2 of variables were 0.634, and the model was good fit. The variables can explain 63.4% variation of BMD. Adjusted R^2 of the variables were 0.535, which was more closely reflect the goodness of fit of the model. Alternatively, 53.5% of variables of BMD closely related to the variables. Durbin Watson test value was 1.158, which indicated the assumption has almost certainly been met. All VIF value of variables were ranges of 1.45 to 2.05 well below the cutoff value of 5. Which indicated that multicollinearity was not threat to the substantive conclusion of this study and data was reliable. The predicted value of this study was -1.403 which was not significant (t = -1.387, P > 0.05). The regression equation written as, the participant predicted BMD = {-1.403 + 0.262 (FVC) + 0.094 (OI)* – 0.008 (IB) – 0.005 (SOF) + 0.056 (SOFC) – 1.734 (MS6) *+ 0.008 (DGS)}. The coefficient for FVC was 0.262 (SE = 0.283), so for every lit. increase in FVC, 0.262 unit increase in BMD was predicted, holding all other

variables constant though the t value shown insignificant result (t = 0.926, P > 0.05). Same way the coefficient for OI was 0.094 (SE = 0.036), so for every unit increase in OI, a 0.094 unit increase in BMD was predicted, and t value shown significant result (t = 2.622, P < 0.05). The coefficient for IB was -0.008 (SE = 0.014), its equivalent to zero and the t value shows insignificant result (t = -0.492, P > 0.05). The coefficient for SOF was -0.005 (SE = 0.01), its equivalent to zero and the t value shows insignificant result (t = -0.569, P > 0.05). The coefficient for SOFC was 0.056 (SE = 0.05), so for every second increase in SOFC, 0.056 unit increase in BMD was predicted, and the t value shows insignificant result (t = 1.128, P > 0.05). The coefficient for MS6 was -1.734 (SE = 0.77) which shows negative relationship and so for every second decreases in velocity of gait, 1.734 unit increase in BMD was predicted, and t value shows significant result (t = -2.231, P < 0.05). The coefficient for DGS was 0.008 (SE = 0.013), its equivalent to zero and the t value shows insignificant result (t = 0.587, P > 0.05).

From the result of the above table, it was observed that factor effect was more significant to predict the BMD status than the individual effects of variables. Although OSTA Index (OI) and velocity gait independently (MS6) predict the status of BMD significantly, but remaining variables were unable to predict the status significantly.

4. Discussion

From the result of ANOVA and t-test, it was observed that all the physiological and fitness variables of older adult group was lower than younger adult group and also from middle aged adult group. Middle aged and younger adult groups didn't shown so much difference between them only the BMD, OI and grip strength shown the difference.

From this result, it was inspected that with augmentation of age FVC gradually loss. It was seen that FVC of younger adult women group was better than older adult women group. The FVC of older adult women group was lower than the other group. Ei-Hoshy et al., 2017 found a strong association between BMD and Pulmonary function and concluded that pulmonary function (FEV_1, FVC, FEV_1/FVC) most important predictor of BMD. The study of Jeon et al., 2014 concluded that pulmonary function, including FVC, FEV_1 were associated with BMD of healthy, nonsmoking premenopausal women but not in post-menopausal women.

It was seen that BMD of younger adult women group was better than middle-aged and older adult women group. The BMD of older adult women group was lower than the other group. From this result, it was inspected that with augmentation of age BMD gradually loss, bone became more fragile, less weight bearing capacity and prone to fracture because less modelling and remodeling of bone tissue, estrogen deficiency and inactive life style. The average BMD of younger adult women group enter the cutoff area of the osteopenic region, middle-aged adult women group considered as the osteopenic group, and older adult women group considered as the osteoporotic group. Result from the National Osteoporosis Risk Assessment (NORA) reported that osteoporosis was associated with fracture rate approximately four times that of normal BMD and osteopenia was associated with 1.8 fold higher rate (Aggarwal et al., 2011).

It was seen that OI of younger adult women group was better than middle-aged and older adult women group. The OI of older adult women group was lower than the other group. The result shows that the younger adult women group OI score was normal, healthy and better than other remaining group. The middle-aged adult women group OI score was normal, healthy and better than older adult women group. Older adult women group OI score was lower than other groups and the score of OI of this group closer to the low risk category. From this result, it was observed that with progressive age and weight loss, the risk of bone health continues to increased and OI score progressing towards the risk region. It was understood that weight control was very important with age for eliminating risk factors regarding bone health. Analogously Patel, Jadhav, & Vieira (2014) reported that OI was a simple and free risk assessment tool that can be used to women with low BMD in the 50 and above age groups.

It was seen that the younger adult women group grip strength better than middle aged and older adult women group. And older adult women group back strength, static balance and velocity of gait lower than younger and middle aged adult women group. Proprioceptive ability of older adult women group significantly lower than younger adult women group. Lindsey et al., 2005 hypothesized that better performance scores for gait speed, SOF time, Grip strength could be associated with higher BMD of hip, spine, whole body, forearm because greater wt. bearing input during usual activities and evaluation of this physical performance measurement may help with osteoporosis prevention and treatment for Peri and post-menopausal women, when BMD score didn't obtained. And advised that measuring only one of the physical performance variables (SOF, Gait speed) would sufficient for estimating hip and whole body BMD, whereas grip strength can provide an estimate of forearm BMD. Alike Minematsu et al., 2017 proved that olderly women low physical function to have low bone mass. SOF, 10 m gait time can be a good predictor of Osteopenia and Osteoporosis. Karkkainen et al., 2009 suggested that increased the grip strength was associated with decreased the risk of fracture. And concluded that grip strength and balance used in medical decision making to identify those women who would benefitted from BMD measurement although alone it may not provide accurate enough tool for Osteoporosis screening. Sirola et al., (2005) concluded after 5 and 10 year follow up of peri and post-menopausal women that grip strength are strongly associated with axial BMD among peri and postmenopausal women. Kitamura et al., 2011 conducted 5-year cohort study and concluded that physical activity was the determinants of physical function like strength, mobility and BMD in postmenopausal women. Ghosal and Bandyopadhyay (2018) reported that grip strength and velocity of gait significantly predict the BMD of osteopenic and osteoporotic women. Specifically, velocity of gait was a good predictor of BMD of Osteoporotic women.

Results of Factor Analysis shown that Physiological condition considered as first factor and may be viewed as the single best summary of linear relationship exhibited in the data.

Fitness condition was the second factor. The second factor defined as a second best linear combination of the variables, and subjects to the constraint that it was orthogonal to the first factor. All the factors had a positive significant effect on BMD. Thus, BMD would be expected to improved as the values of physiological and fitness factors improved. After the multiple regression analysis with both factors and with the variables, it was observed that result of group effect was more prominent than individual parameter effect. Improvement of BMD happens through the constellation of several parameters, or by working several variables together, not by the nature of any one variable. And all the parameters were intercorrelated with each other, and with the development of one variables another variables also developed automatically.

5. Conclusion

It was concluded from this study that with progressing age BMD and other physiological, physical functioning parameters gradually decline. OSTA Index and velocity of gait independently predict the bone health status of all age group of women. There were considerable correlation between Bone Mineral Density and the selected factors. Therefore, BMD must be improved by the improvement of selective considerable factors. Factor effect was more significantly predict the bone health status of all age group of women than the independent effect of the parameters. This study may helpful in the prevention and treatment of the bone health of Indian women.

Acknowledgement

We are very thankful to Dr. Sanjay Gupta (M.D, Regd No: 54578) for his supervision to conducting the tests, Prof. Amalendu Bhunia, Dept. of Commerce, University of Kalyani, for statistical advice, Departmental Research Committee and Head of the Department of Physical Education for approval the research work and Mr. Surajit Modok, Department of Environmental Science for technical support.

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