JACOBS PUBLISHERS

OPEN ACCESS

Jacobs Journal of Gerontology

Research Article

Association between Lean and Fat Mass with Bone Mineral Density in The Elderly Fat and Lean Mass Associated With Bone Mineral Density

Gláucia R Falsarella[1*], Ibsen B Coimbra[1,2], Caroline C Barcelos[2], Isabele Iartelli[1], Kedma T Montedori[1], Manuela NJ Santos[1], Anita L Neri[1], Arlete MV Coimbra[1,3]

[1]*Address Rua: Tessália Vieira de Camargo, 126 Cidade Universitária "Zeferino Vaz" - Campinas-SP, Brazil - CEP: 13083-887. Faculty of Medical Sciences, Gerontology Program, State University of Campinas (Unicamp).*

[2]*Adress Rua: Tessália Vieira de Camargo, 126 Cidade Universitária "Zeferino Vaz" - Campinas-SP, Brazil - CEP: 13083-887. Faculty of Medical Sciences, Department of Medical Clinics, State University of Campinas (Unicamp).*

[3]*Address Rua: Vital Brasil, 50, Barão Geraldo, Campinas-SP 13083-888, Brazil. Faculty of Medical Sciences, Family Health Program, State University of Campinas (Unicamp).*

**Corresponding author: Dr. Gláucia Regina Falsarella, Faculty of Medical Sciences, Gerontology Program, State University of Campinas (UNICAMP), Rua: Tessália Vieira de Camargo, 126 Cidade Universitária "Zeferino Vaz" - Campinas-SP, Brazil - CEP: 13083-887, Tel: 55 19 3521-8945; E-mail: grfalsarella@ig.com.br*

Received: 01-16-2015

Accepted: 02-06-2015

Published: 03-10-2015

Abstract

Purpose

The imbalance between the formation and reabsorption of bone associated with aging contributes to a reduction in bone mineral density (BMD). Understanding the factors related to this reduction is important for the care of the elderly, considering that bone fragility enhances the risk of falls, fractures, morbidity and mortality. To analyze the association between BMD and age, comorbidities, body mass index (BMI), fat and muscle mass, and to identify the profile of the body composition related to a higher BMD in the elderly.

Methods

Cross-sectional study with 99 elderly women (≥65 years) in Campinas-SP, Brazil, recruited in the clinical environment and the community. The evaluation protocol included age, disease, BMI, bone mass, fat mass and lean mass. The statistical analyses included the Spearman, Kruskal-Wallis and post-hoc Dunn tests ($p<0.05$).

Results

There was a negative association between BMD and age ($r=-0.48$) and a positive association with disease ($r=0.21$), BMI ($r=0.66$), fat ($r=0.66$) and muscle ($r=0.62$). According to the analysis of body composition profiles, the group with a higher BMD was characterized by elderly with greater muscle and fat masses ($p<0.001$).

Conclusion

The interrelationship of lean and fat in determining BMD was verified. These data are preventive and diagnostic relevant for the identification of the elderly who are vulnerable to bone changes and suggest the need for the development of preventive measures, diagnostic tests and treatments with a focus on body composition.

Keywords: Elderly; Bone Mass; BMD, Lean Mass; Body Composition; Dual-Energy X-Ray Absorptiometry

Cite this article: *Falsarella G R. Association between Lean and Fat Mass with Bone Mineral Density in the Elderly.Fat and Lean Mass Associated With Bone Mineral Density. J J Geronto. 2015, 1(1): 001.*

Introduction

The body composition is a metabolic and functional component, showing alterations throughout life. Between the observed modifications include the reduction in lean mass and increased fat mass [1]. Both muscle tissue and body fat are related to bone mineral density (BMD), but there is no consensus in the literature about the degree of the contribution of these components to the determination of bone mass [2,3].

The regulation of bone metabolism includes a combination of genetic, mechanical and endocrine factors. In addition to these factors, gender, comorbidities, medication use, the aging process, dietary intake and menopause are variables that affect the regulation of bone activity and its preservation. The imbalance between the formation and reabsorption of bone associated with aging contributes to a reduction in BMD, which is a strong predictor of fractures and the gold standard for screening for osteoporosis [4,5].

One of the most important aspects in the field of geriatrics and gerontology is determining the variability of body composition in the elderly [6]. Understanding this process will differentiate its physiological and pathological evolution, having a huge impact on clinical practice. Understanding the factors that determine the activity of the bone tissue is fundamentally important for the care of the elderly with respect to prevention, diagnosis and treatment, considering that bone fragility enhances the risk of falls, fractures, morbidity and mortality [7].

The biochemical aspects related to the interaction of the different components of body composition have been thoroughly discussed in several scientific papers [-7 9]. However, few researches analyses the impact of this interaction on bone mass and its clinical consequences. Therefore, this study sought to identify the profiles of body composition associated with bone density in elderly women.

Materials and Methods

Participants

The research sample consisted of 99 elderly women aged ≥ 65 years who were living in Campinas-SP, Brazil. The non-institutionalized sample and with heterogeneous body composition, include women who were randomly recruited in a clinical environment and the community: a) community-dwelling elderly participants in a survey of frailty in elderly Brazilians (Study FIBRA Campinas); b) elderly recruited from the Reference Center on Aging Health; and c) ambulatory elderly from the Rheumatology Department of a public hospital in Campinas [10].

The excluded individuals had severe cognitive impairment, functional limitations (prevented ambulation) and with inflammatory rheumatic diseases. Exclusion was based on the declaration of the elderly and/or caregiver and/or the observation of the researcher, and/or evaluation of the rheumatologist. The research was approved by the Ethics Committee of UNICAMP (protocol number 2009/913).

Instruments and measures

The evaluation protocol included: age, weight, height, body mass index (BMI), chronic diseases and body composition.

Chronic diseases: Self-reported items were used to investigate whether, in the 12 months preceding the interview, any doctor had said that the participant had cardiovascular disease, hypertension, stroke, diabetes, arthritis or rheumatism, lung disease, depression, cataracts or thyroidopathy.

Anthropometric measurements: Measurements of height and weight were performed. These two measurements were used the BMI (BMI = weight (kg) / height (m^2)). According to the protocol of Lipschitz [11], underweight BMI was < 22 kg/m^2, normal weight BMI was ≥ 22 to < 27 kg/m^2, and obese BMI was ≥ 27 kg/m2.

Body composition: The investigation of body composition (bone, muscle and fat masses) was accomplished in the total body and in body segments (trunk, upper limbs and lower limbs). The elderly were evaluated with the Body Dual X-ray Absorptiometry "DXA" software version 4.7 (GE / Lunar Radiation / model DPX-IQ). The assessments have been applied by a blind operator. The measurements were done on the same machine each time.

The analysis considered the bone mass values of BMD in g/cm^2 for the total body, trunk, arms and legs. Adipose tissue was measured in grams (g) and categorized as either low fat mass (<24955 g) or high fat mass (≥24955 g) after determining the median value obtained for the sample. The muscle mass was measured in g. The cutoff scores were <36592 g for low lean mass and ≥36592 g for high lean mass, considering the median value found in the sample.

Based on the combination of the median values of the sample relating to the lean mass and fat mass in g, the subjects were classified as having low lean mass (<36592 g), high lean mass (≥36592 g), low fat mass (<24955 g) or high fat mass (≥24955 g). The combination of these measurements enabled the formation of 4 groups of elderly women according to their body composition profile: Group 1) low lean mass and low fat mass, Group 2) high lean mass and low fat mass, Group 3) low lean mass and high fat mass and Group 4) high lean mass and high fat mass.

Statistical analysis

We determined descriptive statistics. For the correlation analysis between BMD and age, disease, BMI, lean mass and fat mass, we used the Spearman correlation coefficient. To compare numerical variables among the 4 body composition groups, we used the Kruskal-Wallis and post-hoc Dunn tests. The statistical significance for the tests was $p<0.05$.

Results

The sample consisted of elderly individuals aged 65 to 94 years (77.03 years 6.51±), with a height of 1.51 m (0.05±), a weight of 66.19 kg (16.78±) and a BMI of 29.12 kg/m2 7.02±)). The descriptive analysis of the bone, lean mass and fat mass in the total body, trunk, upper limbs and lower limbs is presented in Table 1.

regardless of the body segment. This association occurred almost homogeneously, with the correlation coefficients considered to be good to excellent. In particular, when analyzing BMD, the total correlation coefficients for total fat mass and total lean mass were 0.57 and 0.59, respectively (p <0.0001).

The assessment of the body composition profiles indicated that the group having a lower lean mass and lower fat mass

Table 1. Characterization of the sample regarding age, weight, height, BMI, comorbidities, and body composition in different body sites in the elderly*

	Mean	SD**	Min**	Q1**	Median	Q3**	Max**
Age (years)	77.03	6.51	66.00	72.00	77.00	81.00	94.00
Height (m²)	1.51	0.05	1.40	1.47	1.51	1.53	1.67
Weight (kg)	66.19	16.78	37.00	53.10	64.50	75.50	132.00
BMI	29.12	7.02	16.01	23.37	28.77	32.68	57.89
Diseases* **	3.66	1.67	0.00	2.00	4.00	5.00	8.00
Arms Fat (g)	4353.0	2918.5	367.00	2279.0	3878.0	5398.0	16936
Arms Lean (g)	4900.1	1431.6	2555.0	3903.0	4611.0	5773.0	9114.0
Arms BMD (g/cm²)	0.76	0.12	0.46	0.67	0.76	0.84	1.04
Legs Fat (g)	8446.8	3706.4	2391.0	5542.0	8256.0	10036	26469
Legs Lean (g)	12012	2014.5	8472.0	10430	11679	13114	17624
Legs BMD (g/cm²)	1.00	0.15	0.56	0.89	1.03	1.11	1.31
Trunk Fat (g)	11284	4060.4	1678.0	8072.0	11397	13811	22578
Trunk Lean (g)	17606	3337.9	2114.0	15801	17264	19226	28503
Trunk BMD (g/cm²)	0.86	0.11	0.61	0.78	0.86	0.94	1.15
Total Fat (g)	25473	11032	1226.0	17335	24955	31045	70880
Total Lean (g)	37123	6001.8	21442	32735	36592	40339	57305
Total BMD (g/cm²)	1.03	0.12	0.76	0.94	1.04	1.12	1.28

*n=99.

**sd= standard deviation, min=minimum, q1=quartile 1, q3=quartile 3, max=maximum.

Table 2 showed that age had a negative relationship with BMD in all of the body sites evaluated, i.e., a lower bone density was associated with an older age. The correlation coefficients ranged from r=0.30- (p=0.0022) to r=0.48- (p <0.0001), characterizing this association as reasonable.

The number of chronic diseases was not associated with BMD, except when considering the trunk, but this association was weak (r=0.21, p=0.0344). Moreover, the BMI was related to BMD for all sites investigated. For this condition, the correlation coefficients were greater than 0.50, corresponding to a good association.

When investigating the relationship between BMD and the other components of body composition, a positive association was observed for both lean tissue and fat tissue,

(group 1) had a lower average bone mass, independent of the body site evaluated, compared with the other groups. However, when considering significance, group 1 was characterized by a low BMD compared only with group 4 (high lean mass and high fat high mass) for the total body, arms, legs and trunk (Table 3).

The elderly women with high lean mass and low fat mass (group 2) were not significantly different with regard to BMD compared with groups 1 and 3 for the different body sites. These data indicate that the elderly women in group 2 had a BMD that was very similar to that of the women in groups 1 and 3. Apparently, a higher lean mass did not represent a protective factor against a lower BMD in group 2, and similarly, a greater fat mass was not associated with a higher BMD in group 3. Group 2 had a lower BMD than

Table 2. Correlation between age, chronic diseases, BMI and body composition with BMD values (g/cm²) in the elderly

Variables		BMD Arms	BMD Legs	BMD Trunk	BMD Total
Age^{+}	r*	-0.48834	-0.36584	-0.30485	-0.34353
Diseases^{+}		0.13415**	0.08204**	0.21289	0.20481
BMI^{++}		0.62728	0.55613	0.66589	0.59239
Arms Fat^{++}		0.59122	0.53248	0.61547	0.54234
Arms Lean^{++}		0.62680	0.56437	0.65283	0.56371
Legs Fat^{++}		0.61227	0.59140	0.64439	0.59284
Legs Lean^{++}		0.62275	0.59157	0.65887	0.61003
Trunk Fat^{++}		0.65211	0.61144	0.66485	0.60783
Trunk Lean^{++}		0.51955	0.49143	0.55942	0.50878
Total Fat^{++}		0.63376	0.59113	0.66128	0.59280
Total Lean^{++}		0.61499	0.56448	0.62526	0.57703

*r=spearman correlation coefficient n=99.

**not significant.

$^{+}$p <0.005, $^{++}$p<0.0001.

Table 3. Evaluation of lean mass, fat mass and bone mass according to body composition

Group	BMD	N	Mean	SD	Min	Median	Max	
1 Low Lean Mass/ Low Fat Mass	**Arms**	38	0.69	0.08	0.51	0.68	0.86	**P<0.001 (A)***
	Legs	38	0.91	0.15	0.56	0.94	1.23	**P<0.001 (B)***
	Trunk	38	0.79	0.08	0.61	0.78	0.94	**P<0.001 (C)***
	Total	38	0.69	0.11	0.76	0.97	1.20	**P<0.001 (D)***
2 High Lean Mass/ Low Fat Mass	**Arms**	11	0.73	0.13	0.46	0.76	0.93	
	Legs	11	0.99	0.13	0.83	0.94	1.20	
	Trunk	11	0.86	0.11	0.74	0.82	1.04	
	Total	11	1.02	0.10	0.88	1.01	1.18	
3 Low Lean Mass/ High Fat Mass	**Arms**	11	0.75	0.09	0.60	0.73	0.87	
	Legs	11	1.00	0.12	0.77	1.06	1.12	
	Trunk	11	0.87	0.08	0.74	0.89	0.99	
	Total	11	1.02	0.09	0.85	1.06	1.13	
4 High Lean Mass/ High Fat Mass	**Arms**	39	0.84	1.10	0.60	0.85	1.04	
	Legs	39	1.10	0.11	0.86	1.11	1.31	
	Trunk	39	0.94	1.10	0.73	0.94	1.15	
	Total	39	1.11	0.10	0.90	1.11	1.28	

*p-value for the kruskal-wallis test to compare variables among the 4 groups. significant differences (post-hoc dunn test, p<0.05): (a=arms) '2'≠'4', '1'≠'4', '3'≠'4'; (b=legs) '2'≠'4', '1'≠'4'; (c=trunk) '1'≠'3', '1'≠'4'; (d=total body)

group 4 for the upper and lower limbs, showing that lean mass and fat mass together were associated with a higher BMD in group 4.

Group 3 (low lean mass and high fat mass) showed a lower BMD than group 4 for the arms, showing a beneficial effect of lean body mass and fat mass on BMD, as found in group 4. However, group 3 had a higher BMD in the trunk compared with group 1, suggesting that a higher fat mass had a positive relationship with BMD in the trunk, i.e., fat had a protective effect in this region.

Discussion

Consistent with our findings herein, several other studies highlight age and BMI as determinants of the changes that occur in body composition. Age is a factor associated with a lower bone mass and, therefore, is predictive of osteoporosis and osteopenia [6,12,13]. With respect to BMI, the literature describes body weight as accounting for %30 of the variance in bone density, constituting a major determinant of BMD [14,15].

Our research showed that the coefficient of correlation between BMI and BMD at different body sites ranged from 0.55 to 0.66. In the Auckland Calcium Study, which examined 1462 women at menopause, the value was 0.39 for the correlation between hip BMD and BMI, which was greater than the value found in the relationship between hip BMD and lean mass (r=0.28) and fat mass (r=16] (0.30]. In a cohort of 300 women, Saarelainen et al., [17] found that those with a low BMI (20 kg/m^2) became osteopenic 2 years after menopause when evaluating the spine and 4 years after menopause when investigating the femur, whereas the women with a BMI of 30 kg/m^2 developed osteoporosis 5 years after menopause in the spine and 9 years after menopause in the femur.

Based on the knowledge that a larger BMI value is associated with an increased BMD, it is necessary to identify which components of body composition are predominant in this relationship and is therefore associated of bone mass. Determining how the distribution of these components occurs at different body sites is also important. In this regard, this research noted that there was a relationship between BMD and lean and fat mass, independent of the body segment investigated, with correlation coefficients that were considered good to excellent. This finding has great clinical relevance, suggesting that adipose tissue and muscle tissue create a protective mechanism against bone loss [-18 21].

The regulation of bone metabolism also has a combination of mechanical and hormonal aspects among its determinants. Increased serum levels of estrogen, leptin, insulin and amylin in obese individuals can affect the activity of osteoblasts and osteoclasts, positively affecting bone mass. Research suggests that a higher body weight requires greater mechanical loading on bone structures and that consequently there is an increase in this tissue to accommodate the overload [15,22]. Thus, a greater mechanical load activates dendritic cells and osteocytes, which translates the signal into anabolic response, for example the expression of IGF-I and osteocalcin [23,24].

In our study, we found a good correlation between the total BMD and the total lean mass (r=0.57) and total fat mass (r=0.59). These values were very close, which may indicate an interrelationship between these two components in the determination of BMD. Thus, the research reinforced the impact of the interrelationship of fat and lean tissue on the bone health of the elderly women who were evaluated in this study. This result suggests that a greater fat and lean mass were associated on bone structure in old age. Amid the controversy over the performance of fat and lean mass to BMD, studies have claimed that lean mass exerts a significant influence on BMD compared with fat as BMD is influenced particularly by mechanical overload and dynamic interactions from the muscle contraction, which has a strong effect on the bone structure compared with the gravitational effects of body weight [2,18,19,25,26].

Ho-Pham et al., [14] showed that both lean tissue and fat were predictors of bone density but that lean mass was significantly more predictive before menopause, whereas fat was a more significant predictor after menopause. According to Dytfeld et al., [2], lean mass was predictor of bone density in L-1L4 vertebra; the fat associated with lean tissue determined the BMD of the femoral neck in postmenopausal women with a diagnosis of osteoporosis. In another study, the BMD of any site was related to fat, body weight and BMI (r=0.5) and less associated to lean tissue (r=0.2) in postmenopausal women, whereas premenopausal BMD was associated with lean and fat mass [24].

When considering the interaction among bone, lean mass and fat mass, it is essential to mention the influence of the change in body composition associated with aging and inactivity, which contribute to fat accumulation and redistribution to the central and visceral regions [27]. Body fat includes essential body fat and storage body fat. Essential body fat is necessary to maintain life and reproductive functions. The percentage of essential body fat for women is greater than that for men, due to the demands of pregnancy and other hormonal functions. Storage body fat consists of fat accumulation in subcutaneous adipose tissue and visceral fat, part of which protects internal organs in the chest and abdomen [28]. Moreover, the bone marrow adipocytes are able to generate estrogen, this aspect may explain in part why obese men and postmenopausal women tend to have lower bone loss relative to lean individuals [29]. As an endocrine organ, fat has a role in addition to its mechanical load because dysfunction in this tissue leads to the secretion of inflammatory mediators [16,23,30,31]. Another relevant

aspect is that the lower production of adiponectin in obese individuals suppresses osteoclastogenesis and activates osteoclastogenesis. Visceral obesity is related with the alteration of GH/IGF1-, a regulator of bone activity [32,22,33]. However, in our study, the negative associated between fat and bone tissue was not evident.

Distinguishing the function of lean tissue and fat tissue in determinants of BMD has important clinical for the elderly population. The physical activity / physical exercise can result in benefits to the musculoskeletal system because its regular practice acts positively on both muscle mass and BMD. However, the relationship between BMD and fat implies that the accumulation of fat was related to bone. Measuring the effects of these indices or quantifying the effect of fat and lean mass on BMD is complex because these body composition elements are interrelated [14].

We emphasize that the elderly group with greater muscle mass and lower fat mass, that is, the group with a body composition similar to that of an «old athlete,» did not have the highest average bone mass. These results suggest that the profile of body composition is a determining factor of bone tissue with great clinical relevance in relation to preventive and diagnoses measures. The findings reinforce the need for the development of preventive measures, diagnostic tests and treatments focusing on body composition components to identify the profiles of elderly individuals who are vulnerable to the impairment of bone changes.

This research has some limitations. First, because the sample was relatively small and only women were involved, the results do not represent the elderly population as a whole. Second, we conducted a cross-sectional study, which allowed only the identification of associations, making it difficult to determine the causes and effects of lean and fat mass on bone. Another limitation of the study refers no consideration between visceral and subcutaneous fat in analyzes. We suggest that more studies focusing on body composition be conducted to characterize groups of elderly individuals who are vulnerable to osteoporosis.

Conclusion

In this research, we used the DXA, the gold standard technique for assessing body composition, which made it possible to precisely analyze the interaction between these components of body composition. Using this technique, the findings indicated that there was a positive association between bone mass and fat and lean body mass. These data are preventive and diagnostic relevant for the identification of the elderly who are vulnerable to bone changes and suggest the need for the development of preventive measures, diagnostic tests and treatments with a focus on body composition.

Conflict of Interest Statement

"No Competing Interests". The authors declare that they have no competing interests.

Author's contributions: GRF, IBC and AMVC contributed to the conception and design of the study, analysis and interpretation of data, revising it critically for important intellectual content and final approval of the version to be submitted. ALN contributed to the design of the study. CCB, II, KTM and MNJS contributed to the drafting the article or revising it critically for important intellectual content.

Acknowledgments

This work was supported by the Faculty of Medical Sciences, State University of Campinas (UNICAMP) and CAPES (Coordination of Improvement of Higher Education Personnel) from the federal government of Brazil.

References

1. Aleman MH, Lee SY, Javed F, Thornton, Heymsfield SB, et al. Elderly Mexicans have less muscle and greater total and truncal fat compared to African-Americans and Caucasians with the same BMI. J Nutr Health Aging -919 :(10)13 ,2009 923.

2. Dytfeld J, Ignaszak-Szczepaniak M, Gowin E, Michalak M, Horst-Sikorska W. Influence of lean and fat mass on bone mineral density (BMD) in postmenopausal women with osteoporosis. Arch Geront Geriatr. 242-237 :(3)53 ,2011.

3. Shen W, Chen J, Gantz M, Punyanitya M, Heymsfield SB et al. Ethnic and sex differences in bone marrow adipose tissue and bone mineral density relationship. Osteoporos Int .,2012 2301-2293 :(9)23.

4. Johnell O, Kanis JA, Oden A, Johansson H, De Laet C et al. Predictive value of BMD for hip and other fractures. J Bone Miner Res .1194-1185 :20 ,2005.

5. Hillier TA, Stone KL, Bauer DC, Rizzo JH, Pedula KL et al. Evaluating the Value of Repeat Bone Mineral. Density Measurement and Prediction of Fractures in Older Women. The Study of Osteoporotic Fractures. Arch Intern Med.,2007 160-155 :(2)167.

6. Buffa R, Floris GU, Putzu PF, Marini E. Body Composition Variations in Ageing. Coll. Antropol 265-259 :(1)35 ,2011.

7. Gillette-Guyonnet S, Vellas B. Body composition and age-related diseases. Mechanisms Ageing Development. ,2003 248-247 :(3) 124.

8. Cederholm TE, Bauer JM, Boirie Y, Schneider SM, Sieber CC et al. Toward a Definition of Sarcopenia. Clin Geriatr Med. 353-341 :(30)27 ,2011.

9. Waters DL, Baumgartner RN. Sarcopenia and Obesity. Clin Geriatr Med .421-401 :(3)27 .2011.

10. Falsarella GR, Coimbra IB, Barcelos CC, Iartelli I, Montedori Kt et al. Influence of muscle mass and bone mass

on the mobility of elderly women: an observational study. BMC Geriatr .7-1 :(13)14 ,2014.

11. Lipschitz DA. Screening for nutritional status in the elderly. Primary Care .67-55 :(1)21 ,1994.

12. Kyle UG, Genton L, Hans D, Karsegard VL, Michel JP et al. Total Body Mass, Fat Mass, Fat-Free Mass, and Skeletal Muscle in Older People: Cross-Sectional Differences in -60Year-Old Persons. J Am Geriatr Soc .-1633 :(12)49 ,2001 1640.

13. Sornay-Rendu E, Karras-Guillibert C, Munoz F, Claustrat B, Chapurlat RD. Age Determines Longitudinal Changes in Body Composition Better Than Menopausal and Bone Status: The OFELY Study. J Bone Mineral Res .636-628 :(3)27 ,2012.

14. Ho-Pham LT, Nguyen ND, Lai TQ , Nguyen TV. Contributions of lean mass and fat mass to bone mineral density: a study in postmenopausal women. BMC Musculoskelet Disor. ,2010 9-1 :11.

15. Pirro M, Fabbriciani G, Leli C, Callarelli L, Manfredelli MR et al. High weight or body mass index increase the risk of vertebral fractures in postmenopausal osteoporotic women. J Bone Miner Metab .93-88 :(1)28 ,2010.

16. Reid KF, Naumova EM, Carabello RJ, Phillips EM, Fielding RA. Fielding, Lower extremity muscle mass predicts functional performance in mobility-limited elders. J Nutr Health Aging. 498-493 :(7)2008,12.

17. Saarelainen J, Kiviniemi V, Kroger H, Tuppurainen M, Niskanen Let al. Body mass index and bone loss among postmenopausal women: the -10year follow-up of the OSTPRE cohort. J Bone Miner Metab. 216-208 :(2)30 ,2012.

18. Hage RE, Jacob C, Moussa E, Badoura R. Relative Importance of Lean Mass and Fat Mass on Bone Mineral Density in a Group of Lebanese Postmenopausal Women. J Clin Densitom. 331-326 :(3)14 ,2011.

19. Lee K. Soft tissue composition and the risk of low bone mineral density: The Fourth Korea National Health and Nutrition Examination Survey (KNHANES IV2009 .(3-. Calcif Tissue Int 192-86 :(3)90 ,2012.

20. Marques EA, Moreira P, Wanderley F, Pizarro AN, Leão-Rosas JP et al. Appendicular fat mass is positively associated with femoral neck bone mineral density in older women. Menopause. 318-311 :(3)19 ,2012.

21. Park JH, Song YM, Sung J, Lee K, Kim YS et al. The association between fat and lean mass and bone mineral density: The Healthy Twin Study. Bone .-1006 :(4)50 ,2012 1011.

22. Bhupathiraju S, Dawson-Hughes B, Hannan MT, Lichtenstein AH, Tucker KL, Centrally located body fat is associated with lower bone mineral density in older Puerto Rican adults. Am J Clin Nutr .1070-1063 :(4)94 ,2011.

23. Zhao L, Jiang H, Papasian C, Maulik D, Drees B et al. Correlation of obesity and osteoporosis: effect of fat mass on the determination of osteoporosis. J Bone Miner Res .,2008 29-17 :(1)23.

24. Kim JH, Choi HJ, Kim MJ, Shin CS, Cho NH. Fat mass is negatively associated with bone mineral content in Koreans. Osteoporos Int .2016-2009 :(7)23 ,2012.

25. Wang MC, Bachrach LK, Van Loan M, Hudes M, Flegal KM et al. The relative contributions of lean tissue mass and fat mass to bone density in young women. Bone .:(4)37 ,2005 481-474.

26. Gnudi S, Sitta E, Fiumi N. Relationship between body composition and bone mineral density in women with and without osteoporosis: relative contribution of lean and fat mass. J Bone Miner Metab. 332-326 :(5)25 ,2007.

27. American College of Sports Medicine. Chodzko-Zajko WJ, Proctor DN, Fiatarone Singh MA, Minson CT, Nigg CR et al . American College of Sports Medicine position stand. Exercise and physical activity for older adults. Med Sci Sports Exerc. 1530-1510 :(7)41 ,2009.

28. Gallagher D, Heymsfield SB, Heo M, Jebb SA, Murgatroyd PR et al. Healthy percentage body fat ranges: an approach for developing guidelines based on body mass index. Am J Clin Nutr September.701-694 :(3)72 ,2000.

29. Kuk JL, Saunders TJ, Davidson L, Robert R. Age-related changes in total and regional fat distribution. Ageing Res Rev. 348-339 :(4)8 ,2009.

30. Wyshak G. Percent Body Fat, Fractures and risk of osteoporosis in women. The J Nutr Health Aging. ,2010 432-428 :(6)14.

31. Cao JJ. Effects of obesity on bone metabolism. Journal Orthopaedic Surgery Research. 30 :6 ,2011.

32. Greco EA, Fornari R, Rossi F, Santiemma V, Prossomariti G et al. Annoscia C, Aversa A, Brama M, Marini M, Donini LM, Spera G, Lenzi A, Lubrano C, Migliaccio S. Is obesity protective for osteoporosis? Evaluation of bone mineral density in individuals with high body mass. Int J Clin Pract. 820-817 :(6)64 ,2010.

33. Bredella MA, Torriani M, Ghomi RH, Gerweck AV, Harrington LM et al. Determinants of bone mineral density in obese premenopausal women. Bone. -748 :(4)48 ,2011 754.