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Effects of pistachio nuts on body composition, metabolic, inflammatory and oxidative stress parameters in Asian Indians with metabolic syndrome: A 24-wk, randomized control trial

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Objective: The aim of this study was to evaluate the effects of pistachio nuts as an adjunct to diet and exercise on body composition, metabolic, inflammatory, and oxidative stress parameters in Asian Indians with metabolic syndrome.

Methods: In this 24-wk randomized control trial, 60 individuals with the metabolic syndrome were randomized to either pistachio (intervention group) or control group (diet as per weight and physical activity profile, modulated according to dietary guidelines for Asian Indians) after 3 wk of a diet and exercise run in. In the first group, unsalted pistachios (20% energy) were given daily. A standard diet and exercise protocol was followed for both groups. Body weight, waist circumference (WC), magnetic resonance imaging estimation of intraabdominal adipose tissue and subcutaneous abdominal adipose tissue, fasting blood glucose (FBG), fasting serum insulin, glycosylated hemoglobin, lipid profile, high-sensitivity C-reactive protein (hs-CRP), adiponectin, free fatty acids (FFAs), tumor necrosis factor (TNF)-α, leptin, and thiobarbituric acid reactive substances (TBARS) were assessed before and after the intervention.

Results: Statistically significant improvement in mean values for various parameters in the intervention group compared with control group were as follows: WC ($P < 0.02$), FBG ($P < 0.04$), total cholesterol ($P < 0.02$), low-density lipoprotein cholesterol ($P < 0.006$), hs-CRP ($P < 0.05$), TNF-α ($P < 0.03$), FFAs ($P < 0.001$), TBARS ($P < 0.01$), and adiponectin levels ($P < 0.001$).

Conclusion: A single food intervention with pistachios leads to beneficial effects on the cardiometabolic profile of Asian Indians with metabolic syndrome.

Introduction

India is undergoing a rapid nutrition transition [1] due to a shift from traditional high-fiber, low-fat, low-calorie diets to high consumption of refined carbohydrates, fat, and low-fiber diets [1]. These changes have led to an increasing prevalence of diet-related, non-communicable diseases (DR-NCDs), obesity, type 2 diabetes mellitus (T2DM), metabolic syndrome (MetS), and a consequent increase in coronary heart disease (CHD) [2].

MetS is a constellation of metabolic abnormalities that include abdominal obesity, dyslipidemia, elevated blood pressure (BP), and hyperglycemia. Recent data suggest that approximately one-third of the adult urban Indian population has MetS [3–5], with a high prevalence of CVD risk factors: abdominal obesity (31%); hypertriglyceridemia (46%); low high-density lipoprotein cholesterol (HDL-C) levels (66%); hypertension (55%); and increased fasting blood glucose (FBG; 27%) [6]. Asian Indians appear to have enhanced susceptibility to develop various CVD risk factors and MetS. Compared with whites, Asian Indians have

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lower body mass index (BMI), higher waist circumference (WC), lower muscle mass, but higher body fat, subcutaneous abdominal adipose tissue (SCAT), and higher intraabdominal adipose tissue (IAAT) [7]. Furthermore, in Asian Indians, hyperglycemia, hypertriglyceridemia, and hypertension appear at lower levels of BMI and WC [7].

Diet-based strategies are important to optimize metabolic and cardiovascular health. Consumption of diets low in total and saturated fats demonstrates lower risk for CHD [8,9]. Nuts (mainly pistachios, almonds, and walnuts) have been shown to have beneficial effects on glycemic and lipid parameters [10–12]. Compared with other edible nuts, pistachios have higher monounsaturated fatty acid content (67%) and a lower polyunsaturated/saturated fat ratio (1:21), which may be responsible for their favorable effect on lipids [13–15]. Furthermore, pistachios have a low glycemic index, are naturally cholesterol free, and are a source of protein, fiber, phytosterols, and antioxidants. These properties make consumption of pistachios attractive for those at risk for obesity, MetS, and CHD.

To date, nine studies have been conducted in humans investigating the effects of pistachios [13–21]. However, none of the previous pistachio trials studied Asian Indians with MetS or had an observation period longer than 12 wk. In view of the adverse metabolic profile of Asian Indians, an increasing prevalence of DR-NCDs, and changing dietary pattern, it is important to identify foods that, if incorporated in daily diets, can help improve the metabolic profile. In this study, we evaluated the effect of intervention with pistachios on cardio-metabolic risk factors among Asian Indians with MetS.

Materials and methods

Participants

Individuals with MetS were recruited through the outpatient department of the Fortis Hospital, Delhi and by referral between January 2010 and April 2012. Modification of the International Diabetes Federation definition of MetS, which includes abdominal obesity (ethnic specific cut-offs of WC [men > 90 cm; women > 80 cm]), high serum triglycerides (TGs; ≥ 150 mg/dL), low HDL-C (men < 40 mg/dL; women < 50 mg/dL), dysglycemia (FBG ≥ 100 mg/dL), and hypertension ($\geq 130/\geq 85$ mm Hg or on therapy) (any three of five components) was used for the identification of MetS as recommended for Asian Indians [22]. Those with accelerated hypertension (stage 2 hypertension according to Joint National Committee guidelines) [23], uncontrolled hypothyroidism, uncontrolled lipids (serum TGs $\geq$500 mg/dL and low-density lipoprotein cholesterol [LDL-C] $>$160 mg/dL), and T2DM were excluded. Participants were screened for any known food allergy. The study protocol had been approved by an independent review committee and informed consent was obtained.

Methods

BP was measured via the right arm with each participant in a sitting position according to standard protocol [24]. All assessments for anthropometric, glucose, and lipid parameters were carried out as described previously [25]. Levels of fasting insulin, adiponectin, tumor necrosis factor (*TNF*)-α and high-sensitivity C-reactive protein (hs-CRP) were measured as previously described [26–29]. The measurement of thiobarbituric acid reactive substances (TBARS) was done calorimetrically [30]. Fasting free fatty acid (FFAs) levels were measured by enzyme-linked immunosorbent assay technique (Zen-Bio, Inc, Durham, NC, USA). The intra- and inter-assay percentage variations were less than 5% and 4%; 2.1% and 3.3%; 1.8% and 2.9%; 2.2% and 3.4%; 1.8% and 2.3%; 2.5% and 3.1% for insulin, leptin, adiponectin, TBARS, TNF-α, and FFAs, respectively.

Estimation of cross-sectional areas (cm^2) of abdominal adipose tissue was done by single-slice magnetic resonance imaging (MRI; 1.5 Tesla, SIGNA High Definition MR, GE Medical Systems, Waukesha, WI, USA) at lumbar vertebrae L^{2-3} as described previously [31]. Adipose tissue areas were measured by mapping various abdominal adipose tissue compartments (AAT and SCAT) on the computer screen using a track-ball.

Study design

A free-living randomized controlled, parallel design was used to compare two study diets over a period of 6 mo after a run-in period of 3 wk. Similar diet and exercise counseling were given to both groups. To monitor compliance, food-frequency, 24-h dietary recalls, and phone interviews were conducted as shown (Fig. 1). Participants met with the investigators monthly to provide updates on diet and lifestyle compliance and for checkups.

Study diet and compliance

During the run-in period, all participants consumed the standard diets formulated according to the dietary guidelines for Asian Indians [32]. This was continued in the control group for 6 mo after the run-in period. Dietary counseling was given according to height, weight, and physical activity level of the study participants. Instructions were given verbally, in written form, and were discussed in detail individually and during group meetings. The dietary composition of the control diet was 60% carbohydrates, 15% protein, and 25% fat; the pistachio diet was composed of 51% carbohydrates, 20% protein, and 29% fat. Pistachios were substituted for visible fat (cooking oil and butter), a portion of carbohydrates, and dairy. Participants were advised to take pistachios as 20% of total energy (e.g., a 160 cm tall, sedentary man, requiring 1400 kcal for the maintenance of ideal body weight of 57 kg was given 86 pistachios [49 g; 280 kcal] daily). Participants were instructed to maintain the same level of physical activity throughout the study. The general qualitative recommendations for both the control and test diet groups were to eat a diet rich in vegetables and fruits; select whole-grain, high-fiber foods; limit red meat and meat products, and use white meats instead; select fat-free or low-fat dairy products; limit foods containing partially hydrogenated vegetable oils; curtail consumption of soft drinks and foods with added sugar; choose and prepare foods with little or no salt; and limit alcohol intake.

Diet counseling for individuals and groups were given every 30 d for the first 4 mo and then once every 45 d for the next 2 mo. Participants were encouraged to share their experiences with each other. Compliance to the protocol was good, as indicated by compliance checks: weekly compliance questionnaires, biweekly telephone calls, discussion, and crosschecking with the spouse or any close relative. Patients were asked to bring empty packets of pistachios and pistachio shells at the time of their visit to the hospital. Food-frequency questionnaire and 24-h dietary recall were taken during patients' visits to the clinic. Study participants were allotted a quota of pistachios for the consumption by family members to help ensure compliance.

Statistical analysis

The data were managed on an Excel spreadsheet. Sample size was calculated for a two-group parallel superiority randomized control trial. A change in WC was taken as the primary outcome variable. Assuming mean $\pm$ SD reduction in WC in the diet and exercise group as 2.0 ± 0.5 and expecting an additional reduction