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Original Article

Effect of Two Isocaloric Diets, Low Fat- High Calcium and Low Fat- High Fiber on Weight Reduction, Lipid Profile, and Blood Pressure

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Background: Coronary Heart Disease is commonly associated with obesity, raised serum lipid levels and changes in blood pressure. The present study was designed to assess the effect of low fat- high calcium, and low fat- high fiber diets on weight reduction, lipid profile and blood pressure.
Methods: The study sample consisted of 136 referred patients adult, obese men aged 53-64 years. Samples randomly were subdivided in two groups. Group 1 was advised 1600 calories, 20% fat, 1600 mg calcium rich diet and group 2 followed similar diet as for group 1 except a total daily intake of 55g fiber and 900 mg calcium per day for 12 weeks. Blood samples were collected and assayed for total cholesterol, LDL-cholesterol, HDL-cholesterol and TG. Anthropometric assessments included measurement of weight, height, and waist circumferences followed by calculating Body mass index. Systolic and diastolic blood pressures were measured by using sphygmomanometer. Statistical analysis was performed with parametric and non-parametric methods as appropriate.
Results: Data analysis revealed a significant decrease in total cholesterol, LDL-cholesterol, and TG in two groups, without any significant changes in HDL-cholesterol. Weight and blood pressure decreased in two groups, but the rate of reduction in blood pressure, weight and waist circumference were more significant in group 1 compared to group 2.
Conclusion: An increase in dietary calcium intake, together with a Low calorie, low-fat diet can increase lipolysis in fat tissues, make greater weigh loss, ameliorate blood pressure, improve lipid levels, and reduce the risk of coronary vascular diseases.

Key words: Weight Reduction, Low Fat Diet, Fiber, Calcium

Introduction

From a health care perspective, addressing overweight and obesity is an important strategy in the primary and secondary prevention of disease. Obesity is associated with an increased prevalence of chronic disease, including type 2 diabetes, hypertension, dyslipidemia, and cardiovascular disease.[1]

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Weight loss is associated with improvements in related clinical indicators, such as decreased risk for diabetes,[2] reduction in blood pressure and improved lipid profiles.[3]

Currently, the best dietary strategy for producing weight loss is a matter of debate among professionals and the public alike. One approach to weight loss that has gained recognition in the face of modest supportive scientific evidence is the low-fat diet. According to a review by Astrup et al.[4], a 4 to 5 Kg weight loss can be achieved with 10% energy reduction

in dietary fat in obese individuals, at least in short-term (<1 year) studies. Fat contain more energy per gram than other energy-yielding nutrients and also makes the diet palatable, but simultaneously less satiating, and therefore a high fat-diet is believed to promote weight gain;[5,6] however the issue is controversial.[7]

Non-glycemic carbohydrates or dietary fiber, i.e. those carbohydrates that are not absorbed in the small intestine and, therefore, move down to become fermented in the colon, have drawn attention and are able to exert positive health effects.[8] Foods that are high in dietary fiber, have the most impact on reducing hunger and would, therefore, be expected to be most helpful in reducing energy intake.

On the other hand, the possibility that a high calcium intake may affect energy balance has attracted considerable attention. Several observational studies have found inverse associations between calcium intake and body weight.[9-11] On the basis of a reanalysis of data from 4 observational studies, Davis et al.[9] concluded that differences in calcium intake could explain ≈ 30% of the variation in body weight. So, the aim of this study was to evaluate the effect of two type of low fat diet on weight reduction, lipid profile and blood pressure.

Patients and Methods

The study included 136 overweight and obese males referred to the Nutrition Clinic of Motahari Clinic affiliated to Shiraz University of Medical Sciences. They were randomly subdivided into two groups. The participants were overweight or obese with body mass index of 28-33 Kg/m², and between 53 to 64 years old. The inclusion criteria were age from 50 to 65 years, body mass index higher than 25Kg/m², desire to lose weight and no serious medical condition. Exclusion criteria were regular use of medication, using dietary supplements, lactose intolerance, milk allergy, consuming any weight losing diet or diet pills in the previous year, and smoking.

The study was conducted in accordance with the guidelines of ethical aspects of clinical trials.

Anthropometric assessment included measurement of weight, height and waist circumference. Body weight was measured to the nearest 0.1 kg using the Seca 713 scales while participants were minimally clothed. Height was determined without shoes to the nearest 0.2 cm using a wall fixed measuring tape, and subsequently body mass index, was calculated by dividing weight (kg) by squared height (m). Waist circumference was measured midway between the lower rip margin and iliac crest.

Systolic and diastolic blood pressures were measured from the right arm in the sitting position after 10 minutes of rest using a mercury sphygmomanometer.

At the beginning and the end of the intervention period, 10 ml of fasting venous blood samples were drawn from the arm. Serum total cholesterol, HDL-cholesterol, and triglyceride concentrations were measured by using automated enzymatic procedures. The Friedewald formula was used to calculate LDL-cholesterol:[LDL-C=Total-C-(HDL-C+TG/5)]. The intraassay for total cholesterol, HDL-cholesterol and triglyceride were 0.95% and 1.4%, 1.8% respectively and the interassay were 2.3%, 1.9% and 2.7 % respectively.

Interventions:

Samples were randomly subdivided in two groups. Participants were allocated to receive the low fat-high calcium diet (group 1) or low fat-high fiber diet (group 2). The recommended

energy intake was 1600 to 2200 Kcal, 500 to 1000 Kcal less than the participants' calculated energy intake for weight maintenance. Group 1 was advised 20% of daily energy intake from fat, 1600mg calcium and less than 20g fiber, and group 2 followed a similar diet as group 1 except a total daily intake of less than 900mg calcium and 45g fiber. Monthly follow up was conducted at Nutrition Clinic for 4 months. These follow up typically lasted 20 minutes per individual and consisted of dietary and, supportive counseling and weight measurement. Participants were encouraged to exercise for 45 minutes 5 times weekly. The participants completed a 3-days food record at the beginning of study and before every visit. The macro component, energy, fiber and calcium were calculated by using Food Processor Software modified by incorporating the Iranian food table.

Statistical Analysis

The normality of distributions was checked for all variables. Differences between groups during supplementation were tested using paired t-tests, and variables not normally distributed were compared using the Wilcoxon test. Differences between groups at the beginning and the end of the study were tested using t-test. Data are expressed as mean and standard deviation (SD) unless otherwise indicated. A simple regression test was used to test for possible association(s), and multiple linear regression analysis using stepwise methods was performed to determine the most significant predictors of changes in blood pressure. Statistical significance is defined as $P<0.05$.

All statistical analyses were computed using SPSS version 11 for Windows (SPSS Inc., Chicago, 2001).

Results

Of 136 participants 71(52%) were randomly assigned to low fat-high calcium diet and 65 subjects (48%) to the low fat-high fiber regimen. Five participants (7%) assigned to the low fat-high calcium diet group and fifteen (23%) allocated to the low fat-high fiber diet, were unable to adhere to the diet for different reasons. They suffered from adverse effects

Table 1. Base line parameters (mean±SD)

Characteristic	Low fat-high calcium diet (n=60)	Low fat-high fiber Diet (n=56)	P value
Age (year)	54.5±3.5	57.0±5.5	0.71
Weight(kg)	89.0±6.5	92.0±3.5	0.83
BMI (kg/m^2)	33.2±1.7	34.4±1.5	0.88
Energy intake (Cal)	1680±88	1630±60	0.64
Calcium intake (mg)	1600±65	890±33	0.001
Fiber intake (mg)	18±7	46±7	0.001
waist circumference (cm)	101.1±3.6	103.2±1.2	0.43
Systolic blood pressure (mmHg)	13.6±0.7	13.1±1.2	0.43
Diastolic blood pressure (mmHg)	9.1±0.8	8.9±1.1	0.46
Total cholesterol (mg/dl)	269.0±13.0	278.0±20.0	0.67
Triglyceride (mg/dl)	190.7±6.5	193.0±3.5	0.67
LDL- cholesterol (mg/dl)	142.6±8.5	138.0±6.5	0.62
HDL- cholesterol (mg/dl)	36.0±3.0	34.5±2.5	0.58

Table 2. Characteristics of study participants after 12 weeks intervention (mean±SD).

Parameters	Low fat-high calcium diet (n=60)	Low fat-high fiber Diet (n=56)	P value
BMI (kg/m²)	2.3±26.1	28.6±1.8	<0.01
waist circumference (cm)	88.5±3.2	93.0±4.2	<0.01
Weight(kg)	75.0±3.3	84.0±2.7	0.001
Systolic blood pressure (mmHg)	12.5±0.8	12.8±0.5	0.038
Diastolic blood pressure (mmHg)	8.2±0.3	8.6±0.7	0.041
Total cholesterol (mg/dl)	228.5±11.5	231.5±13.0	0.67
Triglyceride (mg/dl)	171.5±8.5	166.8±9.2	0.33
LDl-cholesterol(mg/dl)	111.5±6.8	116.5±9.0	0.36
HDl-cholesterol(mg/dl)	37.5±3.5	34.8±4.8	0.41

such as flatulence and abdominal fullness and restlessness, and therefore did not comply with the follow-up schedule, and discontinued the study before the end of intervention, and were not included in analysis. The rate of dropout in low fat-high fiber diet group was higher than low fat-high calcium diet group. Recipients of low fat-high fiber diet reported more difficulties and adverse effects than did recipients of low fat-high calcium diet.

Physical characteristics and biochemical parameters of two groups of participants are shown in Table 1. Anthropometric data indicated obese population. Lipid profile values showed that all participants at baseline were hyperlipidemic. Both groups were well-matched. Baseline anthropometric and biochemical indices were similar in both groups at the beginning of study and there were no significant differences between two groups (Independent Sample T-test and Mann-Whitney Test ($p>0.05$).

Over 12 weeks, the mean change in body weight was -15 kg (95% CI -16.5 to -12.5 kg) in the low fat-high calcium group compared with -9 kg (95% CI -11.5 to 7.3 kg) in the low fat-high fiber diet group (Table 2).

In between group comparisons, changes in total cholesterol, LDL-cholesterol, and triglyceride were not significant, but in each group, comparison between these indices before and after study revealed a significant decrease, except for HDL-cholesterol (Table 2).

Systolic and diastolic pressures and waist circumference decreased in two groups, but the rate of reduction in these parameters was more significant in group 1compared to group 2. Further investigation into the changes in systolic and diastolic pressures in these participants after intervention, was carried out using multiple regression analysis in which the independent variables included calcium intake, fiber intake, energy intake, weight, and waist circumference. Using a stepwise regression procedure, only weight contributed significantly to the systolic blood pressure in low fat-high calcium recipient and in low fat-high fiber recipient ($r=0.46$, $P<0.001$ and $r=0.31$, $p<0.05$ respectively); thus, participants with lower body weigh also had a lower systolic blood pressure.

Discussion

Reduction in energy intake can be achieved either by decreasing the total amount of food by portion size control, or by changing the

composition of the diet towards lower energy density while maintaining the food quantity.

The major finding of the present study was that over 12 weeks, a low fat-high calcium diet led to greater weight loss, decrease in waist circumference, reduction in blood pressure and decrease in total-cholesterol, LDL-cholesterol and Triglyceride compared with a low fat-high fiber diet. However, the difference in lipid profile between two groups was not significant. These results suggested that research may be warranted on the effects of the low fat-high calcium diet in patients with the metabolic syndrome, which is characterized by increasing blood pressure, hypertriglyceridemia, low HDL-cholesterol levels, abdominal obesity, and insulin resistance.[12] Although weight loss in both groups resulted predominantly from reduced energy intake, many different mechanisms have been suggested to be responsible for the positive effect of a high calcium intake on energy balance. Dietary calcium appears to be related to energy metabolism,[13] and there is evidence to support a relationship between increased dietary calcium intake and lower body weight, specially, reduced fat mass.[14] For example, the CARDIA study reported that overweight individuals consumed fewer dairy products than their normal-weight counterparts.[15] However, the mechanism is still unclear, and a hypothesis to explain this relationship was provided by Zemel MB[16] who suggested that calcium affects adipocytes metabolism and fat oxidation. Increasing concentration of 1,25-dihydroxyvitamin D3 in cultures of human adipocytes and in transgenic mice, led to an acute increase in intracellular calcium concentration.[17] Lowering the intake of dietary calcium caused an increase in the serum concentration of 1,25-dihydroxyvitamin D3 within a few days.[18] In this way, a low intake of dietary calcium may lead to higher body weight by changing the balance of lipolysis and lipogenesis in adipose tissue through an increase in serum 1,25-dihydroxyvitamin D3.[19] On the other hand, animal studies have shown that dietary calcium increases fecal fat excretion.[20] The increased fat excretion was presumably due to formation of insoluble calcium fatty acids soups or to the binding of bile acids, which impairs the formation of micelles.[21,22]

However, a meta-analysis of 13 randomized controlled trials failed to show an association between increased consumption of either calcium supplements or dairy products and weight loss.[23]

A number of dietary changes have been recommended in the management of hyperlipidemia. One of these approaches is the reduction in calorie intake to achieve ideal body weight and reduction in total fat and cholesterol intake. This study has confirmed that at least in short term, weight reduction by limitation in energy intake and dietary fat can ameliorate lipid profile in hyperlipidemic patients. Intake of dietary fiber has been shown to be inversely correlated with body weight and weight change.[24] Apart from limitation in energy intake, this study showed that starchy diet and high intake of dietary fiber have beneficial effects on the lipid profile. The dietary starches used in low fat-high fiber diet involved substitution of such foods as whole wheat bread for white breads, legumes for meat, dry fruits for fresh fruits, and an increased consumption of vegetables. However, amelioration in lipid profile was more significant in recipients of the low fat-high calcium diet.

On the other hand, potentially, important health benefit from a high calcium intake is

a reduction in blood pressure. Observational studies in a variety of population to date have reported an inverse association between dietary calcium intake and blood pressure level,[25-27] that typically showed decrease in both systolic and diastolic pressures of about 0.4 mm Hg for each increase of 100 mg in daily calcium intake.[25]

Although data analysis in our study showed more significant decrease in systolic and diastolic pressures in low fat-high calcium group, but, by using stepwise multiple regression analysis, our study provided support for the contention that decrease in only systolic blood pressure is related to weight status and that the decreased level of systolic blood pressure correlated with changes in weight of participants.

In summary, over 12 weeks, participants who followed a low fat-high calcium diet lost more body weight than did those who observed a low fat-high fiber diet. Serum lipid profile improved in both groups, except HDL-cholesterol, but improvements of these indices were more significant in the low fat-high calcium diet group. However inclusion of an isocaloric control diet with 20% share of daily energy from fat and adjusting dietary calcium and fiber intakes at 900 mg/d and 20 g/d, respectively, could result in better study design and more accurate conclusion.

On the other hand, because of short duration of this study, further long term researches are needed to determine the absolute effects of these diets on weight reduction, lipid profile, blood pressure, and especially weight maintenance. As Heaney et al (28) have indicated in their literature review, that most of the other factors involved in weight control such as appetite, exercise, heredity, and social setting have been notoriously difficult to alter effectively. Hence calcium intake, which can be easily and effectively altered at a population level and which has important beneficial effects on many other body systems, seems a useful stratagem to deploy as a part of an overall approach to the growing problem of obesity.

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