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Higher dietary total antioxidant capacity is inversely related to prediabetes: A case-control study

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ABSTRACT

Objectives: Dietary total antioxidant capacity (DTAC) has been proposed as a tool for assessing the intake of antioxidants. The relationship between DTAC and blood glucose levels has been investigated mostly in healthy people. The aim of this study was to evaluate the association between DTAC and prediabetes morbidity in a case-control study.
Methods: We examined 300 individuals with and without prediabetes (n = 150/group) who attended a Diabetes Screening Center in Shahreza, Iran. The anthropometric measures, physical activity, and blood glucose levels of all participants were measured. Food intake over the previous year was determined using a semiquantitative food frequency questionnaire, and sex-specific, energy-adjusted DTAC was calculated using the U.S. Department of Agriculture's database. Logistic reg/ression was used to model the relationship between DTAC and prediabetes morbidity.
Results: The mean DTAC was significantly lower in individuals with prediabetes than in the control group ($P < 0.001$). Across increasing DTAC quartiles, the participants had lower fasting blood glucose and 2-h postchallenge plasma glucose ($P_{trend} < 0.02$). After adjustment for body mass index; physical activity; education; dietary intake of fiber, fat, energy, and coffee; participants in the fourth quartile of DTAC were less likely to experience prediabetes compared with those in the first quartile (odds ratio, 0.18; 95% confidence interval, 0.07–0.49).
Conclusion: The DTAC score appears useful when assessing the antioxidant capacity of diet and to better understand the relationship between diet and prediabetes morbidity. Future studies are needed to confirm the findings from the present study in other populations.

Introduction

Prediabetes is defined by glycemic variables that are higher than normal, but lower than diabetes thresholds [1]. This condition is an intermediate and reversible condition before the onset of type 2 diabetes mellitus (T2DM) [2]. The prevalence of prediabetes is increasing worldwide and experts have projected that >470 million people will have prediabetes by 2030 [3]. The Tehran Lipid and Glucose Study revealed that 4% of the adult population of Tehran becomes prediabetic every year [4]. The results of the first Survey of Risk Factors of Non-Communicable Diseases of Iran showed that 4.4 million Iranian adults (16.8%) had impaired fasting glucose [5].

Prediabetes is associated with an increased risk for developing overt diabetes and cardiovascular morbidity and mortality [6,7]. Excessive levels of free radicals and decreased antioxidant defense mechanisms are involved in the pathogenesis of prediabetes [8]. Studies have shown that diets rich in dietary antioxidants are inversely related to oxidative stress–induced conditions such as insulin resistance, which is involved in abnormal glucose metabolism [9].

Most foods contain different antioxidant compounds. To evaluate the total antioxidant capacity of foods and their health promotion effects, the concept of dietary total antioxidant capacity (DTAC) was proposed as a novel tool for investigating the relationship between dietary antioxidants and oxidative

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stress–induced health outcomes. Increased DTAC has been associated with higher diet quality scores [10,11].

A study investigated the potential relationship between DTAC and adiposity and metabolic markers in healthy young adults. The results showed that DTAC values were inversely correlated with waist circumference (WC), blood glycemia, total cholesterol-to-high-density lipoprotein cholesterol (HDL-C) ratio, triacylglycerols, and oxidized low-density lipoprotein [12] and positively associated with the concentration of HDL-C [13].

The relationship between DTAC and blood glucose has been investigated in limited studies, mostly with healthy people [12,14,15]. To our knowledge, there has not been a case–control study evaluating this relationship regarding prediabetes. As individuals with prediabetes are at risk for more oxidative stress, the aim of the present study was to compare energy-adjusted DTAC values between individuals with prediabetes and controls in a case–control study.

Methods

Participants

The participants were recruited from a Diabetes Screening Center in Shahreza, Iran, from May to October 2014. The aim of this study was to assess the relationship between dietary intake and prediabetes using a matched case–control study design. The methodology of the study has been described previously [16]. Briefly, 150 individuals with prediabetes (cases) and 150 with normal fasting blood glucose levels (FBG; controls) were recruited. Participants with the following conditions were considered at risk for diabetes and were referred to this center: >30 y of age, overweight or obese, family history of diabetes, or existence of at least two symptoms of diabetes. The diagnosis of prediabetes or diabetes mellitus was made at the clinic. After recruitment of all cases, 150 healthy individuals with normal FBG levels were recruited as the control group. We used the frequency matching method and matched the two groups by age and sex. The age frame for matching was as follows: 35–44, 45–54, and 55–65 y. The inclusion criteria for the cases were age 35 to 65 y, and FBG between 100 and 125 mg/dL or 2-h postchallenge plasma glucose (2 hPG) between 140 and 199 mg/dL diagnosed ≤3 mo before the interview. Control group participants were ages 35 to 65 y with FBG <100 mg/dL or 2 hPG <140 mg/dL during screening. We excluded those with alcohol, drug, and any tobacco product use and body mass index (BMI) ≥40 kg/m^2. Pregnant or lactating women; those on a special diet during the previous year; individuals with diagnosed heart disease, diabetes, hypertension, dyslipidemia, renal or hepatic failure, and multiple sclerosis were excluded from the study. This study was approved by the Ethics Committee of Tehran University of Medical Sciences. All participants signed a consent form before participation.

Anthropometric and physical activity assessment

As previously described [16], anthropometric measurements were carried out without shoes with minimal clothing. Body weight was measured to the nearest 0.1 kg using a Seca scale. Height was measured to the nearest 0.1 cm while standing barefoot using the Seca 216 stadiometer. WC was measured using a flexible measuring tape at the midpoint between the lowest rib and the iliac crest. BMI was calculated as weight divided by height squared (kg/m^2). Physical activity of participants was assessed with the short form of the International Physical Activity Questionnaire (IPAQ) [17]. Participants were asked about vigorous and moderate activities and walking for ≥10 min/d during the previous 7 d. To calculate the activity, the duration and frequency of activity days were multiplied by the metabolic equivalent task (MET) value of the activity. The sum of the scores was calculated as the total exercise per week.

Laboratory assessment

Participants underwent blood tests and 2-hPG after an overnight fast. A fasting blood sample was collected and then a glucose load of 75 g was ingested. Blood samples were drawn at 0, 0.5, and 2 h for the measurement of the glucose level. Plasma glucose was measured using the glucose oxidase method using a commercially available kit (Pars Azmoon, Iran).

Dietary assessment and DTAC calculation

Trained dietitians collected the usual food intake during a structured interview. A validated semiquantitative food frequency questionnaire (FFQ) that included 168 food items was used to assess the dietary intake [18]. For each food item, a standard unit or portion size was specified and participants were asked how often, on average, during the previous year they had consumed that amount. The participants reported the consumption frequency of each food item per day, week, month, or year. Responses to the individual food items were converted to average daily intake of each food item. The nutrient and energy content of the foods were analyzed using the Nutritionist 4 software (First DatabankInc., Hearst Corp., San Bruno, CA) modified for Iranian foods. DTAC was calculated based on the oxygen radical absorbance capacity of each food (except for coffee) reported by US Department of Agriculture, and expressed as μmol of trolox equivalents/100 g of food (μmol TE/100 g) [19].

Statistical analysis

The Statistical Package for Social Sciences, version 16 (SPSS Inc., Chicago, IL, USA), was used for analysis. The Kolmogorov–Smirnov test was used to evaluate the normality of the data. Energy-adjusted DTAC was computed using the residual method [20] and was categorized based on sex-specific quartiles. The independent Student's t test and Mann–Whitney test were used to compare variables with normal and non-normal distribution, respectively. A χ^2 test was used for qualitative variables to identify significant differences across quartile categories of DTAC. Analysis of variance and the Kruskal–Wallis test were used to compare the mean of the variables with normal and non-normal distribution across the quartiles of DTAC, respectively.

Partial correlations adjusted by sex and daily energy intake were performed to evaluate association between food groups and DTAC. Using simple logistic regression, we estimated the odds ratio (OR) and 95% confidence intervals (CIs) of prediabetes for DTAC. In addition to the unadjusted analysis, we used multivariable models to assess the relation between DTAC and prediabetes. The analysis was adjusted for BMI (kg/m^2), education (y), physical activity (MET/h/wk), and dietary intake of fiber (g/d), fat (g/d), energy (kcal/d), and coffee (g/d). Tests for trend across DTAC quartiles were conducted by using median DTAC for each quartile. Statistical significance was set at $P < 0.05$.

Results

The characteristics of control and prediabetic participants and their dietary intake are presented in Tables 1 and 2. Participants with prediabetes had a higher mean education, BMI, WC, FBG, and 2 hPG ($P < 0.001$), and lower physical activity and DTAC scores ($P < 0.001$) than the control group (Table 1). Additionally, there was a significant difference in the intake of several nutrients between the two groups (Table 2).

The participants' characteristics across the quartiles of sex-specific energy-adjusted DTAC are presented in Table 3. There was no difference in age, education, dietary supplement intake, BMI, WC, and energy intake between DTAC quartiles. Across increasing DTAC quartiles, all participants had higher physical activity and lower FBG and 2 hPG ($P < 0.03$).

Correlations between DTAC and food groups including fruits, vegetables, nuts, legumes, fruit juice, tea, and olive oil are presented in Table 4. After adjustment for energy intake and sex, positive correlation was found between DTAC and fruits ($r = 0.78$; $P < 0.001$), vegetables ($r = 0.54$; $P < 0.001$), nuts ($r = 0.48$; $P < 0.001$), legumes ($r = 0.33$; $P < 0.001$), fruit juice ($r = 0.33$; $P < 0.001$), tea ($r = 0.25$; $P < 0.001$), and olive oil ($r = 0.18$; $P = 0.001$). Moreover, food groups such as vegetables (31.9%), fruits (29.2%), tea (13%), legumes (7.8%), and nuts (6.7%) were found to be the main contributors to DTAC. Food groups had similar contribution to DTAC in both men and women (Table 5).

The ORs and 95% CIs for prediabetes in the quartiles of sex-specific energy-adjusted DTAC are shown in Table 6. Compared with participants in the lowest quartile of DTAC, those in the highest quartile had a significantly lower OR for prediabetes (model 1: OR, 0.2; 95% CI, 0.10–0.40), which remained significant after further adjustment for BMI; physical activity; education; and dietary intake of fiber, fat, energy, and coffee (model 2: OR, 0.18; 95% CI, 0.07–0.49).