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Original article

Plasma fatty acid composition, estimated desaturase activities, and their relation with the metabolic syndrome in a population at high risk of cardiovascular disease

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SUMMARY

Background & aims: The metabolic syndrome (MetS) is a clustering of various metabolic abnormalities which is associated with increased risk of cardiovascular disease (CVD) and type 2 diabetes mellitus. Due to its increasing prevalence, it has become an important public health concern. Altered fatty acid (FA) composition and desaturase activities have been associated with several metabolic diseases, including MetS. The aim of the present study was to evaluate the relationship of the plasma FA profile and desaturase activities with the MetS in a Mediterranean population at high risk of CVD.
Methods: Baseline data from 427 participants aged 55–80 years who took part in the interventional PREDIMED study were obtained. Individual FA was determined in plasma and desaturase activities were estimated from product/precursor ratios. Odds ratios (OR) and partial correlation coefficients were used to examine these relations with MetS and its components, respectively.
Results: We found higher levels of C14:0, C16:0, C16:1*n*-7, estimated Δ^9- or stearoyl-CoA desaturase (SCD), and estimated Δ^6 desaturase (D6D), and lower levels of C18:2*n*-6 in people with MetS compared to those without it. After adjustment for several confounders, only higher quartiles of C14:0, C16:0, C16:1*n*-7, and D6D were found to be associated with an increasing prevalence of MetS, while higher quartiles of C18:2*n*-6 were inversely associated with MetS. High proportions of C14:0, C16:0, C16:1*n*-7, C20:3*n*-6, SCD, and D6D, and decreased proportions of C18:2*n*-6 and estimated Δ^5-desaturase (D5D) were associated with adverse profiles of several metabolic risk factors. Women showed more unhealthy FA pattern and lipid profiles than men, but only among those with MetS.

Abbreviations: AA, arachidonic acid; ALA, α-linolenic acid; CVD, cardiovascular disease; D5D, Δ^5 desaturase; D6D, Δ^6 desaturase; DBP, diastolic blood pressure; DGLA, dihommo-γ-linoleic acid; DHA, docosahexaenoic acid; EPA, eicosapentaenoic acid; FA, fatty acid; GLA, γ-linolenic acid; HDL-C, high-density lipoprotein cholesterol; LA, linoleic acid; LDL-C, low-density lipoprotein cholesterol; MA, myristic acid; MetS, metabolic syndrome; MGA, margaric acid; OA, oleic acid; PA, palmitic acid; POA, palmitoleic acid; SA, stearic acid; SBP, systolic blood pressure; SCD, stearoyl coenzyme A desaturase; TC, total cholesterol; WC, waist circumference.

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Conclusion: A FA composition and estimated desaturase activities consisting in high levels of SFA, SCD and D6D, and low levels of PUFA and D5D are associated with increased MetS probability and are characteristic of people presenting MetS, especially women. These findings support those observed in non-Mediterranean populations in which an altered FA profile and estimated desaturase activities are associated with MetS.

1. Introduction

The metabolic syndrome (MetS) is a cluster of interrelated metabolic risk factors in one person[1,2] which increases the risk of developing both cardiovascular disease (CVD) and type 2 diabetes. The evidence available indicates that the prevalence of MetS is about 20–30% among adults from developed countries, increases with age, and is rising in relation to increasing obesity, diabetes and sedentary lifestyles.[2]

Since the predominant underlying risk factors for the pathogenesis of the MetS appear to be abdominal obesity and insulin resistance, environmental factors, such as diet and physical inactivity may play a role in the development of this syndrome.[1] In fact, total fat and type of dietary fat consumed have been associated with MetS and its components.[3]

The assessment of dietary fat composition from different food sources with the use of self-reporting methods is associated with substantial measurement error. Conversely, biomarkers of fatty acid (FA) intake, such as the plasma FA profile, are objective and potentially independent of these errors.[4] However, their ability to reflect dietary intake may be affected by non-dietary factors, such as endogenous metabolism, genetics, smoking, and physical activity.[4] Thus, several FA can be newly synthesized, elongated or desaturated by three desaturases: Δ^9 or stearoyl-CoA desaturase (SCD), Δ^6 desaturase (D6D), and Δ^5 desaturase (D5D), the activity of which may be estimated using FA product/precursor ratios.[5]

On the other hand, the FA profile can be used as an indicator of disease risk. The hallmarks for most pathological stages are the increased content of SFA and a lower content of PUFA. In fact, an altered FA profile and estimated activity of desaturases characterized mainly by high proportions of palmitic acid (PA, C16:0), palmitoleic acid (POA, C16:1*n*-7), dihommo-γ-linolenic acid (DGLA, C20:3*n*-6), SCD and D6D, and decreased levels of linoleic acid (LA, C18:2*n*-6) and D5D, have been associated with insulin resistance and increased risk to develop diabetes,[3] obesity,[6] hypertrygliceridemia,[7] cardiovascular disease,[8] and the development of the MetS.[9–15]

Nonetheless, few studies have investigated the relationship between plasma FA composition, estimated desaturase activities and the MetS. Moreover, to our knowledge, no studies have been conducted in a Mediterranean population. Therefore, the aim of the present study was to analyze for the first time the plasma FA and estimated desaturase activities in relation to MetS status, and to examine the cross-sectional associations between these patterns and the MetS and its components in a Spanish population.

2. Materials and methods

2.1. Study design

A cross-sectional study with baseline data from the PREDIMED (PREvención con DIeta MEDiterránea) study was performed. The PREDIMED study is a large, randomized, parallel-group, multicenter, controlled, 5-year clinical trial aimed at assessing the effects of the two Mediterranean diets supplemented with either virgin olive oil or mixed nuts compared with a low-fat diet on the primary prevention of CVD (http://www.predimed.org; ISRCTN35739639). The detailed protocol of this study has been previously described.[16] The institutional review boards of the participating recruitment centers approved the study protocol and participants provided signed informed consent. The current study was performed in a subset of participants recruited in 3 PREDIMED centers (Barcelona North, Reus, and Pamplona).

2.2. Participants

The population sample consisted of 427 asymptomatic subjects at high risk of CVD. Eligible participants were community-dwelling men, aged 55–80 years, and women, aged 60–80 years, who met at least one of the two following criteria: diagnosis of type 2 diabetes or the presence of ≥3 CVD risk factors (smoking, hypertension, dyslipidemia, overweight or obesity, and a family history of early CVD). Exclusion criteria were history of CVD, any severe chronic illness, drug or alcohol addiction, history of allergy or intolerance to olive oil or nuts, or a low predicted likelihood of changing dietary habits. Participant eligibility was based on a screening visit by the physician.

2.3. Measurements

At baseline, the following questionnaires were administered to the participants[16]: (a) a general 47-item questionnaire about education, lifestyle, medical conditions, and medication use; and (b) a previously validated 137-item FFQ. Moreover, participants underwent anthropometric and blood pressure measurements and collection of fasting blood samples.

2.3.1. Anthropometry

The anthropometric measures used in this study were height (m), weight (kg), BMI (calculated as weight in kg/height^2 in m^2) and waist circumference (WC). Height and weight (with light clothing and no shoes) were recorded using a calibrated balance beam scale and a wall-mounted calibrated stadiometer, respectively. WC was measured using an anthropometric measuring tape, at a horizontal plane midway between the lowest rib and the iliac crest. Blood pressure (BP) was measured in triplicate with a validated semi-automatic sphygmomanometer after a minimum of 5 min rest in the seated position.

2.3.2. Laboratory measurements

Blood samples were collected after an overnight fast, coded, shipped to a central laboratory, and stored at −80 °C until analyses. Laboratory technicians were blinded to the intervention. Plasma glucose level was analyzed by the glucose-oxidase method; total serum cholesterol (TC) and TG levels were measured by enzymatic procedures, and high-density lipoprotein cholesterol (HDL-C) levels were determined after precipitation with phosphotungstic acid and magnesium chloride. The plasma FA profile was determined by fast gas chromatography with a previous derivatization to their corresponding fatty acid methyl esters.[17] Results were expressed as relative percentages of total FA. The average of two measures was used for the analysis of laboratory variables.