Relationship between oxygen radical absorbance capacity (ORAC) index, body composition and blood biochemical markers in overweight /obese compared to normal weight subjects: a cross-sectional study

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Research

Keywords: Oxygen Radical Absorption Capacity (ORAC), Lipid Profile, Fasting blood Glucose, Obesity, Overweight

Posted Date: November 10th, 2020

DOI: https://doi.org/10.21203/rs.3.rs-100919/v1

Abstract

Background: Obesity is an important preventable disease, which promotes the development of chronic disorders by altering several factors including oxidative stress. Dietary antioxidants protect the body against oxidative stress. The purpose of this study was to evaluate the potential association of oxygen radical absorbance capacity (ORAC) index with obesity and its associated features in adults.

Methods: participants were divided in two groups of normal weight and overweight /obesity. General characteristics were registered and a 147-item food frequency questionnaire was completed. Thereafter, anthropometric measurements were conducted. Biochemical indices were obtained from science and Research branch of Islamic Azad University of Tehran, Iran. The amount of the dietary ORAC index was estimated using the data provided by the USDA Foods Table.

Results: The results showed that there was a significant difference between the normal and overweight/obese groups in terms of body mass index (BMI) and waist-to-hip ratio (WHR) ($P=0.0001$). Participants with normal weight consumed more fruits and vegetables than another group. Also, the dietary ORAC index in normal individuals was higher than the case group, but there was not significant difference ($P=0.352$). There was also a significant inverse correlation between dietary ORAC and BMI and WHR, whereas a significant positive correlation between dietary ORAC and plasma HDL was observed ($P<0.05$).

Conclusion: Our findings suggest that dietary antioxidants is inversely associated with BMI, fasting blood glucose, triglyceride, total Cholesterol and LDL in both groups. It seems that following a diet rich in antioxidants can counteract obesity and its associated comorbidities.

Background

Obesity is a complex and multifactorial disease with a high prevalence around the world [1, 2]. The worldwide prevalence of overweight and obesity has doubled since 1980 and about one-third of the world's population is classified as overweight or obese [2]. At least 2.8 million deaths around the world are related to obesity and overweight and the prevalence of the disease is increasing annually. The disease results from complex phenotypes associated with excess fat in the body that affect other metabolic factors in addition to body size [1]. Obesity is associated with numerous disorders, including diabetes, lipid profile abnormalities, liver disease, immune dysfunction and oxidative stress [3–5]. It seems, body mass index (BMI) and anthropometric measurements of abdominal obesity such as the waist-hip-ratio (WHR) may serve as a risk factor for predicting metabolic syndrome and myocardial infarction (MI) [6–8].

Oxidative stress is defined by excessive endogenous oxidative species; especially reactive oxygen species (ROS), such as superoxide, hydrogen peroxide and hydroxyl radical ions which damage cells and manipulate signal pathways [9, 10]. Fat accumulation stimulates lipid peroxidation and damage caused by free fatty acids and cytokines, such as TNF-α, leading to the exacerbation of the oxidative damage

[11]. Subjects with obesity and metabolic diseases have also shown lower levels of antioxidant activity [12]; additionally, studies have shown that obesity increases the risk of metabolic syndrome in obese and overweight people due to increased oxidative stress [5, 13, 14]. On the other hand, oxidative stress disrupts insulin secretion from pancreatic beta cells [15] and induces insulin resistance [16], as well as impaired glucose transport to the muscles and the adipose tissue [15]. Hyperglycemia produces alterations in various metabolic and cellular functions; including dyslipidemia, hypertension, endothelial dysfunction, and oxidative stress [17, 18].

In recent years, antioxidants have been used to overcome the harmful effects of ROSs. Natural antioxidants found in healthy foods, include vitamins E and C, coenzyme Q10, alpha-lipoic acid, lycopene, and polyphenols [19].The results of the studies indicate that there is an inverse relationship between body fat, central fat and antioxidant capacity [20].

Various methods are available for measuring the dietary total antioxidant capacity (TAC) [21, 22]. According to the United States Department of Agriculture (USDA) database, the oxygen radical absorbance capacity (ORAC) index is an indicator that measures the antioxidant power of foods and other chemicals in the laboratory, and it is a preferable method because of its biological relevance to the *in vivo* antioxidant efficacy [23]. Recent studies have shown that fruits and vegetables with high ORAC, such as spinach and blueberry, prevent chronic diseases [23–25].

Since oxidative stress, directly and indirectly, causes many diseases, including obesity and metabolic syndrome, the purpose of the present study was to investigate the relationship between the dietary ORAC index and fasting blood glucose and lipid profile in overweight/obese subjects compared to normal weight subjects.

Methods

Study Type and Participants

This study was a cross-sectional descriptive-analytic case-control study. It was carried out to show how antioxidant power of foods effects on anthropometric and biochemical parameters. The subjects were normal weight and overweight/obese adults who were randomly selected among the staff of Science and Research branch of Islamic Azad University (SRBIAU) clinic of Tehran based on their BMI using simple random method. At least 70 individuals were considered to participate in each group who has BMI > 18.5 and age ranged between 18–65 years. All the basic required information, including BMI, anthropometric measurements and the latest blood test, were available in the University Electronic Health Clinic Database. Main inclusion criteria included BMI = 18.5–24.9 for normal group and BMI > 25 for case group also volunteers should not be under lipid and glucose control drugs, pregnant and in lactation period. Also, leaving free more than 50% of the questions in the food frequency questionnaire (FFQ) or having any inflammatory disease were exclusion criteria.

Study implementation

This study was approved by the ethical Iran National Committee for Ethics in Biomedical Research under code IR.IAU.SRB.REC.1396.66. All the eligible volunteers were informed about the details of the study and written consent were taken. On the day of referral to the SRBIAU Clinic, information about demographic characteristics was obtained through face-to-face interviews using validated questionnaires. Anthropometric measurements, including weight and body composition, were conducted using the bioelectric impedance analyzer (INBODY, Model 270, South Korea); height was measured using a digital freestanding stadiometer (BSM-170, InBody Co. Ltd, South Korea). Dietary assessment was also carried on using a validated semi-quantitative FFQ containing 148 food items [26].

Foods' ORAC measurement

Dietary antioxidant consumption was estimated based on the ORAC index of selected foods reported by the Nutrient Data Laboratory of USDA, and expressed as μmol of Trolox Equivalents per 100 grams of foods (μmol TE/100 g). Based on the USDA table, we analyzed ORAC index of selected foods for each group [23].

Statistical analysis method

Independent T-test or Mann-Whitney test (in the case of nonparametric data) were used to compare the mean of quantitative outcomes between the two groups. Correlation model and multiple regression were used to find out the relationship of the variables of the study. SPSS software version 25 was used for data analysis and P-value < 0.05 was considered as statistically significant.

Results

In the present study, the relationship between dietary ORAC index with lipid profile and fasting blood glucose in obese/overweight and normal weight population was examined. After calculating the sample size and simple random sampling, 220 adults, 110 overweight/obese and 110 with normal weight, were recruited based on the inclusion and exclusion criteria. Amongst these, 20 volunteers were excluded because of incomplete questionnaires (more than half of the items were not completed). Finally, the study was conducted with 100 normal weight and 100 overweight /obese subjects.

Basic information of two groups is presented in Table 1. As shown in Table 1, participants with normal weight had a lower visceral fat mass (five kilograms; $P < 0.01$) and a lower body fat percentage ($P < 0.01$). Waist to hip ratio (WHR) was significantly lower in the normal weight group as compared to overweight/obese group ($P < 0.01$). As expected, fasting blood glucose (FBG), total cholesterol (TC), triglyceride (TG), and low-density lipoprotein (LDL) were higher in overweight/obese volunteers than normal volunteers, whereas HDL was greater in the normal weight group; these differences were not significant.

Table 1
Basic information of two groups

Variable	Normal weight	Overweight/obese	P-Value
N	100	100	
Sex (M/F)	70/30	65/35	0.824
Marital status (S/M)	25/75	45/55	0.762
Age (year)	40.50 ± 8.97	40.60 ± 7.35	0.915
Anthropometric indices, MEAN ± SD			
Weight (Kg)	70.13 ± 9.33	95.05 ± 12.32	0.0001*
Height (Cm)	172.86 ± 4.58	170.20 ± 4.38	0.856
BMI (Kg/m^2)	23.58 ± 1.52	31.28 ± 4.16	0.0001*
WHR	0.88 ± 0.04	1.05 ± 0.06	0.0001*
Visceral fat	7.55 ± 2.10	12.30 ± 3.59	0.0001*
Body fat mass (Kg)	19.76 ± 10.76	28.77 ± 7.48	0.0001*
Body fat percentage (%)	2.14 ± 0.78	3.14 ± 2.77	0.004*
Biochemical parameters, MEAN ± SD			
FBG (mg/dl)	89.01 ± 10.73	92.09 ± 16.33	0.175
TG (mg/dl)	152.52 ± 85.38	164.99 ± 84.67	0.362
TC (mg/dl)	172.17 ± 35.30	175.06 ± 29.90	0.580
LDL (mg/dl)	98.44 ± 29.71	100.22 ± 25.75	0.687
HDL (mg/dl)	44.51 ± 8.41	42.40 ± 9.67	0.151
Abbreviations: BMI, Body mass index; WHR, Waist to hip ratio; F, Female; M, Male; S, Single; M, Married;			
FBG, Fasting blood glucose; TG, Triglyceride; TC, Total Cholesterol; LDL, low-density lipoproteins; HDL, high-density lipoproteins.			
* $P < 0.05$			

Dietary data analyses are presented in Table 2. The consumption of vegetable, fruits, vitamin C, and vitamin E was higher in the normal weight group than the other group; the difference was only significant in fruit consumption (P = 0.026). Moreover, the dietary ORAC index was higher in normal weight volunteers than the overweight/obese group; the difference, though, was not significant (P = 0.352).

Table 2
Comparison of dietary intake and ORAC index in two groups of normal weight and overweight/obese

Variable	Normal weight (n = 100) MEAN ± SD	Overweight/obese (n = 100) MEAN ± SD	P-Value
Vegetable	15.116 ± 1.713	12.426 ± 1.284	0.918
Fruits	20.943 ± 1.415	14.246 ± 2.702	0.026*
Vitamin C	140.60 ± 87.96	123.07 ± 74.85	0.081
Vitamin E (alpha-tocopherol)	11.98 ± 10.42	10.45 ± 9.44	0.064
ORAC	48002.65 ± 14651.20	14785.27 ± 8149.51	0.352

Abbreviations: ORAC, Oxygen radical absorbance capacity.

*$P < 0.05$

The correlation between the dietary ORAC index with anthropometric indices and biochemical parameters in the two groups are presented in Table 3. According to Table 3, ORAC index was inversely correlated with all anthropometric indices and biochemical parameters except for HDL. Despite significant correlation between ORAC index with BMI, WHR and HDL (P < 0.05), weak relationship in normal group and all subjects, and fair relation among over weight/obese group was observed.

Table 3
Regression and Correlation coefficient between anthropometric indices and blood biochemical markers with dietary ORAC index

Variable	Normal weight (n = 100)			Overweight/obese (n = 100)			Total (n = 200)		
	CC	P-Value	R^2	CC	P-Value	R^2	CC	P-Value	R^2
BMI (Kg/m^2)	-0.768	0.047*	0.258	-0.876	0.010*	0.558	-0.831	0.036*	0.246
WHR	-0.796	0.042*	0.312	-0.869	0.023*	0.581	-0.680	0.043*	0.353
Body fat mass (Kg)	-0.188	0.117	0.152	-0.196	0.068	0.421	-0.035	0.661	0.153
Body fat percentage (%)	-0.083	0.489	0.263	-0.201	0.062	0.436	-0.012	0.879	0.341
Visceral fat	-0.094	0.435	0.157	-0.172	0.111	0.341	-0.071	0.377	0.254
FBG (mg/dl)	-0.041	0.734	0.256	-0.008	0.938	0.314	-0.033	0.677	0.341
TG (mg/dl)	-0.031	0.796	0.247	-0.023	0.829	0.346	-0.020	0.802	0.232
TC (mg/dl)	-0.204	0.087	0.280	-0.066	0.544	0.365	-0.076	0.343	0.206
LDL (mg/dl)	-0.194	0.105	0.341	-0.008	0.944	0.412	-0.089	0.266	0.305
HDL (mg/dl)	0.773	0.049*	0.261	0.948	0.012*	0.499	0.890	0.034*	0.284

Abbreviations: BMI, Body mass index; WHR, Waist to hip ratio; FBG, Fasting blood glucose; TG, Triglyceride; TC, Total Cholesterol; LDL, low-density lipoproteins; HDL, high-density lipoproteins; CC, Correlation coefficient

*$P < 0.05$

Discussion

In the present study, we were able to show that the dietary ORAC index was higher in normal weight group as compared to the overweight/obese group. In addition, there was an inverse relationship between the dietary ORAC index and anthropometric indices, FBG, TG, TC and LDL. To the best of our knowledge, this is the first study investigating the association between dietary ORAC index, body composition and plasma biochemical markers in both overweight/obese and normal weight groups. Previous studies have shown an inverse relationship between the consumption of dietary antioxidants and several outcomes such as stroke [27], hypertension [28], MI [29], cancer [30] and mortality [31].

In the present study, the dietary ORAC index was inversely correlated with BMI and WHR. In a study, Hermsdorff et al, demonstrated that dietary antioxidant capacity was negatively and significantly correlated with waist circumference (WC) [20]. As well as, another study showed that high WHR is linked with increased oxidative stress and low concentration of antioxidant's enzyme [32]. Also, among young saudi females, adipose tissue and anthropometric measurements had strong positive association with oxidative stress [33]. Similarly, an increase in dietary antioxidant was shown to reduce the incidence of abdominal obesity [34]. Excessive fat accumulation can lead to obesity [35], So the extra stored fat increases the production of oxygen radicals and inflammatory factors, as well as cholesterol and blood lipids [36]. Excess calories inhibit the production of adiponectin [37]. In the short time, the body tries to modify these damaging anomalies, but in the long run the immune system's ability to function is attenuated and oxidative stress can damage cells. Additionally, increased secretion of leptin usually accompanied by obesity leads to activation of T-lymphocytes leading to the production of proinflammatory factors, such as interleukin-2 and TNF-α which in turn can cause inflammation and oxidative stress in the body [38]. The body responds to these changes by using natural antioxidants, such as vitamins E and C. If the body is unable to eliminate these factors, excessive accumulation of oxidants can lead to impaired protein and fat function, cellular dysfunction and, ultimately, to inflammation [5, 39, 40]. Obesity-induced inflammation and oxidative stress increase insulin resistance, blood sugar, TG and metabolic syndrome[9, 41] by reducing the expression of insulin receptor substrate-1 (IRS-1) [42]. As a result, promoting the body's antioxidant capacity can greatly prevent the complications of diabetes and metabolic syndrome[43, 44]. Similar to the findings of the present study, many studies have shown that there was an inverse association between the dietary ORAC index with FBG, TG, LDL and TC and a positive correlation between ORAC and HDL [45–47].

Consuming antioxidant-rich foods with a high capacity to absorb oxygen radicals will give the immune system a chance to counteract inflammation[48]. Despite the type of the present study as a short study, similar to the findings in the current study, the higher dietary ORAC index has been an indication of higher quality of the diet and was related to higher consumption of fruits and vegetables. The favorable effects of these antioxidant-rich foods on improvement of fasting blood glucose, lipid profile and obesity have been investigated in some pre-clinical and clinical studies[49–53]. In recent years, chemical antioxidants, such as “phytochemicals”, are suggested as plausible candidates in the prevention and/or treatment of specific diseases, including obesity and obesity-related metabolic disorders [54].

In line with our findings, previous studies showed that obesity is related with unhealthy diet, which is full of carbohydrate, fat, simple sugars and sweet beverages, whereas a protective effect against obesity is observed in the consumption of a diet rich in fruits and vegetables [55, 56] and a diet high in vegetables and fruits has been positively related to the consumption of antioxidant vitamins [56].

Some studies have also reported that antioxidant capacity in obese and overweight volunteers is promoted which was postulated to be due to immune system’s trying to override the present inflammation [57, 58].

Conclusion

Our findings suggest that consumption of dietary antioxidant was inversely associated with BMI and other anthropometric measurements, FBG, TG, LDL and TC in both groups. Despite significant correlation between ORAC index with BMI, WHR and HDL, weak relationship in normal group and all subjects, and fair relation among over weight/obese group was observed. It seems that following a diet rich in ORAC can counteract obesity and its associated comorbidities.

Abbreviations

BMI, Body mass index

F, Female

FBG, Fasting blood glucose

FFQ, Food Frequency Questionnaire

HDL, high-density lipoproteins

LDL, low-density lipoproteins

M, Male

M, Married

MI, Myocardial infarction

ORAC, Oxygen radical absorbance capacity

ROS, Reactive oxygen species

S, Single

SRBIAU, Science and research branch of Islamic Azad University

TAC, Total antioxidant capacity

TC, Total Cholesterol

TG, Triglyceride

WHR, Waist to hip ratio

Declarations

Ethics approval and consent to participate

This study was approved by the ethical Iran National Committee for Ethics in Biomedical Research under code IR.IAU.SRB.REC.1396.66. All the eligible volunteers were informed about the details of the study and written consent were taken.

Consent for publication

Not applicable

Availability of data and materials

The data that support the findings of this study are available from Science and Research branch of Islamic Azad University (SRBIAU) clinic. Due to license restrictions, data of the current study is not publicly available. Data are a part of a great database and based on a contract between authors and the clinic, authors would never request for data.

Competing interests

The authors declare that they have no competing interests what so ever.

Funding

Not applicable

Authors' contribution

ZM, MM and GK wrote the manuscript. AD checked it for accuracy of English language MK and AM were adviser and supervisor of the study respectively.

Acknowledgements

Not applicable

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