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IHJ 1400 No. of Pages 5
ARTICLE IN PRESS
Indian Heart Journal xxx (2017) xxx–xxx
Contents lists available at ScienceDirect
Indian Heart Journal
journal homepage: www.elsevier.com/locate/ihj

Acute effects of diets rich in almonds and walnuts on endothelial function

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ARTICLE INFO

Article history:
Received 26 January 2017
Accepted 16 January 2018
Available online xxx

Keywords:
Almonds
Walnuts
Endothelial Function
sVCAM
Flow mediated dilation (FMD)
MUFA
PUFA

ABSTRACT

Objective: Omega-3 fatty acids, especially alpha-linolenic acid (ALA), which are present in nuts may reduce cardiovascular disease (CVD) risk, by changing vascular inflammation and improving endothelial dysfunction. The objective of the study was to evaluate the acute effects of two different diets, one containing walnuts and the other almonds on endothelial function.
Methods: Twenty-seven overweight volunteers underwent a randomized 2-period, crossover, controlled intervention study. The subjects were given either walnut or almond diets which varied in monounsaturated fatty acid (MUFA) and polyunsaturated fatty acid content (PUFA). The walnut diet provided 23.1% energy from PUFA and the almond diet provided 7.6% energy from PUFA. Endothelial function was assessed physiologically by flow-mediated dilation (FMD) and biochemically by sVCAM (soluble vascular cell adhesion molecules).
Results: The walnut diet significantly improved FMD ($p = 0.004$) and decreased sVCAM ($p = 0.009$) whereas the almond diet tended to improve FMD ($p = 0.06$) and significantly decreased sVCAM ($p = 0.004$).
Conclusion: Both walnut and almond diets improved FMD and sVCAM and there was no significant difference in physiological and biochemical markers between the two diets.

1. Introduction

Endothelial dysfunction is an early event in the development of atherosclerotic vascular disease.[1,2] Recent studies indicate that coronary endothelial dysfunction predicts future CVD events.[3–5] Endothelial function can be assessed noninvasively in the peripheral circulation by brachial artery ultrasound and it correlates well with coronary artery endothelial function.[6–8]

Walnuts differ from all other nuts by a high content of ALA, a vegetable n-3 fatty acid, which might confer additional anti-atherogenic properties.[9–11] Replacement of fatty foods in the diet with nuts reduces blood cholesterol and has other beneficial effects on the cardiovascular risk profile.[12–15] MUFA, mainly oleic acid, is predominant in almonds while walnuts are rich in PUFA like linoleic acid and ALA. Walnuts have a higher amount of n-6 and n-3 fatty acids as compared to almonds. Also, the n-6/n-3 ratio is lower in walnuts. A lower ratio of n-6/n-3 fatty acids is more desirable in reducing the risk of many of the chronic diseases.[16] The fatty acids from nuts have a beneficial effect on the cardiovascular system such as lowering blood cholesterol, reducing vascular inflammation and improving endothelial function.[10,17,18]

Various studies have assessed endothelial function and inflammatory markers after supplementing diets with almonds or walnuts separately.[19–23] However none of the studies have investigated the acute effect of a diet rich in both almonds and walnuts on the endothelium.

To test the hypothesis that walnut intake (high PUFA content) would improve endothelial function compared to almond intake

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https://doi.org/10.1016/j.ihj.2018.01.030

(high MUFA content), we performed a randomized, crossover feeding trial with a walnut-enriched diet and compared it with an almond-enriched diet to access the brachial artery vasomotor function and a circulating marker of endothelial activation in over weight subjects.

2. Subjects and methods

2.1. Subjects

Twenty-seven asymptomatic over weight individuals (BMI > 25) were recruited into a protocol approved by the institutional review board and gave informed consent. Of the 27 participants in the study, 16 were women and 11 were men. All participants were non-smokers, had normal blood pressure and took no medications or antioxidant supplements. Health status of the subjects was evaluated by questionnaire. Subjects that did not fit the study criteria were excluded by questionnaire. Exclusion criteria included subjects with diabetes, coronary artery disease, allergy to nuts (walnuts and almonds), abnormal fasting blood glucose, thyroid, renal and hepatic function.

2.2. Study protocol

We conducted a randomized 2-period, crossover, controlled-feeding trial. All the diets were provided. The protocol was approved by the West Virginia University Institutional Review Board and the study was conducted in accordance with the institutional guidelines. Ethic Committee approval number was H-22811. All measurements and blood samples were collected in the vascular laboratory. Between 2 and 6 weeks before testing, candidates were interviewed over the phone for clinical history, had an interview with the dietitian and anthropometric and blood pressure measurements were noted. Participants were individually randomized in a crossover design between 2 diet sequences (high-fat diet with walnuts or almond nuts) and were studied on two separate days 2 weeks apart. The experiments were performed in the afternoon to avoid confounding by the early morning blunting in endothelial function. On each study day, participants were asked to eat a low-fat breakfast at 7:00 AM and to refrain from further food intake until 11:30 AM, when they reported to the vascular laboratory and had a blood sample taken. Blood pressure was measured with a standard mercury sphygmomanometer. At 12:00 PM a baseline ultrasound assessment of endothelial function in the brachial artery was performed after resting for half an hour. Thereafter, participants ate 1 of the 2 diets under the supervision of a clinical investigator. The protocol was repeated 4 h postprandially, with a blood sample taken at 3:30 PM and a second endothelial function test at 4:00 PM after resting for half an hour. Previous studies have shown that 4 h is sufficient time to evaluate the acute effect of nuts.[21] Also, the largest changes in triglycerides and endothelial function have been observed 3–4 h postprandially.[24,25] During the 4-h interval, participants rested in a quiet room and were allowed to drink water.

The end points were the between-diet differences in changes from baseline of FMD assessed as the percentage change in brachial artery diameter during reactive hyperemia and postprandial changes in FMD and plasma concentrations of soluble vascular cell adhesion molecules (sVCAM).

2.3. Test diets

The diets were prepared at the hospital's kitchen and consisted of 1200 kcal with 62.3% fat (20% saturated fatty acids), 15% protein, 23% carbohydrate, and 122 mg cholesterol, for a total fat content of 80 g. In both diets the total fat from walnuts and almonds was kept the same. The diets consisted of a sandwich with 100 g white bread, 75 g salami, and 50 g fatty cheese, 125 g fat-rich (10%) yogurt, and water. Additionally, participants consumed 77 g almonds (almond diet) or 60 g shelled walnuts (walnut diet). 77 g almond or 60 g shelled walnuts were chosen to match the fat content in walnuts and almond (76 g fat in each). The unsaturated fatty acid content of the almond and walnut diets differed: 28.3% and 15.2% MUFA, and 7.7% and 23.1% PUFA, respectively. Only the walnut diet contained ALA (5 g). The nutrient composition of the walnuts and almonds used in the study is listed in Table 1. The dietary analysis was performed using Nutritionist Pro version 5.0.0 licensed modules Core, Client Management, Food Labeling.

2.4. Endothelial function testing

The operator was unaware of diet sequences. Suitable measurements were obtained in all tests. Subjects abstained from tobacco smoking and coffee. After blood samples had been drawn, subjects were placed supine at rest for 15 min in a quiet room at normal room temperature. A continuous ECG was recorded for timing of measurements. The brachial artery was scanned longitudinally 2–5 cm above the antecubital crease. This location was marked on the skin and all subsequent measurements were performed at the same location. FMD measurement using brachial artery reactivity testing was performed by 2-dimensional gray-scale and color flow Doppler vascular imaging by a Philips Sonos 7500 ultrasound machine (HP, Andover, Massachusetts) with an 11-MHz vascular ultrasound probe at baseline and after 4 h. Baseline dimensions were recorded at the center of the vessel with optimal contrast between the anterior and posterior vessel walls and the lumen. Doppler blood flow images were recorded from the center of the vessel. Then an arterial occlusion cuff, placed above the antecubital

Table 1
Average fatty acid composition of walnut and almond diets.

	Walnut Diet				Almond Diet			
	Whole Diet	% Calorie	Walnuts only	% Calorie	Whole Diet	% Calorie	Almonds only	% Calorie
Energy, kcal	1128		392		1178		442	
Fat, g	80	62.3	39	31.1	78	58.7	38	29
SFA, g	25	19.9	3	2.4	24	18.3	2.8	2.1
MUFA, g	19	15.2	5	3.9	37	28.3	23	17.6
18:1, Oleic	17.3	13.8	5	3.9	35.6	27.2	9	6.8
PUFA, g	29	23.1	28	22.3	10	7.6	23	6.9
18:2, Linoleic	23.7	18.9	22	17.5	10.1	7.6	9	6.8
18:3, Linolenic	5.9	4.7	5	3.9	0.5		0	
Protein, g	42	14.70	9	3.2	49	16.4	16	5.4
Cholesterol, mg	122		0		122		0	
Carbohydrate, g	66	23.10	8	2.8	75	24.8	16	5.4

SFA, saturated fatty acids; MUFA, monounsaturated fatty acids; PUFA, polyunsaturated fatty acids.

Please cite this article in press as: R. Bhardwaj, et al., Acute effects of diets rich in almonds and walnuts on endothelial function, Indian Heart J (2018), https://doi.org/10.1016/j.ihj.2018.01.030