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Obesity-related indicators and their relationship with serum antioxidant activity levels in Mexican adults

María Fernanda Amaya-Villalva[1], Gustavo González-Aguilar[2], Ofelia Rouzaud-Sández[1], Shela Gorinstein[3], Humberto Astiazarán-García[2] and Maribel Robles-Sánchez[1]

[1]Departamento de Investigación y Posgrado en Alimentos, Universidad de Sonora. México. [2]Centro de Investigación en Alimentación y Desarrollo, AC (CIAD, AC), Hermosillo Sonora. México. [3]Department of Medicinal Chemistry and Natural Products, School of Pharmacy, The Hebrew University of Jerusalem. Israel.

Abstract

Introduction: **Obesity has been associated with an oxidative process, however there are controversies regarding the potential role of circulating antioxidant activity attributed to non-protein compounds.**

Objective: **The purpose of the present study was to examine the relation between antioxidant activity levels and obesity related-indicators in Mexican young adults.**

Methods: **Anthropometric measures, serum lipids and uric acid were determined in 78 men and 90 women (a total of 168 individuals). Serum antioxidant activity in different fractions also was measured by using TEAC assay ($TEAC_{NP}$, $TEAC_{P}$ and $TEAC_{Total}$).**

Results: **$TEAC_{NP}$ was positively correlated ($p<0.05$) BMI (r=0.307), WC (r=0.322), LDL (r=0.274), TC (r=0.293), TG (r=0.409) and UA (r=0.441). The antioxidant activity measured as $TEAC_{NP}$ in individuals with obesity related-indicators was higher compared to those individuals without obesity-related indicators. When BMI, WC, HDL, LDL, TC, TG and UA were considered as obesity related-indicators, the higher the number of obesity related indicators ($p<0.05$) the higher the $TEAC_{NP}$ values. However, when $TEAC_{P}$ values decreased, the number of obesity related-indicators ($p<0.05$) increased.**

Conclusion: **The positive association between $TEAC_{NP}$ and obesity related-indicators suggests that apparently increase in $TEAC_{NP}$ may not always indicate a healthier condition.**

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Correspondence: Maribel Robles-Sánchez.
Departamento de Investigación y Posgrado en Alimentos.
Universidad de Sonora, México.
Blvd. Luis Encinas y Rosales s/n Col. Centro.
83000, Hermosillo, Sonora, México.
E-mail: rsanchez@guayacan.uson.mx

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INDICADORES ASOCIADOS A OBESIDAD Y SU RELACIÓN CON NIVELES DE ACTIVIDAD ANTIOXIDANTE EN SUERO DE ADULTOS MEXICANOS

Resumen

Introducción: **La obesidad ha sido asociada a un proceso oxidativo, no obstante existen controversias en relación al papel que pueda desempeñar la actividad antioxidante circulante atribuida a compuestos no proteicos.**

Objetivo: **El objetivo del presente estudio fue examinar la relación entre los niveles de actividad antioxidante e indicadores relacionados con obesidad en adultos jóvenes mexicanos.**

Métodos: **Se determinaron las medidas antropométricas y niveles séricos de lípidos y ácido úrico en 78 hombres y 90 mujeres (un total de 168 individuos). También se determinó la actividad antioxidante en distintas fracciones de suero mediante el ensayo de TEAC ($TEAC_{NP}$, $TEAC_{P}$ y $TEAC_{Total}$).**

Resultados: **$TEAC_{NP}$ se correlacionó positivamente ($p<0,05$) con IMC (r=0,307), CC (r=0,322), LDL (r=0,274), CT (r=0,293), TG (r=0,409) y AU (r=0,441). La actividad antioxidante medida como $TEAC_{NP}$ en individuos con indicadores relacionados con obesidad fue más alta comparada con aquellos individuos sin indicadores relacionados con obesidad. Considerando como indicadores de obesidad a IMC, CC, HDL, LDL, CT, TG y AU, se observó que a medida que se incrementó el número de indicadores relacionados con obesidad se incrementaron los valores de $TEAC_{NP}$. Sin embargo, cuando disminuyeron los valores de $TEAC_{P}$ el número de indicadores relacionados con obesidad se incrementó ($p<0.05$).**

Conclusión: **La asociación positiva entre $TEAC_{NP}$ e indicadores relacionados a obesidad sugiere que al parecer un incremento en $TEAC_{NP}$ no siempre puede indicar una condición saludable.**

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Palabras clave: *Obesidad. Aterosclerosis. Capacidad antioxidante.*

Abbreviations

AS: Atherosclerosis
LDL: Low density lipoprotein
CVD: Cardiovascular disease
UA: Uric acid
BMI: Body mass index
TC: Total cholesterol
HDL: High density lipoprotein
TG: Tryglicerides
TEAC: Trolox equivalent antioxidant capacity
ABTS: 2,2'-Azino-di- [3-ethylbenzthiazoline sulphonate]
$TEAC_{NP}$: Trolox equivalent antioxidant capacity non protein fraction
$TEAC_{P}$: Trolox equivalent antioxidant capacity protein fraction
ORAC: Oxygen radical absorption capacity

Introduction

The prevalence of obesity and its related medical consequences are increasing in many countries[1]. Today, México has the second global prevalence of obesity in the adult population (30%), which is ten times higher than that of Korea or Japan. This implies a major challenge for the health sector[2].

Obesity is a risk factor of atherosclerosis (AS), which is normally attributed in some extent to non-insulin dependent diabetes mellitus, arterial hypertension and hyperlipidemia. This atherogenic effect of obesity could be associated to several mechanisms which include inflammatory mechanisms, insulin resistance and stimulation renin–angiotensin system commonly related to atherosclerosis processes[3-6].

The initial event in atherogenesis is the increased transcytosis of low lipoprotein density (LDL) and its subsequent deposition, retention and oxidation in the subendothelium. In this sense, the oxidation of LDL can enhance atheromic plaque formation and consequently the obstruction of blood circulation[7,8]. Several epidemiological studies have shown an association between circulate antioxidants and diminished cardiovascular diseases (CVD)[9,10]. However, there is a controversy based on epidemiological evidence and clinical trials regarding the potential beneficial role of antioxidants in preventing AS disease[11,12]. Particularly, it has been known that proteic and non-proteic antioxidants such as albumin, bilirubin and uric acid (UA) are positively associated with obesity and CVD[13,14].

Several studies are inconsistent regarding antioxidant activity status of different groups of people under various metabolic disorders[15-19]. Most of these studies have evaluated serum total antioxidant activity but not serum non proteic and proteic fractions that could have some effect on the antioxidant activity of different groups. Therefore, the purpose of this study is to evaluate the relationship between obesity related-indicators and serum total antioxidant activity and their non proteic and proteic fractions in Mexican young adults. To the best of our knowledge, it is the first time that this type of study is performed among Mexican population.

Methods

The study included 201 Mexican young men and women from Bachelor Public University in Sonora, México. The study's protocol fulfilled the ethical standards for human experimentation according to the Ethics Committee of the Centre for Food Research and Development AC (CIAD, AC). After receiving detailed information about the conditions of the study, all participants agreed to participate in the experiment. Exclusion criteria were as follows: a) not having consumed vitamin supplements in the last three months prior to the study; b) not being in condition of underweight (Body mass index (BMI)<18.99 kg/m^2), c) positive history for AS (the presence of 1st degree relatives with manifest AS (cardiovascular hearth disease and/or cerebrovascular disease and/or peripheral vascular disease) under the age of 55 years for males and 65 years for females was considered as a positive family history and d) being outside the selected age range (18-25 years).

Blood samples (5 mL) were taken from each study subjects voluntarily and collected in vacutainer tubes, after fasting for 12-14 h. Samples were centrifuged at 130 g for 15 min and serum was separated from whole blood. Total cholesterol (TC), low density lipoprotein (LDL), high density lipoprotein (HDL), trygliicerides (TG) and uric acid (UA) in serum were measured by enzymatic methods using commercial test kits (Randox Lab. Ltd., UK).

The values of lipids profile considered as obesity related-indicators were defined as TC (>200 mg/dl), LDL (>130 mg/dl), HDL (male <40 mg/dl, female <50 mg/dl) and TG (≥150 mg/dl) according to National Cholesterol Education Program Adult Treatment Panel III (2001)[20]. Hyperuricemia was considered as UA (men >7.0 mg/dl, women >5.7 mg/dl) according to the standard established by the supplier.

TEAC assay is based on the ability of the antioxidants to scavenge the blue-green $ABTS^{\cdot+}$ radical cation relative to the scavenging capacity of the water soluble vitamin E analogue Trolox[21]. The antioxidant capacity of the total serum and non-protein fraction was determined and labeled as $TEAC_{Total}$ and $TEAC_{NP}$, respectively. In $TEAC_{NP}$ determination, the serum protein fraction was removed by precipitation, adding (1:1) 0.05 M of perchloric acid. Serum protein fraction ($TEAC_{P}$) antioxidant capacity was calculated by the difference between the $TEAC_{Total}$ and $TEAC_{NP}$.

The percentage of absorbance inhibition at 734 nm was calculated and plotted as a function of that obtained for the serum samples and the standard reference (Trolox). The final TEAC value was calculated by using a regression equation between the Trolox concentration and the inhibition percentage and expressed as mmTE/L.

Height (h) and weight (W) were measured following internationally accepted techniques using a stadiometer (model 202, Seca Ltd, Birmingham, UK) and a digital scale (1631 solar scale, Tanita Corp, Tokyo, Japan), respectively. Obesity was determined by BMI and using the following equation: $BMI=W/h^2$ according to the World Health Organization (WHO). The cut-off points were: normal weight (18.5-24.9 kg/m^2), overweight (25-29.9 kg/m^2) and obesity (≥30 kg/m^2). Waist circumference (WC) was measured at the mid-point between the highest part of the iliac crest and the lowest part of the ribs margin of the median axial line. If WC was ≥90 cm in men or ≥80cm in women, the subject was classified as having central obesity based on the International Diabetes Federation[22].

Statistical analyses were performed using a SAS version 8 software (SAS Institute Inc, Cary, NC). Means and standard deviation from data of all determinations were obtained. Pearson's correlation coefficients were used to assess the relationship between antioxidant activity levels and obesity related indicators. The correlation between the number of obesity related-indicators and antioxidant activity levels was assessed by Spearman's correlation coefficient by rank. In all analyses, $p<0.05$ was considered statistically significant.

Results

This study was achieved with the voluntary participation of 201 individuals; all active students were from the Central Campus of the University of Sonora, México. From these initial number we excluded from the study those out of the age range (18-25 years), below normal weight (<18.5 kg/m^2) and those that consumed some multivitamin. The final sample was 168 individuals (78 women and 90 men), corresponding to 46.4 and 53.55%, respectively. Previous studies used a similar number of subjects to evaluate prevalence of cardiovascular disorders in different groups of individuals[23-25].

Anthropometric and biochemical measures of subjects are shown in table I. BMI and WC did not show statistical differences ($p<0.05$) by gender. From all biochemical determinations, the mean levels of LDL, TC, TG and UA were significantly higher in men than women ($p<0.05$), with the exception of HDL levels. Figure 1 shows the mean serum antioxidant capacity ($TEAC_{Total}$ $TEAC_P$ $TEAC_{NP}$) grouped by gender. The $TEAC_{Total}$ values were higher (3.11±0.06) in men than in women (3.06±0.06). However, the $TEAC_p$ values were higher (2.69±0.06) in women than in men (2.62±0.06) while $TEAC_{NP}$ levels were higher (0.488±0.07) in men than in women (0.371±0.06).

Table I
Anthropometric and biochemical indicators of subjects

	Total (n=168)	*Women (n=78)*	*Men (n=90)*
BMI (kg/m^2)	25.00±4.3	24.9±4.8	25.0±3.9
WC (cm)	83.39±12.3	81.5±13.8	85.0±10.7
HDL (mg/dl)	58.8±14.9	63.2±11.8	54.9±16.3 **
LDL (mg/dl)	79.05±45.0	60.2±33.7	95.3±47.3**
TC (mg/dl)	157.7±44.0	140.3±36.1	172.8±44.8**
TG (mg/dl)	99.3±58.5	83.9±47.3	112.2±63.9*
UA (mg/dl)	3.91±1.44	3.54±1.4	4.2±1.4*

*p<0.001, ** p<0.0001 significantly different from women by independent samples t-test.

Table II shows the Pearson's correlation coefficient between antioxidant capacity ($TEAC_{NP}$, $TEAC_{Total}$ and $TEAC_p$) and obesity-related indicators (BMI, WC, TC, HDL, LDL, TG and UA). $TEAC_{NP}$ was significantly positively correlated with BMI (r=0.307, p<0.001), WC (r=0.322, p<0.001), LDL (r=0.274, p<0.001), TC (r=0.293, p<0.001), TG (r=0.409, p<0.001) and UA (r=0.441, r<0.001). In addition, $TEAC_{NP}$ was significantly negatively correlated with HDL (r=-0.283, p<0.001). $TEAC_{Total}$ only was significantly positively correlated with LDL (r=0.247, p<0.01), TC (r=0.295, p<0.001) and UA (r=0.152, r<0.05). $TEAC_p$ was significantly positively correlated with HDL (r=0.272, p<0.001) and negatively correlated with BMI (r=-0.325, p<0.001), WC (r=-0.278, p<0.001), TG (r=-0.284, p<0.001) and UA (r=-0.288, p<0.001).

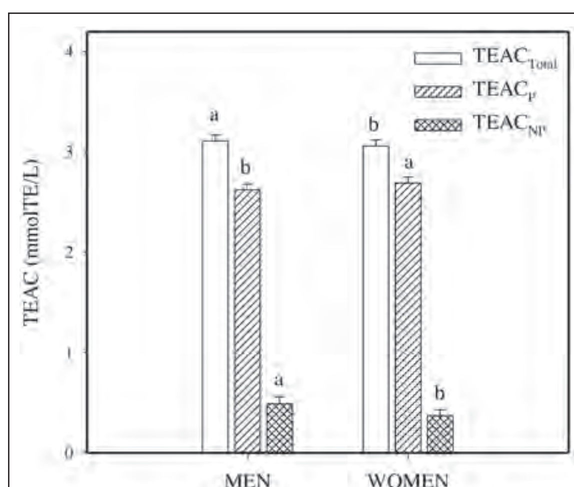

Fig. 1.—Total trolox equivalent antioxidant capacity ($TEAC_T$), Proteic trolox equivalent antioxidant capacity ($TEAC_P$) and Non proteic trolox equivalent antioxidant capacity ($TEAC_{NP}$) (mmol-TE/L) by gender. Bars with different letters within same assay are significantly different (p<0.05).

Table II
Pearson's correlation coefficients between measures

	BMI	*WC*	*HDL*	*LDL*	*TC*	*TG*	*UA*	*$TEAC_{NP}$*	*$TEAC_{Total}$*	*$TEAC_P$*
BMI		0.872***	-0.270***	0.212**	0.210**	0.319***	0.260***	0.307***	-0.079	-0.325***
WC			-0.278***	0.264***	0.259***	0.314***	0.262***	0.322***	0.010	-0.278***
HDL				-0.335***	-0.102	-0.374***	-0.148*	-0.282***	0.034	0.272***
LDL					0.942***	0.130	0.132	0.274***	0.247**	-0.077
TC						0.271***	0.203**	0.293***	0.295***	-0.061
TG							0.446***	0.409***	0.115	-0.284***
UA								0.441***	0.152*	-0.288***
$TEAC_{NP}$									0.193*	-0.754***
$TEAC_{Total}$										0.497***
$TEAC_P$										

* Correlation is significant at the 0.05 level. ** Correlation is significant at the 0.01 level. *** Correlation is significant at the 0.001 level.

Table III shows the comparison of antioxidant capacity ($TEAC_{NP}$, $TEAC_{Total}$, $TEAC_P$) between groups with and without obesity-related indicators, such as obesity (BMI: ≥30 kg/m^2), central obesity (WC: men ≥90 cm, women ≥80 cm), low HDL concentration (men <40 mg/dl, women <50 mg/dl), high LDL concentration (≥130 mg/dl), hypercholesterolemia (≥200 mg/dl), hypertriglyceridemia (≥150 mg/dl) and hyperuricemia (men >7.0 mg/dl, women >5.7 mg/dl).

Among the 168 subjects, mean of $TEAC_{NP}$ of 30 subjects had obesity, 25 subjects had low HDL concentration, 24 subjects had high LDL concentration, 31 subjects had high TC concentration, 27 subjects had high TG concentration and 13 subjects had high UA concentration and were shown to be 3-19% higher than mean $TEAC_{NP}$ of subjects without obesity related indicators. Contrary to this result, means $TEAC_P$ of subjects with obesity related-indicators such as BMI, HDL, TC, TG and UA were significantly lower ($p<0.05$) than means $TEAC_P$ of subjects without obesity related-indicators (Table III).

Figure 2 shows the distribution of $TEAC_{NP}$, (F2a), $TEAC_{Total}$ (F2b) $TEAC_P$ (F2c) according to the number of obesity related-indicators. Mean $TEAC_{NP}$ was elevated with increasing obesity related-indicators ($r=0.409$ $p<0.001$), while mean $TEAC_P$ was diminished with increasing obesity related-indicators ($r=0.305$ $p<0.001$). Mean $TEAC_T$ did not show significant ($p>0.05$) changes regarding obesity related-indicators number.

Discussion

According to Lavie *et al.*[26], obesity has reached global epidemic proportions in both adults and children and is associated with numerous comorbidities, including hypertension, type II diabetes mellitus, dyslipidemia, certain cancers and cardiovascular disease[27]. AS, a major cardiovascular disease, is one of the chronic diseases most prevalent in the adult population, and coronary heart disease is the most frequent and lethal form. Despite the great contribution of established risk factors to AS, they fail to predict coronary heart disease revealing a clear need to explore other indicators more directed to atherosclerotic mechanism associated to obesity.

We studied the association between obesity related-indicators and serum antioxidant activity in young adults studying in a public University of Sonora, localized in Northwest of México. Among 168 individuals examined, 30 had obesity (BMI ≥30 kg/m^2) and 63 had abdominal obesity (WC≥90 cm for men ≥80 cm for women) equivalent to 17.6 and 37% total sample, respectively. According to Barquera *et al.*[28], in México, 38 and 32% of adult Mexican population have overweight and obesity respectively, while 74% had abdominal obesity.

Regarding lipid profile values, in our study, 14.2, 18.4 and 16% of young individuals had increased LDL, TC and TG levels respectively, while 14.8% showed decreased HDL levels. A high prevalence of obesity related-indicators was observed in this sample in accordance with the international literature that revealed obesity related indicators in young individuals were also high[25,29-32].

Dyslipidemia and obesity are changeable risk factors of AS. The increase in LDL levels especially in LDL modified by oxidation represents one of the main causes of endothelial damage/dysfunction, an initial event of atherogenic process[33]. On the other hand, hyperuricemia has been associated with obesity and CVD[34], but it is also well known that UA in circulation is a potent antioxidant non-proteic[35]. Therefore, there is the controversy regarding beneficial effects of antioxidants in circulation on CDV reduction[15,17].

We evaluated antioxidant activity status in serum of young adults with or without obesity related-indicators. Serum antioxidant activity levels measured as $TEAC_{NP}$ tended to increase with all obesity related-indicators. An opposite behavior was observed for $TEAC_P$ which was decreased in obese subjects while that for $TEAC_T$ did not show significant change ($p>0.05$) with respect to obesity related-indicators number. This correlation analysis makes it possible to assume that under obesity conditions at the same time both enzymatic antioxidants (proteic fraction) are utilized and no enzymatic antioxidants (non-proteic fraction) are synthesized in order to counteract the oxidative stress promoted by obesity development. These results suggest that total antioxidant activity of serum is part of tightly regulated homeostatic mechanism.

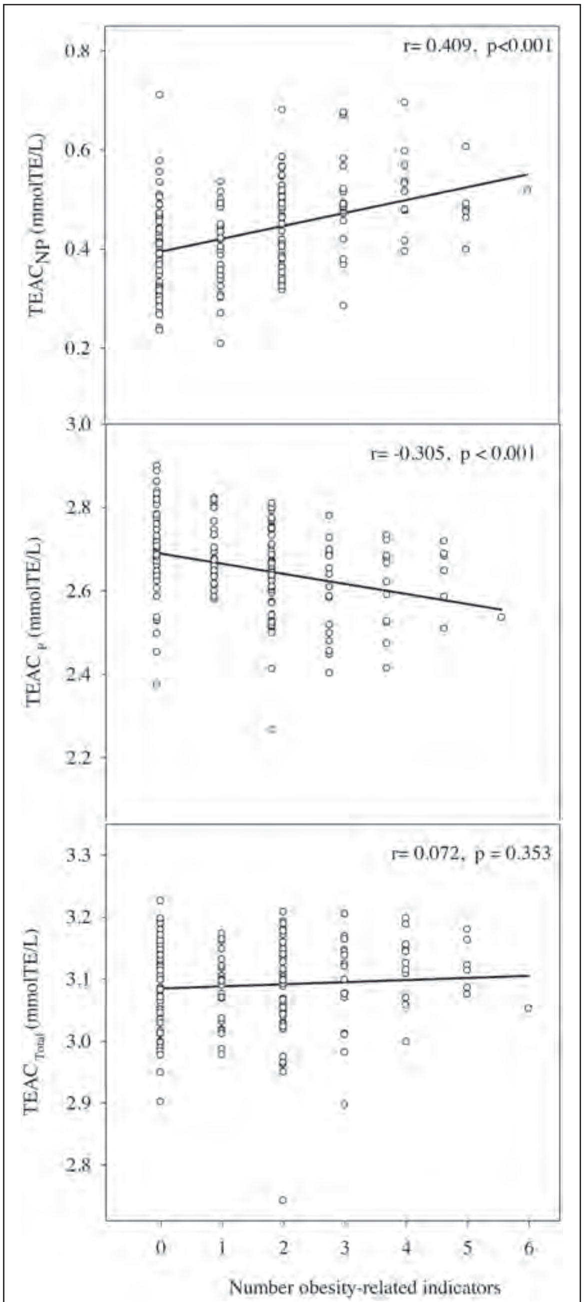

Fig. 2.—Distribution of the serum antioxidant activity levels according to the number of obesity related-indicators. There was correlation between the number of obesity related-indicators and antioxidant activity levels by Spearman's rank correlation coefficient.

Evaluation of antioxidants capacity in body fluid has been used as one of the biological markers for monitoring oxidative stress in humans[13]. Serums treated with perchloric acid allow evaluating antioxidant activity in non-protein fraction that preserves the water-soluble antioxidants within the sample. We have not analyzed individual antioxidants; however, several studies have shown that there is significant correlation between antioxidant activity, BMI, and serum UA levels[15,17]. Cao & Prior (1998) measured antioxidant activity in non-proteic fraction and individuals antioxidants (ascorbic acid, bilirubin and UA) in serum of healthy individuals using ORAC (Oxygen radical absorption capacity) (non proteic fraction) and TEAC (total) assays and found that the contribution of UA to total antioxidant activity was 39 and 19.3% for ORAC and TEAC respectively[13]. It is possible that in obese people this contribution could be higher than in normal weight people. It may be assumed that high values of serum antioxidant capacity of the non-protein fraction in individuals with obesity can be attributed in part to serum UA levels, particularly because this compound showed an increase in obese individuals.

Experimental evidence suggests that hyperuricemia may be a compensatory mechanism to counteract oxidative damage related to AS[15,17]. However, other studies have shown the existence of mechanisms in which UA may be an important mediator of endothelial dysfunction and vascular function[35-37].

This could show that antioxidant capacity in general is closely related to the physiological and metabolic changes related to CVD, especially AS coupled with a condition of obesity.

It is the first time that the antioxidant status is studied and correlated with obesity related indicators in Mexican young people. The findings are very interesting because it was traditionally thought that high serum antioxidant activity is associated with healthy status; however, we have confirmed that under conditions of obesity and dyslipidemia in young people, the antioxidant activity can be significantly increased.

Conclusion

We concluded that the antioxidant capacity of the non-protein fraction of the serum measured as TEAC is associated with BMI and with an increase of UA levels in the individuals studied. The antioxidant capacity of the protein fraction measured as TEAC is associated with a reduction in the BMI and a reduction in the levels of UA. An increase in serum antioxidant

Table III
Comparison of serum antioxidant capacity ($TEAC_{NP}$, $TEAC_{Total}$, $TEAC_P$) between groups with and without obesity related indicators

	n	$TEAC_{NP}$	$TEAC_{Total}$	$TEAC_P$
BMI				
≥30.0 kg/m²	30	0.472±0.08	3.09±0.07	2.61±0.09
<30.0 kg/m²	138	0.405±0.09	3.08±0.06	2.68±0.10
WC				
≥90 cm [a] ≥80 cm [b]	63	0.443±0.08	3.08±0.07	2.64±0.09
<90 cm [a] <80 cm [b]	105	0.429±0.09	3.09±0.06	2.66±0.10
HDL				
<40 mg/dl [a] <50 mg/dl [b]	25	0.471±0.11	3.07±0.06	2.60±0.10
≥40 mg/dl [a] ≥50 mg/dl [b]	143	0.427±0.08	3.09±0.07	2.66±0.10
LDL				
≥130 mg/dl	24	0.477±0.06	3.11±0.06	2.63±0.09
<130 mg/dl	144	0.426±0.09	3.08±0.07	2.65±0.10
TC				
≥200 mg/dl	31	0.482±0.07	3.12±0.06	2.63±0.09
<200 mg/dl	137	0.424±0.09	3.08±0.07	2.65±0.10
TG				
≥150 mg/dl	27	0.509±0.09	3.09±0.06	2.58±0.10
<150 mg/dl	141	0.420±0.08	3.08±0.07	2.66±0.10
UA				
≥7.0 mg/dl [a] ≥5.7 mg/dl [b]	13	0.531±0.09	3.10±0.08	2.57±0.11
<7.0 mg/dl [a] <5.7 mg/dl [b]	155	0.429±0.09	3.08±0.07	2.65±0.10
P value[1]				
BMI		<0.0001	0.8705	<0.0001
WC		0.3526	0.5520	0.2225
HDL		0.0263	0.2621	0.0064
LDL		0.0115	0.0831	0.2877
TC		0.0018	0.0069	0.3496
TG		<0.0001	0.4756	0.0005
UA		0.0024	0.4962	0.0269

[1]p<0.05 Significance by independent samples t-test between groups with and without obesity related indicators.
[a]men [b]women.

capacity could be considered as a biomarker of obesity when associated with high levels of UA.

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Conflicts of Interest

The authors declare no conflict of interest.

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