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# Comparison of serum total antioxidant capacity between subjects with and without metabolic syndrome according their body mass index

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A B S T R A C T

**Background:** This study aimed to determine the differences in plasma total antioxidant capacity between metabolic syndrome patients and those without metabolic syndrome with normal weight, overweight and obesity.
**Methods:** A case-control study was carried out among 146 men and women (aged 20-55 years) in Endocrinology Center of Tehran University of Medical Sciences. The case group included overweight/obese subjects with metabolic syndrome and the two control groups were weight-matched subjects without metabolic syndrome and normal weight subjects without metabolic syndrome. Total antioxidant capacity was determined using colorimetric method.
**Results:** Waist circumference and total antioxidant capacity of case group were significantly higher than that of both control groups (($p<0.001$) for both). There was no significant difference between normal and overweight/obese control groups in total antioxidant capacity level ($p=0.53$).
**Conclusion:** Oxidative stress presumably is an important factor in pathology of metabolic syndrome and total antioxidant capacity may be responsible for defense against oxidants.

## Introduction

Diagnostic criteria of metabolic syndrome have been considered by different organizations with slight variations. The National Adult Cholesterol Treatment Education Program Panel III (NCEP ATP III) described metabolic syndrome as the presence of any of following components: abdominal obesity, dyslipidemia (high levels of triglycerides, low HDL),

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hypertension, and elevated fasting glucose (1).

According to International Diabetes Federation (IDF), metabolic syndrome (MetS) was characterized by central obesity as an essential component associated with two or more complications including hypertension, abnormal blood glucose, high serum triglycerides, and low level of high density lipoprotein cholesterol (2). Prevalence of metabolic syndrome in Iran had been reported as one of the highest, worldwide (3).

Different mechanisms were proposed on the association between oxidative stress, obesity, and metabolic syndrome. For instance, oxidative stress was considered as a bridge between visceral obesity and MetS (4). Moreover, oxidative stress had a major pathophysiological role in all components of metabolic syndrome. It was defined as an imbalance between production and inactivation of reactive oxygen and nitrogen species and various disorders related to metabolic syndrome could happen due to excessive production of ROS or weakening of the antioxidant defense system (5-8). The term of antioxidant was used specifically to refer to a chemical component which prevented the oxidation of other molecules. While molecules including retinol, carotenoids, glutathione, uric acid, minerals including selenium and zinc, and antioxidant enzymes namely SOD, GPx, PRx and PON family can be placed among the most important markers of plasma antioxidant defense, total antioxidant capacity (TAC) is an indicator of coordinative activity of all plasma antioxidants (9). The aim of current study was to compare TAC status between MetS patients and control groups. Moreover, antioxidant capacity of all antioxidant components in a biological sample was determined instead of antioxidant capacity of a single compound.

## Subjects and methods

### *Study Population*

This case-control study was conducted in Endocrinology Center of Tehran University of Medical Sciences in Iran among 20-55 year subjects in 2014. It was approved by the research Ethics committee of Tehran University of Medical Sciences. 150 participants were selected using sequential sampling method. Prior to the commencement of the study, ethical clearance was obtained from the University Research Ethics Committee of the Tehran University of Medical Sciences. Written informed consent was obtained from all participants and food frequency data was collected using validated semi-quantitative food frequency questionnaire (FFQ) with 147 items to estimate annual intake of participants

Out of 150 subjects, four had missing TAC data. Finally the numbers of cases were 48 participants and the control groups which were age and gender matched to the cases made up of 50 weight-matched overweight/obese subjects (without MetS) and 48 normal weight subjects selected from those attending the center for routine medical cares. Patients suffered from metabolic syndrome were selected using inclusion criteria of adult treatment panel (NCEP ATPIII) including waist more than 102 cm and 88 cm for men and women respectively, serum triglycerides circumference more than 150mg/dl, high-density lipoprotein cholesterol less than 40mg/dl and 50mg/dl for men and women respectively, blood pressure more than 130/85 mmHg, and fasting blood glucose concentrations more than 110mg/dl (10). Pregnancy, breastfeeding, menopause, risk of cancer, ischemic heart disease, liver and kidney and blood diseases, medications for reducing fat and blood sugar, uncontrolled thyroid diseases, taking sleep medicines, sedatives, antihistamines, immune system suppressor, and vitamin and mineral supplements, being on vegetarian diet, professional exercise, and history of smoking and hookah and pipe were exclusion criteria.

### *Data Collection*

Anthropometric parameters including height, weight, and waist circumference (WC) were measured. Height was measured using a calibrated stadiometer in a standing position without shoes to the nearest 0.5 cm. Weight was determined using a balance seca scale to the nearest 100 g. WC were measured using tape meter in level interface to the lower margin of the ribs and the iliac crest in standing position and breathing normally with 0.5 cm precision. BMI was calculated as weight divided by height squared and classified. Participants with BMI between 25 kg/ m2 and 30 kg/ m2, 30 kg/ m2 and 34.9 kg/m2, 35 kg/ m2 and 39.9 kg/m2, and more than 40 kg/m2 were defined as overweight, class I obesity, class II obesity, and class III obesity, respectively (11,12).

Blood pressure (BP) was measured two times after a 15-minute rest in sitting position using GAMMA sphygmomanometer on the right arm. Mean of two measurements was considered as participants' BP.

Body composition including total body fat, trunk fat, fat in arms and legs (the thighs area),

**Table 1: Comparison of anthropometric parameters between metabolic syndrome subjects (MetS), Normal weight Control (NC), and Obesity/Overweight Control (OC)**

| Parameters | MetS (n=48) | OC (n=50) | NC (n=48) | MetS vs.NC | MetS vs.OC | NC vs.OC |
|---|---|---|---|---|---|---|
| **Weight(Kg)** | 89.84±11.69 | 88.96±11.52 | 67.77±9.06 | <0.001* | NS | <0.001* |
| **Height(cm)** | 172.10±6.70 | 172.60±6.90 | 172.52±7.70 | NS | NS | NS |
| **WC(cm)** | 106.59±7.37 | 102±10.53 | 88.36±7.01 | <0.001* | 0.008 | <0.001* |
| **BMI(Kg/m$^2$)** | 30.10±3.17 | 29.77±3.1 | 22.77±1.99 | <0.001* | NS | <0.001* |
| **AF (%)** | 26.41±5.73 | 26.46±6.67 | 16.27±6.74 | <0.001* | NS | <0.001* |
| **BW (kg)** | 49.46±6.24 | 49.30±5.66 | 41.76±5.76 | <0.001* | NS | <0.001* |

Kruskal–Wallis test, pairwise comporisons for height. ANOVA test, LSD for other variables.
All data are expressed as Mean ± SD; AF: abdominal fat , BW: Body water, WC: Waist Circumference, BMI: Body Mass Index,
The mean difference is significant at the 0.05 level. NS: Not Significant

lean body mass, and total body water were measured using TANITA (model: BC-418) body composition analyzer (13,14). To achieve accurate data, participants were asked to avoid moderate to severe physical activity for 2 to 3 hours before assessment (15).

Blood samples were collected after over-night fasting (8-12h). Fasting plasma glucose was measured using enzymatic colorimetric method by glucose oxidase. Triglyceride level was determined using enzymatic colorimetric analysis by glycerol phosphate oxidase. using enzymatic methods by commercial kit (all from Pars Azmoon, Iran) via an auto-analyzer system (Selectra E, Vitalab, the Netherlands) and serum insulin with a commercially available radioimmunoassay kit (Pharmacia, Uppsala, Sweden). Serum total antioxidant capacity was measured by quantitative colorimetric assay, using Total antioxidant Capacity - QuantiCromAntioxidant Assay Kit (BioAssay systems, USA; DTAC-100).

## Results

146 men and women aged 20-60 years participated in this study. There was no significant difference of age range between MetS patients and control groups. While mean BMI in case group was 30.16±3.17 kg/m2 control groups had BMI of 22.77±1.99 kg/m2 and 29.77±3.1 kg/m2 among normal-weight and overweight/obese participants, respectively.

Subjects suffered from MetS had significantly higher weight, waist circumference, BMI, abdominal fat and body water compared to normal-weight control group ($p < 0.001$) whereas overweight/obese control group only had lower waist circumference compared to MetS patients ($p=0.008$). In addition, abdominal fat, total body water, weight, and BMI were significantly different among the two control groups ($p < 0.001$) (Table 1).

In comparison to the control groups, metabolic syndrome patients had significantly higher levels of TG ($p < 0.001$), SBP and DBP ($p < 0.001$), FBS ($p =0.003$) and lower HDL-C ($p < 0.001$). Moreover, control groups had significant differences in SBP and DBP ($p < 0.001$) (Table 2). While fat distribution in hands and legs was significantly higher in case group compared to normal-weight controls ($p<0.001$) and in the overweight/obese control group compared to the normal-weight control group ($p <0.001$), no significant difference was found between MetS

**Table 2: Comparison of metabolic syndrome components between metabolic syndrome subjects (MetS), Normal weight Control (NC), and Obesity/Overweight Control (OC)**

| Variable | MetS (n=48) | OC (n=50) | NC (n=48) | MetS vs.NC | MetS vs.OC | NC vs.OC |
|---|---|---|---|---|---|---|
| **FBS(mg/dl)** | 109.50±48.39 | 91.26±7.2 | 92±6.29 | <0.001* | <0.001* | NS |
| **TG(mg/dl)** | 200.68±92.26 | 121.88±61.28 | 112.19±55.55 | <0.001* | <0.001* | NS |
| **HDL-C(mg/dl)** | 52.76±6.37 | 54.52±7.08 | 56.70±7.25 | <0.001* | NS | NS |
| **SBP(mmHg)** | 136.70±11.48 | 127.70±14.07 | 118.72±12.22 | <0.001* | 0.005* | 0.005* |
| **DBP(mmHg)** | 88.93±5.79 | 82.18±9.32 | 76.38±3.1 | <0.001* | 0.003* | 0.03* |

ANOVA test, LSD for HDL-c. Kruskal–Wallis test pairwise comparison for other variables. All data are expressed as mean ± standard deviation.
MetS: Metabolic syndrome ;WC: Waist Circumference; SBP: systolic blood pressure; DBP: diastolic blood pressure; FBS: fasting blood sugar; HDL-c: high-density lipoprotein cholesterol; TG: triglycerides
The mean difference is significant at the 0.05 level

**Table 3: Comparison of body fat distribution between metabolic syndrome subjects (MetS), Normal weight Control (NC), and Obesity/Overweight Control (OC)**

| Body fat distribution | MetS (n=48) | OC (n=50) | NC (n=48) | MetS vs.NC | MetS vs.OC | NC vs.OC |
|---|---|---|---|---|---|---|
| **Left hand(%)** | 24.13±7.12 | 24.49±6.9 | 16.68±5.7 | <0.001 | NS | <0.001 |
| **Right hand(%)** | 23.25±6.9 | 2.37±6.6 | 16.11±5.4 | <0.001 | NS | <0.001 |
| **Left leg(%)** | 20.95±6.4 | 19.71±5.6 | 14.92±6.7 | <0.001 | NS | <0.001 |
| **Right leg(%)** | 20.77±6.6 | 19.47±5.7 | 14.42±7.1 | <0.001 | NS | <0.001 |

Kruskal–Wallis test. pairwise comporisons. **MetS: Metabolic syndrome**. All data are expressed as mean ± standard deviation.

The mean difference is significant at the 0.05 level (Degrees of freedom is 2)

patients and overweight/obese controls (Table 3).

Mean rank of TAC was 102.07, 65.15, and 53.62 in MetS patients, overweight/obese control group, and normal-weight control group, respectively. TAC was significantly different between MetS patients and control groups ($p< 0.001$). However, two control groups did not have any significant difference in TAC mean rank. TAC was significantly positively correlated with WC, BMI, abdominal fat, TG, SBP, and DBP in all groups. BMI and indicators of metabolic syndrome including waist circumference ($r= 0.346$, $p<0.001$), abdominal fat ($r=0.671$, $p<0.001$), and blood pressure ($r=0.372$, $p=0.014$) were significantly correlated in case group. In addition, fat in left hand ($r=0.592$, $p<0.001$) fat in right hand ($r=0.615$, $p<0.001$), fat in left leg ($r=0.531$, $p<0.001$), and fat in right leg ($r=0.521$, $p<0.001$) had significant positive correlation with BMI.

## Discussion

This study aimed to compare the quality of life and plasma antioxidant capacity of the metabolic syndrome in healthy subjects with a BMI ≥25 and healthy individuals with a BMI ≤24/9. According to our knowledge, this is the first study that serum total antioxidant status in individuals with metabolic syndrome were compared with two control groups (obese and non-obese). In this study, patients suffered from metabolic syndrome had significantly higher levels of total antioxidant capacity compared to healthy controls.

While Simão and Kwak reported increased levels of TAC in MetS patients, other studies indicated equal or lower total antioxidant capacity in metabolic syndrome patients (18-21). According to the results, BMI was significantly correlated with waist circumference, abdominal fat, blood pressure, and fat distribution in hands and legs. Similarly, other studies showed that obesity was decisively associated with metabolic syndrome components (10, 17).

Although uric acid was not measured in this study, its levels have been reported higher in MetS patients compared to healthy controls in similar studies (8, 23-24). Studies about antioxidant role of uric acid in non-enzymatic antioxidant defense system, insulin sensitivity, and systematic oxidative stress markers such as 8-iso-prostaglandin F2, and stress markers such as carbonated protein demonstrated that sudden reduction of uric acid level causes 45% to 95% drop in total antioxidant capacity in people with high levels of uric acid (25).

In present study, a strong association between BMI, WC, abdominal fat and metabolic syndrome was found. Palmer et al. reported causal effect of obesity and uric acid on hyperuricaemia (26). In addition; Uaratanawong et al., reported high prevalence of hyperuricaemia among men suffered from metabolic syndrome (27). Becides, increasing number of metabolic syndrome components accompanied with elevated mean serum uric acid levels (28). In this study, significant strong relation between TAC and components of MetS except for FBS was found. Similarly, Venturini et al. in a study on three groups showed that patients with MetS had higher uric acid levels in comparison with two control groups with normal weight and overweight (23). Moreover, results of a study among three groups of participants including newly diagnosed diabetic and diabetic patients during treatment and control group showed higher levels of malondialdehyde (MDA) in serum and erythrocytes in diabetics cases compared to healthy controls. Also, MDA was at the highest level in treated diabetic patients. Furthermore, SOD activity and concentrations of –SH and GSH were lower and levels of activity of GR, GPX, and lipid peroxidation were higher in both diabetic groups compared to healthy controls (29). It was explained that antioxidant defense system

effectively worked against increased free radicals in early stage of type 2 diabetes. However reduced antioxidants levels would appear with disease advancing due to destruction of redox balance (29).

The main limitation of our study is being case-control and we could not identify causal relationships. Moreover, we had no knowledge of the exact time of disease progress, and duration and process of disease. It is because the antioxidant defense system at different stages of the disease situation is different. Physical activity was not calculated, and this may be confounding factor.

## Conclusion

It seems that oxidative stress was an important factor in pathology of metabolic syndrome and total TAC was responsible for defense against oxidant status. Further studies in order to understand TAC status among patients suffered from metabolic syndrome and its influential factors are required.

## Conflict of Interests

The authors declare that there is no conflict of interests regarding the publication of this paper.

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