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DUAL-ENERGY X-RAY ABSORPTIOMETRY ASSESSMENT OF THE BODY COMPOSITION AND BODY FAT DISTRIBUTION IN PRE - AND POSTMENOPAUSAL WOMEN

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Summary: Body composition and body fat distribution show difference in postmenopausal women (postMP) compared to premenopausal women (preMP) with almost equal body mass index (BMI) (28±5kg/m^2 vs. 29±4kg/m^2) and they were compared in this study with dual-energy x-ray absorptiometry (DXA). Total and regional fat mass (FM), FM%, android FM (AFM), gynoid FM (GFM), and central obesity index COI=AFM%/GFM% were determined as well as lean body mass (LBM), bone mineral content (BMC) and bone mineral density (BMD) in 95 women.

Trunkal FM in postMP (17.1±5.2kg) was higher compared to preMP (14.7±5.2kg) ($p<0.042$), as a result of higher AFM (2.97±0.98kg) in postMP compared to 2.39±1.1kg in preMP, but not significantly lower GFM (5.8±1.33kg) in postMP compared to 6.13±1.82kg in preMP. COI value (0.96±0.14) in postMP was higher compared to its value in preMP (0.86±0.14) ($p<0.002$). LBM was not significantly lower in postMP (37.98±4.29kg) compared to preMP (39.35±4.4kg). Total BMC (2.16±0.34kg) in postMP was lower compared to preMP (2.63±0.32kg), as well as total BMD in postMP (1.05±0.09 g/cm^2) compared to preMP (1.17±0.07 g/cm^2) ($p<0.0001$).

Postmenopausal women are characterized with significantly lower BMC and BMD, not significantly lower LBM compared to premenopausal women, and significantly higher trunkal FM and COI as a result of significantly higher AFM but not GFM, confirming the emphasized abdominal obesity in postmenopausal compared to premenopausal women.

Key words: DXA, body composition, body fat distribution, postmenopause, premenopause

Introduction

Menopause is a normal developmental process, and the resulting decline in endogenous estrogen levels can have serious clinical sequelae. Estrogen deficiency has been implicated in an increased risk for vasomotor symptoms, osteoporosis and fracture, central obesity, cardiovascular disease.

Estrogen deficiency is a dominant pathogenic factor in bone loss. Decreasing estrogen concentrations after menopause can cause a decline in bone mineral density, leading to osteoporosis which is a systemic skeletal disease characterized by low bone mass and micro-architectural deterioration of bone tissue, with a consequent increase in bone fragility and susceptibility to bone fracture. Osteoporosis is the leading cause of fractures in the elderly. Age is an independent risk factor for fracture risk. Age-related bone loss continues to occur decades after menopause-related bone loss. BMC and BMD are reduced in postMP women compared to preMP. Dual-energy x-ray absortiometry (DXA) is currently the criterion standard for the evaluation of bone density. Women with higher BMI have higher BMD. In postmenopausal women, adipose tissue is the main site of androgen conversion to estrogen by the enzyme aromatase. Furthermore, body weight, particularly fat mass, contributes to the skeletal load and is therefore an important factor in increasing bone density and reducing bone turnover.

Menopause is a high-risk time for weight gain. Although the average weight gain during the menopausal transition is 2-5 pounds, it can be much greater. In addition, the hormonally driven shift in fat distribution from peripheral to abdominal, which may begin even before menopause, may increase health risks. Postmenopausal women have significantly more fat, a more central fat distribution, and less lean tissue mass than preMP women (Svendsen et al. 1995). An initial event during the menopausal process is BMD loss, which is followed by body fat distribution shift, then LBM loss and reciprocal increase in body fat mass (Morita et al. 2006). Menopause-related central body fat accumulation potentially contributes to the increased incidence of disease observed in postMP, compared with preMP women (Pansini et al. 2008).

Body composition and body fat distribution differences in postmenopausal women compared to premenopausal women with almost equal body mass index were determined in this study with DXA. The effects of climacteric modifications on body composition and fat distribution were evaluated.

Materials and methods

DXA examination was performed on 95 healthy women, divided in two groups: postMP women (N=67) with mean age of 59.69±6.35yr, mean BMI of 29±4 kg/m^2 and mean body weight (BW) of 73±11kg and preMP women (N=28) with mean age of 36.35±9.36yr, mean BMI of 28±5 kg/m^2, mean BW of 72.63±13.89kg. The examinees were divided in 4 groups according to their BMI expressed in kg/m^2: gr.1<25; gr.2 (25-29.9); gr.3 (30-34.9) and gr.4 (35-40).

BMI values were calculated as body mass (kg)/height (m)2. Body height was measured to the nearest 0.1 cm using a stadiometer in barefoot subjects in free-standing position. Body weight was measured to the nearest 0.05 kg using calibrated electronic digital scale in subjects wearing light clothing and having no footwear on.

Body composition was assessed using DXA System Lunar DPX-NT, which uses encore 10.x Windows-XP Professional OS computers. During the DXA scan, the subject was in a supine position while the x-ray scanner performed a series of transverse scans, measured at 1-cm intervals from the top of the head to the bottom of the toes. The DXA machine was calibrated daily in accordance with the manufacturer's guidelines to ensure adequate quality control. The system enables simultaneous assessment of total and regional body composition and fat distribution.

We assessed body fat, total lean mass, and total body bone mineral density and content using DXA. Total and regional fat mass (FM) and FM% were determined, truncal FM (TFM), android FM (AFM), gynoid FM (GFM) and central obesity index as a ratio of the AFM% to GFM%, COI=AFM%/GFM%. Central abdominal fat, AFM was measured from the upper border of L2 to the lower border of L4. DXA assessment of the tissue mass (TM) and TM% was performed. TM is consisted of FM and bone (mineral) free LBM. Fat free mass (FFM) is consisted of bone free LBM and BMC. Also, BMC and BMD were determined. BMC values were expressed in grams, and BMD in g/cm^2. Generally, the T-score is used for the diagnosis of low bone mass or osteoporosis. Regarding the interpretation of bone densitometric findings, a T-score of more than 1 standard deviation (SD) but of less than 2.5 SDs below the mean peak value for bone mineral content for young adult confirms osteopenia; a level of more than 2.5 SDs below the mean peak value for young adults is diagnostic of osteoporosis. Subjects' total body and regional values (arm, leg, trunk, android, and gynoid) were evaluated.

Statistical analyses were performed using SPSS for Windows statistical software program, version 14.0. P<0.05 values were considered significant. Each parameter was presented as the mean±SD. Differences among groups were evaluated by performing an analysis of variance (ANOVA) for normally distributed parameters or by the Kruskal-Wallis test for non-parametric data. Correlation coefficients were determined by Pearson's product moment.

Results

Total BMC (2.16±0.34 kg) in postMP was significantly lower compared to preMP (2.63±0.32 kg) (p<0.0001). Total BMD in postMP (1.05±0.09 g/cm2) was significantly lower compared to preMP (1.17±0.07 g/cm2) (p<0.0001). Regional BMD and BMC values (arm, leg, trunk, spine, ribs, pelvis and hip) were significantly higher in preMP compared to postMP. Mean lumbar spine BMD in preMP was 1.11±0.11 g/cm2, significantly higher compared to postMP (0.98±0.13 g/cm2) (p<0.0001). BMI increase was associated with total BMD and BMC increase as well as hip neck and mean lumbar spine BMD increase in pre and postMP. BMC and BMD values and T-score in dependence on BMI in preMP and postMP are shown in table 1.

Total FM in postMP was 31.72±8 kg, not significantly different compared to preMP (29.62±10.1 kg). Total FM% in postMP 43.6±5.87% was significantly higher compared to preMP (40±6.92%). Trunkal FM in postMP (17.1±4.7 kg) was higher compared to preMP (14.7±5.2 kg) (p<0.042). TFM% in postMP was 45.83±6.42%, significantly higher compared to preMP (41.64±7.74%) (p<0.016). AFM in postMP was 2.97±0.97 kg, significantly higher compared to preMP (2.39±1.1 kg) (p<0.017), and AFM% in postMP was 48.64±7.53%, significantly higher compared to preMP (43.59±9.84%) (p<0.019). GFM in postMP was (5.8±1.33 kg), not significantly different compared to preMP (6.13±1.82 kg), as well as GFM% in postMP 50.29±5.38% compared to preMP (49.99±5.56%). COI value (0.96±0.14) in postMP was higher compared to its value in preMP (0.86±0.14) (p<0.002).

LBM was not significantly lower in postMP (37.98±4.29 kg) compared to preMP (39.35±4.4 kg). Total LBM in postMP: in the 1st gr. 34.2±4.49 kg, in the 2nd gr. 36.81±3.14 kg, in the 3rd gr. 39.56±3.38, and in the 4th gr. 42.62±2.91 kg and these values were not significantly lower compared to correspondent preMP: in the 1st gr. 37.04±2.1 kg, in the 2nd gr. 37.75±3.06 kg, in the 3rd gr. 43.14±3.02 and in the 4th gr. 46.37±5.74 kg.

Leg LBM in postMP (12±1.53 kg) and leg FFM (12.81±1.65 kg) were significantly lower compared to preMP (13.23±1.82 kg) and (14.13±1.96 kg) (p<0.003).

Table 1. Total BMD and BMC, mean lumbar spine BMD and lumbar spine T-score, mean hip neck BMD and hip neck T-score values in preMP compared to postMP in dependence on BMI

	gr.1	gr.2	gr.3	gr.4
Premenopausal women				
Total BMC (kg)	2.52±0.27	2.63±0.33(1	2.86±0.42(2	2.79±0.22(3
Total BMD (g/cm^2)	1,11±0,05	1,17±0,07	1,23±0,04	1,26±0,04
Mean lumbar spine BMD (g/cm^2)	1,04±0,097	1,12±0,09	1,23±0,09(4	1,23±0,03(5
Lumbar spine T-score	-0.018±1.2	0.06±1.12	0.74±1.17(6	0.55±0.49(7
Mean hip neck BMD (g/cm^2)	0,92±0,12	0,95±0,06(8	1,11±0,08	1,1±0,11(9
Hip neck T-score	-0.37±0.96	-0.14±0.53	1.06±0.43	0.78±0.95(10
Postmenopausal women				
Total BMC (kg)	1.95±0.38	2.13±0.27	2.25±0.34	2.32±0.31
Total BMD (g/cm^2)	0,97±0,08	1,02±0,07	1,08±0,09	1,15±0,09
Mean lumbar spine BMD (g/cm^2)	0,88±0,1	0,95±0,09	1,06±0,13	1,09±0,1
Lumbar spine T-score	-2.26±0.89	-1.86±1.1	-0.95±1.55	-0.61±1.62
Mean hip neck BMD (g/cm^2)	0,72±0,09	0,83±0,12	0,87±0,1	0,88±0,08
Hip neck T-score	-2.02±0.81	-1.14±1.01	-0.78±0.95	-0.73±0.95

Not signed values are highly significantly higher in preMP compared to postMP (p<0.0001).
1. p<0.002; 2. p<0.03; 3. p<0.05; 4. p<0.007; 5. p<0.016; 6. p<0.027; 7. p<0.05; 8. p<0.001; 9. p<0.039; 10. p<0.041 significantly higher compared to postMP

Discussion

The secretion of the ovarian hormones estrogen and progesterone ends with menopause. Estrogen deficiency occurring after natural or surgically-induced menopause leads to an uncoupling between osteoclasts and osteoblasts, which is responsible for accelerated loss of bone, resulting in a 3% reduction in bone mass per year for the first 5 years; thereafter, the rate of loss of bone ranges from 1%-2% per year (Nordin et al. 1998). Bone loss is more abrupt for the first decade after the onset of menopause, followed by more gradual loss thereafter. For a given bone mass, the risk of fracture increases significantly with age. Extremely important is the total amount of bone a woman has at the time of menopause. Low preMP BMD, a decrease in BMD, and an increase in bone fragility, which occur as a result of both aging as well as menopause are major determinants of subsequent risk for osteoporotic fracture (Guthrie et al. 2000).

BMD is typically measured via DXA at the lumbar spine and hip. DXA is the only validated method for diagnostic classification of BMD as normal, osteopenia, or osteoporosis, according to the WHO criteria (WHO, 1994). DXA is also used to assess fracture risk and to monitor changes in BMD over time.

BMC and BMD are reduced in postMP women compared to preMP. Our study confirmed lower BMD and BMC in postMP. Total BMC and BMD and their regional values (arm, leg, trunk, spine, ribs, pelvis and hip) in postMP were significantly lower compared to preMP. Lumbar spine and hip neck mean BMD in preMP were significantly higher compared to postMP. Hip neck T-score values in preMP indicated higher BMD compared to postMNP.

BMD reduction is both age- and sex-related (Yao et al. 2001). Thinner women have lower bone density, especially at weight-bearing sites such as the hip and the spine. Low body weight is a strong risk factor for hip fractures in older women. Underweight elderly women have a greater risk of fractures because of low BMD (Dargent-Molina et al. 2000). Weight reduction in older women may lead to bone loss and hip fracture due to lower levels of endogenous estrogens produced in adipose tissue and muscle (Ensrud et al. 2003).

In our study, postmenopausal women with higher BMI had higher BMD. BMI increase was associated with total BMC, total BMD, total lumbar spine BMD and hip neck BMD increase in preMP and postMP. Lower BMI values were associated with more negative lumbar spine and hip T-score values, confirming lower lumbar spine and hip BMD in postMP and preMP, and lower BMD in postMP compared to preMP. Higher BMI in pre- and postmenopausal women in our study was associated with higher FM, LBM, BMC and BMD. FM and LBM correlated with BMD. The positive relationship between increased weight and increased BMD is probably the result of increased mechanical forces on the bone. Because lean and fat mass are the 2 major components of body weight, it is not surprising that fat and lean mass have both been found to be positively related to BMD. It does appear that the association between fat and lean mass and BMD probably depends on the age and menopausal status of the population studied. Adipose tissue contains aromatase, and this enzyme is responsible for the conversion of androgenic steroids into estrogens; the greater the fat mass, the greater the amount of estrogen synthesized, which is a major source of estrogen only after the menopause.

Obesity prevalence is increasing across all ages, but women are particularly vulnerable to weight gain in the years surrounding menopause. BMI of 30 or higher usually indicates excess body fat. It is estimated that abdominal visceral adipose tissue increases with greater BMI (Šubeska, 2009). An android fat pattern is attributed to overweight females and, even more pronounced, to the weight cyclers (Wallner et al. 2004). It was found that low weight, independent of menopausal status, leads to the typical gynoid pattern of fat distribution while excess weight and obesity result in the android pattern of distribution in pre- and postmenopausal women (Kirchengast et al. 1998).

Studies using dual-energy X-ray absorptiometry showed an increased trunk fat in postmenopausal women. These studies suggest that the menopause transition is associated with an accumulation of central fat and, in particular, intra-abdominal fat (Toth et al. 2000) that is independent of age and total adiposity (Garaulet et al. 2002). The proportion of android adipose tissue is greater in postMP women, while the proportion of gynoid adipose is greater in preMP women (Toth et al. 2000). In both groups of women, however, the proportion of android fat is less than in men. In the study of Ley (1992), postMP women had a 20% greater fat mass than preMP women. The proportion of android fat was the greatest in men (48.6%), but it was significantly lower in preMP (38.3%) than in postMP women (42.1%). The reverse was found for gynoid fat.

In obese women, postmenopause and perimenopause are associated with differences in fat and lean distribution, independently of age and total fat (Panotopoulos et al. 1996). Body composition, including fat mass, fat distribution and muscle mass, gradually changes with aging, even if the body weight remains unchanged (Srrensen et al.

2001; Dionne et al. 2000). Lean body mass decreases significantly, while fat mass increases and is preferentially stored in abdominal tissues. Percentage of body fat, trunk fat mass, and trunk-leg fat ratio increased with aging and after menopause (Douchi et al. 2002).

It was shown that postMP obese women had a higher proportion of total fat mass in the trunk and a lower proportion of total fat and lean mass in the femoral and leg regions than preMP women after adjustment for age and total fat mass (Panotopoulos et al. 1996). In our study, leg LBM and FFM in postMP were significantly lower compared to preMP. In postMP women, leg fat tissue, total body and leg lean tissue were significantly lower ($p < 0.05$) than in preMP and periMP groups, in the study of Genazzani, 2006. In the arms a slight but not significant ($p < 0.18$) difference was shown in fat distribution. Endocrine changes during the menopausal transition, rather than the aging process, are related to changes in body weight and fat distribution (Genazzani, 2006). PeriMP and postMP women show a shift to a central, android fat distribution that can be counteracted by HRT. Menopause is associated with increases in body fatness, particularly in the abdominal region. Abdominal adiposity is more strongly associated with the development of type 2 diabetes, coronary artery disease, and cardiovascular disease-related mortality than is total adiposity (Corrigan et al. 2006). Visceral AT is an independent predictor of metabolic risk (Koskova et al. 2009). Because upper body obesity is associated with the metabolic and cardiovascular complications of the hyperinsulinemic-dyslipidemic syndrome, the assessment of upper body fat accumulation in postMP women is an important screening tool for the prevention of these health complications. DXA is very accurate way to assess body fat (Panotopoulos et al. 1996). This method will allow us to determine more accurately the degree of obesity of a particular patient as well as body fat distribution. In our study total FM, GFM and GFM% did not differ between postMP and preMP, but total FM%, TFM, TFM%, AFM, AFM% and COI in postMP were significantly higher compared to preMP. It was confirmed that BMI increase was associated with android pattern of fat distribution.

Our findings suggest that DXA measurements of fat distribution may be useful for studies related to obesity-associated disease risk. DXA measurements in this study evaluated body composition and body fat distribution in BMI matched pre- and post MNP women very precisely, and discovered their menopause-induced differences.

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DUAL-ENERGY X-RAY ABSORPCIOMETRISKA PROCENA TELESNOG SASTAVA I TELESNE DISTRIBUCIJE KOD PRE I POSTMENOPAUZNIH ŽENA

Izvod

Telesni sastav i telesna distribucija pokazuju razlike kod postmenopauznih žena (postMP) u poređenju so premenopauznim ženama (preMP) sa skoro identičnim body mass indexom (BMI) (28±5kg/m^2 prema 29±4kg/m^2) i oni su bili upoređeni u ovoj studiji sa dual-energy x-ray absorpciometrijom (DXA). Ukupna i regionalne masne mase (MM), MM%, androidna MM (AMM), ginoidna MM (GMM), indeks centralne gojaznosti COI=AMM%/GMM% su bili određeni kao i lean body mass (LBM), koštana mineralna sadržina (BMC) i koštani mineralni denzitet (BMD) kod 95 žena.

MM trupa kod postMP (17.1±5.2kg) je bila veća u poređenju sa preMP (14.7±5.2kg) (p<0.042), kao rezultat veće AMM (2.97±0.98kg) kod postMP u poređenju sa (2.39±1.1kg) kod preMP, i ne značajno niža GMM (5.8±1.33kg) kod postMP u poređenju sa (6.13±1.82kg) kod preMP. COI vrednost (0.96±0.14) kod postMP je bila veća u poređenju sa njenim vrednostima kod preMP (0.86±0.14) (p<0.002). LBM je bio nesignifikantno niži kod postMP (37.98±4.29kg) u poređenju sa preMP (39.35±4.4kg). Ukupna BMC (2.16±0.34kg) kod postMP je bila niža u poređenju sa preMP (2.63±0.32kg), isto kao i ukupni BMD kod postMP (1.05±0.09 g/cm^2) u poređenju sa preMP (1.17±0.07 g/cm^2)(p<0.0001).

Postmenopauzne žene karakteriziraju se sa značajno nižim BMC i BMD, ne značajno nižom LBM u poređenju sa premenopauznim ženama, i značajno većom trunkalnom MM i COI kao rezultat značajno veće AMM ali ne i GMM, potvđujući izraženiju abominalnu gojaznost kod postmenopauznih žena u poređenju sa premenopauznim ženama.

Ključne reči: DXA, telesni sastav, telesna distribucija masti, postmenopauza, premenopauza