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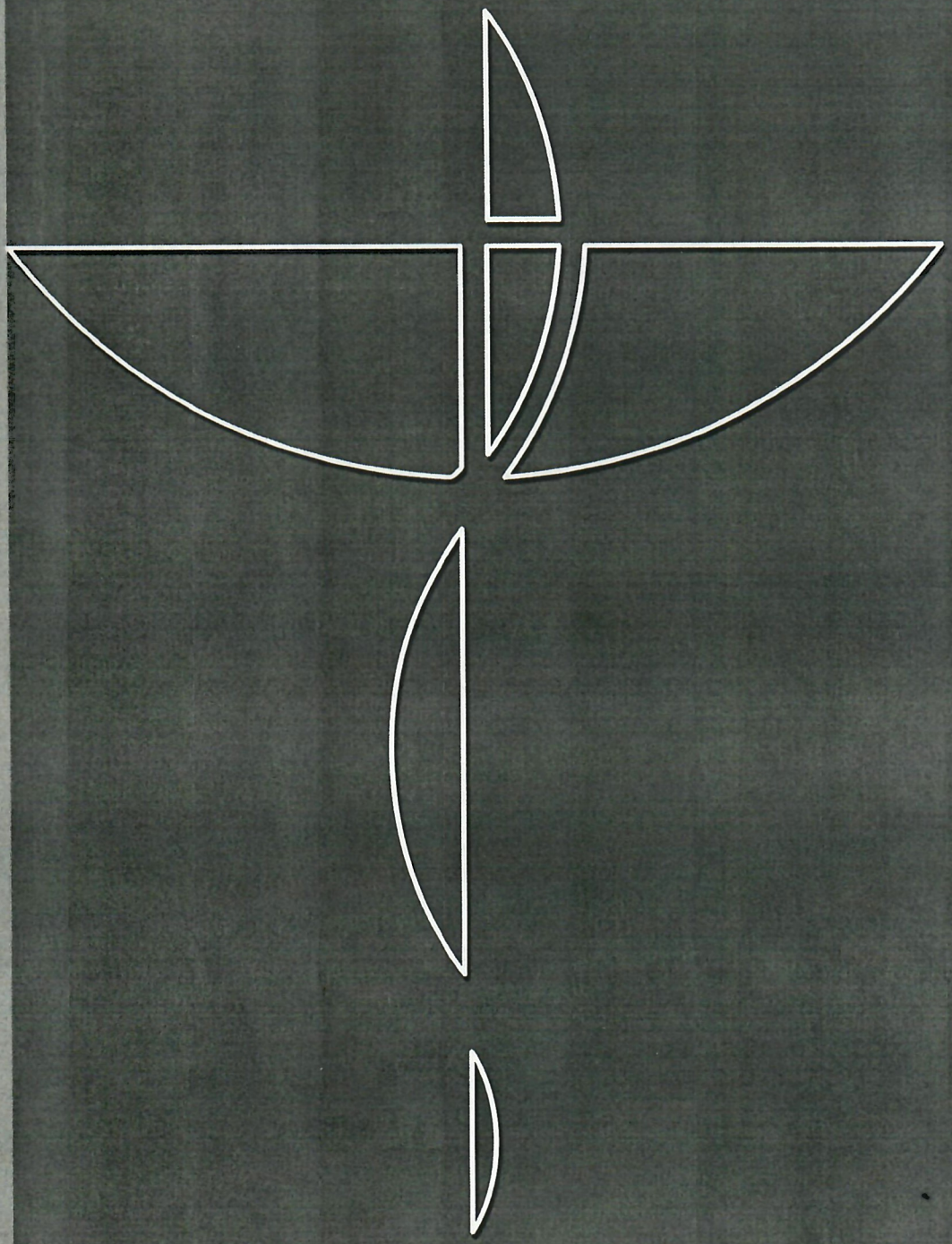

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BODY FAT DISTRIBUTION CHANGES DURING WEIGHT LOSS DETERMINED BY DXA ANDROID/GYNOID INDEXESOF ABDOMINAL OBESITY

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Abstract

The effect of weight loss on body fat distribution was examined through central obesity indexes (COI), which areandroid/gynoid tissue and fat mass ratiosdetermined by dual-energy X-ray absorptiometry (DXA) and their relationship with lipid profile changes.

The following parameters were determined before and after weight loss in 4 postmenopausal women: body mass index (BMI), body weight (BW), android (A) and gynoid (G) tissue mass (TM) and fat mass (FM) and their %with DXA, and their ratiosas indexes of abdominal fat distributionCOI_1 (A/G-TM), COI_2 (A/G-FM), COI_3 (A/G-TMfat%) and COI_4 (A/G-FM%), as well as lipid profile: total cholesterol (C), triglycerides (TG), HDL-C, LDL-C, LDL/HDL-C, C/HDL-C and TG/HDL-C.

BW of 63±1.4kg and BMI value of 29±0.65 kg/m^2 lowered after the weight loss to 49±1.6 kg and normalBMI22.62±0.74 kg/m^2 ($p<0.012$). COI_1value decreased significantly from 0.5±0.01 to normal value 0.42±0.02 ($p<0.003$). COI_2 value decreased significantly from 0.45±0.02 to normal value 0.34±0,02($p<0.0004$).COI_3 value decrease from 0.95±0.026 to 0.74±0.012 was significant ($p<0.0009$) and COI_4value decrease from 0.95±0.01 to 0.74±0.02 was also significant ($p<0.0001$). Atherogenic indexes TG/HDL-C, LDL/HDL-C and C/HDL lowered significantly after the weight loss ($p<0.002$; $p<0.03$and$p<0.05$)as well as TG, C and LDL values($p<0.001$; $p<0.01$; $p<0.01$).

It was confirmed that DXA indexes of central, abdominal obesity COI_1 and COI_2 were increased in overweight women before the weight loss and lowered significantly after the weight loss to normal values, indicating that normal BMI and BW reached after the weight loss were associated with normalized body fat distribution, and significant reduction of the atherogenic lipid profile indicating reduced atherogenic risk.

Key words: DXA indexes, abdominal obesity, weight loss, lipid profile.

ПРОМЕНИ НА ТЕЛЕСНАТА МАСНА ДИСТРИБУЦИЈА ОДРЕДЕНИ СО DXA АНДРОИДНИ/ГИНОИДНИ ИНДЕКСИ НА АБДОМИНАЛНА ДЕБЕЛИНА ПО СЛАБЕЕЊЕ

Апстракт

Ефектите од слабеењето врз телесната масна дистрибуција беа испитани преку индексите на централна дебелина (COI), кои се количници на андроидна/гиноидна

ткивна и масна маса одредени со апсорпциометрија со х зраци со двојна енергија (DXA) и нивната поврзаност со промените на липидниот профил.
Следните параметри беа одредени пред и по слабеење кај 4 постменопаузни жени: индекс на телесна маса (BMI), телесна маса (BW), андроидна (A) и гиноидна (G) ткивна маса (TM) и масна маса (FM) и нивните %со DXA, и нивните количници како индекси на абдоминална телесна дистрибуција COI_1 (A/G-TM), COI_2 (A/G-FM), COI_3 (A/G-TMfat%) иCOI_4 (A/G-FM%), како и липидниот профил: вкупен холестерол (C), триглицериди (TG), HDL-C, LDL-C, LDL/HDL-C, C/HDL-C и TG/HDL-C.

Вредностите на BW63±1.4 kg и BMI 29±0.65 kg/m^{2}се намалија по слабеењето на 49±1.6 kg и нормален BMI22.62±0.74 kg/m^2 ($p<0.012$).COI_1се намали значајно од 0.5±0.01 до нормална вредност 0.42±0.02 ($p<0.003$).COI_2се намали значајно од 0.45±0.02 до нормална вредност 0.34±0.02 ($p<0.0004$).COI_3намалувањето од 0.95±0.02бна 0.74±0.012беше значајно ($p<0.0009$) и COI_4намалувањето од 0.95±0.01 на 0.74±0.02беше исто така значајно ($p<0.0001$). Атерогените индекси TG/HDL-C, LDL/HDL-Си C/HDL се намалија значајно по слабеењето ($p<0.002$; $p<0.03$ ир<0.05), аисто така и вредностите на TG, C и LDL ($p<0.001$; $p<0.01$; $p<0.01$).
DXA индексите на централна, абдоминална дебелина COI_1 и COI_2беа зголемени кај жени со зголемена телесна тежина пред слабеењето и се намалија значајно по слабеењето до нормални вредности, укажувајќи дека нормалните BMI и BW вредности постигнати по слабеењето беа поврзани со нормална телесна масна дистрибуција и значајна редукција на атерогениот липиден профил укажувајќи на намален атероген ризик.

Клучни зборови:DXA индекси, абдоминална дебелина, слабеење, липиден профил

Introduction

Central obesity can be an early warning sign of a condition called metabolic syndrome. The core abnormality of metabolic syndrome is increased body weight, and particularly central, abdominal obesity as well as dyslipidemia.Dyslipidemic profile, and increasedC/HDL-C, LDL/HDL-C and TG/HDL-C ratios values are especially important components and indicators of cardiovascular risk. Their predictive value is greater than the isolated parameters.

Obesity and central body fat distribution are known risk factors for cardiovascular and metabolic diseases. Excess abdominal fat is referred to as android obesity and it is an important, independent risk factor for disease,whichis associated with increased risk for cardiovascular disease. Android obesity, which is predominantly visceral, intra-abdominal, is more predictive of adipose-related comorbidities than gynecoid obesity, which has a relatively peripheral (gluteal) distribution.

Shubeska S. (1) discovered with DXA that BMI increase in healthy women was associated with a more pronounced abdominal body fat distribution (2), indicating a substantially higher risk for development of metabolic and cardiovascular complications. DXA also measures and monitors body composition changes in obese patients undergoing weight loss.It monitors how much fat was lost in different body compartments. Some relationship ratios between central (android, abdominal) regional tissue and FM to peripheral gynoid regional parts of the body in patients with Cushing's syndrome (CS) were discovered as diagnostic criteria of visceral, abdominal obesity in patients with CS (4,5).DXA indexes of

central, abdominal obesity android/gynoid TM and FM and android/gynoid TMfat% and FM% ratios discovered extreme central body fat distribution in CS, differentiated them significantly from healthy women with normal BMI and obese with the same BMI as CS, and theseare discovered DXA indexes of abdominal, central obesity that should be used as DXA indexes of extreme central, abdominal obesityin CS and in non CS obese women. They are indicators of abdominal obesity (5,6).The assessment of abdominal fat accumulation,especially in postmenopausal (postM) women, is an important screening tool for theprevention of the obesity associated health complications (7). DXA measurements of fat distribution are very useful in studies related to obesity-associated disease risk.
The aim of this study was to investigate body composition and body fat distribution with DXA indexes of central, abdominal obesity, android/gynoid TM and android/gynoid FM ratios and their TMfat% and FM% ratios as well as lipid values and atherogenic indexes and their changes after weight loss with consequent normal BMI. It was important do discover weight loss influence on body fat distribution and lipid metabolism.

Material and methods

The examinees were four postmenopausal women with mean BMI 29±0.65 kg/m^{2}that lowered to normal values of 22.62±0.74 kg/m^{2}and BW 63±1.4kg that lowered to 49±1.6 kg after the weight loss ($p<0.012$).Android (A) and gynoid (G) fat mass (FM) and its percentage (FM%), tissue mass (TM) and TM fat percentage (TMfat%) were determined with DXA before and after weight loss and the changes of the DXA indexes of abdominal body fat distribution COI_1 (A/G-TM), COI_2 (A/G-FM) and COI_3 (A/G-TMfat%) and COI_4 (A/G-FM%).

Total cholesterol (TC), triglycerides (TG), high density lipoprotein cholesterol (HDL-C), low density lipoprotein cholesterol (LDL-C), LDL/HDL-C, TC/HDL-C and TG/HDL-C were also determined.

Body height was measured by a wall stadiometer in barefoot subjects with head in a horizontal Frankfurt plane to the nearest 0.1 cm. BW was measured by a digital scale while wearing light clothing and it was estimated in kilograms (kg). BMI was calculated with the following formula: weight (kg)/height (m^2). DXA assessment was performed with DXA System Lunar DPX-NT, which uses encore 10.x Windows-XP Professional OS computers.

The entire body of the subject was scanned.During 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 enabled simultaneous assessment of total and regional body composition and body fat distribution.

Statistical analyses were performed using the statistical software program SPSS for Windows, version 22.0. Quantitative series were analyzed with measures of central tendency (average, median), as well as with dispersion measures (standard deviation). Values of different parameters before and after the weight loss were tested by T-test for dependant samples. P values <0.05 were considered to be statistically significant.

Results

Table 1 COI_1, COI_2,COI_3 andCOI_4 values before and after weight loss

Indexes	Before weight lost	After weight lost	T-test for dependent samples
COI_1 (A/G TM)	0,5 ±0,01	0,42±0,02	t-test= 8,1847; df=3; p=0,0038*
COI_2 (A/G FM)	0,45±0,02	0,34±0,02	t-test=17,298; df=3; p=0,0004*
COI_3 (A/G TMfat%)	0.95±0.026	0.74±0.012	t-test=13,237; df=3; p=0,0009*
COI_4 (A/G FM%)	0.95±0.01	0.74±0.02	t-test=22,968; df=3; p=0,00018*

*Significant for p<0.05
COI_1 - A/G-TM (android/gynoid tissue mass ratio)
COI_2 - A/G-FM (android/gynoid fat mass ratio)
COI_3-A/G-TMfat% (android/gynoid tissue mass fat percent ratio)
COI_4 - A/G-FM% (android/gynoid fat mass percent ratio)

COI_1, COI_2, COI_3as well as COI_4 were highly significantly lower after the weight loss.

Table2 Android and Gynoid TM, TMfat%, FM and FM% values before and after weight loss

Parameters	Before weight loss	After weight loss	T-test for dependent samples
Android TM (gr)	5415,75±74,37	3692,50±188,39	t-test= 23,999; df=3; p=0,0002*
Gynoid TM (gr)	10768,75±48,71	8817,50±309,67	t-test= 12,833; df=3; p=0,0011*
Android FM (gr)	2634,25±106,45	1141,75±33,01	t-test=90,427; df=3; p=0,000003*
Gynoid FM (gr)	5841,25±84,12	3352,75±125,13	t-test= 24,29; df=3; p=0,0001*
Android TMfat%	49.83±0.83	29.78±1.51	t-test=48,043; df=3; p=0,00002*
Gynoid TMfat%	52.53±2.26	40.03±1.69	t-test=34,893; df=3; p=0,00005*
Android FM%	49.13±1.01	28.13±1.45	t-test=21,000; df=3; p=0,00008*
Gynoid FM%	51.68±1.3	37.85±1.43	t-test=13,825; df=3; p=0,00009*

*Significant for p<0.05
TM - tissue mass FM - fat mass
TMfat% - tissue mass fat percent FM% - fat mass percent

A and G TM and FM values and their percentages were highly significantly different and the values of android and gynoid TMfat% and FM% showed the highest significance of the difference between the values before and after weight loss.

Table 3 Lipid levels and atherogenic indexes before and after weight loss

Lipid levels	Before weight loss	After weight loss	T-test for dependent samples
Triglycerides	1.23±0.05	0.78±0.11	t-test=10,678; df=3; p=0,0017*
Total Cholesterol	6.55±0.1	5.2±0.55	t-test=4,666; df=3; p=0,0185*
HDL cholesterol	1.61±0.07	1.61±0.08	t-test=-0,0524; df=3; p=0,9615
LDL cholesterol	4.3±0.08	3.17±0.52	t-test=4,6152; df=3; p=0,0191*
LDL/HDL-C	2.68±0.09	1.98±0.39	t-test=43,5712; df=3; p=0,0375*
C/HDL-C	4.1±0.26	3.24±0.47	t-test=-3,0225; df=3; p=0,0566
TG/HDL-C	0.77±0.07	0.49±0.08	t-test=10,0948; df=3; p=0,0021*

C – cholesterol HDL - high density lipoprotein
TG – triglyceridesLDL - low density lipoprotein

Total cholesterol levels were significantly lower after the weight loss ($p<0.01$) as well as LDL cholesterol levels ($p<0.01$), LDL/HDL-C ratio ($p<0.03$), TC/HDL-C ratio ($p<0.05$). Triglycerides had higher significance of thedifference between the values before and after weight loss ($p<0.001$) and TG/HDL-C ($p<0.002$).

Discussion

The main characteristic of the metabolic syndrome is the increased body weight, and particularly central, abdominal obesity as well as dyslipidemia.People with metabolic syndrome have elevated blood pressure, high triglycerides, low levels of HDL cholesterol and insulin resistance. This combination of factors creates an especially high risk for stroke, coronary artery disease, cardiovascular disease-related mortality and type 2 diabetes.

Obese subjects have higher percentage of FM from the total body mass compared to non obese.Obesity and central body fat distribution are known risk factors for cardiovascular and metabolic diseases.

Menopause is a high-risk time for weight gain. PostMP women have significantly more fat, a more central fat distribution, and less lean tissue mass than premenopausal (preMP) women (8, 9). Menopause-related central body fat accumulation potentially contributes to the increased incidence of disease observed in postMP, compared with preMP women (10, 11).The subjects in this study were postmenopausal.

There is growing evidence that intra-abdominal adipose tissue (IAAT), rather than total body fat, is a risk factor for metabolic conditions associated with obesity. For this reason the evaluation of intra-abdominal adipose tissue is clinically important (12). Because of that, effective methods for assessing visceral fat are important to investigate its role in the increased health risks in obesity (13).There is an increased interest in the evaluation of various methods for assessment of body composition and fat distribution (14). DXA body

composition and fat distribution assessment may be useful in studies related to obesity-associated risks (15, 16).

DXA enables precise, accurate body composition and body fat distribution assessment. In a previous study, in 2011 Shubeska S.(1) discovered with DXA that BMI increase in healthy women was associated with a more pronounced abdominal, visceral fat distribution (1, 2). Also, BMI reduction, the quantity of fat loss, body composition and body fat distribution changes are monitored with DXA in obese patients undergoing weight loss.It monitors how much fat was lost during weight loss.
DXA method determines absolute (kg) and relative (%) total, bone, lean and fat body mass andseparately their regional values on arms, legs, head and trunk. Body composition, including fat mass, body fat distribution and muscle mass, gradually change with aging, even if the body weight and BMI remain unchanged. LBM decreases significantly, while fat mass increases and is preferentially stored in abdominal tissues (17, 18, 19). Trunk FM increase is a result of dominant android, abdominal FM increase indicating increased risk for metabolic complications (6). Body fat distribution is simply determined with DXA by the relationship of the regional (segmental) fat compartments. The relationship of the predominantly central, android, abdominal FM and tissue mass (TM) and the gynoid (peripheral FM and TM) is an indicator of the central, abdominal obesity (4). DXA is fast becoming the new goldstandard because it provides a higher degree of precision in only one measurement and has the ability to show exactly where fat is distributed throughout the body. It is a very reliable method and its results are extremely repeatable; in addition, the method is safe and presents little burden to the subject.
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 an android pattern of fat distribution in pre- and postMP women (15). 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. Since a scale measures "body weight", which includes fat,muscles, bones and organs, it can't specifically tell how much fat had been lost, and the only way to measure actual fat loss is to measure "body composition",not body weight in weight loss programs. DXA can precisely monitor how much fat is lost during weight loss(20, 21).

Total body analysis with DXA is the ideal way for the serious athlete, the person monitoring or beginning a program of exercise or weight loss, or anyone curious or concerned about their health to receive a quick, painless, accurate and confidential assessment of their body's composition. Also, measurements of body composition and body fat distribution with DXA have provided a research tool to study the metabolic effects of aging, obesity, and various wasting conditions.
Changes in body composition during weight loss programs might have a significant effect on long-term results and sensitive DXA indexes of abdominal, central obesity are needed, because of lack of normal reference data, which is an issue that is currently being addressed.
CS patients are discovered gold standard of extreme central, visceral, abdominal body fat distribution. DXA indexes of central, abdominal body fat distribution in Cushing's (CS) could also be used as a gold standard for abdominal obesity in non CS. They were discovered as a diagnostic criterion of extreme central, visceral obesity in CS and abdominal obese controls (CO), non Cushing's (non CS) with the same BMI as CS. Shubeska-Stratrova S. (2015) (4), showed that the ratios of insignificantly different central and peripheral regional parts of the body, precisely differentiated the patients with CS and non CS obese, and confirmed central body fat distribution in CS (16, 21, 22). In that study it was found

with DXA thatA/G TM (0.67±0.1) and A/G FM ratios (0.72±0.2) in CS were significantly higher compared to CO (0.48±0.05) ($p<0.0001$) and (0.46±0.09) ($p<0.001$) (4). They differentiated CS and CO with very high significance and discovered extreme central body fat distribution in CS, and could be used as DXA indexes of extreme central, abdominal obesity in CS and non CS abdominal obese women.DXA indexes of central body fat distribution in CS could also be a gold standard and diagnostic criterion of extreme central, abdominal fat distribution in different types of obesity (non CS).

Cut-off points of the following indexes confirmed extreme central, abdominal obesity: COI_1 (A/G-TM) ratio higher than 0.54 and COI_2 (A/G-FM) ratio higher than 0.51 (4, 16, 23).Normal cut-off point values were also discovered, A/G-TM value lower than 0.51 and A/G-FM value lower than 0.38 (23).In this study COI_1value decreased significantly from 0.5±0.01 to normal value 0.42±0.02 ($p<0.003$). COI_2 value decreased significantly from 0.45±0.02 to normal value 0.34±0.02 ($p<0.0004$). COI_3 value decrease from 0.95±0.026 to 0.74±0.012 was significant ($p<0.0009$) and COI_4 value decrease from 0.95±0.01 to 0.74±0.02 was also highly significant ($p<0.0001$).

Shubeska-Stratrova S. (2019) (23), discovered that COI_3 was significantly higher in CS 1.05±0.15 compared to 0.67±0.15 in healthy non obese women with normal BMI ($p<0.0001$). $COI_3$and COI_4also lowered significantly after the weight loss ($p<0.0009$; $p<0.0001$). Significantreduction in these indexes of central obesity after the weight loss confirmed reduction of abdominal obesity and normalized body fat distribution.

An increase in total cholesterol concentration, and specifically LDL cholesterol (an atherogenic lipid marker), and reduced HDL cholesterol concentration are correlated with numerous risk factors, including the components of the metabolic syndrome, and probably involve independent risk (24, 25, 26). Low-density lipoprotein (LDL) cholesterol concentration has been the prime index of cardiovascular disease risk and the main target for therapy.

In an attempt to optimize the predictive capacity of the lipid profile, several lipoprotein ratios or "atherogenic indices" have been defined. These ratios can provide information on risk factors difficult to quantify by routine analyses and could be a better mirror of the metabolic and clinical interactions between lipid fractions. Total/high-density lipoprotein (HDL) cholesterol, TG/HDL-C and LDL/HDL cholesterol ratios are risk indicators with greater predictive value than isolated parameters used independently, particularly LDL. Total cholesterol/HDL ratio is considered a more sensitive and specific index of cardiovascular risk than total cholesterol (27,28, 29,30).

In this study lipid levels in the examined overweight subject also showed higher risk for development of metabolic complications.LDL/HDL-C and TC/HDL-C significantly lowered after the weight lost and BMI normalization. Atherogenic indexes TG/HDL-C, LDL/HDL-C and C/HDL lowered significantly after the weight loss ($p<0.002$; $p<0.03$ and $p<0.05$) as well as TG, C and LDL values ($p<0.001$; $p<0.01$; $p<0.01$).

BW and BMI reduction to normal levels was associated with significant decrease of indexes of central body fat distribution android/gynoid TM and FM to normal values, as well as significant reduction of atherogenic lipid indexes indicating reduced atherogenic risk.

Conclusion

It can be concluded that the increased values of the relationships between regional central, abdominal and peripheral gynoid parts of the bodyCOI_1, COI_2, COI_3 and COI_4before the weight loss confirmed abdominal obesity with dyslipidemic profile indicating higher cardiovascular risk in a DXA examined overweightwomen. Their significant reduction to normal levels after the weight loss confirmed reduced abdominal body fat distribution and

consecutive normalized body composition and body fat distribution, confirming the importance of determining these DXA indexes as diagnostic criteria of abdominal obesity. Significant reduction in these indexes of central obesity after the weight loss confirming reduction of abdominal obesity and normalized body fat distributionshowed that body weight reduction in overweight subjects and especially in obese subjects is important in order to improve body composition and body fat distribution and minimize the cardiometabolic profile and risk.These results confirmed that DXA measurements of body composition and bodyfat distribution are very useful in studies related to obesity-associated disease risk. This study confirmed that COI_1 and COI_2indexes are valuable diagnostic procedure parameters of abdominal obesity and obesity associated health risks.COI_3 and COI_4 are also useful DXA indexes in body fat distribution assessment.

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