VISCERAL OBESITY MAY HAVE DIFFERENT EFFECTS ON METABOLIC SYNDROME PARAMETERS IN WOMEN AND MEN

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ABSTRACT

Introduction*: This study aims to assess whether female and male individuals have different parameters of metabolic syndrome when they are classified as being viscerally obese or non-obese.*

Material and methods*: We enrolled 288 subjects (169 women, 119 men) who were admitted to Clinic of Internal Medicine, Ankara Education and Research Hospital. They underwent physical examinations and anthropometric evaluation. They also underwent ultrasonography and blood samples were collected for further investigation. After cut-off values for visceral fat were determined, female and male subjects were classified as they were viscerally obese or not obese and all their parameters were compared.*

Results*: Female viscerally obese subjects had statistically higher values of blood glucose, blood pressure, insulin, cholesterol, triglyceride and homeostasis model assessment - insulin resistance index than female who were not obese. Men with visceral obesity had higher values of blood pressure, insulin, triglyceride and homeostasis model assessment - insulin resistance index than men who were not obese.*

Conclusions*: Visceral obesity was linked to high blood pressure, triglyceride, insulin resistance in all subjects, but high blood glucose, total cholesterol levels were elevated only in females. We think that visceral fat thickness measured by ultrasonography can estimate not only visceral obesity but also risks of cardiovascular diseases and metabolic syndrome both in females and males.*

Key words*: Visceral obesity, metabolic syndrome, women, men.*
DOI:10.19193/0393-6384_2016_1_06

Received *March 30, 2015;* ***Accepted*** *November 20, 2015*

Introduction

Obesity as being a major public health problem, is an important risk factor in diabetes mellitus (DM), hypertension (HTA), hyperlipidemia (HL) and cardiovascular disease (CVD)[1]. It is also associated with increased morbidity and mortality[1,2]. After Vague, many studies have shown the importance of fat tissue distribution and its association with chronic diseases such as DM, HTA and CVD[3,4]. By an increase in fatty acid production, accumulation of visceral adipose tissue may cause suitable conditions for genesis of these diseases and also metabolic syndrome through insulin resistance[5-7].

In 2013, reported prevalence rates of obesity (BMI of ≥30 kg/m2) included 20 % of men and 21.7 % of women in Belgium, 25 % of men and women in the United Kingdom, 21 % of men and 33 % of women in Mexico, 13.5 % of men and 42 % of women in South Africa, and 14 % of men and women in Pakistan[8]. In United States based upon a study between 2011 and 2012, the measured prevalence of obesity in adults is 34.9 percent[9]. The

prevalence has significantly increased among adult Turkish population over the past 20 years. In 1990, 18.8% of the adult population was obese (28.5% among women and 9% among men), and the prevalence increased to 36% in 2010 (44% among women and 27% among men)[10]. According to another study published in 2013 obesity prevalence increased from 30% to 36% in 12 years[11]. Both in males and females a peak prevalence was seen in ages 45-64[11].

There are a few techniques for measuring abdominal fat tissue. Anthropometric measurements[12-14], computed tomography (CT)[14-16], magnetic resonance imaging (MRI)[17-19], bioelectric impedance analysis[20,21] and ultrasound (US)[22-28] are some of those methods. All these techniques have advantages and disadvantages.

In this study after measuring visceral fat by US we aimed 1) to establish US cut-off values for defining visceral fat levels in our population, 2) to classify female and male individuals according to those cut-off values as viscerally obese and non-obese 3) compare the parameters of metabolic syndrome in viscerally obese and non-obese female and male individuals.

Material and methods

Patients

A total of 288 subjects 169 female, 119 male aged from 18-70 years, were recruited from Clinic of Internal Medicine, Ankara Education and Research Hospital from June 2013 to January 2014.

Our exclusion criteria were having DM, heart failure, congenital cardiac disease, valvular and atherosclerotic heart disease, active infection or a systemic disease (renal, gastrointestinal, hepatobiliary, hematological, oncological, neurological disease) and women having doubt of pregnancy. Individuals who have malnutrition, weight-reducing aid and morphological changes effecting anthropometric measurements such as amputation, orthopedic diseases were also excluded.

In all subjects, after detailed physical examination body weight and height were measured. Waist Circumference was measured when fasting, in standing position halfway between costal edge and iliac crest, whereas hip circumference was measured at the greatest circumference around the buttocks, by a non elastic measure. Waist to hip ratio (WHR) was calculated. Body mass index (BMI) was calculated as weight in kilograms divided by the square of height in meters (kg/m2).

Systolic blood pressure and diastolic blood pressure (DBP) were measured after 5 minute rest in the semi-sitting position with a sphygmomanometer. Blood pressure was determined at least three times at the right upper arm, and the mean was used in the analysis.

Blood was withdrawn after 12 hour of overnight fasting, at 08.30 a.m. for fasting plasma glucose (FPG), Hemoblobin A1c (HbA1c),fasting insulin (FI), serum total cholesterol (TC) and high density lipoprotein cholesterol (HDL-C), triglyceride (TG). Another blood sample was taken for postprandial plasma glucose (PPPG) 2 h after breakfast. Low density lipoprotein cholesterol (LDL-C) was calculated by the Friedewald Formula (LDL= (Total cholesterol - HDL-TG/5).

This study was performed according to the Decleration of Helsinki for Ethical Principles for Medical Research Involving Human Subjects 2008. The local ethics committee approved this study and all the subjects gave written informed consent.

Plasma glucose, TC, TG and HDL-C concentration were determined by Original Roche Diagnostics kits in a Roche Modular DP analyzer. HbA1c was examined by TOSOH HPLC, insulin with DRG Diagnostic's (DRG Instruments GmbH, Germany) ELISA kits.

An indirect measure of insulin resistance was calculated from the fasting plasma insulin (μunite / ml) x fasting plasma glucose (mmol /l) / 22. 5 formula as homeostasis model assessment –insulin resistance (HOMA-IR).

US measurements

US measurements were performed in Radiology Department of Ankara Education and Research Hospital with 3.5-MHz USG probe. The measurements were made after at least 10 hours fasting in the morning between 8.30- 11. 00. In making the US measurements of subcutaneous fat (SCF), we used the distance between the skin and the lateral edge of musculus rectus abdominalis, and of visceral fat (VF), we used the distance between medial edge of musculus rectus abdominalis and anterior wall of aorta. Both measures were obtained 1 cm above the patients umbilicus[23-25].

Statistical analysis

Calculations were performed using Statistical Package for the Social Sciences (SPSS) version 21 (Open access internet version was used). After

making Receiver Operating Characteric (ROC) analysis, for the comparison of the groups Student's test was used. Data are presented as mean ± SD. A p value of <0.05 was considered as statistically significant.

Results

This study was performed with 169 female, and 119 male individuals. All the demographic, anthropometric and laboratory findings of the groups were illustrated in Table I.

	Female n: 169	Male n: 119
Age (years)	44.7 ± 8.9	51.1 ± 13.0
BMI (kg/m^2)	30.9 ± 5.2	28.5 ± 3.9
W. Circ.(cm)	94.5 ± 10.7	98.2 ± 9.8
H. Circ.(cm)	107.0 ± 9.5	92.5 ± 7.5
WHR	0.8 ± 0.06	0.9 ± 0.06
FBG (mg/dl)	98.8 ± 12.3	101.4 ± 11.3
PPBG (mg/dl)	107.8 ± 21.1	119.6 ± 30.4
HbA1c (%)	5.7 ± 0.4	5.8 ± 0.3
FI (µU/ ml)	11.3 ± 6.8	11.3 ± 7.0
HOMA-IR	2.8 ± 2.0	2.8 ± 1.8
T. C (mg/dl)	203.8 ± 42.0	190.5 ± 37.4
LDL-C (mg/dl)	121.9 ± 34.1	114.9 ± 33.3
HDL-C (mg/dl)	53.3 ± 9.8	45.5 ± 8.0
TG (mg/dl)	147.8 ± 70.6	162.5 ± 91.9
SBP (mm/Hg)	126.3 ± 18.9	135.0 ± 21.7
DBP(mm/Hg)	78.6 ± 10.9	86.4 ± 14.1
SCF(mm)	17.4 ± 7.2	14.2 ± 5.8
VF(mm)	47.0 ± 18.3	56.7 ± 20.5

Table I: Characteristics of female and male individuals. *BMI: Body mass index, W. Circ.: Waist circumference, H. Circ.: Hip circumference, WHR: Waist-hip ratio, FBG: Fasting blood glucose, PPBG: Postprandial blood glucose, HBA1c: Hemoglobin A1c, FI: Fasting insulin, HOMA-IR: Homeostasis model assessment insulin resistance index, T.C: Total cholesterol, LDL-C: Low-density lipoprotein cholesterol, HDL-C: High-density lipoprotein cholesterol, TG: Triglyceride, SBP: Systolic blood pressure, DBP: Diastolic blood pressure, SCF: Subcutaneous fat, VF: Visceral fat.*

Then we made ROC curve analysis for women and men individuals. For women ROC curve analysis identified the cut-off of 38.5 cm for VF (specificity of 80 %, sensitivity of 62.5 %). Then we evaluated visceral obesity as having VF value ≥38.5 and classified all female individuals as they were having and not having visceral obesity (VO) according to the cut off value of VF (38.5 cm). The findings of the women were as follows (Table II)

Women with VO had statistically highly significant elevated values of waist circumference, hip circumference, WHR, FBG, HbA1c, FI,TG, SBP and SCF. PPBG, HOMA-IR, TC, LDL-C, DBP values were also high. We did not find difference in age, BMI and HDL-C of our individuals.

	VO (+) n: 108	VO(-) n: 61	P
Age (years)	47.5 ± 8.1	45.0 ± 7.8	NS
BMI (kg/m^2)	34.4 ± 5.6	28.5 ± 6.8	NS
W. Circ.(cm)	101.0 ± 9.7	87.3 ± 11.1	<0.001
H. Circ.(cm)	110.6 ± 8.2	102.7 ± 10.3	<0.001
WHR	0.91 ± 0.04	0.84 ± 0.06	<0.001
FBG (mg/dl)	103.6 ± 15.7	94.2 ± 8.9	<0.001
PPBG (mg/dl)	113.5 ± 26.6	102.9 ± 18.6	<0.01
HbA1c (%)	5.8 ± 0.3	5.6 ± 0.4	<0.001
FI (µU/ ml)	13.7 ± 9.2	8.7 ± 4.1	<0.001
HOMA-IR	3.4 ± 3.0	2.0 ± 1.4	<0.01
T. C (mg/dl)	212.2 ± 91.7	193.7 ± 41.2	<0.01
LDL-C (mg/dl)	127.2 ± 37.0	115.5 ± 32.8	<0.05
HDL-C (mg/dl)	51.8 ± 10.1	53.6 ± 10.9	NS
TG (mg/dl)	174.7 ± 91.7	122.8 ± 60.9	<0.001
SBP (mm/Hg)	132.3 ± 19.1	120.7 ± 21.2	<0.001
DBP(mm/Hg)	80.9 ± 9.7	76.7 ± 13.5	<0.05
SCF(mm)	19.5 ± 8.6	15.2 ± 6.3	<0.001

Table II: Characteristics of women with and without VO and their comparison.
VO: Visceral obesity, BMI: Body mass index, W. Circ.: Waist circumference, H. Circ.: Hip circumference, WHR: Waist-hip ratio, FBG: Fasting blood glucose, PPBG: Postprandial blood glucose, HBA1c: Hemoglobin A1c, FI: Fasting insulin, HOMA-IR: Homeostasis model assessment insulin resistance index, T.C: Total cholesterol, LDL-C: Low-density lipoprotein cholesterol, HDL-C: High-density lipoprotein cholesterol, TG: Triglyceride, SBP: Systolic blood pressure, DBP: Diastolic blood pressure, SCF: Subcutaneous fat, VF: Visceral fat. Data are presented as mean ± SD. NS: nonsignificant.

For men ROC curve analysis identified the cut-off of 52.7 cm for VF (specificity of 80%, sensitivity of 64%). Then we classified our male individuals as they were having and not having visceral obesity (VO) according to the cut off value of VF (52.7 cm). Their findings were as follows (Table III)

Men with VO had statistically highly significant elevated values of waist circumference, hip circumference, WHR and TG. FI, HOMA-IR, SBP, DBP and SCF values were also high. We did not find difference in age, BMI, FBG, PPBG, HbA1c, TC, HDL-C and LDL-C of our individuals.

Discussion

Visceral fat may be evaluated by anthropometric measurements[12-14]. Widely used ones are BMI,

	VO (+) n: 71	VO(-) n: 48	P
Age (years)	46.5 ± 7.1	49.0 ± 8.8	NS
BMI (kg/m^2)	29.4 ± 6.1	26.5 ± 5.8	NS
W. Circ.(cm)	103.2 ± 9.1	91.9 ± 11.4	<0.001
H. Circ.(cm)	95.2 ± 8.2	89.2 ± 7.2	<0.001
WHR	1.0 ± 0.05	1.0 ± 0.06	<0.001
FBG (mg/dl)	101.7 ± 11.2	101.5 ± 12.0	NS
PPBG (mg/dl)	121.1 ± 31.2	119.5 ± 33.4	NS
HbA1c (%)	5.8 ± 0.3	5.8 ± 0.3	NS
FI (µU/ ml)	12.9 ± 8.7	9.3 ± 4.3	<0.01
HOMA-IR	3.2 ± 2.2	2.3 ± 1.0	<0.01
T. C (mg/dl)	193.5 ± 39.4	186.1 ± 34.0	NS
LDL-C (mg/dl)	115.4 ± 35.2	113.6 ± 30.6	NS
HDL-C (mg/dl)	42.7 ± 9.2	45.9 ± 8.9	NS
TG (mg/dl)	190.4 ± 115.7	129.4 ± 69.4	<0.001
SBP (mm/Hg)	141.0 ± 23.9	128.2 ± 21.0	<0.01
DBP(mm/Hg)	89.1 ± 14.7	83.6 ± 14.5	<0.05
SCF(mm)	15.3 ± 6.3	12.7 ± 5.1	<0.05

Table III: Characteristics of men with and without VO and their comparison.

VO: Visceral obesity, BMI: Body Mass index, W. Circ.: Waist circumference, H. Circ.: Hip circumference, WHR: Waist-hip ratio, FBG: Fasting blood glucose, PPBG: Postprandial blood glucose, HBA1c: Hemoglobin A1c, FI: Fasting insulin, HOMA-IR: Homeostasis model assessment insulin resistance index, T.C: Total cholesterol, LDL-C: Low-density lipoprotein cholesterol, HDL-C: High-density lipoprotein cholesterol, TG: Triglyceride, SBP: Systolic blood pressure, DBP: Diastolic blood pressure, SCF: Subcutaneous fat, VF: Visceral fat. Data are presented as mean ± SD. NS: nonsignificant.

waist circumference and WHR. They are easy and cheap measurements. BMI has been extensively used to estimate body fat ratio. In many epidemiological studies its role was determined in overall morbidity and mortality[29,30]. BMI with waist circumference WHR is also the most used anthropometric parameter for showing intraabdominal fat deposition. These methods are not able to differentiate visceral and subcutaneous fat, but it was demonstrated that they were strongly correlated with visceral fat. But this correlation was not found in all ages and in all BMI values[14]. Recently mid-upper arm, forearm and calf circumference measurements have been proposed[21]. Changes shown in measurements calculated by different examiners and also by the same examiner, may affect anthropometric measurements. Moreover, in non-obese individuals anthropometric measurements have been found to be insufficient in estimating cardiovascular risk.

For measuring abdominal fat CT has been accurate method and can be repeated[14-16], but it is expensive, time consuming and exposes the patient to radiation. With MRI[17-19] satisfying results have been obtained compared to CT, but it is more expensive. Bioelectric impedance analysis[20,21] determines visceral fat concentration by bipolar or tetra-polar electrodes placed on legs or arms. This method is cheap, easy, portable and does not need cooperation of the patient and does not expose the patient to radiation, But body composition changes like hydration or edema may cause problems in interpreting its measurements.

US is a safe, non-invasive technique. It was shown that it was at least non-inferior to CT[22,24,28,31-33]. In studies with US where visceral adipose tissue was measured as thickness or area, both of the measurements were found to be harmonious to the visceral fat area determined by CT[22,28,31-33]. When patients were classified as female and male no difference was also found between US and CT measurements[25]. In our study, we chose US as it is reliable and easy method to estimate visceral fat.

In recent studies it has been demonstrated that the vascular risk associated with obesity is correlated particularly with visceral fat deposition. Clinical observations indicate that various adipose tissue depots may have different effects on vascular risk. Cellular parts of fat tissue secrete cytokines and chemokines that may have effect on vascular disease. The adipose tissue secretory profile may reflect the influx of macrophages, related to the increase of fat stores. It was believed that macrophage infiltration may lead to a chronic low grade, systemic, inflammatory state. Since circulating markers of inflammation are associated with cardiovascular events, the inflammation triggered by adipose tissue may contribute to increased vascular disease. It is nowadays agreed that visceral fat has detrimental potential for cardiovascular morbidity and morbidity[34-37]. In our study, we planned to measure VF in female and male subjects. Then we wanted to determine cut-off values of VF in both sexes. In women it was 38.5 mm and in men 52.7 mm.

Ribeiro- Filho et al. found VF cut-off value as 69.0 mm with the specificity of 82.8 % and sensitivity of 69.2 % in obese women[22]. This finding was higher than our result. We think that the difference may be explained by their inclusion criteria; they included in the study only obese females. In our group there were obese subjects but also females having normal BMI. In another study, 35 women having BMI 25 were examined and VF cut-off values were found to be 32.0 mm[28]. In our study BMI was 30.9 ± 5.2, this result explains the difference. In

Kim's study, where all women were diabetic, VF cut-off value was similar, they found the value of 35.5mm[27]. Similar to our study he also found a cut-off value of 47.6 mm in males[27].

After determining the cut-off values we classified our female and male subjects as they have or do not have visceral obesity, according to cut-off values and compare all the values of the groups. In females viscerally obese subjects had statistically high elevated values of FBG, PPBG, SBP,DBP, FI, TC, LDL-C), TG, HOMA-IR. Men with visceral obesity had high SBP, DBP, FI, TG and HOMA-IR. These results were harmonious with former studies[27,34]. It was interesting that men did not have any difference in cholesterol and blood glucose values as they were viscerally obese or non-obese. This may be explained with limited number of subjects or lower levels of obesity markers in men.

In our study we also measured SCF in our subjects. Although it was thought that visceral fat express more inflammatory cytokines than subcutaneous fat, there are studies where the expression of critical pro-inflammatory genes are higher in subcutaneous adipose tissue than in abdominal visceral adipose tissue[38]. SCF was also found to be less related to metabolic and cardiovascular diseases[39], and insulin resistance[40,41]. In our both female and male subjects SCF values were higher in viscerally obese subjects than non-obese ones. We wonder if the increase in SCF is related to the increase in VF

There are a few limitations of this study. One is the moderate sample size. Second is that, there is not a consensus about the cut-off values of both SCF, more studies are warranted. Finally, the findings are limited to our groups, which included only adults from our district, so our results may not be applicable to all our country or other nationalities.

In conclusion detection of visceral fat thickness by US may be helpful in detecting visceral obesity. We also determined that visceral obesity is linked with risk factors of cardiovascular diseases and metabolic syndrome both in women and men. Therapies that target visceral obesity may be beneficial in reducing those risks.

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Acknowledgements:
We thank the patients.

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