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Association between body composition and bone mineral density in healthy, non-obese, young Romanian adults and effects of menopause

Associate Professor Carmen Emanuela GEORGESCU MD, PhD[a];
Assistant Professor Ioana ILIE, MD[a]; Cristian BRAD, MD[b];
Professor Ileana DUNCEA, MD, PhD[a]

[a]Department of Endocrinology, "Iuliu Hatieganu" University of Medicine and Pharmacy, Cluj-Napoca, Romania
[b]Clinic of Endocrinology, Emergency County Hospital, Cluj-Napoca, Romania

Running head: Body composition in non-obese young adults

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ABSTRACT

Introduction: *The link between bone mass and body composition is widely recognized, but the mechanism remains unclear. Most studies enrolled subjects irrespective of their body weight and only few works were selectively performed on healthy subjects with body mass index (BMI) within normal limits.*

Material and methods: *We aimed to determine the relevance of body composition parameters to bone mass in healthy, young and non-obese Romanian volunteers (n=42) and in postmenopausal women (n=20) and to establish the effects of menopausal transition. Both bone mineral density (BMD) and body composition were assessed using whole-body dual X-ray absorptiometry (DXA).*

Outcomes: *Despite normal mean BMI, large variability of the whole-body fat mass (FM) content was noted, ranging between 18.6-49.7% in women and 22-40.3% in men. Fat mass was not related to bone density; in contrast, BMD at all sites was positively associated to fat-free mass (FFM) in young non-obese women (r=0.34-0.53). In women, the trunk fat mass/leg fat mass ratio was significantly predicted by age (p=0.001), explaining about 20% of the pattern variability. Menopausal status appeared not to significantly influence whole-body fat or FM distribution. A tendency towards a higher trunk FM/legs FM ratio was observed after menopause, but lost after age-adjustment.*

Conclusion: *In non-obese subjects, even of young age, the FM content and distribution is highly variable. FFM mass appears to be the main composition contributor to bone mass, at least in young, healthy, non-obese women. Menopause is not associated to major changes of whole-body fat and trunk adipose tissue, although a significant decrease in peripheral FM content and a tendency towards an age-dependent central redistribution of adiposity is noticed.*

Key words: bone mineral density, peak bone mass, body composition, fat mass, fat-free mass, menopause, dual X-ray absorptiometry

Address for correspondence:
Carmen Emanuela Georgescu, MD, PhD, Associate Professor in Endocrinology, Department of Endocrinology, "Iuliu Hatieganu" University of Medicine and Pharmacy, 3 Louis Pasteur Street, Cluj-Napoca, Zip Code 400349, Romania
email address: c_e_georgescu@yahoo.com

INTRODUCTION

Last years researches brought evidence for a strong relationship between body composition and bone mass. At first sight, the link appears to be mainly related to the endocrine function of the adipose tissue, which releases several bone-active adipocytokines such as leptin, adiponectin, resistin (9) or visfatin (15). However, association studies between body composition and BMD gave conflicting results, some reports showing a positive correlation between FM and BMD (6, 10), while no association (3) was obtained by others.

Most studies that addressed this issue enrolled individuals irrespective of their body mass index (BMI). It is known that in subjects of the same BMI, the adipose mass to muscle mass ratio may vary significantly, and this, in turn, may influence bone mass; in addition, it cannot be excluded that the relationship between body composition and BMD, two dynamic body compartments, may differ between obese and non-obese subjects.

Therefore, in the present study we aimed to evaluate the influence of body composition parameters on peak bone mass in a group of young healthy, non-obese, Romanian volunteers. To establish the effect of menopausal transition on FM content, FM distribution and the FM-BMD relationship, we compared the group of young, healthy, non-obese women with BMI-matched postmenopausal subjects. ❑

MATERIAL AND METHODS

Randomly selected, apparently healthy 62 subjects (42 young adults and 20 postmenopausal women) were enrolled in the study. Of the 42 young adults, 13 were men, aged 27.8±0.4 years (range 25-30 yrs), BMI 24.4±0.3 kg/m2 and 29 were women, aged 26.7±0.3 years (range 23-30 yrs), BMI 20.8±0.4 kg/m2. Postmenopausal women had a mean age of 60.3±1.5 years (range 45-75 years) and a BMI of 23.2±0.4 kg/m2. All subjects were scanned by whole-body dual X-ray absorptiometry (DXA, DPX-NT, GE, Madison, USA); following BMD and body composition parameters were assessed: lumbar spine (L1-L4) BMD (g/cm2), femoral neck and total hip BMD (g/cm2), whole-body BMD (g/cm2), whole-body and segmental (trunk, legs, arms) FM and FFM. For quality control, the device was calibrated at least 3-times weekly using two phantoms and precision was calculated from three repeated scans with repositioning and standing up between scans in 10 subjects. The coefficient of variation (CV) for lumbar spine was <1%, for hip measurements was <2% and for total body <3%. ❑

Statistical analysis

Results were expressed as mean±SEM. Pearson or Spearman correlation coefficients were calculated to express association of continuous data with parametric or non-parametric distribution. Differences between groups with parametric distribution were determined by two-tailed t-test for independent samples. ❑

Outcomes

As expected, in all groups, a strong correlation between FM and BMI was seen (young women: r=0.88, p=0.0001; men: r=0.70, p=0.01; post-menopausal women: r=0.74, p=0.0002) while FFM failed to correlate with BMI (young women: r=0.05, p=0.79; men: r=0.13, p=0.68; post-menopausal women: r=0.26, p=0.25) or with FM (young women: r=-0.08, p=0.63; men: r=-0.03, p=0.9; post-menopausal women: r=0.01, p=0.94). Age had no significant influence on FM in either group, but was inversely correlated with FFM in young, non-obese adults (young women: r=-0.35, p=0.05; men: r=-0.7, p=0.01).

In neither group, FM was related to BMD of the lumbar spine, hip or whole-body (Table 1). BMD at all sites was positively associated to FFM in young, non-obese women (Table 1). Femoral neck BMD was related to FFM in post-menopausal non-obese women (Table 1). After adjusting for age and FM, the correlation remained statistically significant in young subjects, but not in postmenopausal women.

We further sought to establish differences in body composition between apparently healthy, young, pre-menopausal and post-menopausal women that were matched for BMI. Mean whole-body FM and trunk FM, respectively, showed slightly higher values in post-menopausal in comparison to pre-menopausal women, but the differences between groups reached no statistical significance (p=0.25 and p=0.38, respectively, Table 2). In contrast, legs fat mass was better represented in young women in comparison to postmenopausal BMI-matched

	Young Non-obese Women (n=29)		Young Non-obese Men (n=13)		Postmenopausal Non-obese Women (n=20)	
	Fat mass	Fat-free mass	Fat mass	Fat-free mass	Fat mass	Fat-free mass
L_1-L_4 BMD (g/cm²)	-0.19	+0.53$^{0.003}$	-0.23	+0.15	+0.19	+0.21
Femoral Neck BMD (g/cm²)	-0.18	+0.34$^{0.04}$	-0.30	+0.30	+0.02	+0.44$^{0.05}$
Hip BMD (g/cm²)	-0.17	+0.53$^{0.003}$	-0.36	+0.27	+0.11	+0.41
Whole-body BMD (g/cm²)	+0.09	+0.52$^{0.003}$	-0.24	+0.30	+0.33	+0.42

TABLE 1. Relationships of body composition parameters (fat mass, fat-free mass and BMD) in non-obese young adults and postmenopausal women

	Whole-body fat mass (%)	Trunk fat mass (%)	Legs fat mass (%)	Trunk/Legs fat mass ratio
Young Non-obese Women (n=18)	33.02±1.46 (18.6 – 49.7)	32.27±1.56 (17.7 – 48.5)	40.3±1.5$^{0.04}$ (24.4-57.3)	0.88±0.02
Postmenopausal Non-obese Women (n=18)	35.76±1.78 (19.3 – 46.9)	35.65±2.07 (21.7 – 49.5)	35.2±1.9 (18-46.8)	0.94±0.04

TABLE 2. Whole-body, trunk and legs fat mass in healthy, non-obese post-menopausal women vs. healthy, non-obese young women. Groups were matched for body mass index. Results were expressed as percent of total body mass

women (p=0.04, Table 2). In the whole study population of women, a significant correlation was noticed between age and trunk fat mass to leg fat mass ratio (r=0.45, p=0.001, n=49), supporting the idea that the trunk fat mass/leg fat mass ratio as pattern distribution could be modulated by age. Moreover, in univariate regression analysis, age explained 18.8% of the trunk fat mass/leg fat mass ratio variability in women. In addition, analysis of pattern distribution showed a higher mean trunk fat mass/leg fat mass ratio in postmenopausal women in comparison to young BMI-matched adults, suggesting a tendency towards central redistribution of fat mass after menopause, but the difference reached no statistical significance (p=0.19, Table 2) even after age-adjustment.

In the present study, body composition parameters of non-obese, apparently healthy Romanian subjects were determined. Despite normal values of BMI, large variability of the FM content was noted, with limits ranging between 18.6-49.7% in women and 22-40.3% in men for whole-body FM. Age, gender or menopausal status appeared not to influence significantly the amount of fat tissue as assessed by DXA. Thus, diet and life-style factors seem to play a major role as determinants of the fat to lean mass ratio in non-obese subjects. It has been observed that higher energy intake and lower physical activity predict lower adiponectin and higher ghrelin values in non-obese women (13), both being related to insulin sensitivity (1, 8) and, possibly, a low-grade inflammation status (14). Prospective studies are needed to better characterize cardiovascular and metabolic risk associated with high fat mass content in non-obese subjects.

Several studies have documented the strong link between fracture risk and body mass index (BMI). Using FRAX, a recently developed tool to assess fracture probability, Kanis et al. have shown that BMI has an important effect on fracture probability, i.e. a BMI of 40 kg/m2 leads to a fourfold decrease in 10-year probability hip fracture risk (4). Low fracture risk in obese people suggests a role of fat tissue in maintaining bone mass, either mediated by mechanical loading or due to bone-active adipokines such as leptin. In human osteoblastic cell cultures, leptin enhances osteoblastic cell differentiation (11), while inhibiting RANKL expression and increasing expression of osteoprotegerin (2). Clinical studies brought evidence for a positive correlation between leptin and BMD; however, the association was no longer significant after adjusting for fat mass (12). Adiponectin is inversely related to BMD (7), but no relationship of adipokines with fracture risk is demonstrated. Our findings could not confirm an association between FM and bone mass in non-obese young adults and postmenopausal women. In a recent study on the relationship between lean and fat mass and bone mineral in young adults and adolescents, Janicka et al. found that lean mass, but not FM was associated with BMD, suggesting that muscle mass is the major body composition parameter stimulating bone mineral acquisition (3).

Although data from medical literature show that menopausal transition is associated with increased total body and visceral fat tissue (5), we could not demonstrate differences in whole-body and trunk fat or in the trunk fat mass/leg fat mass ratio between young women and BMI-matched postmenopausal women. This may be explained by DXA, with lower value in quantifying visceral adipose tissue compared to computer tomography or magnetic resonance imaging, or the small numbers of subjects from our study. Also, it is possible that changes in body composition linked to menopause are temporary and, at least in part, reversible, several years after menopause. Peripheral fat mass (legs) was significantly higher in young women, probably linked with higher estradiol levels, increasing FM deposition on the lower part of the body. ❑

CONCLUSION

To conclude, in non-obese subjects, the FM content and distribution is highly variable. In young, apparently healthy women, FFM appears to be the main body composition contributor to bone mass. Menopause is not associated to major changes of whole-body fat and trunk adipose tissue, although we noticed a decrease in peripheral fat mass content and a tendency towards an age-dependent central distribution of adiposity. ❑

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