Diabetes & Metabolic Syndrome: Clinical Research & Reviews 13 (2019) 2541–2547

Contents lists available at ScienceDirect

Diabetes & Metabolic Syndrome: Clinical Research & Reviews

journal homepage: www.elsevier.com/locate/dsx

Original Article

Waist circumference is a major determinant of oxidative stress in subjects with and without metabolic syndrome

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ARTICLE INFO

Article history:
Received 9 June 2019
Accepted 8 July 2019

Keywords:
Metabolic syndrome
Oxidative stress markers
Waist circumference
Obesity

ABSTRACT

Aim: Oxidative stress (OS) plays a major role in pathogenic mechanisms associated with metabolic syndrome (Mets) yet the main component of Mets contributing most to OS is not well elucidated. Hence, the aim of this study was to investigate the oxidative-antioxidative status in Mets subjects and to determine the main predicting component of OS.
Methods: Anthropometric measures, fasting blood glucose, lipid profile, antioxidant enzymes [catalase, superoxide dismutase (SOD) and glutathione peroxidase (GPx)], reduced glutathione (GSH), malondialdehyde (MDA) and protein carbonyl were assessed in 172 adult UAE residents. International Diabetes Federation criteria were used for Mets diagnosis. Mets Scores (0–5) were calculated and assigned per subject based on number of components.
Results: Of all participants, 22.1% had Mets and 49.4% had large waist circumference (WC). Significant lower levels of catalase, SOD, GPx and GSH, and higher levels of MDA and protein carbonyl were observed in subjects with Mets. In addition, catalase, SOD, GPx, and GSH correlated negatively, while MDA and protein carbonyl correlated positively with almost all Mets components. Similar trend of correlations was noticed with Mets Scores. When adjusted for age and gender, linear regression analysis revealed that subjects with large WC demonstrated significantly lower levels of antioxidative enzymes and GSH, and higher levels of MDA and protein carbonyl. Consequently, WC emerged as the best predictor of OS.
Conclusions: The degree of OS is dependent on the Mets Scores, and WC contributes independently to increased OS among adults in UAE.

1. Introduction

Oxidative stress (OS) is defined as a state of imbalance between production and degradation of reactive oxygen species (ROS) resulting in oxidative damage to structure and function of various macromolecules including lipids, proteins and nucleic acids [1]. Accumulation of ROS along with impaired antioxidative mechanisms are well-recognized factors contributing to the development and progression of many pathological conditions [2].

Metabolic syndrome (Mets) is a worldwide medical problem playing a role in the development of various metabolic disorders, namely cardiovascular disease and type 2 diabetes mellitus (T2DM) [3]. Mets comprises a cluster of metabolic abnormalities including central obesity, dyslipidemia (high triglycerides and low HDL-cholesterol), hyperglycemia, and hypertension [4]. The diagnosis of Mets is mostly based on the presence of at least three of its five components, where central obesity is considered a major factor for the diagnosis of Mets [5]. The International Diabetes Federation (IDF) and World Health Organization (WHO) criteria adopts waist circumference (WC), a reflection of abdominal obesity, along with two other components when classifying persons with Mets [5]. In this regard, it is well established that anthropometric waist-related measurements are important predictors for risk of cardiovascular disease [6]. On the other hand, the National Cholesterol Education Program – Adult Treatment Panel III (NCEP – ATP III) considers any

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https://doi.org/10.1016/j.dsx.2019.07.010
1871-4021/

three of the five components for establishing the diagnosis of Mets [7]. In the United Arab Emirates (UAE), the prevalence of Mets is estimated to be around 40%, which is much higher than the global average percentage [8,9]. In addition, UAE has a high prevalence of T2DM and obesity that increase the risk of cardiovascular disease [10].

Compelling lines of evidence indicate that OS plays a critical role in the pathogenic mechanisms associated with Mets [11,12]. Increased rate of ROS production, reduced antioxidant protection, and increased markers of oxidative damage have been associated with Mets overall, as well as with all its individual components [11,13–20].

Although several studies have demonstrated proportional association between the OS and Mets, the major determinant component of Mets contributing to the increased OS and its associated complications is not well established [15,16,20–22]. Previous researchers have shown that blood pressure [23], visceral fat and obesity [11,16,24] are possibly the strongest determinants of OS in subjects with Mets.

To the best of our knowledge, no previous study has investigated the association between markers of OS [malondialdehyde (MDA), protein carbonyl and antioxidative enzymes] and components of Mets in the UAE residents. Therefore, the aim of this study was to investigate the antioxidative-oxidative status in a group of healthy subjects and those with Mets. Further, the study explored the relationships of OS with Mets components in order to determine the main predictor of OS.

2. Materials and methods

2.1. Study design and subjects

A cross-sectional study design was adopted, in which 172 male and female adults subjects (between 20 and 60 years of age) residing in the UAE were recruited. Normal, healthy subjects with no diagnosed chronic diseases such as T2DM, cardiovascular disease, hypertension, and dyslipidemia were included. On the other hand, any individual with reported acute inflammatory conditions, illness or on antioxidant supplements and pregnant women were excluded. In addition, subjects who did not fast at least 10 h or had missing data were excluded from the data analysis. The study was conducted between September 2015 and February 2017 in the Research Institute of Medical and Health Sciences, University of Sharjah, UAE. The Research and Ethics Committee at the University of Sharjah and Ministry of Health and Prevention approved the study protocol and consent form. The objectives of the study were explained and information sheets were given to all subjects and written consent was obtained prior to data and blood collections.

2.2. Anthropometric measurements

Height, body weight, WC and neck circumference (NC) were measured using standardized techniques. Waist circumference was measured between the iliac crest and lower border of ribs as recommended by the WHO and IDF [25]. Body mass index (BMI) was calculated by dividing body weight in kilograms by square of height in meters. According to the WHO, BMI value $< 18.5\ kg/m^2$ reflected underweight; $18.5–24.9\ kg/m^2$ indicated a healthy weight (normal-weight); BMI$\geq$25.0 to $< 30.0\ kg/m^2$ was considered as overweight and a BMI$\geq 30.0\ kg/m^2$ as obesity. Blood pressure was also measured using a digital automated blood pressure monitor (OMRON®-BP742 N, OMRON, Matsuzaka, Mie, Japan) on the right upper arm with the subjects in the sitting position. It was ensured that the subjects were relaxed and comfortable before taking the measurement.

2.3. Biochemical parameters

Venous blood specimens (10 mL) were collected in heparinized tubes from all subjects after 10–12 h overnight fasting. Plasma was separated by centrifugation and erythrocyte lysate was prepared according to manufacturer instructions. Both plasma and lysates were stored directly in freezer at $-80^{o}C$ until the time of analyses. Reduced glutathione (GSH) and antioxidative enzymes including SOD, catalase, and glutathione peroxidases (GPx) were all measured in erythrocytic lysates using commercially available ELISA kits (Cayman Chemical, MI, USA). Malondialdehyde (MDA) and protein carbonyl were measured in plasma using ELISA kits of the same manufacturer. Fasting glucose (FG) levels and lipid profile were measured by conventional procedures using chemistry autoanalyzer (Pchem 1 chemistry Analyzer, Adaltis, Milano, Italy).

2.4. Metabolic syndrome diagnosis and score

The diagnosis of Mets was determined using the IDF criteria [5]. Subjects with WC $\geq$ 94 cm (males) and $\geq$80 cm (females) plus two or more of the following parameters were classified as having Mets: fasting blood glucose $\geq$ 100 mg/dL, triglycerides (TG) $\geq$ 150 mg/dL; high-density lipoprotein-cholesterol (HDL-C) for males $\leq$ 40.0 mg/dL and for females $\leq$ 50.0 mg/dL; and blood pressure $\geq$ 130/85 mmHg. Furthermore, in order to investigate the association of the number of Mets components with the degree of OS, all subjects were divided into six groups designated as metabolic syndrome score (Mets Score). Thus, subjects lacking any component were assigned with a Mets Score 0, and those with one or more of the Mets components were assigned with respective Mets Score from 1 to 5.

2.5. Statistical analysis

Statistical analysis was done using the Statistical Package for the Social Sciences version 21.0 (SPSS Inc., Chicago, IL). Statistical comparison between groups was evaluated by the Mann–Whitney *U* test for nonparametric variables and results were presented as median and inter-quartile range (IQR). Spearman's and regression correlational analyses were conducted to evaluate the association between oxidative/anti-oxidative biomarkers and the relevant components of Mets. Statistical significance levels were set at $p < 0.05$.

3. Results

Table 1 shows the demographic characteristics of the 172 subjects (87 females and 85 males). The majority were aged less than 40 years (122; 70.9%), and were non-smokers (158; 91.9%). Little less than half of the subjects had normal BMI (75; 43.6%), while the rest were overweight and obese (68; 39.5% and 29; 16.9% respectively). Almost equal proportions had normal and large WC [87 (50.6%) and 85 (49.4%) respectively]. Table 1 also highlights that the majority of the subjects (115; 66.9%) had one or two components (Mets Score 1 and 2) as compared to thirty-eight (38; 22.1%) having three or more components of Mets (Mets Score 3 to 5). Thus, the prevalence of Mets in this study was 22.1%.

Subjects with Mets documented highly significant higher values of age, BMI, WC, systolic blood pressure (SBP), diastolic blood pressure (DBP), TG, and FG ($p < 0.001$), and significantly higher total cholesterol ($p < 0.05$), and similar HDL-C and LDL-C ($p > 0.05$) as compared to subjects without Mets. Moreover, those with Mets had significantly lower levels of the antioxidants catalase, SOD, GPx and GSH ($p < 0.001$) and higher levels of oxidants- protein carbonyl and MDA ($p < 0.001$) as demonstrated in Table 2.

Table 1
General characteristics of the participants (n = 172).

Variables		N (%)
Sex	Male	85 (49.4)
	Female	87 (50.6)
Age Group	<40 years	122 (70.9)
	≥40 years	50 (29.1)
Smoking	Yes	14 (8.1)
	No	158 (91.9)
Body Mass Index	Normal Weight	75 (43.6)
	Overweight	68 (39.5)
	Obese	29 (16.9)
Waist Circumference	Normal	87 (50.6)
	Large	85 (49.4)
Metabolic Syndrome Score	0	19 (11.0)
	1	60 (34.9)
	2	55 (32.0)
	3	18 (10.5)
	4	18 (10.5)
	5	2 (1.2)
Metabolic Syndrome Diagnosis	With	38 (22.1)
	Without	134 (77.9)

Table 2
Comparison of the medians (interquartile ranges) anthropometric and biochemical parameters in participants with and without metabolic syndrome.

Variables	All (N = 172)	With Mets (N = 38)	Without Mets (N = 134)	P value
Age (years)	26.0 (21.2)	44.4 (16.5)	22.1 (12.5)	<0.001
Body Mass Index (kg/m^2)	25.5(5.7)	28.2 (6.2)	24.6 (5.2)	<0.001
Waist Circumferences (cm)	88.9 (21.6)	100.7 (8.1)	85.4 (7.4)	<0.001
Males	94.4 (14.3)	101.4 (7.2)	89.5 (13.7)	<0.001
Females	79.6 (20.3)	97.5 (17.5)	77.2 (16.9)	<0.001
Systolic blood pressure (mmHg)	115.6 (20.2)	130.5 (17.7)	113.4 (16.6)	<0.001
Diastolic blood pressure (mmHg)	78.5 (14.2)	88.0 (9.5)	76.7 (10.2)	<0.001
Total Cholesterol (mg/dL)	190.5 (73.2)	212 (77.8)	186.7(69.2)	<0.01
HDL-C (mg/dL)	46.1 (14.8)	49.1 (24.1)	45.4 (12.8)	0.07
Males	44.3 (11.9)	47.5 (24.7)	43.7 (8.8)	0.13
Females	47.3 (14.4)	49.5 (19.6)	46.9 (14.6)	0.23
Triglycerides (mg/dL)	78.4 (79.6)	153.7 (147.6)	62.5 (57.4)	<0.001
LDL-C (mg/dL)	124.7 (55.3)	122.2 (56.3)	129.5 945.8)	0.1
Fasting glucose (mg/dL)	95.9 (13.8)	107.4 (21.1)	93.7 (10.7)	<0.001
Catalase (nmol/min/mL)	10502 (3581)	8455 (1665)	11298 (3093)	<0.001
Superoxide Dismutase (U/mL)	43.8 (11.9)	37.3 (13.34)	45.3 (13.5)	<0.001
Glutathione peroxidases (nmol/min/mL)	1581 (1061)	980 (392)	1658 (892)	<0.001
Reduced Glutathione (uM/L)	11.8 (4.1)	10.6 (3.5)	12.7 (4.7)	<0.001
Protein Carbonyl (nmol/mL)	57.4 (24.1)	65.4 (14.1)	47.9 (21.6)	<0.001
Malondialdehyde (uM/L)	2.44 (1.62)	3.33 (1.10)	2.00 (1.42)	<0.001

HDL-C: High Density Lipoprotein-Cholesterol.
LDL-C: Low Density Lipoprotein-Cholesterol.

Table 3
Correlations of markers of oxidative stress and Mets components in all subjects (n = 172).

Variables	Catalase (*r*)	Superoxide Dismutase (*r*)	Glutathione peroxidases (*r*)	Reduced Glutathione (*r*)	Malondialdehyde (*r*)	Protein Carbonyl (*r*)
Superoxide Dismutase	0.46**	–	–	–	–	–
Glutathione peroxidases	0.63**	0.40**	–	–	–	–
Reduced Glutathione	0.52**	0.41**	0.54**	–	–	–
Malondialdehyde	−0.47**	−0.46**	−0.47**	−0.47**	–	–
Protein Carbonyl	−0.38**	−0.31**	−0.3**	−0.44**	0.51**	–
Age	−0.62**	−0.31**	−0.63**	−0.60**	0.56**	0.50**
Fasting glucose	−0.38**	−0.15*	−0.30**	−0.36**	0.29**	0.25*
Triglycerides	−0.44**	−0.34**	−0.30**	−0.34**	0.46**	0.31**
High Density Lipoprotein-Cholesterol	−0.29**	−0.09	−0.20**	−0.18*	0.17*	−0.03
Body Mass Index	−0.61**	−0.45**	−0.51**	−0.40**	0.53**	0.35**
Waist Circumference	−0.64**	−0.42**	−0.55**	−0.47**	0.64**	0.44**
Systolic blood pressure	−0.37**	−0.26**	−0.27**	−0.22**	0.32**	0.24*
Diastolic blood pressure	−0.41**	−0.31**	−0.27**	−0.29**	0.39**	0.29**

*p < 0.05.
**p < 0.001.

Table 3 illustrates the correlations of OS markers with Mets components and other parameters in all subjects. The levels of antioxidant enzymes catalase, SOD and GPx, and GSH, correlated negatively with age, FG, TG, HDL-C (not with SOD), BMI, WC, SBP, and DBP. Biomarkers of OS, MDA and protein carbonyl on the other hand, correlated negatively with all antioxidant enzymes and GSH, and positively with all the other above-mentioned parameters, except HDL-C. Similarly, Fig. 1 (A-D) shows that Mets Score correlated negatively with each of catalase, SOD, GPx and GSH, while Fig. 2 (A-C) shows that Mets Score correlated positively with MDA, protein carbonyl and WC.

Linear regression analysis before and after adjustment for age and gender was conducted to investigate the single Mets component that contributes most to the observed increase in OS. Protein carbonyl and MDA were used as dependent variables, and Mets components as independent variables (Table 4). WC was found to be the best predictor for the levels of both protein carbonyl (adjusted Beta = 0.33; $p = 0.03$) and MDA (adjusted Beta = 0.45; $p < 0.001$). For further examination of the association between WC and OS, subjects were divided into two groups: normal and large WC (Table 5). Subjects with large WC had significantly lower levels of anti-oxidative enzymes and GSH, and higher levels of MDA and protein carbonyl than those with normal WC.

4. Discussion

In general, findings reported in this study demonstrate that the degree of OS observed in subjects with Mets was proportional to the number of Mets components, i.e. Mets Score. The main finding, however, points at the importance of WC (central obesity) in being the major Mets component that contributes most to OS.

Globally, the prevalence of Mets varies with gender and age but generally it is 8%–24% in men and 7%–46% in women [9]. Previous studies have shown that the prevalence of Mets in the UAE varies from 13% to 44% depending on the study population and on diagnostic criteria applied [8,26,27]. A UAE study that included subjects with an age of 20 years or more demonstrated that the prevalence of Mets was 39.6% and 40.5%, using the NCEP/ATP III and the IDF criteria, respectively [8]. Another study conducted on young UAE adolescents (below 18 years of age) using the IDF criteria, showed that the prevalence of Mets was 13% [26]. More recently, a study conducted on subjects similar to ours (age 22–65 years) reported the prevalence as 22% applying the NCEP/ATP III criteria [27]. In the current study, 63% of subjects with Mets were above age of 40 years and 66% were males. The overall prevalence of Mets was 22.1% that clearly indicate the influence of age and gender and is in line with other studies [8].

As expected, the levels of all Mets components, except HDL-C, were significantly higher in subjects with Mets than those without. Although 45% of subjects with Mets had HDL-C below the identified levels of the IDF criteria, the lack of significant differences between the groups may be attributed to lifestyle factors such as physical activity and dietary habits.

Overall, the findings of this study demonstrate that subjects with Mets were under greater OS than those without. This was evident in the decreased levels of antioxidant enzymes (catalase, SOD, and GPx) and GSH, and increased levels of lipids and protein oxidation products (MDA and protein carbonyl, respectively) in the subjects with Mets. Additionally, increased OS was also evident in the positive correlations of MDA and protein carbonyl with each of

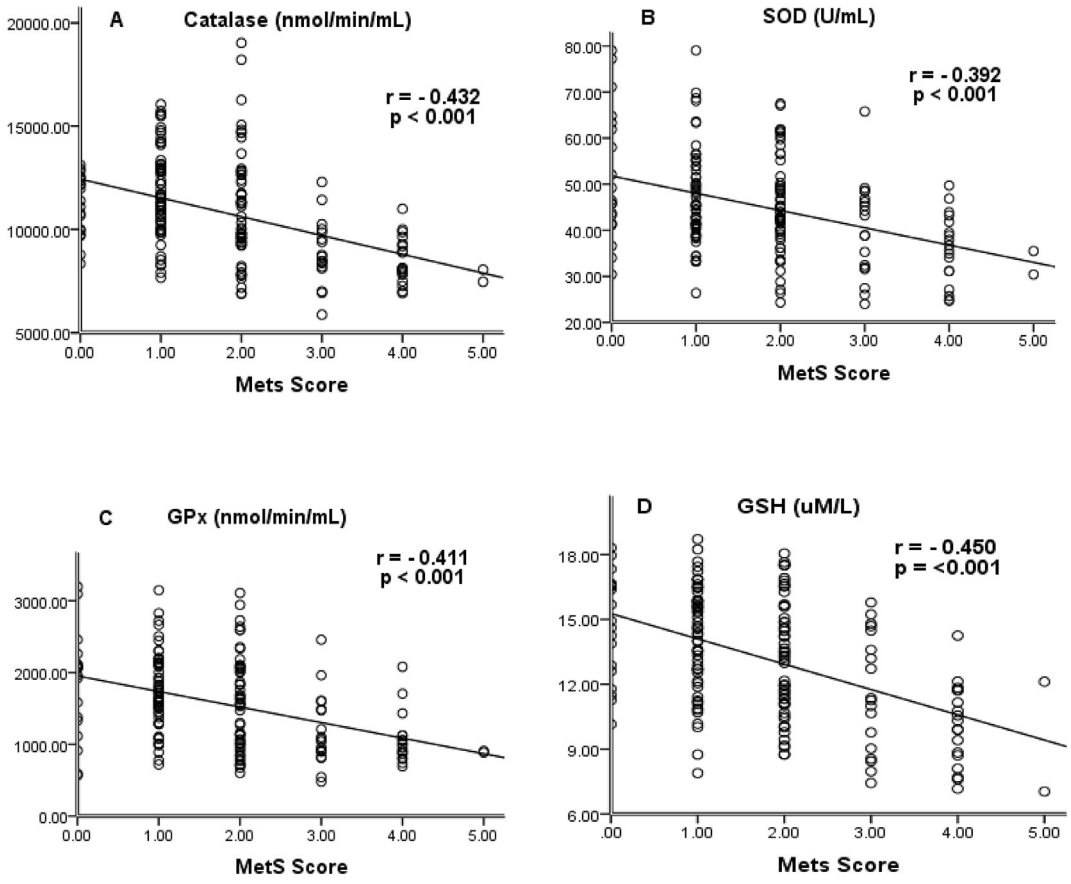

Fig. 1. (A–D). Correlation of the five categories of Mets Score (0–5) with levels of erythrocytic antioxidant enzymes (catalase, SOD and GPx) and reduced glutathione (GSH).

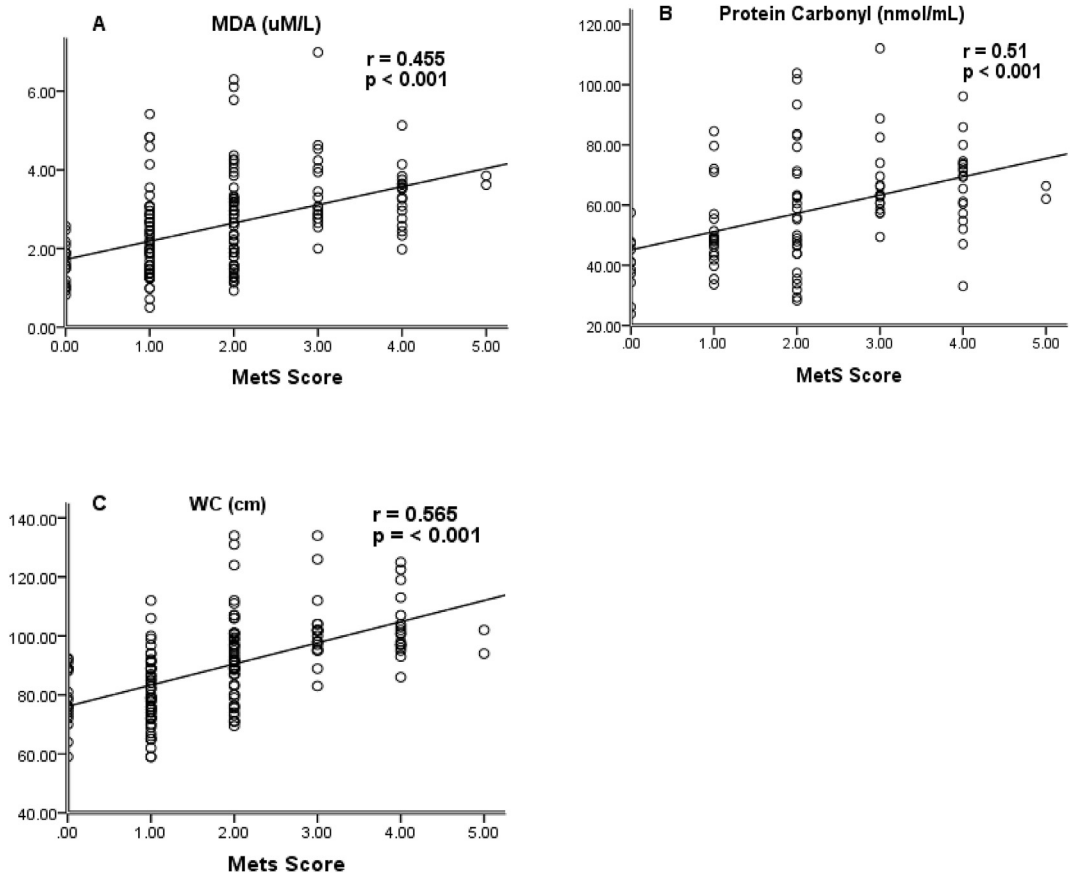

Fig. 2. (A–C). Correlation of the five categories of Mets Score (0–5) with plasma levels of MDA and Protein carbonyl, and with waist circumference (WC).

Table 4
Linear regression analysis using protein carbonyl and malondialdehyde as dependent variables before and after adjustment for age and sex.

Metabolic Syndrome Components	Protein Carbonyl				Malondialdehyde			
	Unadjusted		Adjusted		Unadjusted		Adjusted	
	Beta	P value	Beta	P value	Beta	P value	Beta	P value
Fasting glucose	0.18	0.08	0.11	0.25	0.10	0.11	0.06	0.32
Triglycerides	0.05	0.63	0.10	0.33	0.12	0.10	0.12	0.08
HDL-Cholesterol	0.04	0.67	−0.06	0.52	−0.05	0.41	−0.13	0.06
Waist Circumference	0.39	0.001	0.33	0.003	0.51	<0.001	0.45	<0.001
Systolic blood pressure	−0.17	0.33	−0.08	0.60	−0.12	0.2	−0.02	0.84
Diastolic blood pressure	0.14	0.37	−0.01	0.92	0.17	0.06	0.09	0.3

Table 5
Comparison of the median (interquartile ranges) values of antioxidants and oxidative stress products in subjects with normal and large waist circumference (WC).

	Normal WC (n = 87)	Large WC (n = 85)	P value
Catalase (nmol/min/mL)	11972(2370)	9242(1949)	<0.001
Superoxide Dismutase (U/mL)	46.5(14.9)	40.0(12.5)	<0.001
Glutathione peroxidases (nmol/min/mL)	2004(619)	1071(704)	<0.001
Reduced Glutathione (uM/L)	14.8(3.8)	11.5(3.8)	<0.001
Malondialdehyde (uM/L)	1.79(1.11)	3.00(1.18)	<0.001
Protein Carbonyl (nmol/mL)	45.7(13.50)	63.3(18.8)	<0.001

the Mets components, and negative correlations with the erythrocytic antioxidants.

Various biomarkers and approaches have been utilized in assessing the status of OS in subjects with and without Mets. Similar to our study, lower antioxidant enzymes activity (catalase, SOD, GPx) and higher levels of markers of lipids and protein oxidation (MDA, protein carbonyl) and thiobarbituric acid reactive substances (TBARS) were reported previously by several researchers [18,28–30]. Other investigators reported decreased levels of antioxidant vitamins (A, E and C), antioxidant trace elements and tocopherol, and increased levels of the lipid peroxide TBARS in subjects with Mets [13,19]. Further, decreased total

antioxidant capacity (TAC) in association with increased DNA damage were demonstrated in subjects with Mets [15]. Increased levels of urinary 8-epi-prostaglandin F2α (8-epi-PGF2α), marker of systemic OS, were also reported in Japanese subjects with Mets [16]. Others have also reported higher levels of TAC, MDA, allantoins, α_1-antiproteinase, and oxidized/reduced glutathione ratio in obese subjects exhibiting Mets [14]. Besides, levels of advanced oxidation protein products (AOPP) and TAC were reported to be higher in patients with Mets than in controls [31]. In contrast, increased activity of SOD and glutathione reductase, decreased catalase activity and GSH concentration, with no difference in GPx activity, were reported in subjects with Mets compared to healthy controls [32].

Our study has also shown that the degree of OS is proportional to the number of Mets components (Mets Score) which is in line with previous reports [15,16,21–23,28,33]. This is evident by the trend of decreased antioxidant activity in parallel with increased Mets Score that can be seen in Fig. 1 (A-D). In addition, a trend of increased levels of MDA and protein carbonyl was also seen as the Mets Score increases (Fig. 2; A-C). Fujita et al. reported that urinary levels of 8-epi-PGF2α, marker of lipid peroxidation, increased as the number of Mets components increased, and that visceral fat was the strongest independent determinant [16]. In a recent study, the level of hydrogen peroxide and lipids peroxidation products (LPO), SOD and GPx, were found to be higher in subjects with higher number of Mets components [22]. The same researchers have also suggested that SOD activity is a good predictor of the degree of OS in Mets. Another study on elderly Mexicans showed a ten-fold increase of OS in subjects with five Mets components as compared to subjects with one component [23]. They also showed that high blood pressure was the most important component linked to OS in elderly. Recently, a group of researchers demonstrated that advanced oxidation protein products (AOPP) is a better indicator of OS than lipid peroxidation in Mets, and correlated significantly with the number of Mets components [21]. A trend of significant decrease in total antioxidant capacity and a trend of increase in levels of DNA damage along with the number of Mets components has been established elsewhere [15]. Isogawa et al. also reported a negative correlation of SOD activity with the number of Mets components [33]. Furthermore, Li et al. demonstrated that the levels of SOD and GPx decreased significantly with increased number of Mets components [28].

Although several studies have demonstrated an existing association of OS with one or more of Mets components, the Mets component contributing most to OS, however is not well defined. Waist circumference emerged as the best predictor for MDA and protein carbonyl in the current study, which is a distinct finding in this population. In addition, our results have also shown that subjects with larger WC had lower levels of antioxidative enzymes and GSH than those with normal WC. In agreement with our results, visceral fat was documented as the strongest independent determinant for urinary 8-epi-PGF2α [16]. On the other hand, high blood pressure was identified as the most important component linked to OS in the elderly [23].

In support of our observations, several other studies have demonstrated strong associations of obesity or WC with one or more of OS markers. Sankhla et al. reported significant correlation of BMI in obese subjects with plasma levels of MDA as compared to subjects with normal weight [34]. Similarly, Furukawa et al. found that WC and BMI correlated significantly with plasma levels of TBARS and urinary 8-epi-PGF2α [35]. Recently, Ercan et al. conducted a study on subjects with Mets and have reported higher levels of 8-isoprostane that correlated significantly with WC, blood pressure and total cholesterol [36]. In addition, several studies have also shown that the levels of oxidized LDL (oxLDL) correlated significantly with WC in overweight or obese subjects [18,20,37]. Contrary to our results, however, Jialal et al. in a study on cohort with Mets, observed lack of association of WC with neither Mets components nor with markers of OS [38]. Besides, Pahwa and colleagues also demonstrated that BMI as well, does not correlate either with cardio-metabolic features or with biomarkers of OS [39]. Hurtado-Roca et al. have also shown that the levels of ox-LDL were associated with Mets components independent of central obesity or insulin resistance [40].

As indicated above, our results and that of others clearly highlight that subjects with Mets are under greater OS than normal healthy subjects, and that the degree of OS increases as the number of Mets components increases. Several lines of evidence suggested that central obesity and chronic hyperglycemia, features of Mets, play a major role in the development of OS by either increasing the release and accumulation of reactive oxygen species (ROS) or by decreasing antioxidants capacity [41,42]. Increased release of ROS and formation of hydrogen peroxide, increased activity of NADPH oxidase (NOX), and decreased antioxidant mechanisms are well documented factors contributing to OS in subjects suffering from obesity, with or without Mets [11,41,42]. The possible mechanism explaining the association of OS with increased WC may be attributed to the increased accumulation of fat (expansion of adipocytes), which is typically white adipose tissue, that is infiltrated with macrophages [43,44]. Together with macrophages, the adipocytes produce pro-inflammatory cytokines and ROS leading to enhanced activity of NADPH oxidase isoforms (NOX2 in macrophages and NOX4 in adipocytes) [45]. Collectively, the activity of the NOX pathways increase leading to higher state of OS.

5. Limitations

Limitations to this study include the sample size and the fact that it did not study individual lifestyle factors or compare between different age groups. Future studies may be conducted on larger samples and consider comparisons among different age groups, gender as well as variations in lifestyle factors.

6. Conclusions

In conclusion, results from this study demonstrate that the degree of OS is dependent on the number of Mets components, and that WC contributes independently to increased OS in adults residing in the UAE. WC may be a simple and effective measure that can be used clinically to assess OS.

Conflicts of interest

The authors declare that they have no conflict of interest.

Acknowledgments

The work of this study was supported by the Office of Vice Chancellor for Research and Graduate Studies, University of Sharjah, Sharjah, UAE [research grant # 15010501014-P, 2015]. Authors extend their deepest gratitude to the Research Institute for Medical and Health Sciences- University of Sharjah to which the research group is affiliated.

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