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EFFECT OF ELASTIC RESISTANCE TRAINING ON PHYSICAL FUNCTIONING AND BONE HEALTH OF INDIAN WOMEN

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ABSTRACT

The aim of this study to classify the predictor variables and to observe the independent and group effect of physiological and fitness variables on BMD, to find out the effect of resistance exercise on Bone Mineral Density, other physiological and fitness variables. Total 34 subjects of three different age group viz. young adult (30 – 39 yr.), middle aged adult (40 – 49 yr.), and older adult (> 50 yr.) women were complete the training programme. Forced Vital Capacity was measured through Spirometer. OSTA score was used to predict the BMD risk factors. Distal radius site BMD measured through Quantity Ultrasound. Physical functioning test included grip strength, isometric back strength, balance, proprioceptive ability and gait velocity. The 17 weeks elastic resistance-training conducted 8 – 10 exercise, 70 min/session, 3 days/week, 8 repetitions and 3 sets with 20 – 30 sec recoveries. According to adaptation of the load, repetitions and resistance level were changed. For statistical analysis, one way ANCOVA, Paired sample t test, Factor Analysis and linear regression analysis were computed. The value of Physiological Condition ($t = 8.229$, $P<0.01$) and Fitness Condition ($t = 3.287$, $P < 0.01$) were significant. OSTA Index ($t = 2.622$, $P < 0.05$) and velocity gait ($t = -2.231$, $P < 0.05$) independently predict the status of BMD significantly. It was concluded that the training programme was effective for all age groups of women specifically for olderly adult women and BMD may be improved by the improvement of selected physiological and fitness factors.

Keywords: Bone Mineral Density, Women, Physical functioning, Physiological condition, Resistance exercise.

1. INTRODUCTION

Several risk factors contribute to low bone mass which include non-modifiable factors like female sex, old age, small thin built, Caucasian or Asian and family history of fractures. Ethnic

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differences in BMD are strongly influenced by body weight. Important modifiable risk factors include calcium and Vit. D deficiency, sedentary life style, smoking, excessive alcohol and caffeine intake (Keramat & Mithal, 2005). The pathogenesis of osteoporosis is complex. During childhood to adolescent period approximate at the age 30 years' bone formation exceeds bone resorption and bone density reach its peak. After that resorption begin to exceed formation and average 0.7% loss bone mass per year. After menopausal in women the process of osteoporosis is accelerated due to deficiency of estrogen. Estrogen helps in the positive calcium metabolism and osteogenesis. Menopause accelerates the bone loss to 2-5% per year, which may continue till 10 years. After this period of rapid activity, bone remodeling slows down, but continues at a faster rate than in premenopausal women (Iniguez-Ariza, Nicole, Bart, Clarke, 2015). Prevalence of osteoporosis increases with age in women and not in men. Peak bone mass is primarily determined by genes but may be modified to a considerable extent by certain factors like physical activity, calcium, vitamin D, nutrition, smoking, alcohol, concurrent illnesses, and medications (Ghosal & Bandyopadhyay, 2018a).

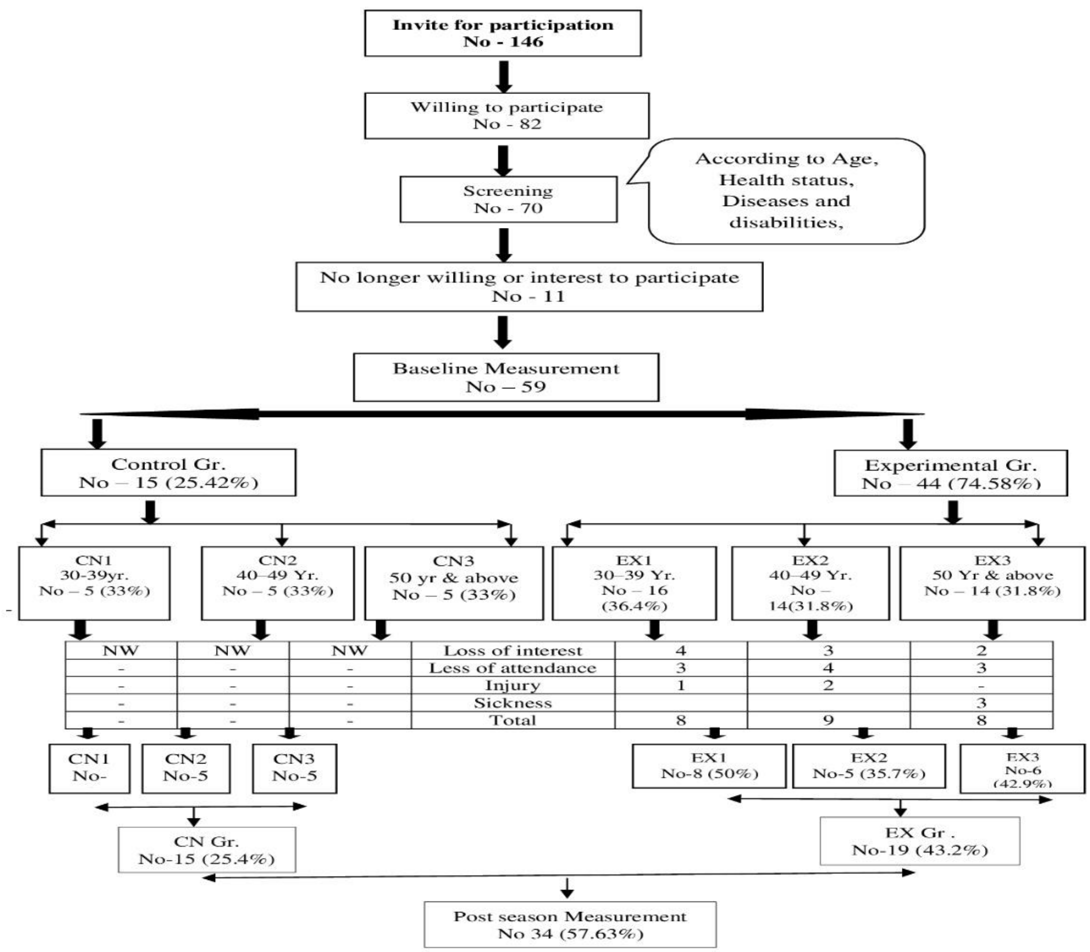
Women face more than double the risk of getting fractures compared with men, largely due to osteoporosis, or major loss of bone mass. It is one reason they spend 10.7% of their lives in poor health, compared with 9.4% for men. Women start to lose bone mass from age 35, against 45 for men. Between 2007 and 2009, 1,477 women and 634 men per thousand fractured their hips each year. These fractures often result in long periods of immobility, loss of muscle strength and bedsores. The bone loss of women do at a faster rate 0.75 % to 1 % a year compared with 0.5 % a year for men (Salma Khalik, The Straits Times on January 14, 2017).

The aim of this study firstly to classify the predictor variables according to interrelationship and to observe the independent and group effect of physiological and fitness variables on BMD. Secondly to find out the effect of 17-weeks of resistance exercise on Bone Mineral Density (BMD), other physiological variables and selected fitness variables of women of three different age groups, viz. young adult (30 – 39 yr.), middle aged adult (40 – 49 yr.) and older adult (> 50 yr.) women groups.

2. METHODOLOGY

2.1 Subjects

The subjects of this study were residents of different localities of Kalyani, Nadia, WB. They comprise of middle class sedentary young adults, middle-aged adults and elderly adult women age range from 30 years to 74 years. For the purpose of this study investigator screened and selected total 59 sedentary young adults [(30 – 39 years) CN_1 and EX_1], middle-aged adults [(40 – 49 years) CN_2 and EX_2] and older adults [(50 years and above) CN_3 and EX_3] women during baseline measurement (Petry, 2002). The investigator had six groups three in Control Group, CN_1 (N = 5), CN_2 (N = 5), and CN_3 (N = 5). And three in Experimental group, EX_1 (N = 16), EX_2 (N = 14) and EX_3 (N = 14). Among 59 subjects 9 subjects (EX_1 = 4, EX_2 = 3, EX_3 = 2) did not take part in training programme due to lack of interest, 6 of them due to injury and sickness [Injury = 3 (EX_1 = 1, EX_2 = 2), Sickness = 3 (EX_3 = 3)] and 10 subjects (EX_1 = 3, EX_2 = 4, EX_3 = 3) were eliminated from post-test due to lack of optimum attendance during training programme. Finally, 34 subjects from both groups could finish the training program. 5 subjects from each control group and 8 subjects from EX_1, 5 subjects from EX_2 and 6 subjects from EX_3 completed the training protocol.



NW	NW	NW		EX1	EX2	EX3
NW	NW	NW	Loss of interest	4	3	2
-	-	-	Less of attendance	3	4	3
-	-	-	Injury	1	2	-
-	-	-	Sickness			3
-	-	-	Total	8	9	8

Fig 1: Summary of the recruitment strategy and allocation

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Table 1: Percentage of attendance of training programme of three Experimental groups

Group	Percentage of attendance
EX_1	96.6%
EX_2	98%
EX_3	90.2%
Average attendance	94.93%

Investigator included those volunteers who tried to attained 3 days/week in a regular manner and percentage of attendance more than 90%. Who did not participated in regular manner and attendance less than 90% were excluded from this study.

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 variables

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, T score was used for analysis.

2.4 Physical fitness variables

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; Sias and Mohammad, 2014; Ghosal and Bandyopadhyay, 2018b; Ghosal and Bandyopadhyay 2018c).

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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; Ghosal and Bandyopadhyay 2018c).

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; Ghosal and Bandyopadhyay 2018c).

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 (Ghosal and Bandyopadhyay 2018c).

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, 2018b; Ghosal and Bandyopadhyay, 2018c).

2.5 17 weeks of progressive elastic resistance training programme

The study was conducted in the gymnasium of the Department of Physical Education, University of Kalyani. The elastic resistance-training program conducted 8 – 10 exercise, 70 min/session, 3 days/week, for 17 weeks (Black Mountain Elastic Resistance Band). After the warm up session (10 min), each EX group was performed selected elastic resistance exercises with elastic bands (50 min). Training protocol was selected according to the guideline of ACSM (2011). Each exercise was selected according to muscle group and for the fulfilment of the purpose of the investigation. Degree of the load was gradually increased and exercises were modified according to load adaptation for each individual. It's classified into 3 groups – I) Upper extremity Exercises

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II) Core Exercises III) Hip and Lower extremity exercises and each group had 2 to 3 exercises but the specific focus given on the arm. At the beginning of the training period subjects were started with light colour (Yellow) low resistance level band. Each resistance band exercises started with 8 repetitions, 3 sets with 20 – 30 sec. recoveries, and according to the adaptation of the load gradually the repetitions were changed to 10 – 15, subsequently the resistance level also changed (Blue and then Green colour resistance band). The training intensity of elastic band strength training was approximate by the resistance level or colour coded of the resistance band. Training session finished with cooling down (10 min).

2.6 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 Covariance (ANCOVA) was used to determine differences among the groups. Paired sample t-test was computed to compare the effects of 17-week elastic resistance training program on each group. 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.

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3. RESULTS

Table 2: Cronbach's Alpha, KMO, and Bartlett test value of Pretest result

Cronbach's Alpha and KMO and Bartlett's Test		
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

The internal consistency assessed by Cronbach's alpha (0.665) was accepted, reasonable and adequate level for the whole scale of pretest data. Kaiser-Meyer-Olikin measure of sampling adequacy index 0.828, which represents the ratio of squared correlation between variables to the squared partial correlation between variables. The value 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.

Table 3: Factor Analysis Statistics of Pre-test result

Variables	**Communalities**	**Loading**	
		Physiological condition	**Fitness condition**
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

The Exploratory Factory Analysis (EFA) revealed from that 2 out of 8 factors had eigen value greater than 1, because eigen value represents the variance and that each standardized variables contributes to principle component extraction was 1, component less than 1 not considered as a factor. Selected 2-factor total explained 64.88% of the total variation of the variables in FA,

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which was satisfactory. The communalities value for variables were good because it was more than 0.35. Factor 1, considered as physiological function and contain four variables FVC, OI, BMD and MS6. In addition, factor 2 considered as health and fitness function and contain 4 variables, IB, SOF, SOFC, and DGS. The orthogonal varimax rotation, the values of factors loading all correlations between variables and corresponding factor higher than 0.5 level. Greater the loading was more the variable pure measured of factor. For instance, FVC, BMD, OI, which shows the highest correlation with factor 1, or physiological functioning for this reason it was considered as a group. In a same way DGS, SOF, SOFC and MS6 shows the second highest correlation with factor 2 or fitness functioning for this reason it considered as a group. There was no negative correlation found in any factor.

Table 4: 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 condition	0.529	0.064	8.229	0.01	1.00
Fitness condition	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)		

Factor score coefficients in Table 4 were used to determine the significant predictors of BMD (DV). Factors score value for selected 2 factors of pre-test result were used as independent variables in linear regression analysis to determine the significant factors of BMD. As seen from the above table all the selected factors (Factor 1 and 2) were found significant (at 0.01 level) linear relationship with BMD. Therefore, the measurement model in this study shows satisfactory reliability and validity. The unstandardized beta coefficients of the predicted value was -2.065 (SE = 0.063) which was highly significant at (t = -32.598, $P < 0.01$) 0.05 level. The regression equation written as -

*BMD = {-2.065 + 0.529** (Physiological Condition) + 0.211** (Fitness condition)}*

When the variables measured in-group or factors. The coefficient for PC was 0.529 (SE = 0.064), so for every unit increase in PC, a 0.529 unit increase in BMD was predicted, holding all other variables constant. The same way the coefficient for FC was 0.211 (SE = 0.064), so for every unit increase in FC, a 0.211 unit increase in BMD was predicted, holding all other variables

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constant. The significant value of PC (t = 8.229, P < 0.01) and FC (t = 3.287, P < 0.01) was significant evidence to suggest that both the grouping factor was not zero (P < 0.01) (Hair et al., 2010; Field 2000).

Table 5: Multiple Regression Analysis between dependent and independent variables of pre-test result

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)		

Table 5 revealed the Multiple Regression Analysis between dependent and independent variables of pre-test data. After the confirmation for the model fit, want to know the relative importance of each predictors (IV) in predicting BMD (DV). The unstandardized beta coefficients predicted value of this study was -1.403 which was not significant (t = -1.387, P > 0.05) at 0.05 level. The regression equation written as -

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, a 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, holding all other variables constant 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, holding all other variables constant and the t value shows insignificant result (t = 1.128, P >

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0.05). The coefficient for MS6 was -1.734 (SE = 0.77) which shows negative relationship and so for every second decreases in MS6 or velocity of gait, 1.734 unit increase in BMD was predicted, holding all other variables constant 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).

Table 6: Cronbach's Alpha, KMO, and Bartlett test value of Post-test result

Cronbach's Alpha and KMO and Bartlett's Test		
Cronbach's Alpha = 0.739	Cronbach's Alpha based on standardized items = 0.697	
Kaiser-Meyer-Olikin measure of sampling adequacy	0.768	
Bartlett's test of sphericity	***Approx. Chi-square***	143.886
	df	28
	P	0.01

The internal consistency (0.739) was accepted, and relatively high (0.45 – 0.98, Accepted: 0.70 – 0.77) level for the whole scale of post-test data. Sampling adequacy index 0.768, which came under good category because it was near to one. Bartlett's test of sphericity was 143.886, which was significant at 0.01 level. Which indicated that the data were suitable for factor analysis.

Table 7: Factor Analysis Statistics of Post-test result

Variables	**Communalities**	**Loading**	
		Fitness condition	**Physiological condition**
FVC Post	0.654	0.710	
BMD Post	0.621		0.679
OI Post	0.862		0.927
IB Post	0.603		0.763
SOF Post	0.765	0.732	
SOFC Post	0.805	0.894	
MS6 Post	0.772	0.866	
DGS Post	0.668	0.684	
Eigen Value		4.352	1.398
% of Variance		40.354	31.342

Selected 2-factor total explain 71.696% of the total variation of the variables in FA, which was satisfactory. The communalities value for all variables were good because it was more than 0.6. Factor 1 considered as Fitness function and contain five variables, FVC, SOF, SOFC, and DGS,

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MS6. In addition, factor 2 considered as Physiological function and contain three variables, OI, BMD and IB. In the orthogonal varimax rotation, the values of factors loading, all correlations between variables and corresponding factor higher than 0.6 level. There was no negative correlation found in any factor.

Table 8: Multiple Regression Analysis between BMD Post and Factors

Model	Unstandardized coefficients		t	P	Collinearity statistics
	B	***S. E***			***VIF***
Constant	-1.97	0.08	-24.538	0.01	
Fitness condition	0.295	0.08	3.619	0.01	1.00
Physiological condition	0.502	0.08	6.146	0.01	1.00
R = 0.788	***R Square*** = 0.621		***Adjusted R Sq***. = 0.597		***S. E. of the estimate*** = 0.47
Durbin-Watson = 1.503			***F-stat*** = 25.435 (*P* = 0.01)		

Factors score value for selected 2 factors of post-test result were used as independent variables in linear regression analysis to determine significant factors of BMD. As seen from the table all the selected factors (Factor 1 and 2) were found significant (at 0.01 level) linear relationship with BMD. Therefore, the measurement model in this study shows satisfactory reliability and validity. The predicted value of this study was -1.97 (SE = 0.08) which was highly significant at 0.05 level (t = - 24.538). The regression equation written as-

*BMD = {-1.97 + 0.295** (Fitness condition) + 0.502** (Physiological Condition)}.*

When the variables measured in-group or factors. The coefficient for FC was 0.295 (SE = 0.08), so for every unit increase in FC, 0.295 unit increase in BMD was predicted, holding all other variables constant. Same way the coefficient for PC was 0.502 (SE = 0.08), so for every unit increase in PC, 0.502 unit increase in BMD was predicted, holding all other variables constant. The significant value of FC (t = 3.619, P < 0.01) and PC (t = 6.146, P < 0.01) was significant evidence to suggest that both the grouping factor was not zero (P < 0.01) (Hair et al., 2010; Field 2000).

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Table 9: Multiple Regression Analysis between dependent and independent variables of post-test data

Model	Unstandardized coefficients		*t*	*P*	Collinearity statistics
	B	***Std. Er.***			***VIF***
(Constant)	-0.443	1.29	-0.344	0.734	
FVC Post	0.09	0.29	0.302	0.765	2.106
OI Post	0.16	0.036	4.435	0.01	1.855
IB Post	0.05	0.023	2.244	0.034	2.074
SOF Post	0.026	0.017	1.540	0.136	3.494
SOFC Post	-0.015	0.022	-0.691	0.495	2.386
MS6 Post	-1.462	0.983	-1.486	0.149	2.453
DGS Post	0.002	0.014	0.137	0.892	2.334
R = 0.815	***R Square*** = 0.664		***Adjusted R Sq.*** = 0.574		***S.E. of the estimate*** = 0.48
Durbin-Watson = 1.586			***F-stat*** = 7.342 (*P* = 0.01)		

After the confirmation for the model fit, want to know the relative importance of each predictor variables (IV) in predicting BMD (DV). The predicted value of this study was -0.443 (SE = 1.29) which was not significant (t = -0.344, P > 0.05). And the regression equation written as -

BMD = {-0.443 + 0.09 (FVC) + 0.16 (OI) + 0.05* (IB) + 0.026 (SOF) - 0.015 (SOFC) – 1.462 (MS6) + 0.002 (DGS)}*

The coefficient for FVC was 0.09 (SE = 0.283), so for every lit. increase in FVC, 0.09 unit increase in BMD was predicted, the t value shows insignificant result (t = 0.302, P > 0.05). Same way the coefficient for OI was 0.16 (SE = 0.036), so for every unit increase in OI, a 0.16 unit increase in BMD was predicted, and t value shown significant result (t = 4.435, P < 0.05). The coefficient for IB was 0.05 (SE = 0.023), so for every Kg increase in IB, a 0.05 unit increase in BMD was predicted, and the t value shows significant result (t = 2.244, P < 0.05). The coefficient for SOF was 0.026 (SE = 0.017), so for every Sec. increase in SOF, a 0.026 unit increase in BMD was predicted, and the t value shown insignificant result (t = 1.540, P > 0.05). The coefficient for SOFC was -0.015 (SE = 0.022), it was equivalent to zero and the t value shown insignificant result (t = -0.691, P > 0.05). The coefficient for MS6 was -1.462 (SE = 0.983) which shows negative relationship and so for every second decreases in MS6 or velocity of gait, 1.462 unit increase in BMD was predicted, and t value shows insignificant result (t = -1.486, P > 0.05). The coefficient for DGS was 0.002 (SE = 0.014), its equivalent to zero and the t value shown insignificant result (t = 0.137, P > 0.05).

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From the result of the above table, it was observed that group effect was more significant to predict the BMD status than the individual effects of variables. OI only a predictor predict the status of BMD independently in both pre and post-test analysis.

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Table 10: Descriptive statistics of Pre and Post-test result of all the variables of CN and EX. groups

Variables		Group											
		CN₁ (*n = 5*)		EX₁ (*n = 8*)		CN₂ (*n = 5*)		EX₂ (*n = 5*)		CN₃ (*n = 5*)		EX₃ (*n = 6*)	
		Pretest	**Posttest**	**Pretest**	**Posttest**	**Pretest**	**Posttest**	**Pretest**	**Posttest**	**Pretest**	**Posttest**	**Pretest**	**Posttest**
		M (SD)	***M (SD)***	***M (SD)***	***M (SD)***	***M(SD)***	***M (SD)***	***M (SD)***	***M (SD)***	***M (SD)***	***M (SD)***	***M (SD)***	***M (SD)***
PD	**Age (Yr.)**	34.2 (±3.11)		35.88 (±2.53)		43.2 (±2.77)		46.2 (±1.64)		60.2 (±1.79)		57.83 (±8.68)	
	Height (cm)	153.4 (±4.62)		152.31 (±4.59)		155.00 (±5.29)		150.8 (±3.35)		150.2 (±2.05)		150.00 (±4.24)	
	Weight (Kg)	59.60 (±11.84)	60.00 (±12.06)	64.00 (±11.56)	62.63 (±10.62)	63.40 (±7.73)	65.00 (±7.71)	61.80 (±6.72)	59.80 (±6.46)	56.20 (±5.67)	56.20 (±5.67)	54.67 (±7.03)	53.33 (±6.65)
PV	**FVC (lit.)**	1.92 (±0.23)	1.92 (±0.23)	2.09 (±0.15)	2.36 (±0.21)	2.04 (±0.23)	2.04 (±0.23)	2.05 (±0.30)	2.15 (±0.44)	1.44 (±0.58)	1.44 (±0.58)	1.66 (±0.26)	1.995 (±0.18)
	BMD (T score)	-1.34 (±0.38)	-1.44 (±0.32)	-1.44 (±0.43)	-1.18 (±0.66)	-2.08 (±0.40)	-2.16 (±0.40)	-2.20 (±0.25)	-1.98 (±0.23)	-2.82 (±0.16)	-2.88 (±0.18)	-2.75 (±0.32)	-2.57 (±0.35)
	OI	5.08 (±1.91)	5.16 (±1.93)	5.63 (±2.25)	5.35 (±2.10)	4.04 (±1.84)	4.32 (±1.88)	3.12 (±1.44)	2.72 (±1.38)	-0.80 (±1.33)	-0.80 (±1.33)	-0.63 (±2.00)	-0.90 (±1.91)
FV	**DGS (Kg)**	28.70 (±7.19)	28.50 (±7.02)	33.97 (±5.73)	38.41 (±5.71)	23.60 (±3.32)	23.60 (3.31)	25.30 (±7.67)	30.15 (±6.47)	16.30 (5.37)	16.30 (±5.03)	21.92 (±9.30)	26.92 (±7.28)
	SOF (Sec)	22.60 (±9.42)	22.00 (±7.04)	22.55 (±11.89)	28.22 (±4.27)	21.00 (±5.66)	20.80 (±1.92)	22.78 (±6.74)	29.01 (±1.40)	2.80 (±2.95)	4.00 (±2.55)	11.77 (±14.27)	23.13 (±6.85)
	SOFC (Sec)	3.60 (±0.89)	3.20 (±1.30)	4.12 (±1.64)	10.45 (±5.45)	2.30 (±2.11)	2.40 (±2.07)	2.53 (±2.53)	9.99 (±6.58)	1.20 (±0.45)	1.20 (±0.45)	3.00 (±2.93)	9.46 (±6.54)
	MS6 (m/s)	0.78 (±0.09)	0.84 (±0.07)	0.77 (±0.08)	0.69 (±0.06)	0.92 (±0.10)	0.92 (±0.10)	0.77 (±0.13)	0.70 (±0.14)	0.996 (±0.08)	0.986 (±0.05)	0.91 (±0.08)	0.75 (±0.05)
	IB (Kg)	30.15 (±5.00)	30.20 (±4.92)	29.86 (±10.12)	31.55 (±4.20)	32.75 (±3.86)	32.50 (±4.36)	28.85 (±3.44)	34.27 (±2.98)	23.20 (±4.68)	23.00 (±4.90)	23.71 (±4.40)	26.54 (±3.42)

M: Mean, SD: Standard Deviation, PD: Personal Data, PV: Physiological Variables, FV: Fitness Variables, FVC: Forced Vital Capacity, BMD: Bone Mineral Density, OI: OSTA Index, MS6: Velocity of 10m walk, DGS: Dominant hand Grip Strength, SOF: Standing on one Foot, SOFC: SOF with eye close.

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Table 11: One-way ANCOVA and Paired sample t-test of pre and post-test result of Control and Experimental groups

Variables	F (df =5,27)	t test					
		EX_1 (df = 7)	EX_2 (df = 4)	EX_3 (df = 5)	CN_1 (df = 4)	CN_2 (df = 4)	CN_3 (df = 4)
FVC	4.22**	4.75**	-0.79	2.97*	-	-	-
BMD	4.62**	-2.23	-11.0**	-5.97**	1.29	1.63	2.45
OI	4.17**	1.67	2.58	4.00**	-1.63	-1.51	-
DGS	7.73**	3.10*	5.47**	3.20*	1.63	0	0.54
SOF	18.72**	1.75	2.24	2.76*	0.29	0.10	1.50
SOFC	4.08**	2.99*	2.92*	3.56*	1.63	1.00	0
MS6	7.45**	4.38**	0.73	3.95**	2.02	-0.18	0.66
IB	4.61**	-0.64	3.26*	2.78*	1.00	1.00	1.37

* Significant at 0.05 level, ** Significant at 0.01 level

The One Way ANCOVA result of all parameters were significant at 0.01 level after 17 weeks of elastic resistance training. Paired sample t-test manifests significant improvement of FVC of younger adult experiment (EX_1) and older adult experimental (EX_3) groups; though the change of FVC of middle-aged adult experimental (EX_2) group not significant but little positive repercussion was observed after 17 weeks of elastic resistance training programme. Due to the same pre post result of FVC of the control groups, the present investigator unable to conduct the analysis. 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 and also FEV_1 were associated with BMD of healthy, nonsmoking premenopausal women but not in post-menopausal women. The average BMD of younger adult women group enters 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). Total 58.82% subjects of the present study came under the category of Osteopenia (No-20) and remaining 35.29% of subjects came under the category of Osteoporosis (No-12). Osteopenia destined as a bone density that is -1 to -2.5 SD T score below the young adult reference range, Osteoporosis destined as bone density more than -2.5 SD T score below the young adult reference range (IOF, 2010). This consequence alluded that all the pre and post-menopausal women prone to fracture risk in hip, spine and distal forearm. From the paired sample t-test, investigator observed BMD of Middle age adult women group (EX_2) and olderly adult women group (EX_3) had been improved significantly. Younger adult women group (EX_1) improvement was not significant, but BMD moving towards the normal value (T score -1

SD to upwards) and gained T-score -0.26 SD after 17 weeks of elastic resistance training programme. The pre and post-test means of entire control groups BMD were not changed. The significant changes in BMD of the experimental groups were observed due to the acceleration of blood circulation in the whole body and skeleton, which help to transport important larger molecules of nutrients to the osteocytes. During the state of disuse or lack of mechanical strain, inhibition of lager molecules of nutrients supply to the osteocytes and inadequate removal of waste, that was possible reason for apoptosis of bone formation cell (Hughes, 2010). And some time contraction and relaxation of the muscle stimulate the Osteogenesis. Intern this may prevent and decelerate the processes of bone loss (Liu et al., 2015). Adami et al., 1999 designated that overall mass of the bone segment did not change, a remarkable reshape of its structure and geometry. The compact bone area rose. The expansion of this area lead increased the BMD. The enlargement of cortical area due to mostly corticalization of trabecular bone at the endosteal surface and some physiological bone expansion (periosteal apposition). These cortical changes predict a sustainable increase in the bending resistance. The finding of Liang et al., (2012) shown that 10 weeks, 3day/week upper body resistance and elastic band strength training produced significant improvement in strength performance but not BMD of distal radius site but sustain the site specific BMD. This study helped to perceive the duration of resistance training leads to increase the muscle strength without urging osteogenic adaptation in untrained premenopausal women. According to Lohman (1995) reported that strength training increases the smaller muscular strength but significant increases the regional BMD after 5, 12, 18 months but no changes in total arm and leg BMD after 5 months for exercises group. Simkin et al., (1987) reported that 3.8% increase in radial bone mass with 20 weeks of upper body resistance exercise in post-menopausal women. Heinrich et al., 1990 suggest that strength training may provide a better improvement BMC and BMD of distal radius lumbar vertebral femur, femoral neck, word triangle, greater trochanter than running and swimming of premenopausal athletes. Immobilization has been shown to accelerate bone loss. Furthermore, it has been suggested that changes in bone mass are mediated through interaction with muscle strain via the sensory function of osteocytes. Muscle strength, impact and non-impact exercise as well as the overall physical activity level positively related with bone mass changes in postmenopausal women (Frost 1964; Sirola, Tuppurainen, Honkanen, Jurvelin, & Kröger 2005). As regards the general acceptability of the present progressive elastic resistance training programme were the ways of functional human movement, safe, inexpensive and easy to start and train. These present analysis imply a good ratification, of this kind of training programme among healthy subjects as a part of their everyday life. Moreover, not only the skeletal benefits but also many other discernible health benefits were also observed for the all age groups of women. Initially the results shows that the younger adult women group (CN_1, EX_1) OI score was normal, healthy. The middle-aged adult women group (CN_2, EX_2) OI score was normal, healthy and older adult women group OI

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score was closer to the low risk category. From the result of the paired sample t-test, it was observed that there was no significant difference between pre and posttest measurement of young adult (EX_1), middle-aged adult women experimental groups (EX_2), and all the control groups, only the older adult women group (EX_3) showed significant change in the OI score after 17 weeks of elastic resistance training. OSTA Index score of EX_3 age group had deteriorated in a significant way, after post-test the OI score of this group positioning near the intermediate risk category (> -1: Low Risk Category, -1 to -4: Intermediate Risk Category and < -4: High Risk; Koh et al., 2001). It was very necessary to mention that 32.35% of the total subjects represent by the older adult women group (EX_3 and CN_3). 14.71% of the total population, and 45.45% of the total older adult osteoporotic women's were came under intermediate risk category (-1 to -4). However, the outcome of BMD T score shows that 35.29 % of the total population were osteoporotic, where EX_3 and CN_3 represents 91% osteoporotic women. Remaining other groups (85.29% of the total subjects) come under low risk category (> -1). After observing the result of pretest and posttest it may be understood that OI score progressing towards the risk region. And it was suggested 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. t-test result of grip strength manifests significant improvement of the entire experimental groups after 17 weeks of elastic resistance programme and inactive control groups grip strength were same after the 17-weeks of training. After 17 weeks of elastic resistance training only EX_3 age group improved balance ability significantly, because the body was inactive for a long time and due to participation in this resistance-training programme, some of the components of balance had developed rapidly among them. And remaining experimental groups improved mean balance ability but not significantly because huge dispersion of data in relation to its mean value. No significant changes was observed in balance ability of control groups due to the inactivity after 17-weeks of training programme. Paired sample t-test manifests that each experimental group improved their Proprioceptive ability after 17-weeks of elastic resistance training programme, but the ability of CN groups was unchanged due to inactivity. Riberio & Oliveria (2007) reviewed that proprioceptive ability involve central and peripheral components. Through physical activity improved both central and peripheral components, which help to improve the proprioceptive ability. Training induces morphological adaption in the major mechanoreceptors like muscle spindle, the latency of the stretch reflex response decrease and the amplitude increases. In this way repeated practice of motor skill is thought to increase mechanoreceptors output, which could bring about plastic changes in the CNS such as increased strength of synaptic connection and structural changes in the organization and no. of connection among the neuron. Only younger adult women group (EX_1), older adult women group (EX_3) group significantly improved the gait velocity after 17-weeks of elastic resistance training programme. Although the result of middle-aged adult women group (EX_2) was not significantly different, but little improvement of velocity was noticed by the observation of average value during 17 weeks of elastic resistance training programme. Present investigation suggest that velocity of gait may promote osteogenic effect in distal radius BMD. The impact of load against gravity, which stimulates the biomechanical component, may help to prevent bone loss. For this reason velocity of gait associated with BMD. Only middle-aged adult (EX_2), older adult women groups (EX_3) significantly improved the back strength after 17-weeks of elastic resistance training programme. Although the result of younger adult women group (EX_1) was not significantly different, but little improvement of back strength was notified by the observation of average value during 17 weeks of elastic resistance training programme.

4. DISCUSSION

In a poor country like India, where most people live under the poverty line, it was very difficult to test the BMD for a huge amount of money, the aim of the present investigator was to solve this problem indirectly through examining some physical ability test. After reviewing the various research papers, a general idea was developed in the mind of the present researcher was that as soon as the BMD decrease, strength, balance, proprioceptive abilities were also decreased rapidly, which severely damages the functional capacity of daily life.

Physical fitness measurements can easily perform at low cost and do not require specialized equipment. Thus, they can be used effectively to identify young and olderly adult individuals with low bone mass at an early stage 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. Physical fitness test 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 factors and variables that were analysed through factor analysis helped in clarifying as quality indicators for bone health of women. This result demonstrated that these eight parameters in separate two factors can provide positive information for predicting the bone health of women. And the factor analysis results shown that eight parameters and two factors were significant in explaining the women bone health of different age category.

The significant issue was the Physiological condition and Fitness condition had interchanged their position among themselves during posttest analysis. During pretest results, Physiological condition was considered as the first factor and may be viewed as the single best summary of linear relationship exhibited in the data. Fitness condition was considered as 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. But during posttest result it had become reversed and Fitness condition emerged as first factor and Physiological condition emerged as second best linear combination. Among with them the position of FVC was unchanged due to the higher correlation, though other factors of Physiological Condition (PC) and Fitness Condition (FC) interchanged their positions among themselves. It may be due to effect of training and have had more impact on the data of fitness variables.

Factor score was used for regression analysis as independent variables, to observe the grouping effects significantly, which may predict the Bone Mineral Density. Both pre and post results showed that the entire factor score revealed significant linear relationship with BMD. Furthermore, 71.7% and 62.1% variance in BMD during pre and posttest score was accounted for these two factors. As was seen from table all the factors had a positive significant effect on BMD. Thus, BMD would be expected to improve as the values of physiological and fitness factors improve. Afterwards the parameters of all variables were used as independent variables for multiple regression analysis to observe the individual effect to predict the Bone Mineral Density. Both pre and post test result showed that all the factors had no significant linear relationship with BMD. Only OSTA Index had shown a significant linear relationship with BMD in both pre and posttest measurement. And the velocity of gait significantly predicts the BMD in pretest measurement and Isometric Back strength predicts the BMD in posttest measurement.

After the multiple regression analysis with both factors and with the variables, it was observed that result of factor effect was more prominent than individual parameter effect. Improvement of BMD occurred 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. Ghosal and Bandyopashyay (2018c) reported that there were considerable correlation between Bone Mineral Density and the selected physiological and fitness 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. 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 weight 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 was not available. They advised that measuring only one of the physical performance variables (TUG, 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 with low

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physical function to have low bone mass. The score of SOF, 10 m gait can be a good predictor of Osteopenia and Osteoporosis. Karkkainen et al., 2009 suggested that the increment of grip strength was associated with the decreased risk of fracture. And concluded that grip strength and SOF 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 functions like strength, mobility and BMD in postmenopausal women. Ghosal and Bandyopadhyay (2018b) 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. Ghosal and Bandyopashyay (2018c) concluded that OSTA Index and velocity of gait independently predict the bone health status of all age group of women.

Olderly adult women group (Experimental-3 group) mostly benefited from this training programme. It was proven from this study that problem related to long days of inactivity and age related physiological changes could be prevented through this training programme. Physical and movement related function improved along with the physiological function. It has been noticed by the investigator that OSTA Index gradually goes towards risk category due to the loss of weight. Therefore, it should be recommended that quality body weight should be maintained at a certain level with age. Remaining two experimental groups mean results show that all parameters were improved, but few parameters improvement were significantly and few were not statistically significant. Both the young (EX_1) and Middle aged (EX_2) groups loses their body weight, but not significantly for this reason no significant change was observed in OSTA Index value. Both the experimental groups (EX_1 & EX_2) improved grip strength and proprioceptive ability significantly, but balance showed not significant results because the huge dispersion of data in relation to its mean. The BMD and isometric back strength of middle-aged women group (EX_2) showed significant improvement, but gait velocity, vestibular function and Forced Vital Capacity result showed no significant improvement. The young aged women group BMD and isometric back strength result revealed no significant improvement, but gait velocity, vestibular function and Forced Vital Capacity results showed significant improvement.

5. CONCLUSION

It was concluded from this study that the training programme was effective for all age groups of women specifically it was more effective for olderly adult women group. Both the factors had

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significant correlation to each other. Therefore, it may be suggested that BMD may be improved by the improvement of selected physiological and fitness factors.

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