

# Relationships between bone mineral density and new indices of body composition in young, sedentary men and women

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## Abstract

**Introduction.** Data concerning the relationship between body fat and BMD are equivocal since both positive and negative effects have been noted. Recently, the index of fat mass (IFM) representing subjects with different body fat and similar lean mass and index of lean mass (ILM) representing subjects with different lean body mass and similar body fat, have been used to evaluate body composition effect on BMD in middle-aged women. This study aimed at determination of ILM and IFM association with BMD in young men and women.

**Materials and methods.** A total of 212 university students of Public Health (125 women and 87 men) participated in the study. Body composition was determined by the bioelectrical impedance method (BIA) using BC 418 MA equipment (Tanita Co., Japan). Fat mass and fat free mass were used to calculate ILM and IFM. Bone mineral density was measured on the wrist of the non-dominant hand using the DEXA method and EXA 3000 equipment (HFS Ltd., Korea). BMD was evaluated using Z-score, with values lower than -2.0 indicating inadequate BMD for subject chronological age.

**Results.** Exclusively in women, IFM was markedly and positively correlated with Z-score ( $r=0.366$ ,  $P<0.001$ ). In both genders, a significant relationship was found between ILM and Z-scores ( $r=0.420$ ;  $p<0.001$  and  $r=0.220$ ;  $p<0.02$  in men and women, respectively). Women with lower than median IFM but similar ILM, were characterized by significantly lower Z-scores vs. women with higher IFM ( $-1.016$  vs.  $-0.512$ ;  $p<0.001$ ). Irrespective of gender, participants with higher ILM but similar IFM, were characterized by markedly higher Z-score vs. their counterparts with low ILM.

**Conclusions.** The use of IFM and ILM in the present study, allowed the observation that in young adults lean body mass was associated with BMD, regardless of gender, while fat mass is significant for bone mineral density only in women.

## Key words

young adults, gender, bone mineral density, body composition

## INTRODUCTION

Among many factors affecting bone mass, body weight is a strong and positive predictor acting through mechanical stress, which in turn increases osteogenesis and bone mineral density (BMD) [1]. In turn, it has been suggested that the reduction in body weight brings about bone loss [2]. However, it should be stressed that body weight consists of two major components – fat mass (FM) and lean mass (LM) both contributing to mechanical stress, and many efforts have been made to establish their individual impact on bone health [3].

There is no doubt that LM exerts a positive influence on bone structure [4]. In contrast, decrease in LM due to age-related sarcopenia is responsible for low BMD [5]. Additionally, irrespectively of age, a weight-bearing exercise which increases LM also positively affects BMD [6]. On the contrary, data concerning the relationship between FM and BMD are equivocal since both positive and negative effects of body fatness on BMD have been noted [7,8]. The reason for this discrepancy is unknown; however, it seems that fat-derived adipokines may exert either positive and/or

negative action on BMD [9, 10]. It should be stressed that FM associations with BMD are of special importance in women characterized by lower BMD than men, and increased risk of osteoporosis at menopausal transition [11]. However, even this issue is controversial. Makovey et al. [12] demonstrated that in both genders BMD is mostly affected by lean body mass, with positive effect of fat mass exclusively in women under 50 years old, but not in older ones. In contrast, Yoo et al. [13] found negative effects of body fat on BMD exclusively in premenopausal women. There are also data suggesting that it is not total body fat, but android fat distribution that affects bone health decrease in both BMD and BMC in middle-age subjects [14]. More recent data have suggested that age, gender and race are more important for bone health than body composition [15]. However, it could not be excluded that the above-mentioned discrepancy is due to different methods used in body shape evaluation (easily calculated surrogate indices of body fat as body mass index and waist to hip ratio, or precisely calculated index of fat mass) [13–15].

Recently, Nouvenne et al. [16] introduced new indices of body composition – index of fat mass (IFM) representing subjects with different body fat and similar lean mass, and index of lean mass (ILM) representing subjects with different lean body mass and similar body fat. Until now, both indices have been found to affect BMD in middle-aged premenopausal and menopausal women.

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## OBJECTIVE

The study was undertaken to elucidate the validity of IFM and ILM in anticipation of BMD, and to evaluate IFM and ILM effects on BMD in young adults of both genders.

## MATERIALS AND METHOD

A total of 212 university students of Public Health (125 women and 87 men) participated in the study, recruited on the basis of advertisements in student dormitories and by word of mouth. All volunteers were healthy, non-smokers, and not using any medications on a regular basis. Their physical activity was less than 3 h/week. All participants declared no eating disorders and all women were regularly menstruating. The study was approved by the local Ethics Committee and informed written consent was obtained from each participant.

Basic anthropometric parameters, such as body mass and height, were evaluated using standard medical scales. Body composition was determined by the bioelectrical impedance method (BIA) using BC 418 MA equipment (Tanita Co., Japan). Inter- and intra-assay coefficients of variation for body fat measurements did not exceed 2%. Fat mass (FM) and lean mass (LM) were further used to calculate ILM and IFM, according to a formula proposed by Nouvenne et al. [16]:

$$\text{Index of fat mass (IFM): IFM} = (\text{LM} + \text{FM}) / (\text{LM} - \text{FM});$$

$$\text{Index of lean mass (ILM): ILM} = \text{LM}^2 - \text{FM}^2$$

Both male and female participants were divided in two groups according to median value of either IFM or ILM.

Bone mineral density was measured on the wrist of the non-dominant hand using DEXA method and the EXA 3000 equipment (HFS Ltd., Korea). BMD was evaluated according to the WHO recommendations, by using a Z-score with values lower than -2.0 indicating inadequate BMD for subject of chronological age [17].

Descriptive statistics are presented as means  $\pm$  SD. Data distribution was evaluated using the Shapiro-Wilk test. The Mann-Whitney U test was applied for comparison of data with respect to gender. Spearman rank correlations were evaluated between Z-score and anthropometric variables. Values of  $p < 0.05$  were accepted as significant. All analyses were performed using Statistica v.10. (Stat Soft, USA).

## RESULTS

Women in the study were characterized by a significantly higher percentage of body fat and IFM compared to men ( $P < 0.001$ ) (Tab. 1). On the other hand, in male participants, significantly higher values of ILM were noted ( $p < 0.001$ ). Z-score values were also higher in men vs. women ( $p < 0.001$ ). In 92.8 % of women and 97.7 % of men participating in the study, Z-score values were higher than -2.0.

In men, no relationship was noted between IFM and Z-score. In contrast, in women, IFM was markedly and positively correlated with Z-score ( $r = 0.366$ ;  $p < 0.001$ ). In both genders, a significant relationship was found between ILM and Z-scores ( $r = 0.420$ ;  $p < 0.001$  and  $r = 0.220$ ;  $p < 0.02$ ), in men and women, respectively.

**Table 1.** Anthropometric characteristics and bone mineral density of young men and women (mean $\pm$ SD)

Variables	Women (n = 125)	Men (n = 87)
Age (yrs)	22.7 $\pm$ 2.6	23.2 $\pm$ 3.2
Weight (kg)	61.4 $\pm$ 13.2**	80.1 $\pm$ 12.0
Height (cm)	165.5 $\pm$ 6.0**	179.7 $\pm$ 5.7
Fat (%)	26.0 $\pm$ 7.9**	15.8 $\pm$ 5.3
Fat (kg)	17.0 $\pm$ 8.5*	13.1 $\pm$ 5.9
FFM (kg)	45.0 $\pm$ 7.2**	66.9 $\pm$ 7.8
IFM	2.46 $\pm$ 1.35**	1.50 $\pm$ 0.26
ILM	1714.0 $\pm$ 780.8**	4331.0 $\pm$ 957.8
Z-score	-0.775 $\pm$ 0.766** (97.7%)	-0.428 $\pm$ 0.727 (92.8%) <sup>^</sup>

FFM – fat free mass; IFM – index of fat mass; ILM – index of lean mass; \* $P < 0.01$ ; \*\* $P < 0.001$  significantly different vs. men; <sup>^</sup> percent of subjects with adequate BMD according to chronological age

Women with lower than median IFM but similar ILM, were characterized by significantly lower Z-scores vs. women with higher IFM ( $p < 0.001$ ) (Tab. 2). In contrast, in males, differences in IFM did not affect Z-score.

**Table 2.** Anthropometric characteristics of participants divided into groups according to IFM median value

Variable	Women (n = 125)		Men (n = 87)	
	IFM < 1.99 (n = 64)	IFM > 1.99 (n = 61)	IFM < 1.46 (n = 44)	IFM > 1.46 (n = 43)
Fat (kg)	11.1 $\pm$ 2.9***	23.3 $\pm$ 8.0	7.8 $\pm$ 2.8***	17.6 $\pm$ 4.3
FFM (kg)	43.4 $\pm$ 8.1***	46.7 $\pm$ 5.6	65.0 $\pm$ 7.7***	70.2 $\pm$ 7.0
IFM	1.70 $\pm$ 0.18***	3.27 $\pm$ 1.57	1.27 $\pm$ 0.10***	1.69 $\pm$ 0.24
ILM	1819.3 $\pm$ 1033.1	1599.8 $\pm$ 312.4	4210.5 $\pm$ 1000.2	4646.4 $\pm$ 943.2
Z-score	-1.016 $\pm$ 0.723***	-0.512 $\pm$ 0.742	-0.123 $\pm$ 0.777	-0.301 $\pm$ 0.693

FFM – fat free mass; IFM – index of fat mass; ILM – index of lean mass.

\* $P < 0.01$ ; \*\* $P < 0.001$  significantly different vs. subjects with IFM value higher than median.

**Table 3.** Anthropometric characteristics of participants divided into groups according to ILM median values

Variable	Women (n = 125)		Men (n = 87)	
	ILM < 1616 (n = 61)	ILM > 1616 (n = 64)	ILM < 4290 (n = 44)	ILM > 4290 (n = 43)
Fat (kg)	17.5 $\pm$ 8.9	16.5 $\pm$ 8.2	10.2 $\pm$ 5.6**	14.6 $\pm$ 5.8
FFM (kg)	42.2 $\pm$ 4.1***	47.7 $\pm$ 8.3	61.5 $\pm$ 4.3***	73.0 $\pm$ 5.9
IFM	2.75 $\pm$ 1.69	2.18 $\pm$ 0.82	1.16 $\pm$ 0.30	1.51 $\pm$ 0.24
ILM	1411.5 $\pm$ 166.4***	2002.1 $\pm$ 1000.2	3663.8 $\pm$ 488.9***	5117.6 $\pm$ 799.3
Z-score	-0.981 $\pm$ 0.782**	-0.558 $\pm$ 0.693	-0.432 $\pm$ 0.854*	-0.048 $\pm$ 0.569

FFM – fat free mass; IFM – index of fat mass; ILM – index of lean mass.

\* $P < 0.05$ ; \*\* $P < 0.01$ ; \*\*\* $P < 0.001$  significantly different vs. subjects with ILM higher than median value.

Irrespective of gender, participants with higher ILM but similar IFM, were characterized by markedly higher Z-score vs. their counterparts with low ILM (Tab. 3).

## DISCUSSION

To the best of the authors' knowledge, the presented study is the first in which IFM and ILM have been used, and new indices of body composition to evaluate associations between body composition and bone mineral density in

young men and women. In addition, the data obtained, together with that of Nouvenne et al. [16], suggest that the IFM-BMD relationship in women is observed irrespective of their age. Furthermore, comparison of the current data with other studies indicate that the body fat-BMD relationship in women, but not in men, is not related to the method of body fat evaluation [18, 19].

As mentioned earlier, the effect of gender on body fat – BMD associations is still under debate. However, it is postulated that leptin secretion from adipose tissue in women is greater than in men, and consequently its influence on BMD is more potent and reflected by significant correlations between BMD and indices of body fat [20].

A significant effect of ILM on BMD, irrespective of gender, found in the presented study is in agreement with other data indicating that the method of lean body mass assessment is of minor importance [21, 22]. On the other hand, it should be stressed that the mechanism of associations between body composition and BMD is far from being fully elucidated [23, 24].

However, it is worth noting that this study has some limitations. The most important is related to the small area of skeleton in which mineral density was evaluated. This seems especially important, since recent data have indicated that in both genders body fat affects BMD in a side-specific manner [25]. Thus, validity of new indices of body composition (IFM and ILM) has to be confirmed in different skeleton compartments. In addition, most of the male participants in the current were lean in contrast to the female counterparts who were characterized by higher incidents of overweight and obesity. In consequence, the data obtained did not provide information concerning IFM and ILM associations with BMD in overweight and/or obese men.

## CONCLUSIONS

The results of the study indicate the following:

- 1) Index of lean mass (ILM) is markedly associated with wrist bone mineral density in both genders.
- 2) The relationship between index of fat mass (IFM) and wrist bone mineral density is observed exclusively in young women.

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## Conflict of interest

The authors declare that they have no conflicts of interest.

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