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Dietary total antioxidant capacity is negatively associated with some metabolic syndrome features in healthy young adults

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Abstract

Objective: Oxidative stress has been related to the development of obesity and other features accompanying chronic diseases. Furthermore, dietary antioxidant intake has been suggested to protect against oxidative damage and related clinical complications. Therefore, the aim of this study was to assess the potential associations among dietary total antioxidant capacity (TAC) and several early metabolic syndrome manifestations in healthy young adults.

Methods: Anthropometric variables and blood pressure from 153 healthy subjects (20.8 ± 2.7 y old) were measured. Dietary intake was assessed by a validated food-frequency questionnaire and a 3-d record, which were also used to calculate TAC and to adjust by daily energy intake. Fasting blood samples were collected for measuring biochemical markers.

Results: Dietary TAC showed positive and significant associations with fiber, folic acid, vitamin A and C, magnesium, selenium, and zinc intakes, after adjusting by sex and daily energy intake. Interestingly, systolic blood pressure, serum glucose, and free fatty acids were also found to be negatively associated with dietary TAC independently of sex and daily energy intake. Also, a relevant relation was found between body mass index and TAC values. Interestingly, after adjusting by sex and daily energy intake, complement factor-3 circulating levels appeared to be negatively and significantly associated with dietary TAC, whereas blood plasminogen activator inhibitor-1 and homocysteine concentrations showed an inverse marginally statistical trend.

Conclusions: These data suggest that dietary TAC may be also a potential early estimate of the risk to develop metabolic syndrome features and that dietary TAC could be a useful research tool in assessing antioxidant intake.

Keywords: Oxidative stress; Antioxidant intake; Inflammation; Food-frequency questionnaire; Systolic blood pressure; Complement factor-3; Plasminogen activator inhibitor-1

Introduction

The role of oxidative stress and inflammation in several chronic diseases is receiving increasing attention due to identified links with chronic diseases such as atherosclerosis, obesity, or type 2 diabetes [1]. Also, food intake has been related to oxidative stress modulation [2,3], being described as energy restriction that might decrease the levels of oxidative stress mediators [4]. Cause-and-effect relations between oxidative stress status and disease are not fully clear, but several studies have associated both with higher concentrations of inflammatory biomarkers [5,6].

In contrast, in addition to an energy-storage function, adipose tissue is now recognized as a major endocrine organ synthesizing a variety of cytokines (adipokines) that are central in the control of energy balance and food intake [7]. Moreover, it is now well established that at least some of these adipokines, such as tumor necrosis factor-α, interleukin-1β, interleukin-6, or interleukin-10, play a role in inflammation [8,9], endothelial dysfunction [10], and vascular repair [11]. Furthermore, antioxidant intake has been suggested to protect

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against oxidative damage and related inflammatory complications [5]. Given that the concentration of single antioxidants may not reflect the total antioxidant power of food, the concept of total antioxidant capacity (TAC) was introduced [12]. In addition, dietary TAC has been suggested as a tool for investigating the potential healthy effects of dietary antioxidants occurring in mixed diets [13].

Thus, the objective of this study was to assess the potential associations between dietary TAC and several early metabolic syndrome markers and manifestations in healthy young adults.

Materials and methods

Subjects

One hundred fifty-three Caucasian, healthy, young subjects were recruited to participate in the study (101 women and 52 men, age 20.8 ± 2.7 y). Initial enrollment screening evaluations included a medical history and a physical examination to exclude subjects with evidence of any disease related to chronic inflammation, oxidative stress, hydric imbalance, and nutrient absorption and a fasting blood profile assessment to exclude subjects with disorders linked to nutrient metabolism such as diabetes or dyslipidemia. Other exclusion criteria were drug or dietetic treatment up to 6 mo before participation in this study. In accordance with the Declaration of Helsinki [14], after a clear explanation of the study protocol, all subjects gave written informed consent to participate, which was previously approved by the ethics committee of the University of Navarra (reference 79/2005). At the time of the initial interview, lifestyle issues were assessed. Information regarding physical activity was gathered with a specific questionnaire previously validated in Spain [15], which assessed the time spent in 17 different activities. Each of these activities was assigned a multiple of the resting metabolic rate in order to calculate the metabolic equivalent of task score. For this purpose, we used information on average intensity of each activity from previously published guidelines [16].

Anthropometric and body composition measurements

All anthropometric measurements were carried out with the subjects barefoot, wearing only their underwear, and after an overnight fast according to standardized protocols [17]. All these measurements were done three times, but not consecutively. Body weight was measured to the nearest 0.1 kg and body fat to the nearest 0.1% by using a Tanita TBF 300 (Tanita Corp., Arlington Heights, IL, USA). Body mass index (BMI) was calculated as body weight (kilograms) divided by height (meters) squared. Skinfold thicknesses were measured at the right side to the nearest 0.2 mm by means of a Holtain skinfold caliper (Holtain, Crymych, UK) at the triceps, biceps, and subscapular and suprailiac areas [18]. Truncal fat was calculated as follows: truncal fat = (subscapular + suprailiac)/(tricipital + bicipital + subscapular + suprailiac). Waist and hip circumferences were measured with an inelastic tape to the nearest 1 mm as described elsewhere [17]. Blood pressure was measured by a mercury sphygmomanometer (Minimus II, Riester, Jungingen, Germany) to the nearest 5 mmHg according to standardized protocols [19].

Dietary intake assessment

The habitual diet was assessed with the semiquantitative 136-item Seguimiento Universidad de Navarra (SUN) food-frequency questionnaire (FFQ) previously validated in Spain for energy and nutrient intake [20]. In addition, a dietitian trained the subjects to fill a 3-d weighed-food record (3D-WR), which included all foods, beverages, and supplements consumed during 2 non-consecutive working days plus a weekend day. Participants were asked to provide a detailed description of each food, including methods of preparation and recipes whenever possible. The dietitian reviewed the 3D-WR with the participants to check for errors or omissions and to estimate the portions of foods eaten outside the home using a book of photographs and standard household measurements. The energy and nutrient intake of the 3D-WR was assessed by using the Medisystem Nutritional Database Application (Sanocare Human Systems S.L., Alcobendas, Spain).

The dietary TAC value was calculated for the SUN FFQ and the 3D-WR by adding TAC values from the ferric reducing-antioxidant power assay of each food as previously reported [21–25] and was expressed as TAC in mmol/100 g of food. To assign a value to TAC-providing foods not available in previous reports, the data for a similar food item (e.g., same botanical group) were used as a proxy. When TAC values of cooked food were not available, TAC values of fresh food were used to calculate TAC values. The mean of TAC values of foods contained in each item of the SUN FFQ was used to calculate the dietary TAC value from this food questionnaire. The TAC values from the SUN FFQ were used to assess the associations with metabolic syndrome features. Thus, the dietary TAC from the 3D-WR was calculated as the average of dietary TAC values from the 3 d and used only to validate the dietary TAC from the SUN FFQ.

Analyses of biological samples

All blood samples were drawn after an overnight (12-h) fast, centrifuged immediately for 15 min at 2205 × *g* and 4 °C, and stored at −80 °C. Serum glucose, triacylglycerols, total cholesterol, high-density lipoprotein cholesterol, free fatty acids, and homocysteine were assessed by an automatized colorimetric assay (COBAS MIRA, Roche, Basel, Switzerland) with specific commercial kits (ABX Pentra, Roche). The reported serum low-density lipoprotein