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Effects of pistachios on the lipid/lipoprotein profile, glycemic control, inflammation, and endothelial function in type 2 diabetes: A randomized trial

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ABSTRACT

Objective. The health benefits of regular nut consumption have been well-documented; however, effects on cardiovascular risk in diabetes are emerging. This study examined the effects of daily pistachio consumption on the lipid/lipoprotein profile, glycemic control, markers of inflammation, and endothelial function in adults with type 2 diabetes.

Materials/Methods. We enrolled 30 adults (40–74 years) with well-controlled type 2 diabetes (mean glycated hemoglobin 6.2%) in a randomized, crossover, controlled feeding study. After a 2-week run-in period, participants consumed nutritionally-adequate diets with pistachios (contributing 20% of total energy) or without pistachios for 4 weeks each, separated by a 2-week washout. We assessed fasting lipids/lipoproteins, glycemic measures (while fasted and during a 75 g oral glucose tolerance test), inflammatory markers, and endothelial function after each diet period.

Results. Total cholesterol and the ratio of total to HDL cholesterol were significantly lower ($p < 0.05$) following the pistachio diet (4.00 mmol/L and 4.06 mmol/L, respectively) compared to the control diet (4.15 mmol/L and 4.37 mmol/L, respectively). Triglycerides were significantly lower ($p = 0.003$) following the pistachio diet (1.56 mmol/L) compared to the control diet (1.84 mmol/L). There were no treatment differences in fasting glucose and insulin, but fructosamine was significantly lower ($p = 0.03$) following the pistachio diet (228.5 μmol/l) compared to the control diet (233.5 μmol/l). Inflammatory markers and endothelial function were unchanged.

Abbreviations: AI, augmentation index; AI@75, augmentation index standardized to heart rate of 75 beats per minute; AUC, area under the curve; CRP, C-reactive protein; FMD, flow-mediated dilation; F-RHI, Framingham reactive hyperemia index; HbA1c, glycated hemoglobin; HOMA-IR, homeostatic model of insulin resistance; ICAM, intracellular adhesion molecule; PAT, peripheral arterial tonometry; RHI, reactive hyperemia index; VCAM, vascular cellular adhesion molecule.

Clinical Trial Registration: www.clinicaltrials.gov (NCT00956735).

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Conclusion. Daily pistachio consumption can improve some cardiometabolic risk factors in adults with well-controlled type 2 diabetes. Our findings support recommendations that individuals with diabetes follow healthy dietary patterns that include nuts.

1. Introduction

The health benefits of regular nut consumption have been well-documented in both observational studies and clinical trials [1]. Frequent nut consumers are 19%–29% less likely to experience cardiovascular events compared to infrequent consumers, and they have a 17% reduced risk of all-cause mortality [2,3]. Daily nut consumption has been shown repeatedly to improve the lipid/lipoprotein profile [4] and may also benefit glycemic control [5], inflammation [6], and endothelial function [7].

Among individuals with type 2 diabetes, for whom cardiovascular disease is the leading cause of death [8], management of such cardiometabolic markers is vital to reducing risk. Numerous studies have shown that nutrition interventions are effective in managing type 2 diabetes, including following dietary patterns consistent with the Mediterranean diet, the Dietary Approaches to Stop Hypertension diet, vegetarian or vegan diets, a prudent diet, and a moderately low carbohydrate diet [9]. Nut consumption is an appealing non-pharmacologic approach to risk management in this population, particularly since concerns that nut consumption may promote weight gain and obesity have been refuted [10]. However, nut studies in populations with type 2 diabetes are limited. A few trials reported beneficial effects on the lipid/lipoprotein profile [11–15], and a recent meta-analysis concluded that daily nut consumption reduces fasting glucose and glycated hemoglobin (HbA1c) [16]. Two studies that assessed inflammatory markers following nut interventions reported mixed results [17,18], and one study reported a significant improvement in endothelial function following 8 weeks of walnut consumption [14]. However, most trials (regardless of the population) have studied mixed nuts or walnuts, and the health benefits of other nuts, such as pistachios, are less clear.

The purpose of this study was to examine the effects of daily pistachio consumption on the lipid/lipoprotein profile, glycemic control, markers of inflammation, and endothelial function in adults with type 2 diabetes. This is a secondary analysis of data collected as part of clinical nutrition trial with the primary outcome being systemic hemodynamics, for which the main results have been published previously [19]. We hypothesized that a diet containing 20% of daily energy from pistachios would benefit multiple cardiometabolic risk factors over a 4-week treatment period compared to a pistachio-free control diet.

2. Methods

This study was registered at ClinicalTrials.gov (NCT00956735) and the protocol described previously [19]. All data were collected at the Clinical Research Center at The Pennsylvania State University between July 2009 and March 2013. Written informed consent was obtained from all participants, and approval for the study was granted by the Institutional Review Board of The Pennsylvania State University.

2.1. Subjects

Potential participants were recruited through campus and community advertisements (Fig. 1) and were assessed for eligibility over the phone. Participants were required to have a self-reported diagnosis of type 2 diabetes, be 30–75 years of age (women had to be post-menopausal), and have a body mass index (BMI) of 18.5–45.0 kg/m^2. Exclusion criteria were insulin use, self-reported history of chronic disease other than type 2 diabetes, history of bariatric surgery, major surgery in the prior 6 months, nut or latex allergies, and use of tobacco, daily aspirin, anti-inflammatory medications, oral steroids, hormone replacement therapy, or anti-hypertensive medication. Individuals who met the phone screening criteria completed a clinic screen for blood pressure measurement, an electrocardiogram, and a fasting blood draw. Further exclusion criteria were blood pressure ≥160/100 mmHg, abnormal electrocardiogram, fasting triglycerides ≥5.65 mmol/L, or HbA1c ≥7.4%.

In January 2010, due to low enrollment, the criteria were revised to allow individuals taking a single drug for hypertension to participate, under the conditions that their personal physician provide written approval to temporarily discontinue anti-hypertensive monotherapy and that resting blood pressure remain below 160/100 mmHg for the study duration. In November 2010, after discovery of significant inflammation in a participant, (who, in the interest of safety, was withdrawn from the study and referred for follow-up care; Fig. 1), the criteria were revised to exclude individuals with C-reactive protein (CRP) ≥10.0 mg/l. Thirty participants (50% female) completed the full study, and their baseline characteristics are presented in Table 1.

2.2. Intervention

We implemented a 2-period, randomized, crossover, controlled-feeding design, preceded by a 2-week run-in period with a standardized diet to determine baseline values. The treatment diets were assigned in a randomized, counterbalanced order determined by simple randomization (www.randomization.com). The study coordinator (KAS) generated the allocation scheme and assigned the participants to the intervention orders. Technicians who measured outcome variables were blinded to treatment assignments, but due to the nature of the dietary intervention, participants were aware of their treatment order assignment.

Participants were instructed to discontinue omega-3 fatty acid supplements 8 weeks prior to starting the study and all