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Dietary diversity as a proxy measure of blood antioxidant status in women

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ABSTRACT

Objective: Dietary diversity is recognized as a key indicator of dietary quality. However, its association with blood antioxidant levels has not been investigated. The aim of this study was to assess the association of the dietary diversity score (DDS) with blood antioxidant status in women who attend the sports clubs of a municipality in western Tehran, Iran.
Methods: A cross-sectional survey was conducted with 397 randomly selected women from the sport clubs of a Tehran municipality. Sociodemographic data were recorded and the women's weight and height were measured. Body mass index (BMI) was calculated by dividing the weight (kg) by height squared (m^2). A 24-h recall questionnaire was used to estimate food intake. Biochemical indices, including serum total antioxidant capacity (TAC) and erythrocyte activities of glutathione peroxidase (GPx) and superoxide dismutase (SOD), were measured in 90 women selected randomly from all participants. DDS was computed according to the guidelines of the Food and Agriculture Organization. The mean of SOD, TAC and GPx were compared across DDS quartiles after adjustment for age, education level, physical activity, energy intake, and BMI using analysis of covariance test.
Results: The mean of TAC, SOD, and GPx was linearly increased with increasing the quartile of DDS, after adjustment for age, education level, physical activity, energy intake, and BMI ($P_{trend} < 0.001$). Significant differences were observed for intake of different food groups, except cereals and white roots, between the DDS quartiles.
Conclusion: DDS is associated with blood antioxidant markers. Increasing the dietary diversity might be associated with a reduction in oxidative stress.

Introduction

The antioxidant defense system is composed of two categories including enzymatic and nonenzymatic groups with endogenous and exogenous sources. Micronutrients such as minerals and vitamins like vitamin A, C, E, carotenoids, and selenium have an important role as nonenzymatic antioxidants. Also, micronutrients have an essential role in functions of enzymatic antioxidants including superoxide dismutase (SOD), glutathione reductase (GR), and glutathione peroxidase (GPx) [1].

Oxidative stress is defined as an imbalance between the generation of free radicals and compensatory response of the antioxidant defense of the body. In this pathologic condition, the concentration of free radicals increases as the level or function of antioxidants decreases [2]. In addition to the exogenous source, free radicals including reactive oxygen species and reactive nitrogen species are normally produced due to the

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metabolic reactions in the body such as the mitochondrial electron-transport chain [3]. The literature has shown that oxidative stress may be attributed to the higher incidence of many chronic diseases including atherosclerosis, immune diseases, and cancers by damaging the cells, including lipids and membranes, proteins, and DNA [3–5].

Dietitians are interested in the dietary pattern or a combination of nutrients instead of one specific single nutrient in the diet–disease relationship [6]. Food variety and food diversity are two indicators of a healthy dietary pattern [7], and are frequently used to reflect the quality of diet [8]. In accordance with the recommendation of dietary guidelines in many countries regarding the intake of a variety of foods within and between food groups, a growing number of studies have shown that moving from a monotonous to a diverse diet can increase the probability of nutrient adequacy in all age groups [9–11]. According to the results of an Austrian cohort study, food diversity was positively associated with healthy outcomes [12]. Diets low in diversity were related to chronic diseases such as cancer [13,14] and metabolic syndrome [15], as well as cardiovascular risk factors [16]. According to data from previous investigations, there is a positive relationship between dietary diversity score (DDS) and the greater intake of all nutrients in adults [10,17,18]. Moreover, a positive correlation was found between the number of food groups consumed and mean adequacy ratio of nutrients in children [19]. However, to the best of our knowledge, no study has examined the relationship between dietary diversity and blood antioxidant status to date. The aim of the present study was to assess the association between DDS and the blood antioxidant status in women who attended the sport clubs in western Tehran.

Material and methods

Study population

In this cross-sectional study that was performed from May 2013 to February 2014, 397 healthy women ages 20 to 55 y were selected randomly from the sports clubs of Tehran municipality. Fourteen sport clubs were randomly selected from seven areas in western Tehran. Approximately 30 women who began sports for the first time or maximum from 1 wk before the beginning of the study were randomly selected from each sports club. The exclusion criterion was being diagnosed with diseases such as diabetes, liver and kidney dysfunction, cardiovascular diseases, and cancer. Pregnant and lactating women were not included in the study. Women who used any drugs or minerals and/or vitamin supplements in the previous month or those who consumed tobacco products, and professional athletes were also excluded from the study. Before data collection, the objective and procedure of the study were explained to the participants and written informed consent was received.

Dietary diversity measurement

One 24-h recall questionnaire was completed for each participant. This questionnaire was completed by a trained dietitian in a face-to-face interview. DDS were calculated by summing the score of food groups consumed by the women in the 24-h period as described by the guideline of the Food and Agriculture Organization [20]. All food items consumed by the women were categorized into 9 groups including:

1. cereals and white roots,
2. milk and dairy products,
3. vitamin A-rich vegetable and fruits,
4. green leafy vegetables,
5. other vegetable and fruits,
6. meat, fish, and seafood,
7. organ meat,
8. eggs, and
9. nuts, seeds and legumes.

DDS was calculated considering a minimum consumption of half serving of any food from each mentioned food groups. The maximum score was 9, with 1 point given for each food group consumed.

Anthropometry and physical activity assessment

Weight and height were measured using a Seca scale (Seca725 GmbH & Co. Hamburg, Germany) with the women wearing light clothes and no shoes in standing posture. The accuracy of weight and height was 0.1 kg and 0.5 cm, respectively. Body mass index (BMI) was calculated as weight (kg) divided by height squared (m^2). For assessing physical activity levels of participants, the classified physical activity questionnaire was used according to metabolic equivalents task (METs), which includes nine activity levels from sleep/rest (METs = 0.9) to high-intensity physical activities (METs >6). Hours spent on each physical activity were multiplied by their MET quantities and the numbers obtained were summed together to calculate MET.H/d value [21]. The reliability and validity of this questionnaire were previously approved in an Iranian population [22].

METs are units of measure expressing the energy cost of physical activities, and are defined as the ratio of metabolic rate during a specific physical activity to a reference metabolic rate. One MET is equal to 3.5 mL of oxygen/•kg•min^{-1} in adults, or expressed as 1 kcal•kg•h^{-1} [23].

Blood sampling

Ninety women were randomly selected from all participants for blood sampling. After overnight fasting, 5 mL of venous blood was drawn before 1000 h by a trained nurse. Blood samples were collected in two trace element-free tubes: the first tube was for serum separation and the second tube, which contained EDTA, was for plasma separation. Plasma samples were separated from cells by centrifugation at 3000*g* for 10 min, and the remaining blood was washed three times with 0.9 g/l NaCl solution. Cell membranes were removed by centrifugation at 1200*g* for 5 min at 4°C. The hemolysates were then used to determine antioxidant enzyme levels. Serum was separated by centrifugation with coagulated blood at 1000*g* for 10 min at 4°C. All samples were then stored at −79°C.

Laboratory measurements

Erythrocyte GPx and SOD activities were measured with enzyme-linked immunosorbent assay kits (Bioassay Technology Laboratory, China) according to the manufacturer's instructions. Fasting serum total antioxidant capacity (TAC) was measured based on the 6-hydroxy-2,5,7,8-tetramethyl-chroman-2-carboxylic acid (Trolox) equivalent antioxidant capacity (TEAC) assay previously developed [24]. The TEAC assay measures the relative abilities of antioxidants to scavenge the 2,2'-azino-bis(3-ethylbenzothiazoline-6-sulfonic acid) (ABTS) radical cation ($ABTS^+$) in comparison with the antioxidant potency of standard amounts of Trolox, the water-soluble vitamin E analog. The ABTS radical was generated from the interaction between $ABTS^+$ and potassium persulphate. Serum samples (10 μl) were mixed with 1 mL of 47 μM $ABTS^+$ and incubated for 1 min at 30°C. Optical density (absorption) was read at 734 nm against 5 mm phosphate-buffered saline (pH 7.4). The percentage inhibition of absorption was calculated. The assay was calibrated against a Trolox standard curve, and the results were expressed as mmol/L Trolox.

Statistical analysis

Statistical Package for Social Sciences Software version 16 (SPSS Inc., Chicago, IL, USA) was used for all statistical analyses. The respondents were categorized according to the cut-points of DDS in quartiles categories as follows: Q1, 2–3; Q2, 4; Q3, 5–6; Q4, 7–9. Association between food group consumption with DDS was assessed using χ^2 test. Analysis of variance with Tukey's post hoc test was used to compare the crude means of erythrocyte activity of SOD, GPx and serum level of TAC across quartiles of DDS. Analysis of covariance was used to compare the means of these variables after adjustment for age, education level, physical activity, total energy intake, and BMI across the quartiles of DDS. A value of $P < 0.05$ was considered statistically significant.

Results

In this study, 397 women with mean age of 34.3 ± 8.0 y participated. Basic characteristics of the participants are presented in Table 1. Mean ± SD DDS was 4.7 ± 1.5. The respondents' DDS ranged from 2 to 9: 2 to 3 in Q1 (27.2%); 4 in Q2 (24.7%); 5 to 6 in Q3 (32%) and 7 to 9 in Q4 (16.1%). Age and BMI were significantly decreased from Q1 to Q4 of DDS. Moreover, education level, physical activity, and energy intake increased from Q1 to Q4 of DDS. Distribution of food group consumption across the quartiles of dietary diversity in healthy women is shown in Table 2. Statistically significant differences were observed for intake of different food groups, except cereals and white roots,