

Total Testosterone and Sex Hormone-Binding Globulin as Predictor Markers of Metabolic Syndrome among Obese People from Basrah

Abstract

Background: Metabolic syndrome (MetS) is an important public health target for disease prevention. Studies on MetS among obese people alone are few. In this study we aimed to see whether total testosterone (TT) and sex hormone-binding globulin (SHBG) have a role in the prediction of MetS in obese adult people from Basrah.

Methods: A cross-sectional study conducted during the period from October 2016 to the end of October 2017 in Faiha Specialized Diabetes, Endocrine, and Metabolism Center (FDEMC) in Basrah. Participants were obese adults referred to the Center from other hospitals, Primary Care Centers, and private clinics. The total enrolled patients in this study were 169 patients (89 women [52.66%] and 80 men [47.33%]). A short history and clinical examination were taken from each participant for age, gender, blood pressure, weight, height, waist circumference, blood pressure and body mass index (BMI). A fasting morning blood sample was taken for measurement of basal serum TT, serum SHBG, serum C-peptide, plasma insulin, plasma sugar and serum lipid profile.

Results: Both TT and SHBG were significantly lower in obese men with MetS in comparison with men without ($P=0.0002$ and $P=0.003$ respectively). Mean TT in ng/dL in obese men with MetS was (250.08 ± 96.07) vs. (400.37 ± 149.37) in obese men without. While mean SHBG in nmol/L in obese men with MetS was (28.95 ± 14.21) vs. (42.49 ± 24.11) in obese men without. In obese women, there was no significant different in SHBG levels when compared between those with MetS and without ($P=0.8$). On univariate and multivariate analysis for obese men, both TT and SHBG remained significantly and independently lower in obese men with MetS, for TT (OR 6.4 CI (-321.9- -157.9) $P<0.00001$), and for SHBG (OR 1.39, CI (-49.3- -19.6) $P=0.00001$). In men with no MetS, both TT and SHBG were significantly higher in men with severe insulin resistance (IR) when compared with normal and moderate IR, ($P=0.01$, $P=0.01$ respectively). Mean TT was (396.09 ± 19.3) in men with severe IR as compared with (311.4 ± 26) and (274.6 ± 23.9) in normal and moderate IR respectively. Mean SHBG in men with severe IR was (41.1 ± 3.5) as

compared with (28.2 ± 4.7) and (31.9 ± 4.3) in normal and moderate IR respectively.

Conclusion: Both TT and SHBG were significantly and independently lower in obese men with MetS than those with no MetS, but not in obese women with MetS. The effect of MetS overcomes the effect of IR in decreasing the level of both TT and SHBG among obese men in the presence of MetS.

Keywords: Metabolic syndrome; Obesity; Total testosterone; Sex hormone-binding globulin

Abbreviations: MetS: Metabolic Syndrome; TT: Total Testosterone; FDEMC: Faiha Specialized Diabetes, Endocrine, and Metabolism Center; HOMA: Homeostasis Model Assessment; ROC: Receiver Operating Characteristic; SBP: Systolic Blood Pressure; DBP: Diastolic Blood Pressure

Introduction

Studies on metabolic syndrome (MetS) among obese people alone are few [1,2]. Most of the studies using comparison for the prevalence of MetS among non-obese people [3,4]. Low levels of serum total testosterone (TT) and sex hormone-binding globulin (SHBG) are associated with an increase in the incidence of development of MetS [5]. The insulin resistance syndrome is significantly associated with increased risk of T2DM and CVD [6].

Testosterone itself may have a central or preventive role in the pathogenesis of T2DM and the MetS by increasing skeletal muscle mass and lowering abdominal obesity and non-esterified fatty acids, and thus may improve the sensitivity of insulin [7]. This study aimed to see whether TT and SHBG have a role in the prediction of MetS among obese adult people from Basrah.

Patients and Methods

Setting and participants

This cross-sectional study was conducted during the period from October 2016 to October 2017 in Faiha Specialized Diabetes, Endocrine, and Metabolism Centre (FDEMC). Participants were obese adults referred to the Center from other hospitals, primary health care Centers, and private clinics.

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The total enrolled patients in this study were 169 patients (89 women [52.66%] and 80 men [47.33%]). All subjects provided with the written informed consent and the ethical committee of the Basrah College of Medicine approved the research protocol.

Inclusion criteria

Obese adult's people with body mass index (BMI) ≥ 30 kg/m².

Exclusion criteria

- History of hypogonadism.
- Patients on testosterone replacement therapy, androgen deprivation therapy, contraceptive pills or hormone replacement therapy.
- Patients with a history of chronic liver disease and/ or chronic kidney disease.

Clinical data

From each participant, history taking and clinical examination was done for assessment of inclusions and exclusions criteria, and clinical data collection in form of blood pressure, weight, height, and waist circumference. Weight and height were measured using light clothes. BMI was calculated as weight (kg)/height (m)². Waist circumference was measured as the circumference of the abdomen at its narrowest point in midway point between the lower costal border (10th rib) and the top of the iliac crest, perpendicular to the long axis of the trunk.

Biochemical data

Instructions were given to the patients to avoid any drug that may interfere with laboratory assay and to come next day early morning at 8:00 a.m. after at least 8-12hours fasting for sample collection. Ten ml of the blood sample was obtained and collected in tubes containing clot activator. The serum was separated by using centrifuge 3000 r.p.m. and stored frozen at -20 degree centigrade until analysis. The Fully automated chemiluminescence immunoassay kits Cobas e411 analyzer series/ Roche Diagnostics, Germany, was used for the assessment of TT (reference value [adult men from 300 to 1200 ng/dL [10.40 to 41.60 nmol/L]], adult women (reference value 20 to 75ng/dL[0.69 to 2.60 nmol/L]), C-peptide(reference value from 0.9 to 4.3 ng/mL[0.29 to 1.43 nmol/L]), insulin level (reference value 2.6 to 24.9 μ U/mL [18.05 to 172.9 pmol/L]) and SHBG (reference value for male 10 to 60 nmol/mL and for women 20 to 130 nmol/mL). C-peptide and glucose was measured within 7 hours of blood sampling to avoid loss of stability [8]. Glucose and lipid profile was measured by cobas c311 analyzer.

MetS diagnosis was according to the 2005 IDF criteria [9].

HOMA-IR calculation

Among individuals with normal glucose regulation, the IR was assessed from FPG and insulin concentrations with the homeostasis model assessment (HOMA) equation: HOMA = fasting plasma glucose (mg/dL) $\times$ fasting plasma insulin (μ U/mL)/405 which are superior to insulin measurement alone [10].

Statistical analysis

All data were computerized and analyzed using Statistical Package for Social Sciences (SPSS), (version 23.0). Continuous variables were summarized as the mean $\pm$ standard deviation (SD), and categorical variables were summarized as percentages. The Multivariate and univariate analysis were used to study the effect of multiple factors in form of age, MetS, and HOMA-IR on both TT and SHBG in men, and on SHBG in women. Receiver operating characteristic (ROC) was plotted to identify the sensitivity and specificity of the level of TT and SHBG with MetS.

For all the tests were has been done, a *P* value of < 0.05 was considered statistically significant.

Results

In women, as shown in Table 1, the mean age was 43.7 $\pm$ 9.5 years, BMI 38.5 $\pm$ 7.3 kg/cm². The mean systolic blood pressure (SBP), diastolic blood pressure (DBP) and waist circumference (WC) were 133.9 $\pm$ 17.5 mmHg, 83.3 $\pm$ 9.4 mmHg, and 120.3 $\pm$ 12.20 cm respectively. MetS was prevalent in 59/89 patients (66.3%). Both T2DM and hypertension (HTN) were seen in 45/89 (50.6 %) and 28/89 (31.5 %) respectively. Mean FPG, insulin, C-peptide, high density lipoprotein cholesterol (HDL-C), triglyceride (TG), TT, SHBG were 181 $\pm$ 102.5 mg/dl, 17.9 $\pm$ 17.25 μ U/mL, 4.1 $\pm$ 3 ng/mL, 47.2 $\pm$ 12.5 mg/dl, 209.3 $\pm$ 163.4 mg/dl, 19.26 $\pm$ 16.3 ng/dl, and 41.37 $\pm$ 22.3 nmol/L respectively. The mean HOMA-IR was 8.4 $\pm$ 10.6, with 25(29.2%) had normal, 17 (20.2%) had moderate, and 42 (50%) had severe HOMA-IR.

In men, the mean age was 44.5 $\pm$ 11.3 years, mean BMI was 35.2 $\pm$ 7 kg/cm². Mean SBP, DBP and WC were 138.8 $\pm$ 20.5 mmHg, 87.9 $\pm$ 10 mmHg, 115.5 $\pm$ 12.7 cm respectively. The prevalence of MetS was 59/80(73.8%) patients, while T2DM and HTN were seen in 59/80 (73.8%) and 30/80 (37.5%) respectively. The mean FPG, insulin, C-peptide, HDL-C, TG, TT, SHBG were 182.4 $\pm$ 91 mg/dL, 23.2 $\pm$ 27.5 μ U/mL, 4 $\pm$ 3.3 ng/mL, 38.4 $\pm$ 10.4 mg/dL, 242.9 $\pm$ 182.3 mg/dL, 290.5 $\pm$ 130.3 ng/dL and 32.6 $\pm$ 22.3 nmol/L respectively. The mean HOMA-IR was 9.2 $\pm$ 9.5, 12(16.7%) had normal, 16 (22.2%) moderate, and 44 (61.1%) had severe HOMA-IR.

It was found that in this study that TT level was significantly lower in obese men with MetS than those without MetS (*P* value =0.0002). Among male group with MetS the mean TT was (250.08 $\pm$ 96.07 ng/dl, 8.67 $\pm$ 3.33 nmol/L), while in those without MetS it was (400.37 $\pm$ 149.37 ng/dl, 13.89 $\pm$ 5.17 nmol/L), as shown in Table 2.

SHBG affected in a way similar to that of TT, obese men with MetS had a significantly lower levels of SHBG when compared to those without MetS, (*P* value = 0.003), Table 2. The means SHBG were (28.95 $\pm$ 14.21 nmol/L) and (42.49 $\pm$ 24.1 nmol/L) in men with MetS and without respectively. In women, there was no significant difference in SHBG between those with MetS and without. (*P* value =0.8), Table 2 & 3.

Obese women with MetS was tended to be older than those without, (46.03 years $\pm$ 8.2 years) versus (39.10 years $\pm$ 10.42 years) respectively (*P* value =0.001), however, age did not vary

significantly in men group (p -value =0.07). BMI and IR had no significant different when correlated with MetS neither in men nor women, Table 2 & 3.

Assessment of the effect of MetS, IR, and age on SHBG in obese women using univariate analysis showed that these factors had no statistically significant effect on SHBG as shown in Table 4.

Table 1: General characteristics of the study population.

	Women Mean $\pm$ SD* or N** (%)	Men Mean $\pm$ SD or N (%)
	89(52.66%)	80(47.33%)
Age(Years)	43.7 $\pm$ 9.5	44.5 $\pm$ 11.3
BMI ^Ω (kg/m ²)	38.5 $\pm$ 7.3	35.2 $\pm$ 7.0
SBP [¥] (mmHg)	133.9 $\pm$ 17.5	138.8(20.5)
DBP ^π (mmHg)	83.3 $\pm$ 9.4	87.9(10)
WC [†] (cm)	120.3 $\pm$ 15.20	115.5(12.7)
T2DM [⊞] N (%)	45 (50.6%)	59 (73.8%)
HTN [©] N (%)	28 (31.5%)	30 (37.5%)
MetS [◊] N (%)	59 (66.3%)	59 (73.8%)
Fasting plasma glucose(mg/dL)	181.5 (10.08 mmol/L) $\pm$ 102.5 (5.69 mmol/L)	182.4 (10.13 mmol/L) $\pm$ 91 (5.05mmol/L)
Insulin(μu/mL)	17.9 (124.30 pmoL/L) $\pm$ 17.25 (119.79 pmoL/L)	23.2 (161.11 pmoL/L) $\pm$ 27.5 (190.97 pmoL/L)
C-peptide(ng/mL)	4.1 (1.36nmol/L) $\pm$ 3(0.99nmol/L)	4(1.33nmol/L) $\pm$ 3.3(1.09nmol/L)
HDL-C ^β (mg/dL)	47.2 (1.22mmol/L) $\pm$ 12.5 (0.32 mmol/L)	38.4 (0.99mmol/L) $\pm$ 10.4 (0.26 mmol/L)
TG ^Ψ (mg/dL)	209.3(2.37mmol/L) $\pm$ 163.4 (1.84 mmol/L)	242.9(2.74mmol/L) $\pm$ 182.3 (2.05mmol/L)
TT [®] ng/dL	19.26(0.66 nmol/L) $\pm$ 16.3 (0.56 nmol/L)	290.5(10.08 nmol/L) $\pm$ 130.3 (4.52 nmol/L)
SHBG [∞] (nmol/L)	41.37 $\pm$ 22.3	32.6 $\pm$ 18.3
HOMA-IR ^Δ	8.4 $\pm$ 10.6	9.2 $\pm$ 9.5
N (%)	Normal25 (29.2%)	Normal12 (16.7%)
	Moderate17 (20.2%)	Moderate16 (22.2%)
	Severe42 (50%)	Severe44 (61.1%)
*SD: Standard Deviation ΩBMI: Body Mass Index. πDBP: Diastolic Blood Pressure. © HTN: Hypertension. β HDL-C: High-Density Lipoprotein Cholesterol. ®TT: Total Testosterone. ΔHOMA-IR: Homeostatic Model Assessment of Insulin Resistance. **N: Number. ¥SBP: Systolic Blood Pressure ⊞T2DM: Type 2 Diabetes Mellitus. ◊MetS: Metabolic Syndrome. ΨTG: Triglyceride. ∞SHBG: Sex Hormone-Binding Globulin. †WC: Waist Circumference		

Table 2: Comparison of TT, SHBG, age, BMI and IR among obese patients with MetS and obese patients with no MetS in men.

Variable	MetS	Non-MetS	P Value
Age (Years) Mean ± SD	46.10±10.36	40.24±13.23	0.07
BMI (kg/m ²) Mean ± SD	35.76±7.13	33.65±6.66	0.2
TT (ng/dL) Mean ± SD	250.08 (8.67 nmol/L)± 96.07 (3.33 nmol/L)	400.37 (13.89 nmol/L) ±149.13(5.17 nmol/L)	0.0002
SHGB (nmol/L) Mean ± SD	28.95±14.21	42.49±24.11	0.003
HOMA-IR Mean±SD	9.02±7.78	9.82±13.36	0.8

Table 3: Comparison of TT, SHBG, age, BMI and IR among obese patients with MetS and obese patients with no MetS in women.

Variable	MetS	Non-MetS	P Value
Age (Years) Mean±SD	46.03±8.2	39.10±10.42	0.001
BMI (kg/m ²) Mean±SD	37.68±7.21	40.34±7.43	0.1
SHGB(nmol/L) Mean±SD	41.0±22.59	42.13±22.29	0.8
HOMA-IR Mean±SD	9.82±10.58	5.72±10.34	0.09

Table 4: Correlation of TT and SHBG with MetS by adjustment with age and IR by using univariate analysis in men and women patients.

Dependent Variable	Factors	Mean	Std. Error	OR	P Value	95%CI
Men						
TT(ng/dL)	MetS	248.677	15.944	6.4	<0.00001	-321.9-(-157.9)
	Non MetS	406.072	21.636			
	Age < 45 years	321.343	19.345	0.03	0.9	-146- 139.5
	Age ≥ 45 years	333.406	18.657			
	HOMA-IR Normal	311.425	26.043	1.4 2.13	0.016 0.014	-319.1-34.1 -324-38.2
	Moderate	274.608	23.969			
	Severe	396.090	19.301			
SHBG(nmol/L)	MetS	26.822	2.892	1.39	0.00001	-49.3-(-19.6)
	Non MetS	40.724	3.924			
	Age < 45 years	30.894	3.508	2.5	0.09	-48.1- 3.7
	Age ≥ 45 years	36.653	3.384			
	HOMA-IR Normal	28.283	4.723	1.26 3.7	0.01 0.069	-60.2-(-8.3) -49.9-1.9
	Moderate	31.937	4.347			
	Severe	41.100	3.500			

Women						
SHBG(nmol/L)	MetS	43.8	3.3	3.4	0.1	-43.3-4.3
	Non MetS	45	4.6			
	Age < 45 years	42.1	3.7	8.4	0.7	-53.4-2.3
	Age ≥ 45 years	46.7	4.3			
	HOMA-IR Normal	45.2	5.2	4.8 2.5	0.2 0.2	-15-59 -52.8-13.1
	Moderate	37.9	5.5			
	Severe	41	3.9			

In obese men, on univariate analysis (Table 4 & Figure 1), TT was significantly lower in those with MetS independently of the presence of IR than those without MetS (MetS OR 6.4 CI (-321.9-157.9) $P < 0.00001$). In men with no MetS, TT was significantly higher in men with severe IR when compared with normal IR (OR 1.4, CI (-319-34.1), $P=0.016$) and moderate IR (OR 2.13 CI (-324-38.2) $P=0.014$). Mean TT was (396.09±19.3) in men with severe IR as compared with (311.4±26) and (274.6±23.9) in normal and moderate IR respectively. The effect of MetS is higher than the IR in decreasing the level of TT.

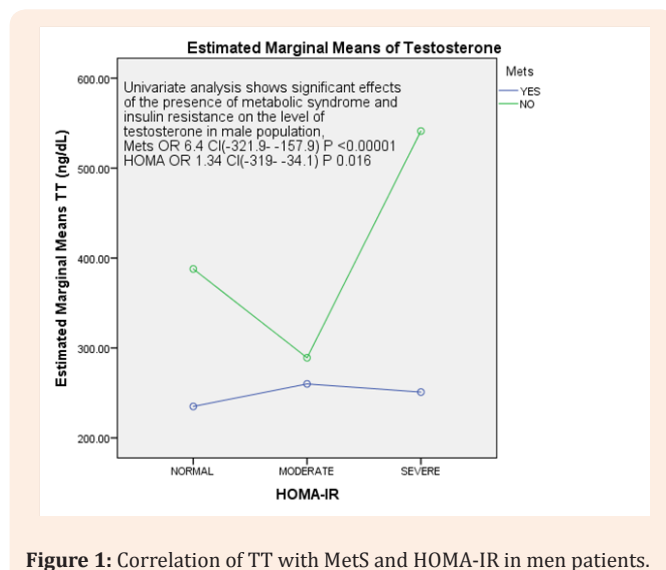


Figure 1: Correlation of TT with MetS and HOMA-IR in men patients.

SHBG had been affected in a similar manner as shown in (Table 4 & Figure 2). SHBG was significantly lower in men with MetS independently of the presence of IR than patients with no MetS. (MetS OR 1.39, CI (-49.3-19.6) $P=0.00001$). On the other hand in men without MetS, SHBG was significantly higher in men with severe IR when compared with normal IR (OR 1.26 CI (-60.2-8.3), $P=0.01$). Mean SHBG in men with severe IR was (41.1±3.5) as compared with (28.2±4.7) and (31.9±4.3) in normal and moderate IR respectively. The effect of MetS is higher than the IR in decreasing the level of SHBG. These findings indicate that MetS reduced both TT and SHBG independently in men patients.

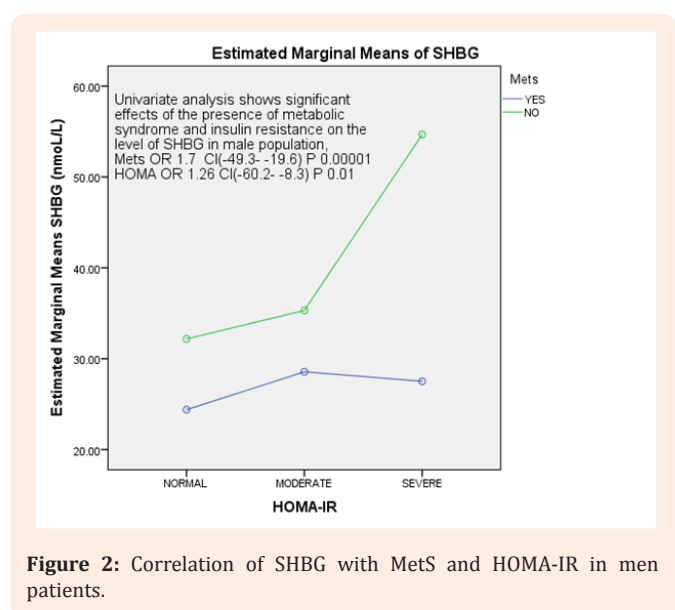


Figure 2: Correlation of SHBG with MetS and HOMA-IR in men patients.

On multivariate analysis (Table 5), with both TT and SHBG used as dependent variables in men. TT was significantly decreased in patients with MetS ($P < 0.00001$), and significantly increased with increased IR ($P=0.001$). The effect of IR in increasing TT was mainly in the absence of MetS, ($P=0.0003$). Similar finding was observed on SHBG, which was significantly decreased in patients with MetS ($P=0.006$), and it was higher in men with severe IR especially in absence of MetS but with no statistical significance on multivariate analysis. While the age of the patients failed to have a significant effect on TT and SHBG. These findings indicate that both TT and SHBG decreased significantly and independent of each other in patients with MetS.

In men, TT and MetS demonstrated an ROC curve with good accuracy (area under the curve AUC = 0.831, Std. error = 0.058, $P=0.000008$, 95%CI (0.7-0.9) as seen in Figure 3. TT cutoff of 237.5 ng/dl(8.23 nmol/L) or less had 47.4% sensitivity and 95.2% specificity, cutoff 404.6 ng/dl(14.02 nmol/L) or less had 94.7% sensitivity and 43% specificity, and cutoff of 344 ng/dl(11.92 nmol/L) or less had 87.7% sensitivity and 72% specificity for MetS.

Table 5: Correlation of TT and SHBG with MetS by adjustment with age and IR by using multivariate analysis in male patients.

Dependent	Factor		Mean	SD	P Value
TT(ng/dL)	MetS		250.9923	98.14253	<0.00001
	Non MetS		405.1945	151.32524	
	Age < 45 years		321.343	122.52483	0.6
	Age ≥ 45 years		333.406	136.14831	
	HOMA-IR Normal		311.425	106.67763	0.001
	Moderate		274.608	83.99907	
	Severe		396.090	153.42502	
	MetS	HOMA-IR Normal	225.6000	79.75222	
		Moderate	259.2333	54.54691	
		Severe	253.8694	110.04437	
	Non MetS	HOMA-IR Normal	392.3000	38.62596	0.0003
		Moderate	258.0000	116.92500	
		Severe	542.0488	79.96699	
SHBG(nmol/L)	MetS		26.822	13.48361	0.006
	Non MetS		40.724	24.21864	
	Age < 45 years		30.894	12.08034	0.2
	Age ≥ 45 years		36.653	21.9	
	HOMA-IR Normal		28.283	8.81639	0.07
	Moderate		31.937	15.36010	
	Severe		41.1	21.26299	
	MetS	HOMA-IR Normal	24.2571	5.59192	0.1
		Moderate	27.7889	14.01441	
		Severe	27.7250	14.57976	
	Non MetS	HOMA-IR Normal	32.3200	10.92918	
		Moderate	32.5571	17.69292	
		Severe	60.2250	26.95863	

On the other hand SHBG and MetS demonstrated an ROC curve with poor accuracy (area under the curve AUC = 0.693, Std. error = 0.07, P = 0.01, 95%CI (0.5-0.8) as shown in Figure 4. A SHBG cutoff of 20.8 nmol/L or less had 36.8% sensitivity and

86% specificity, cutoff 47.7 nmol/L or less had 91% sensitivity and 29% specificity, and cutoff of 36.1 nmol/L or less had 72% sensitivity and 67% specificity for MetS.

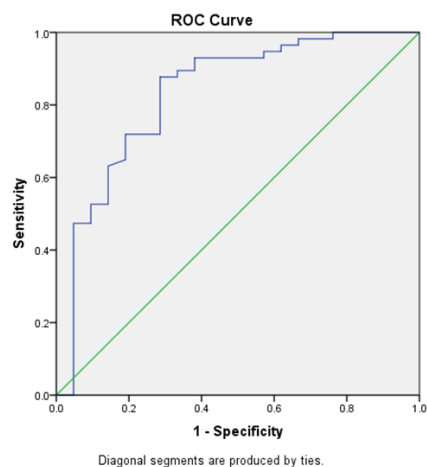


Figure 3: ROC Curve for the correlation of the low TT with the MetS in the men.

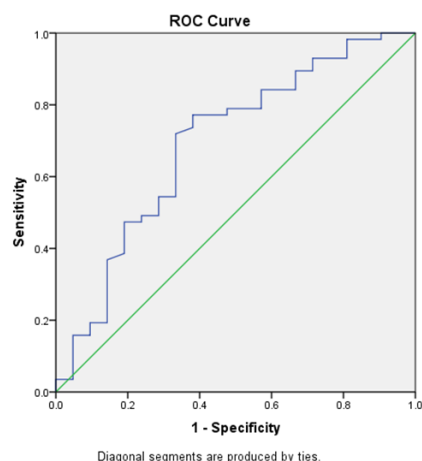


Figure 4: ROC Curve for the correlation of the low SHBG with the MetS in men.

Discussion

The primary outcome results in our study were that in obese men, the TT in the presence of MetS was significantly lower than those obese men without the MetS and this compatible with Tanabe et al., study which concluded that only TT predicts MetS among middle aged Japanese men [11]. In another study was done in Korea, they found that MetS has negative effect on the level of both TT and SHBG [12], consequently Laaksonen et al., found that low level of TT and SHBG predict MetS and T2DM in middle age men [13].

Why are these finding? It seems to be that an excess adipose tissue leads to the conversion of testosterone to estradiol which may result in secondary hypogonadism [14].

Previous studies found that inflammatory cytokines may have a direct effect on the pituitary gland to decrease LH secretion, and a direct effect on secretion of testosterone from the Leydig cell (these two factors will reduce TT) [15,16].

There is dysregulation hypothalamic pituitary adrenal axis due to increased glucocorticoid production among obese patients and subsequent hypoandrogenism in men [17].

Additional evidence that low TT which caused by androgen deprivation treatment in patients with prostate cancer may lead to increases the risk of MetS as seen in Basaria et al., study [18].

For the first time had been found that testosterone replacement therapy improves insulin sensitivity and control of glucose in euglycemic clamp studies for men with obesity while reducing central adiposity [7].

Two studies in women revealed that TT was not associated with the incidence of MetS. A longitudinal study of Menopause and the metabolic syndrome concluded that both high TT and low SHBG can predict MetS only in women during early menopause [19]. Additionally, another cohort study found that there is an association between TT in women and increase the risk of both IR and T2DM, but not MetS [20].

Another impressive finding of this study is that SHBG was significantly lower in men with MetS than those without, which is similar result also seen in other studies [12,13]. In a cross-sectional study by Haring et al. [21] they found that low SHBG correlate with MetS independent of TT level, a finding comparable to this study. Additionally in another study in China, found that low SHBG level associated with MetS both in adults and older population [22].

The low SHBG in patients with MetS could be explained on the following hypothesis. Obesity associated with hyperinsulinism which suppresses SHBG synthesis and secretion by the liver [23]. Additional evidence supporting the role of hyperinsulinism is the study of Pasquali et al. [24] which notes a significant elevation in levels of SHBG happened after an acute decrease of insulin levels in obese men by treatment with diazoxide for one week and simultaneously, it increases TT production. However, in our study, we found that both TT and SHBG significantly increased with increase insulin level and severity of IR in men with no MetS only. While the study of Pasquali et al. [24] has neglected the presence of MetS in the sample.

In this study, SHBG was not statistically significantly lower in obese women with MetS than those obese women with no MetS (low normal in both groups). This was agreed with the finding of a prospective cohort study in Spain which found that SHBG level was higher in women than that in men and it may have a protective function. Furthermore, SHBG does not affected by the presence of MetS in women [20].

In study of Azrad et al. [25] they found that intra-abdominal adipose tissue in healthy adult premenopausal women is associated negatively with SHBG. Consequently SHBG increased following weight loss in those women. Additionally, the level of SHBG is not affected by insulin.

Furthermore, genetic variations of peoples may affect circulating levels of SHBG. Subsequently, the levels of SHBG vary among persons and regions [26].

We found that IR was present in obese patients independent of the presence of MetS, but IR present more in the severe category in patients with MetS. In this study, MetS overcomes the effect of IR in decreasing the level of TT among obese men MetS and this finding comparable with the results of a longitudinal study in European men which concluded that TT decrease in men with MetS independent of IR [27]. However, in our study we found that in obese men with MetS IR does not affect the level of TT and SHBG.

MetS, but not IR had a significant effect in decreasing the levels of TT in obese men, a finding comparable to what was seen in Greece study, which found that MetS itself was responsible for low level of TT in older men. [28].

While both MetS and IR had a significant effect in lowering the level of SHBG in the obese men only versus no effect in obese women patients and this may be attributed to the positive effect of estrogen on SHBG level in adult women during reproductive age [29].

There was a significant effect of the presence of MetS on low levels of both TT and SHBG in obese men patients' independent of age and IR. These results were the same as the Namwon study [30]. In another study Liao et al., found that only 12.2% of enrolled subjects met the criteria of MetS in spite of the presence of IR in the most of participants [31].

Limitation of the study

The main limitations of this study were small study sample and cross-sectionality.

Conclusion

In obese men, both low TT and SHBG were independently predict MetS. While in obese women, SHBG was not. The effect of MetS overcomes the effect of IR in decreasing the level of both TT and SHBG among obese men.

Acknowledgment

None.

Conflict of Interest

None.

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