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DUAL-ENERGY X-RAY ABSORPTIOMETRY ASSESSMENT OF THE BODY COMPOSITION IN OBESE WOMEN

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Summary: Dual-energy x-ray absorptiometry (DXA) is considered to be the gold standard for assessment of the body composition (BC). BC dependence on body mass index (BMI) increase was assessed with DXA in 88 women, divided in 4 groups according to their BMI (kg/m^2): gr.1<25; gr.2 (25-29.9); gr.3 (30-34.9) and gr.4 (35-40). Fat mass (FM) and FM% were determined as well as lean body mass (LBM), fat free mass (FFM) and bone mineral content (BMC).

Body weight (BW) values in gr.1 (58.73±5.78kg), gr. 2 (69.14±5.58kg), gr.3 (80.58±6.16kg) and gr.4 (90.67±8.53kg), were significantly different between the groups and correlated with BMI (p<0.0001). FM progressively and significantly increased from the 1stgr. (19.79±4.89kg), to the 2nd gr. (28.7±3.87kg), 3rdgr (36.49±4.71kg) and 4thgr. (43.91±6.36kg). Android FM (AFM) increased progressively, and percentage of its increase was higher compared to gynoid FM (GFM) increase in all groups. LBM in the 1stgr was (35.71±3.79kg) and 2ndgr. (37.01±2.84kg), but in the 3rdgr. (40.51±3.98kg) and 4thgr. (43.27±3.09kg) were significantly higher. LBM/FM ratio was significantly higher in the 1stgr. compared to the other groups in which it progressively lowered, showing higher FM compared to LBM increase in obese women. BMI correlated significantly with BW, FM and FM% . BMC was not significantly different among the groups.

BMI increase in obese women was characterized with no significant increase of BMC, lower LBM increase compared to FM increase, significant BW and FM increase in all compartments, significant trunk FM increase as a result of dominant AFM increase, and lower legFM increase. DXA provided accurate and precise BC assessment.

Key words: DXA, body composition, BMI, obesity

Introduction

BMI has been proposed as a simple and valid measure for monitoring fatness. It also shows a consistently high correlation with body weight. BMI serves as a good surrogate marker for obesity in population studies. BMI and total body weight do not assess lean vs. fat mass and does not quantitate body composition. At the same BMI, more body fat tends to have women compared to men, and older people compared to younger adults. A bodybuilder with a large muscle mass and low percentage of body fat may have the same BMI as a person who has more body fat. BMI does not provide information on fat distribution. It do not monitor the regional fat distribution (e.g., visceral vs. subcutaneous), which is clinically useful in relation to cardiovascular disease risk, glucose metabolism, and insulin resistance (Dencker, 2007).

DXA is sensitive technique of body composition assessment, which measures whole and segmental body fat and lean body mass. Today DXA is considered the gold standard to assess bone health and body composition. Body composition is simply the ratio of lean body mass to fat body mass. Using DXA to determine the proportion of lean body mass (muscle) versus total body fat is a valuable clinical tool in the management of long-term health and fitness. This study performed DXA body composition assessment in dependence on BMI.

Materials and methods

DXA examination was performed on 88 healthy women with mean age 50.79±13.57yr, BMI 28.22±5.12 kg/m^2 and BW 71.5±12.5kg. The examinees were divided in 4 groups according to their BMI expressed in kg/m^2: 1stgr. with mean BMI value 22.45±1.86; 2ndgr. 27.38±1.16; 3rdgr. 32.04±1.41 and 4thgr 36.86±1.82. The 1stgr consisted of 27 patients, the 2ndgr. 28, the 3rdgr. 22 and the 4thgr. 11 patients. The patients groups did not differ according to their age.

BMI was defined as the weight (in kilograms) divided by the square of the height in meters (kg/m^2). Height was measured by a wall stadiometer in subjects without shoes and weight was measured by a digital scale.

DXA assessment was performed with Lunar DPX-NT system which uses encore 10.x Windows-XP Professional OS computers. For body composition measurements, a scan of the entire body was performed. DXA assessment of the tissue mass (TM) and TM%, as well as FM, FM%, bone (mineral) free LBM, BMC and bone mineral density was performed. TM is consisted of FM and bone (mineral) free LBM. Fat free mass (FFM) is consisted of bone free LBM and BMC. Their total body and regional values (arm, leg, trunk, android, and gynoid) were evaluated. Central abdominal fat, AFM was measured from the upper border of L2 to the lower border of L4.

Statistical analyses were performed using statistical software program SPSS for Windows, version 14.0. P<0.05 was 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

BMI correlated and showed positive association with BW, TM, FM, FM%. BC assessment values expressed in kilograms are presented in Table 1.

Only BMC not significantly increased, but all other body composition components increased significantly. Total and regional FM progressively and highly significantly increased from the 1st to the 4th group (p<0.0001). BW increase was a result of the highest percentage of the mean FM increase 32.96%, lower mean LBM increase

6.18% and lowest BMC increase 2.29%. Mean TM increase was 17.35% and for FFM 6.76%.

Table 1. Body composition values expressed in kilograms

	gr.1	gr.2	gr.3	gr.4
TM	55.95±6.74	64.27±5.56	75.76±5.22	84.91±3.79
FM	19.79±4.89	28.7±3.87	36.49±4.71	43.91±6.36
LBM	35.71±3.79	37.01±2.84	40.51±3.98	43.27±3.09
BMC	2.26±0.42	2.29±0.38	2.43±0.44	2.48±0.29
FFM	37±4.62	39±2.7	42.15±3.86	45±3.07

TM – tissue mass; FM – fat mass;
LBM – lean body mass (BMC free)
BMC – bone mineral content;
FFM – fat free mass

LBM/FM ratio in the 1stgr. was 1.94±0.64, which was for mean 51.91% higher compared to the 2ndgr. (1.31±0.19), for 73% higher compared to the 3rdgr. (1.13±0.18), and for 95.1% higher than the 4thgr. (1±0.14), and the difference between the groups was highly significant ($p<0.0001$).

FM values in the 1st, 2nd, 3rd and 4th gr. were: 1.61±0.53kg, 2.55±0.43kg, 3.63±0.54kg and 4.24±0.8kg in the arms, 7.97±1.87kg, 10.1±2.5kg 12.29±2.85kg and 14.92±3.2kg in the legs, 9.5±2.9kg, 15.3±2kg, 19.72±2.8kg and 23.82±3.53kg in the trunk, and correspondent AFM values were 1.43±0.58kg, 2.55±0.45kg, 3.38±0.59kg and 4.4±0.66kg as well as GFM values were 4.48±0.91kg, 5.53±1kg, 6.44±1.25kg and 7.8±1.4kg. GFM increased in the 2nd group of overweight compared to controls ($p<0.001$) as well as GFM% ($p<0.002$), but AFM and AFM% increased with highest significance ($p<0.0001$).

Mean percentage of FM increase in the 2nd, 3rd and 4thgr. compared to the 1stgr. was: 39%, 56% and 62% for armFM; 21%, 34% and 47% for legFM; 37%, 52% and 60% for trunkFM; 44%, 58% and 68% for AFM;18.9%, 30% and 43% for GFM; and 32%, 46% and 56% for total FM%. It was significantly higher for armFM compared to legFM. TrunkFM mean percentage increase was a result of dominant AFM increase, which was significantly higher compared to GFM increase.

FM% values in the 1st, 2nd, 3rd and 4th gr. were: 27.44±7.87%, 36.93±3.93%, 42.66±4.62%, 45.72±3.39% in the arms, 38.58±6.38%, 43.51±6.12%, 46.77±6.16%, and 50.1±4.54% in the legs, 34.32±7.9%, 44.84±3.52%, 48.42±3.94% and 51.1±3.42% in the trunk, and correspondent AFM% values were 34.35±10.22%, 47.45±4.61%, 51.75±3.52% and 53.62±3.23% as well as GFM% values were 45.74±5.77%, 49.94±4.65%, 51.11±5.39% and 53.62±3.23%.

BMI increase was characterized with progressive significant LBM increase in all regions ($p<0.0001$) except for leg. LegLBM had lowest mean percentage of increase ($p<0.002$). Overweight in the 2nd gr. compared to the 1st gr. were characterized with no LBM increase in all compartments, significant FM increase and lower LBM/FM ratio. BMC values on the arms, trunk, android region and total were not different among the groups ($p>0.05$), but they increased from the 1st to the 4th group on the legs: (0.8±0.1kg; 0.83±0.1kg; 0.9±0.1kg and 0.95±0.1kg) ($p<0.014$), and gynoid region (0.21±0.04kg; 0.23±0.03kg; 0.25±0.04; 0.24±0.03kg) ($p<0.003$).

Discussion

The core abnormality of Metabolic Syndrome is increased body weight and particularly . Obesity and body fat distribution are known risk factors for cardiovascular disease. BMI is used as a practical marker to assess obesity, and it is closely correlated with the degree of body fat in most settings. It is often used as a surrogate estimate of body fat in epidemiological studies. It is relatively inexpensive, easy to collect and to analyse. In a clinical setting, physicians take into account race, ethnicity, lean mass (muscularity), age, sex, and other factors which can affect the interpretation of BMI. BMI does not quantitate body composition (Dencker, 2007), and does not show the difference between excess fat and muscle. Two people can have the same BMI but different body fat percentages. BMI overestimates body fat in persons who are very muscular, and it can underestimate body fat in persons who have lost body mass (e.g. many elderly).

BMI cannot provide accurate information about fat distribution, as the relationship between BMI and body fat content varies according to body build and body proportion. Percentage body fat and total body fat are all closely associated with BMI, but a significantly lower correlation exist for BMI vs. body fat distribution (Dencker, 2007), which may be a limitation when BMI is used to study cardiovascular risk factors in epidemiological studies. BMI as well as weight is only one factor related to risk for disease.

DXA determines total and regional body composition. DXA is considered a gold standard because of its reliability, precision, and the fact that it is based on a three-compartment model. DXA method determines total body fat mass and FM%, bone mass and lean mass, and separately their regional values for the arms, legs, head and trunk (which included ribs, pelvis, thoracic spine, and lumbar spine). DXA is also used to quantify abdominal fat mass (Lear, 2006).

The most accurate anatomical methods of intraabdominal fat measurement are CT, MRI and DXA. Measurement of intra abdominal fat by MRI, was highly correlated to the central abdominal fat measured by DXA (Kamel, 1999). A strong correlation existed between DXA and CT values for total abdominal fat. DXA is a good alternative to CT for predicting total abdominal fat in an elderly population (Kim, 2007). Excess body fat in the abdominal region is referred to as android obesity, and is associated with increased risk of cardiovascular disease. DXA measurements of fat distribution may be useful for studies related to obesity-associated disease risk (Ley, 1992). Individuals with an “apple,” or abdominal fat distribution pattern (upper body) are at a substantially higher risk of developing cardiovascular and metabolic diseases compared with those with a “pear,” or lower body fat distribution pattern (hips, thighs and buttocks). Most females store fat in the gynoid pattern while most males store fat in the android pattern. Android obesity, which is predominantly abdominal, is more predictive of adipose-related comorbidities than gynecoid obesity, which has a relatively peripheral (gluteal) distribution. Because of that, effective methods for assessing visceral fat are important to investigate its role for the increased health risks in obesity (Snijder, 2002).

BMI of 30 or higher usually indicates excess body fat. Estimates of abdominal visceral adipose tissue increase with greater BMI. The majority of normal weight women show a gynoid fat pattern. An android fat pattern is attributed to overweight females and, even more pronounced, to the weight cyclers (Wallner, 2004). The proportion of android adipose tissue is greater in postmenopausal women, while the proportion of gynoid adipose is greater in premenopausal women (Toth, 2000). In both groups of women, however, the proportion of android fat is less than in men. In obese women, post menopause and perimenopause are associated with differences in fat and lean distribution, independently of age and total fat (Panotopoulos, 1996). Body composition, including fat mass, fat distribution and muscle mass, gradually changes with aging, even if the body weight remains unchanged (Srrensen, 2001; Dionne, 2000). Lean body mass decreases significantly, while fat mass increases and is preferentially stored in abdominal tissues.

Weight scales can be misleading since body weight is muscle, fat and bone all added together. Body composition analysis by DXA allows seeing these individual components. Standard scales can tell a total weight, but can't determine the lean-to-fat ratio of that weight. Body composition is simply the ratio of lean body mass (structural and functional elements in cells, body water, muscle, bone, heart, liver, kidneys, etc.) to fat body (essential and storage) mass. Measurements of body composition have been used to study how lean body mass and body fat change during health and disease. Naturally, the objective for optimum health is to minimize body fat and maximize lean mass. By measuring body composition, a person's health status can be more accurately assessed and the effects of both dietary and physical activity programs better directed. Also, measurements of body compositions have provided a research tool to study the metabolic effects of aging, obesity, and various wasting conditions. Because a scale measures "body weight," which includes fat, muscles, bones and organs, it can't specifically tell how much fat have been lost, and the only way to measure actual fat loss is to measure "body composition," not body weight in weight loss programs.

In our study BMI increase was associated with highest FM increase, lower LBM and lowest BMC increase. BMI increase was associated with significant FM increase in all regions ($p<0.0001$). Mean percentage of the FM increase was significantly higher in arms compared to legs, as well as in A compared to G. TrunkFM increase was a result of dominant AFM increase indicating increased risk for metabolic complications. BMI increase was associated with more pronounced abdominal fat distribution. GFM increased in the 2nd group of overweight compared to controls ($p<0.001$) as well as GFM% ($p<0.002$), but AFM and AFM% increased with higher significance ($p<0.0001$) indicating increased metabolic risk in overweight patients. BMI increase was associated with significant FM% increase ($p<0.0001$) in all regions. These data confirmed positive association of the BMI increase with emphasized abdominal body fat distribution and abdominal type of obesity, which is the main characteristic of the metabolic syndrome.

LBM increase was highly significant in all regions ($p<0.0001$), except for leg. Leg LBM increase had lower significance ($p<0.002$). Overweight in the 2ndgr. compared to the 1stgr. were characterized with no LBM increase in all regions, significant FM increase and lower LBM/FM ratio. BMI increase was associated with lowering of the LBM/FM ratio, confirming dominant FM increase. BMI increase was associated only with BMC increase on the legs ($p<0.014$) and gynoid region ($p<0.003$), confirming stronger bone of the legs and hips in obese.

DXA investigates the normal and pathological topography of fat distribution to reveal possible correlation with metabolic disorders. The trunk fat is a deleterious risk factor for cardiovascular disease (insulin resistance and dyslipidemia) in women. Leg fat mass was associated with a more favourable metabolic profile after adjustment for risk attributable to central adiposity, whereas arm fat mass had no such association (Tatsukawa, 2000; Christou, 2004). Increased leg fat mass appears to be favourably associated with cardiovascular disease risk factors after adjusting for central adiposity (Williams, 1997). FT in legs have a protective effect against the metabolic disorders. The apparent protective effect of increased leg fat mass is simply indicative of a propensity to store fat subcutaneously. Peripheral FT has a negative association with metabolic dIsfunction. Lower leg FM increase in our study was associated with more pronounced abdominal obesity which is related more to metabolic abnormalities.

In addition to general obesity, the distribution of body fat is independently associated with the metabolic syndrome. Our findings suggest that DXA measurements of the fat distribution may be useful for studies related to obesity-associated disease risk.

DXA enabled precise, accurate body composition assessment and showed that BMI increase was associated with more pronounced abdominal obesity, indicating substantially higher risk of developing cardiovascular and metabolic diseases.

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DUAL-ENERGY X-RAY APSORPCIOMETRIjSKA PROCENA TELESNOG SASTAVA KOD GOJAZNIH ŽENA

Izvod

Dual-energy x-ray absorptiometry (DXA) smatra se zlatnim standardom u proceni telesnog sastava (BC). Povezanost BC sa porastom body mass indexom (BMI) je procenjena pomoću DXA kod 88 žena, podeljenih u 4 grupe prema vrednostima BMI (kg/m^2): gr.1<25; gr.2 (25-29.9); gr.3 (30-34.9) i gr.4 (35-40). Masna masa (FM) i FM% bile su određene, a isto tako i lean body mass (LBM), bezmasna masa (FFM) i koštana mineralna sadržina (BMC).

Vrednosti telesne mase (BW) u Gr. 1 (58.73±5.78kg), Gr. 2 (69.14±5.58kg), Gr. 3 (80.58±6.16kg) i Gr. 4 (90.67±8.53kg), bile su značajno različite između grupa i korelirale su sa BMI (p<0.0001).

FM progresivno i značajno se povećala od Gr.1 (19.79±4.89kg), prema Gr. 2 (28.7±3.87kg), zatim Gr. 3 (36.49±4.71kg) i Gr. 4 (43.91±6.36kg). Androidna FM povećala se progresivno, i procenat povećanja je bio veći u poređenju sa porastom ginoidne FM (GFM) u svim grupama. LBM u Gr. 1 iznosi (35.71±3.79kg) i u Gr. 2 iznosi (37.01±2.84kg), a u trećoj (40.51±3.98kg) i u četvrtoj grupi (43.27±3.09kg) je značajno veći. LBM/FM odnos je bio značajno veći u gr.1 u poređenju sa ostalim grupama u kojima se progresivno smanjio, pokazujući veći porast FM u poređenju sa LBM porastom kod gojaznih žena. BMI korelira značajno sa BW, FM i FM%. BMC se nije razlikovao između grupa.

Porast BMI kod gojaznih žena karakterizirao se sa neznačajnim porastom BMC, manjim porastom LBM u poređenju sa porastom FM, značajnim porastom BW i FM u svim kompartmanima, značajnim porastom trunkalne FM kao rezultatom dominantnog porasta AFM, i manjim porastom FM na nogama. DXA je omogućio tačnu i preciznu procenu telesnog sastava.

Ključne reči: DXA, telesni sastav, BMI, gojaznost