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DIETARY INTAKE OF SUBJECTS WITH PERIPHERAL ARTERY DISEASE AND CLAUDICATION

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Abstract

We compared the dietary intakes of subjects with peripheral artery disease (PAD) and claudication with diet recommendations of the National Cholesterol Education Program (NCEP) and dietary reference intake values recommended by the Institute of Medicine (IOM) of the National Academy of Sciences. Forty-six subjects consumed a mean macronutrient composition of 17% protein, 51% carbohydrate, and 30% fat. Compared to the NCEP and IOM recommendations, few subjects met the recommended daily intakes for sodium (0%), vitamin E (0%), folate (13%), saturated fat (20%), fiber (26%), and cholesterol (39%). Subjects with PAD and claudication have poor nutrition, with diets particularly high in saturated fat, sodium, and cholesterol, and low in fiber, vitamin E and folate intakes. Subjects should be encouraged to reduce consumption of dietary fat, saturated fat, cholesterol, and sodium, and to increase fiber and vitamin intakes to meet recommendations of the NCEP and IOM.

Keywords

Diet; Intermittent Claudication; Nutrition; Peripheral Artery Disease

INTRODUCTION

Claudication is a symptom of peripheral arterial disease (PAD), and is associated with elevated rates of mortality[1-4] and morbidity.[5] Claudication afflicts 5% of the US population older than 55 years of age[6] and occurs during ambulation when the peripheral circulation is inadequate to meet the metabolic requirement of the active leg musculature. Thus, intermittent claudication impairs ambulation[7,8] and reduces daily physical activity.[9]

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Subjects with PAD and claudication not only have high atherosclerotic burden, they also have numerous cardiovascular and metabolic co-morbid conditions including dyslipidemia, hypertension, diabetes, smoking, obesity, abdominal obesity and metabolic syndrome.[10-15] Despite the impact that diet has on these cardiovascular and metabolic risk factors,[16,17] little is known about the dietary intakes of subjects with claudication. General dietary recommendations for those with cardiovascular disease typically include dietary intakes high in fruits, vegetables, and grain, and low in fat, saturated fat, cholesterol and sodium.[18]

In addition to the long-term detrimental influence that a high-fat diet has on cardiovascular and metabolic co-morbid conditions, consumption of a high-fat meal acutely impairs endothelial function.[19-21] This finding suggests that high dietary fat intake by subjects with PAD and claudication may further impair an already compromised peripheral circulation to the lower extremities and worsen walking performance.

The purposes of this study are (a) to compare the dietary intakes of subjects with PAD and claudication with diet recommendations of the National Cholesterol Education Program (NCEP)[22-24] and dietary reference intake values recommended by the Institute of Medicine (IOM) of the National Academy of Sciences,[25] and (b) to determine whether the dietary intake of fat negatively impacts vascular function and ambulatory function. The hypotheses are that subjects with PAD consume a diet which exceeds the daily recommendations of fat, saturated fat, and cholesterol, and that dietary fat and cholesterol impair vascular and ambulatory function.

METHODS

SUBJECTS

Recruitment—Subjects participated in this study at the Geriatrics, Research, Education, and Clinical Center, Maryland Veterans Affairs Health Care System (MVAHCS) at Baltimore. Subjects were recruited from the Vascular Clinic in the Baltimore MVAHCS. The procedures used in this study were approved by the Institutional Review Boards at the University of Maryland and the MVAHCS at Baltimore. Written informed consent was obtained from each subject prior to investigation.

Screening—Subjects with claudication secondary to vascular insufficiency were included in this study if they met the following criteria: (a) a history of claudication, (b) ambulation during a graded treadmill test limited by claudication,[7] and (c) an ankle-brachial index (ABI) ≤ 0.90 at rest,[26] or an ABI ≤ 0.73 after a treadmill exercise test in the symptomatic leg.[27] Subjects were excluded from this study for the following conditions: (a) absence of PAD (ABI > 0.90 at rest and > 0.73 after exercise),[26,27] (b) inability to obtain an ABI measure due to non-compressible vessels, (c) asymptomatic PAD, (d) use of medications indicated for the treatment of intermittent claudication (cilostazol and pentoxifylline), (e) exercise tolerance limited by factors other than leg pain (e.g. severe coronary artery disease, dyspnea, poorly controlled blood pressure), and, (f) active cancer, renal disease or liver disease. A total of 46 subjects with claudication were deemed eligible for this investigation.

MEASUREMENTS

Medical History, Physical Examination, and Anthropometry—Demographic information, height, weight, body mass index (BMI), waist and hip circumferences,[28] cardiovascular risk factors, co-morbid conditions, claudication history, blood samples, and a list of current medications were obtained from a medical history and physical examination at the beginning of the study.

Treadmill Test

Claudication Times and Peak Oxygen Uptake: Subjects performed a progressive, graded treadmill protocol to determine study eligibility, as well as to obtain outcome measures related to peak exercise performance.[7] The claudication onset time (COT), defined as the walking time at which the patient first experienced pain, and the peak walking time (PWT), defined as the time at which ambulation could not continue due to maximal pain, were both recorded to quantify the severity of claudication. Peak oxygen uptake was measured by oxygen uptake obtained during the peak exercise work load with a Medical Graphics VO2000 metabolic system (Medical Graphics Inc, St. Paul, MN). Using these procedures, the test-retest intraclass reliability coefficient is R = 0.89 for COT,[7] R = 0.93 for PWT,[7] and R = 0.88 for peak oxygen uptake.[29]

ABI and Ischemic Window: As previously described, ABI measures were obtained from the more severely diseased lower extremity before and 1, 3, 5, and 7 min after the treadmill test.[7,30] The reduction in ankle systolic blood pressure after treadmill exercise from the resting baseline value was quantified by calculating the area under the curve, referred to as the ischemic window.[31] Because the ischemic window is a function of both PAD severity and the amount of exercise performed, the ischemic window was normalized per meter walked.

Dietary Intake—Subjects were given detailed verbal and written instructions to record all foods and beverages consumed for seven consecutive days. Additionally, subjects were provided food scales to weigh food portions for more accurate completion of the seven-day food record. Upon returning the dietary records, data was reviewed with the subjects to better ensure completeness, preparation methods, and food description. Dietary records were analyzed by a registered dietitian using the NUTRITIONIST IV software program (Silverton, OR).[32]

STATISTICAL ANALYSES

Descriptive statistics were calculated on clinical characteristics, exercise measures, and dietary measures of subjects with PAD and claudication. Primary outcome variables include COT, PWT, and ischemic window. Partial Spearman correlation coefficients and their significance were determined for our primary outcome variables and dietary measures after adjusting for total caloric intake. All analyses were performed with a two-tailed significance level of 0.05 Analyses were conducted using SAS version 9.1 (Cary, NC).

RESULTS

The clinical characteristics of the subjects with claudication are shown in Table I. The group consisted of a mix of older, overweight Caucasian and African-American men. Cardiovascular risk factors were highly prevalent in the group, particularly hypertension, dyslipidemia, metabolic syndrome and diabetes. Exercise performance measures of the subjects are shown in Table II. COT and PWT occurred approximately 2.7 and 6.7 min during the treadmill test, and peak oxygen uptake and ischemic window values are typical for those with claudication.[11]

The dietary measures of the subjects with claudication are shown in Table III. On average, the subjects consumed fewer than the daily reference value of 2000 kcals/day for men 51 years of age and older,[25] and their mean macronutrient composition consisted of 17% protein, 51% carbohydrate, and 30% fat. Compared to the NCEP and IOM recommendations, few subjects met the recommended daily intakes for sodium (0%), vitamin E (0%), folate (13%), saturated fat (20%), fiber (26%), and cholesterol (39%).

The correlation coefficients between macronutrient measures of dietary intake and exercise performance measures are shown in Table IV. After adjustment for total caloric intake, monounsaturated fat intake was negatively correlated with PWT ($p < 0.05$) and positively correlated with ischemic window ($p < 0.01$), and fiber intake was negatively correlated with COT ($p < 0.05$). During a follow-up analysis, we examined whether smoking status had an influence on dietary intake. Subjects who currently smoked (n = 15 had a lower intakes of carbohydrate (209 ± 51 vs. 262 ± 64 g/day; $p = 0.008$), vitamin B6 (1.3 ± 0.6 vs. 1.8 ± 0.6 mg/day; $p = 0.011$), and fiber (11.3 ± 7.0 vs. 16.1 ± 7.9 g/day; $p = 0.051$) than non-smokers (n = 31). None of the other dietary variables were influenced by smoking status.

DISCUSSION

The novel findings of this study were that none of the subjects met the daily IOM recommendation for sodium consumption, and 80% exceeded the NCEP recommendation for saturated fat intake. Both dyslipidemia and hypertension are risk factors for the development of PAD,[13] symptomatic PAD,[15] and are highly prevalent co-morbid conditions in subjects with claudication.[10-12,14] Although medical management of dyslipidemia and hypertension can reduce cardiovascular risk, subjects with PAD are typically under-treated compared with those with coronary artery disease.[33] The high dietary intakes of saturated fat, cholesterol and sodium partially counteract the beneficial influences of pharmacologic therapy, if administered at all. Thus, subjects with PAD and claudication need to be better informed and encouraged to follow the dietary guidelines of consuming a diet low in fat, saturated fat, cholesterol and sodium to reduce risk of subsequent cardiovascular outcomes. Compliance with dietary therapy is enhanced with counseling from a registered dietitian to provide an individualized, aggressive diet modification.[34]

Another key finding in the current investigation was that very few subjects with PAD and claudication, particularly those who smoke, met the daily recommendation for dietary fiber. This indicates that the subjects had diets low in whole grains, fruits, vegetables, and legumes. Fiber may be beneficial in reducing inflammation, as there is a strong relationship between increased fiber intake and lower C-reactive protein levels.[35] Furthermore, dietary fiber may have a protective effect against developing PAD, as a positive association between cereal fiber and ABI was found in the Edinburgh Artery study,[36] the Health Professional's Follow-up study,[37] and a recent report examining data from the National Health and Nutrition Examination Survey.[38] The benefit of dietary fiber is dose-dependent, as the risk of PAD decreased with each quartile increase in fiber intake.[38] Thus, subjects with PAD and claudication may experience some cardiovascular benefits by increasing dietary fiber intake, possibly manifest as reduced inflammation and improved macrovasculature and microvascular function. The potential benefits of increasing dietary fiber intake may be magnified in subjects who smoke.

The consumption of mono-unsaturated fat was negatively associated with PWT, and was positively associated with the ischemic window. These data indicate that subjects with higher intake of mono-unsaturated fat had impaired ambulatory and vascular function during a standardized exercise test. The dietary intake of saturated fat and cholesterol showed the same trends, although they did not reach statistical significance. The correlation coefficients between mono-unsaturated fat and PWT and ischemic window supports our hypothesis that dietary fat impairs exercise performance, and suggests that mono-unsaturated fat may have a negative influence on endothelial function.[19-21] However, it is surprising that mono-unsaturated fat was more predictive than saturated fat. Our results do not support a previous randomized trial which found that dietary supplementation, which included mono-unsaturated fat, increased COT and ABI.[39] Additionally, we found a negative correlation between dietary fiber and COT. Given that nearly all of the subjects had very lower fiber intakes, it is difficult to interpret this association.

There are several limitations to this study. The sample size is small and the results are generalizable to subjects with PAD and claudication during a standardized treadmill test. Thus, the present findings cannot be generalized to subjects with asymptomatic PAD or to those who are limited in their exercise performance by other significant co-morbid conditions. Another limitation is that all of the participants were veteran men. Despite this select sample of PAD subjects, African-Americans are well represented, and typical risk factors for PAD such as smoking, diabetes, hypertension, dyslipidemia, and obesity are highly prevalent. Thus, in subjects with PAD and claudication, the findings of the present study are generalizable to the large proportion with numerous co-morbid conditions. Another limitation is that dietary intake was measured with a 7-day food record, and is subject to errors of self-report. Finally, there are limitations associated with the cross-sectional design of the study. The correlations calculated between dietary measures and exercise performance measures do not allow causality to be established, as it is possible that diet influences exercise performance or vice versa.

CONCLUSION AND CLINICAL SIGNIFICANCE

The main findings of this investigation were that: (a) subjects with PAD and claudication had dietary intake high in saturated fat, sodium, and cholesterol, and low in fiber, vitamin E, and folate intakes, and, (b) high intake of mono-unsaturated fat was associated with low

PWT and high ischemic window. We conclude that subjects with PAD and claudication have poor nutrition, and that dietary intake of mono-unsaturated fat was associated with impaired ambulatory and vascular function. The clinical significance is that subjects should be encouraged to reduce their consumption of dietary fat and sodium, and to increase fiber, vitamin E and folate intakes to meet NCEP and IOM recommendations. Along with appropriate medical management and advice to walk and avoid smoking, these dietary modifications, preferably with counseling from a registered dietitian, should also be viewed as a key component to reduce cardiovascular risk and enhance ambulatory and vascular function in subjects with PAD and claudication.

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Table I

Clinical characteristics of 46 subjects with peripheral artery disease and claudication

Variables	Mean (SD) or %
Age (years)	69 (6)
Weight (kg)	83.2 (14.8)
Body Mass Index (kg/m^2)	28.1 (4.4)
Ankle/Brachial Index	0.62 (0.17)
Race (% Caucasian)	57
Current Smoking (% yes)	33
Diabetes (% yes)	59
Hypertension (% yes)	87
Dyslipidemia (% yes)	70
Abdominal Obesity (% yes)*	36
Metabolic Syndrome (% yes)*	58
Obesity (% yes)	35

*n=45

Table II

Exercise measures of 46 subjects with peripheral artery disease and claudication

Variables	Mean (SD)
Claudication Onset Time (sec)	159 (122)
Peak Walking Time (sec)	399 (257)
Peak Oxygen Uptake ($ml \cdot kg^{-1} \cdot min^{-1}$)*	13.9 (3.6)
Ischemic Window (mmHg × min/m)	0.93 (0.84)

*n=45

Table III

Dietary measures of 46 subjects with peripheral artery disease and claudication.

Variables	Mean (SD)	NCEP[a] / IOM[b] Recommendations Based on a 2000 kcal/day Diet	Percentage Meeting[c] NCEP / IOM Recommendations
Caloric Intake (kcal/day)	1918 (422)		
Protein (g)	81 (21)	75[a]	67
Carbohydrate (g)	245 (65)	250-300[a]	46
Total Fat (g)	65 (23)	< 55-78[a]	80
Saturated Fat (g)	21 (8)	< 15[a]	20
Mono-unsaturated Fat (g)	22 (9)	≤ 44[a]	93
Polyunsaturated Fat (g)	11 (4)	≤ 22[a]	98
Cholesterol (mg)	280 (173)	< 200[a]	39
Alcohol (g)*	2 (5)		
Fiber (g)	15 (8)	20-30[a]	26
Sodium (mg)	3339 (876)	< 1200-1300[b]	0
Vitamin A (μg)	1078 (847)	900[b]	43
Vitamin B6 (mg)	1.7 (0.7)	1.7[b]	59
Folate (μg)	233 (106)	400[b]	13
Vitamin B12 (μg)	4.8 (2.8)	2.4[b]	93
Vitamin E (mg)**	2.9 (1.8)	15[b]	0
Vitamin C (mg)	118 (69)	90[b]	67

[a]NCEP = National Cholesterol Education Program recommendations

[b]Institute of Medicine recommendations for men 51 years of age and older.

[c]For carbohydrates and fiber, meeting the recommendation is defined as achieving the lower end of the recommended range or higher. For total fat and sodium, meeting the recommendation is defined as achieving the higher end of the recommended range or lower.

*n=45

**n=31

Table IV

Correlation coefficients between macronutrient measures of dietary intake and exercise performance in 46 subjects with peripheral artery disease and claudication.

Variables	COT	PWT	IW
Protein	-0.14	-0.16	-0.06
Carbohydrate	0.02	0.11	-0.15
Total Fat	0.01	-0.03	0.20
Saturated Fat	-0.14	-0.14	0.19
Mono-unsaturated Fat	-0.27	-0.38*	0.39**
Polyunsaturated Fat	0.09	0.04	0.04
Cholesterol	0.02	-0.17	0.16
Fiber	-0.35*	-0.15	-0.02
Sodium	0.13	0.09	-0.06

Values are Spearman partial correlation coefficients adjusted for daily caloric intake. COT = claudication onset time, PWT = peak walking time, IW = ischemic window.

* $p < 0.05$

** $p < 0.01$.