Men and women do not have the same relation between body composition and bone mineral density in Brazilian people


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ABSTRACT

Objectives: The main objective this study was to examine if lean mass and the adiposity related with BMD in a eutrophic population of Brazilian adults, in different sites and gender.

Methods: A crosssectional observational study, without intervention. One hundred non-obese men and women, aged 20–40 years, who did not practice regular physical activity were evaluated. Body composition analysis was conducted by dual energy X-ray absorptiometry (DXA), and multiple regression was used to examine the sex-specific association between adiposity and lean mass profiles.

Results: Even after adjusting for age, sex, and BMI, total fat mass was inversely associated with total BMD (β=-4.52 g/cm², p<0.01). Lean mass was positively associated with BMD and female groups. In our study the lean mass has a positive effect in BMD for eutrophic Brazilian adults, opposite of adiposity. Although when stratified by gender, in adults women lean mass and adiposity have positive effects on BMD, which did not happen with men.

Keywords: bone density, body composition, adults, adiposity, body mass index.

1 Introduction

Obesity and osteoporosis are increasing in prevalence, globally, and pose a large burden to public health. Clinical presentation of both is heterogeneous and although widely studied, the interrelationship between excess adiposity and bone mineral density (BMD) is less understood (BOGL, LATVALA, KAPRIO et al., 2011).

Osteoporosis is defined as a loss of bone mass and diminished integrity of the microarchitecture structure, which leads to fragility in the bone and elevated risk of fractures. According to a study published in 2014, the prevalence of osteoporosis in United States was 10.2 million, in people over 50 years (JOHNELL and KANIS, 2006). Risk of fracture coincides with an elevated risk for multiple comorbidities and early mortality.

The convention that higher body mass index (BMI) has a positive association with bone mineral density (BMD) is well supported by the literature (BIAN, LI, YING et al., 2015; VAN LANGENDONCK, CLAESSENS, LEFEVRE et al., 2002; JIANG, ZHANG, JIN et al., 2015; PLUIJM, VISSER, SMIT et al., 2001; PARK, SONG, SUNG et al., 2012; SHAO, LI, LIU et al., 2015; HO-PHAM, NGUYEN, LALI et al., 2010).

In relation to the fat mass, there is no consensus. Some studies suggest that fat mass has a negative association with BMD (SHAO, LI, LIU et al., 2015; HO-PHAM, NGUYEN, LALI et al., 2010; SILVA, MENDONÇA, CONCEIÇÃO et al., 2007; ZHANG, PETERSON, SU et al., 2015), while others claim the opposite. As the fat mass is a component of the body composition, there should be the same correlation with the body composition and the BMI (HSU, VENNERS,
Table 3

Table 1. Characteristics of the study population (anthropometric and age).

<table>
<thead>
<tr>
<th>Variables</th>
<th>Whole group Mean (SD) N = 100</th>
<th>Female group Mean (SD) N = 50</th>
<th>Male group Mean (SD) N = 50</th>
</tr>
</thead>
<tbody>
<tr>
<td>Age (years)</td>
<td>27.2 (5.7)</td>
<td>26.4 (5.1)</td>
<td>28.0 (6.1)</td>
</tr>
<tr>
<td>Anthropometrics</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Height (cm)</td>
<td>168.8 (9.5)</td>
<td>161.8 (6.8)</td>
<td>175.8 (6.2)</td>
</tr>
<tr>
<td>Body mass (kg)</td>
<td>69.9 (14.3)</td>
<td>61.2 (10.9)</td>
<td>78.6 (11.8)</td>
</tr>
<tr>
<td>BMI (kg/m²)</td>
<td>24.3 (3.6)</td>
<td>23.2 (3.7)</td>
<td>25.3 (3.3)</td>
</tr>
<tr>
<td>Waist-hip ratio (cm)</td>
<td>81.7 (7.6)</td>
<td>77.9 (7.6)</td>
<td>86 (0.5)</td>
</tr>
</tbody>
</table>

Legend: SD: Standard deviation; BMI: body mass index.

2 Methods

One hundred Brazilian adults, aged 20-40 years were evaluated (n=50 women 26.4±5.1 years old. and n=50 men 28±6.1 years old). All the participants gave their written informed consent to participate in this study. Which was approved by the University of São Paulo Medical School (# 1256/06).

The inclusion criteria were: (1) not engaged in regular physical activity over the previous six months as defined by the International Physical Activity Questionnaire (IPAQ); (2) and BMI between 18.5 a 29.5 (kg/m²).

The characteristics of the individuals who participated in the study are described in Table 1.

2.1 Procedures

The anthropometric measurements were performed in accordance with the International Society for the Advancement of Kinanthropometry (ISAK) standard.

Body composition was assessed using bone densitometry with a dual energy X-ray absorptiometry (DXA) on a LUNAR-DPX apparatus (Madison Corporation. USA).

2.2 Statistical analysis

The data were analyzed in the SPSS 20.0 software. The Kolmogorov–Smirnov test was used to ascertain whether the continuous variables presented normal distribution. Spearman’s correlation coefficient was used to correlate the dependent variable (BMD) with the independent variables (anthropometric characteristics and body composition). Multiple regression was used to evaluate the association between adiposity and bone density, adjusting for age, sex, and BMI. An alpha of 5% was used for all statistical tests.

3 Results

After adjusting for age, sex, and BMI, total fat mass was inversely associated with total BMD (β = -4.52 g/cm², p<0.01).

The Table 2 shows a positive correlation between BMD and heights; body mass; BMI and waist-hip ratio in the female group (except for height).

Lean mass and fat mass was positively correlated with BMD in the female groups in different sites (Table 3).

4 Discussion

The present study shows that BMI has a positive correlation with BMD, which is supportive of previous research (3-5).
However, after adjusting for age, sex and BMI, we found a negative association between fat mass and BMD. Accordingly, to the lean mass the association was positive in all the three group. These findings are the same as in the literature (VAN LANGENDONCK, CLAESSENS, LEFEVRE et al., 2002; PARK, SONG, SUNG et al., 2012; SHAO, LI, LIU et al., 2015; ZHU, HUNTER, JAMES et al., 2015).

We can explain the positive correlation between lean mass and BMD through the effects of the muscle in the bone. The muscle contraction promotes micro stretches in the bone, stimulating osteocytes and promoting the activation of the osteoblasts, leading to a bone remodeling. This leads to a mechanical overload to the bone and the piezoelectric effect also stimulates the osteoblasts (WONG, BEATTIE, MIN et al., 2014).

A study in postmenopausal women demonstrated that for every 5 kg increase in lean mass represented an increase in the BMD; however, this finding was not the same with the increase of 5 kg in fat mass (SHAO, LI, LIU et al., 2015).

A study in Chinese adults over 50 years showed that the lean mass was an independent factor for BMD of the lumbar spine, in femoral diaphysis and in hip. It was observed that the lean mass peak in this population was found between 50 and 59 years. From this age on, there is an inevitable fall of the lean mass associated with aging, favoring the development of osteopenia, osteoporosis and increasing the fracture risk. In this study they also found that there is an increased of fat mass with aging, mainly after 80 years, maintaining the BMI at the same, but with the fat mass occupying the lean mass place (JIANG, ZHANG, JIN et al., 2015).

With regards to adiposity, the link with BMD is not well known. Some previous studies have found no association between adipose tissue and bone mineralization and others that found negative relation (PARK, SONG, SUNG et al., 2012; ZHANG, PETERSON, SU et al., 2015; WONG, BEATTIE,

### Table 2. Correlation between Body Mineral Density (BMD) and anthropometrics.

<table>
<thead>
<tr>
<th>Variables</th>
<th>Whole group N = 100</th>
<th>Female group N = 50</th>
<th>Male group N = 50</th>
</tr>
</thead>
<tbody>
<tr>
<td>BMD (g/cm²)</td>
<td>r(p)</td>
<td>BMD (g/cm²)</td>
<td>r(p)</td>
</tr>
<tr>
<td>Height (cm)</td>
<td>.415 (p≤0.001)*</td>
<td>.160 (.282)</td>
<td>-.003 (9.987)</td>
</tr>
<tr>
<td>Body mass (kg)</td>
<td>.550 (p≤0.001)*</td>
<td>.435 (.002)*</td>
<td>.107 (.479)</td>
</tr>
<tr>
<td>BMI (kg/m²)</td>
<td>.450 (p≤0.001)*</td>
<td>.372 (.010)*</td>
<td>-1.89 (.207)</td>
</tr>
<tr>
<td>Waist-hip ratio (cm)</td>
<td>.528 (p≤0.001)*</td>
<td>.383 (.008)*</td>
<td>-.028 (.855)</td>
</tr>
</tbody>
</table>

Legend: BMD: Body Mineral Density; r: Spearman’s correlation coefficient; *P<0.05.

### Table 3. Correlation between Body Mineral Density (BMD) and corporal composition.

<table>
<thead>
<tr>
<th>Variables</th>
<th>Whole group N = 100</th>
<th>Female group N = 50</th>
<th>Male group N = 50</th>
</tr>
</thead>
<tbody>
<tr>
<td>BMD (g/cm²)</td>
<td>r(p)</td>
<td>BMD (g/cm²)</td>
<td>r(p)</td>
</tr>
<tr>
<td>Arm</td>
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</tr>
<tr>
<td>Fat mass (%)</td>
<td>-.512 (P≤0.001)*</td>
<td>.020 (.89)</td>
<td>.084 (.58)</td>
</tr>
<tr>
<td>Soft Tissue (g)</td>
<td>.460 (P≤0.001)*</td>
<td>.332 (.02)*</td>
<td>.050 (.73)</td>
</tr>
<tr>
<td>Fat mass (g)</td>
<td>-.234 (.02)*</td>
<td>.200 (.17)</td>
<td>-.066 (.66)</td>
</tr>
<tr>
<td>Lean mass (g)</td>
<td>.618 (P≤0.001)*</td>
<td>.350 (.01)*</td>
<td>.138 (.36)</td>
</tr>
<tr>
<td>Leg</td>
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<td></td>
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</tr>
<tr>
<td>Fat mass (%)</td>
<td>-.527 (P≤0.001)*</td>
<td>.142 (.34)</td>
<td>.177 (.24)</td>
</tr>
<tr>
<td>Soft Tissue (g)</td>
<td>.407 (.001)*</td>
<td>.242 (.10)</td>
<td>.087 (.56)</td>
</tr>
<tr>
<td>Fat mass (g)</td>
<td>-.293 (.004)*</td>
<td>.176 (.23)</td>
<td>-.194 (.19)</td>
</tr>
<tr>
<td>Lean mass (g)</td>
<td>.520 (P≤0.001)*</td>
<td>.165 (.26)</td>
<td>.020 (.89)</td>
</tr>
<tr>
<td>Trunk</td>
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<td></td>
<td></td>
</tr>
<tr>
<td>Fat mass (%)</td>
<td>-.330 (.001)*</td>
<td>.288 (.05)*</td>
<td>-.110 (.46)</td>
</tr>
<tr>
<td>Soft Tissue (g)</td>
<td>.530 (P≤0.001)*</td>
<td>.450 (.00)*</td>
<td>.005 (.97)</td>
</tr>
<tr>
<td>Fat mass (g)</td>
<td>.064 (.54)</td>
<td>.386 (.00)</td>
<td>.057 (.70)</td>
</tr>
<tr>
<td>Lean mass (g)</td>
<td>.608 (P≤0.001)*</td>
<td>.391 (.00)*</td>
<td>.51 (.73)</td>
</tr>
<tr>
<td>Body total</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Fat mass (%)</td>
<td>-.467 (P≤0.001)*</td>
<td>.231 (.11)</td>
<td>.125 (.40)</td>
</tr>
<tr>
<td>Soft Tissue (g)</td>
<td>.554 (P≤0.001)*</td>
<td>.449 (.00)*</td>
<td>.015 (.92)</td>
</tr>
<tr>
<td>Fat mass (g)</td>
<td>-.108 (.30)</td>
<td>.332 (.02)*</td>
<td>.085 (.57)</td>
</tr>
<tr>
<td>Lean mass (g)</td>
<td>565 (P≤0.001)*</td>
<td>.227 (.12)</td>
<td>.077 (.61)</td>
</tr>
</tbody>
</table>

Legend: BMD: Body Mineral Density; r: Spearman’s correlation coefficient; *P<0.05.
MIN et al., 2014). In our study we found that fat mass has a
negatively association with BMD in men, but not in women.
This could be because more fat mass percentage in males is
associated with increased visceral adiposity and bone and muscle
fat infiltration (PARK, SONG, SUNG et al., 2012; HO-PHAM,
NGUYEN, LAI et al., 2010; ZHANG, PETERSON, SU et al.,
2015; WONG, BEATTIE, MIN et al., 2014).
The Chinese study revealed that fat mass had a positive
relation with BMD in lumbar spine and no significant in
other sites (JANG, ZHANG, JIN et al., 2015). The post
menopause women study also cited previously identified that
the relation was positive between fat mass and DMO in lumbar
spine, femoral diaphysis and whole body, but less important
than the relation associated with lean mass. The explanation
for this was that any gain of weight may promote an increase
of mechanic overload, being fat mass or lean mass, and
stimulates the osteoblasts, mainly in axial skeleton (SHAO,
LI, LIU et al., 2015).

However, the accumulation of visceral fat is an independent
factor for lower quality in bone tissue and for an increase
in fracture risk. The bone and muscle fat infiltration would
explain this association (ZHANG, PETERSON, SU et al.,
2015; WONG, BEATTIE, MIN et al., 2014).

Wong, Beattie, Min et al. (2014) investigated the muscle
density through computed tomography (CT) and demonstrated
that this could be an indirect measure of adiposity. Small
values of muscle density would be associated with a larger fat
infiltration in muscles, decreasing the positive effects of this
contraction in bone. This would lead to an increased fracture
risk. Schafer, Vittinghoff, Lang et al. (2010) corroborates
with this hypothesis showing that in 2672 men and women
a small muscle density had a bigger relation with fracture risk.

In our study we found a negative association between
fat mass and BMD in the whole group. However, when we
stratified the group by sex, we observed a tendency of negative
correlation but only in men. In the Wong, Beattie, Min et al.
(2014) study, they identified that men have a larger visceral
fat accumulation than women that lead to an increase of a fat
infiltration in muscle and bone. This would make the bone
become more fragile and would increase the fracture risk.
This could be why we found these results.

Physical activity and a better nutrition are the two mainly
factors that would make the lean mass predominated over fat
mass in the BMI determination. They should be motivated
for all and with our findings we can say that they are important
elements in the prevention and in the osteopenia and osteoporosis
control, leading consequently in the decreased of fracture risk
(BOGL, LATVALA, KAPRIO et al., 2011; JIANG, ZHANG,
JIN et al., 2015).

Study limitation: We believe that if we had a bigger number
of men, the results would be more statistically significant.
In women, the fat mass has a positive relation with DMO.

We consider that more studies should be made to establish
the real association between fat mass and DMO, because the
literature still shows conflicted data about it. Factors related to
the metabolic and endocrine system and this repercussion in
the bone tissue should be better known so we can understand
better the relation between obesity and osteoporosis.

In our study the lean mass has a positive effect in BMD
for eutrophic Brazilian adults, opposite of adiposity. Although
when stratified by gender, in adult’s women lean mass and
adiposity have positive effects on BMD, which did not happen
with men.

References
BIAN, P., LI, X., YING, Q., CHEN, J., JIN, X., YAO, J. and SHOU,
Z. Factors associated with low femoral neck bone mineral density in
very elderly Chinese males. Archives of Gerontology and Geriatrics,
10.1016/j.archger.2015.08.010.

BOGL, LH., LATVALA, A., KAPRIO, J., SOVIIJARVI, O., RIISANEN,
A. and PIETILAINEN, KH. An investigation into the relationship
between soft tissue body composition and bone mineral density in
a young adult twin sample. Journal of Bone and Mineral Research,
org/10.1002/jbmr.192.

BREDELLA, MA., GILLI, CM., GERWECK, AV., LANDA, MG.,
KUMAR, V., DALEY, SM., TORRIANI, M. and MILLER, KK.
Ectopic and serum lipid levels are positively associated with bone

GOODPASTER, BH., KELLEY, DE., THAETE, FL., HE, J. and
ROSS, R. Skeletal muscle attenuation determined by computed
tomography is associated with skeletal muscle lipid content. Journal

GOWER, BA. and CASAZZA, K. Divergent effects of obesity on bone
joct.2013.08.010.

HO-PHAM, LT., NGUYEN, ND., LAI, TQ. and NGUYEN, TV.
Contributions of lean mass and fat mass to bone mineral density: a
study in postmenopausal women. BMC Musculoskeletal Disorders,

HSU, YH., VENNERS, SA., TERWEDOW, HA., FENG, Y., NIU,
T., LI, Z., LAIRD, N., BRAIN, JD., CUMMINGS, SR., BOUSEXN,
ML., ROSEN, CJ. and XU, X. Relation of body composition, fat mass,
and serum lipid to osteoporotic fractures and bone mineral density
in Chinese men and women. The American Journal of Clinical

JIANG, Y., ZHANG, Y., JIN, M., GU, Z., PEI, Y. and MENG, P.
Aged related changes in body composition and association between
body composition with bone mass density by body mass index in
Chinese han men over 50-year-old. PLoS One, 2015, vol. 10, n. 6,
p. e0130400.

JOHNELL, O. and KANIS, JA. An estimate of the worldwide prevalence
and disability associated with osteoporotic fractures. Osteoporosis

KIN, K., KUSHIDA, K., YAMAZAKI, K., OKAMOTO, S. and
INOUE, T. Bone mineral density of the spine in normal Japanese
subjects using dual-energy X-ray absorptiometry: effect of obesity
BF02565129.

PARK, JH., SONG, YM., SUNG, J., LEE, K., KIM, YS., KIM, T.
and CHO, SI. The association between fat and lean mass and bone
mineral density: the Healthy Twin Study. Bone, 2012, vol. 50, n. 4,
bone.2012.01.015.

PASCO, JA., GOULD, H., BRENNAN, SL., NICHOLSON, GC.
and KOTOWICZ, MA. Musculoskeletal deterioration in men
ALONSO, A. C., RIBEIRO, T. C., FERREIRA, R. B. et al.


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