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Healthy and Unhealthy Diet Intake and Carotid Intima Media Thickness in Older Adults

Kelsey Joelle Da Silva
Brigham Young University - Provo

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Kelsey J. Da Silva

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Ronald L. Hager, Chair
Pat R. Vehrs
James D. George

Department of Exercise Sciences

Brigham Young University

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ABSTRACT

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Kelsey J. Da Silva
Department of Exercise Sciences, BYU
Master of Science

Background – Cardiovascular disease (CVD) is a primary premature killer of adults and risk of CVD has been linked to modifiable risk factors including dietary intake. Many diet assessment tools are costly, time consuming, and complicated. This study investigated the relationship between diet quality and cardiovascular disease risk as indicated by carotid intima-media thickness (cIMT) using a validated, simple, self-administered rapid food screener.
Methods – Participants were 51 male and 33 female older adults with an average age of 67 years. Carotid intima-media thickness was assessed using B-mode high resolution diagnostic ultrasound. Unhealthy and healthy diet intake was assessed using a validated 22-item rapid food screener. Data on other potentially confounding variables were also collected and included blood lipid profile, BMI, and resting blood pressure.
Results – Pearson correlation analysis showed a significant relationship for the unhealthy diet pattern and cIMT for both average and maximum region cIMT ($r = 0.218$, $p = .023$; $r = 0.197$, $p = .037$ respectively). There were no significant correlations related to the healthy diet pattern. ANOVA results did indicate significant differences in cIMT means (average cIMT and maximum region cIMT) when highest intakes of fruits and vegetables were compared with lowest intakes (average cIMT, (F (1,30) 4.54, $p = .041$; maximum region cIMT, (F (1,30) 5.41, $p = .027$). Average cIMT was 0.729mm vs 0.853mm respectively for highest vs lowest fruit and vegetable intake. Maximum region cIMT was 0.864mm vs 1.023mm when comparing highest vs lowest fruit and vegetable consumers.
Conclusion – Results of this study are similar to other studies that have indicated a relationship between diet and CVD/cIMT. Dietary intakes in the present study were assessed with an easy to use, self-administered rapid food screener. This is an important aspect of the study considering previous studies have used lengthier, complicated, time intensive tools. Because the rapid food screener can be self-administered and is inexpensive it may be used as an indicator of CVD /cIMT risk by health promotion professionals and even individuals themselves.

Key Words: diet, intima-media thickness, CVD, older adults

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Introduction

Cardiovascular disease (CVD) is the leading cause of death in the United States today.[1,2] The primary cause of CVD is atherosclerosis.[3-6] Atherosclerosis is characterized by a build-up of plaque in the arteries which can narrow the lumen and reduce blood flow.[6] If blood flow to the brain or heart is severely restricted or the vessel becomes completely occluded, a person can have a stroke or heart attack.[1,2,4]

One way to assess the severity of atherosclerosis and the risk of developing CVD is to measure the thickness of the interior lining of the major arteries in the body.[7] A typical site for such assessment is the common carotid artery in the neck.[7,8] Diagnostic ultrasound can be used to measure carotid artery intima-media thickness (cIMT) and determine subclinical and clinical risk for CVD.[9,10]

Risk factors for CVD can be classified as either modifiable risk factors or non-modifiable risk factors. Modifiable risk factors that have been shown to be related to increased risk of CVD include smoking,[11] physical inactivity, elevated BMI,[11] hypertension,[12] high blood cholesterol,[12,13] and unhealthy diet.[11,14] Research suggests that CVD risk, as indicated by cIMT, decreased in those who consume more whole grains,[14,15] berries and fruits,[16-18] and consume healthy oils relative to saturated fat and trans fat.[19] Non-modifiable risk factors that have also been associated with risk of CVD include gender,[20] ethnicity[21] and increasing age.[22,23]

The effect of dietary patterns on CVD risk as measured by cIMT in different populations has been studied using diet assessment instruments.[15-19] Although validated, some instruments, such as interviewer administered questionnaires, food frequency questionnaires, and detailed food and diet recalls can be complicated and time consuming. Assessing diet using interviewer administered food frequency questionnaires and lengthy diet recalls is not a novel approach when attempting to understand CVD risk. But, using a simple rapid food screener that is self-administered may have some advantages. Conducting a study that uses a validated, brief, cost effective, and self-administered[24] rapid food screener for the purpose of correlating cIMT risk to diet may be helpful in further understanding the effects of diet on CVD risk and identifying persons with subclinical risk.

The purpose of this study was to evaluate the relationship between healthy and unhealthy dietary practices as determined by a rapid food screener, and cIMT while controlling for other potentially confounding factors (e.g., blood pressure, blood lipids, and BMI) known to be related to risk of CVD. If relationships between healthy diet and decreased cIMT or unhealthy diet and increased CIMT can be identified using a simple rapid food screener, the findings from this study may have implications for clinicians and public health professionals in identifying persons at risk of CVD due to dietary practices. Additionally, findings may be helpful in improving assessment techniques for CVD risk.

Methods

Participants

Men and women were recruited from health screening participants (n=113) at the 2011 Huntsman World Senior Games (HWSG) held in St. George, UT. All of the health screening participants were at least 50 years old at time of participation in October 2011. All participants completed a research-based cardiovascular risk screening that included a carotid ultrasound IMT assessment, measures of height, weight, resting blood pressure, and a blood lipid profile. All participants provided written informed consent that included an option to give permission to be contacted via email or phone to be invited to participate in future studies. Of the 155 participants that participated in the health screening at the 2011 HWSG, the 113 participants who provided permission to be contacted in the future received an email invitation to participate in the present study. The invitation to participate in this study included a link to an internet-based survey instrument and informed consent documents.

Informed consent was implied if the participant completed and submitted the rapid food screener via the internet or regular mail. All participation was voluntary. All procedures for this study were approved by the Internal Review Board for Human Subjects use prior to any data collection.

Procedures

Data Collection During the 2011 HWSG

Participant height was measured using a calibrated wall scale to the nearest one-quarter inch. Weight was measured using a digital scale to the nearest tenth of a pound (Healthometer Professional, Model 349KLX/320KL, Sunbeam Products, Inc., Boca Raton, FL USA). Body mass index (BMI; kg/m^2) was computed from measures of height and weight.

Resting blood pressure was assessed using an automated blood pressure monitor (Omron Model HEM-780, Omron Healthcare, Inc., Bannockburn, Illinois, USA). Three consecutive blood pressure measurements separated by 30 second intervals were made in the seated position on the left arm after at least 5 minutes of rest. The average of the three systolic and diastolic blood pressure measurements was recorded.

Participants were instructed to fast 8-12 hours prior to attending the health screening so blood could be drawn to measure fasting blood lipids. An 18.0 mL blood draw was made by trained phlebotomists. Assays included total cholesterol (TC), high-density lipoprotein cholesterol (HDL-C), low-density lipoprotein cholesterol (LDL-C), very low-density lipoprotein cholesterol (VLDL-C), and triglycerides. All blood samples were analyzed by LabCorp (Salt Lake City, UT).

The ultrasound images were taken from the left and right common carotid arteries approximately 1 cm proximal to the common carotid bulb by an experienced sonographer. A SonoSite Titan (SonoSite Inc., Bothell, WA) portable ultrasound system was used with a 5-MHz linear transducer. One image from an anterior, direct, and posterior view was taken on each side of the neck while the participant was lying in a supine position. A total of 6 images were obtained from each subject. All images were analyzed with an automated software program (SonoCalc, SonoSite Inc., Bothell, WA). The SonoCalc software has been previously described and validated by Fritz.[25] Using edge detection capabilities, the software defines the average thickness (mm) of the far wall of the intima-media border across a 10 mm segment of the arterial wall. The average cIMT was calculated by averaging the individual IMT measurements from each of the 6 images and described in millimeters of thickness. The maximum region cIMT was identified by the SonoCalc software as the thickest one millimeter region of the 10mm segment being measured. The maximum region cIMT gives an indication of the smoothness of the arterial wall.

Data Collection

Within 12 weeks of participation in the health screening at the 2011 HWSG, participants received an email invitation to participate in the present study. In addition to data previously collected during the health screening at the 2011 HWSG, participants were asked to complete a rapid food screener via the internet.

The rapid food screener consisted of questions designed to assess dietary intakes of certain foods. The questions have been validated previously.[24] The food screener includes 7 healthy diet questions about fiber, whole grain, and fruit and vegetable consumption and 15 unhealthy diet questions about meat, processed meats, high-fat dairy, and snack consumption. The rapid food screener was presented in electronic format using the Qualtrics online survey tool,[25] and a paper version for those unable to complete the rapid food screener using a computer. It took approximately 5 minutes to complete the screener online or paper.

Participants were given an incentive to complete the rapid food screener. Upon completion and submission of the screener a book titled "The Stop & Go Fast Food Nutrition Guide"[1] was mailed to the participant. Email follow-up was sent to participants beginning 7 days after being invited if they had not already completed the rapid food screener. After the first week two emails per week were sent encouraging survey completion for 2 weeks. A daily email reminder was sent the last week of data collection. If the participant was unreachable by e-mail, a hard copy of the survey was mailed, followed by a phone call to confirm the status of their survey. Seven individuals completed paper copies of the rapid food screener and 77 participants completed the rapid food screener electronically. All rapid food screener data were matched with previous cardiovascular risk data collected at the 2011 HWSG and prepared for data analysis.

Statistical Analysis

Statistical analysis was performed using IBM SPSS version 20 (IBM Corp. Somers, NY). To determine relationships between cIMT and healthy diet and unhealthy diet patterns data were analyzed using Pearson correlation coefficients with statistical significance set at $p \leq .05$. Partial correlation was used to describe the cIMT - diet relationships while controlling for potentially confounding factors (e.g., gender, age, total cholesterol, systolic and diastolic blood pressure, and BMI). Healthy and unhealthy diet scores were calculated as average scores from the sum of scores for the healthy and unhealthy diet questions respectively. All questions were scored based on a 5-6 item Likert-type scale that ranged from less than once per month (scored as a 1) to 2+ times a day (scored as a 6). Analysis of variance (ANOVA) was used to determine if differences in the dependent variable (cIMT) existed between categorical groups of healthy and unhealthy diet patterns. Groups were categorized according to highest (2+ times a day) and lowest (less than 1/week) responses for questions related specifically to fruit and vegetable intake for healthy diet comparisons and red meat and processed meat for the unhealthy diet comparisons. Significant differences were identified when statistical significance reached $p \leq .05$.

Results

Of the 113 participants who were invited to participate in the study, 84 individuals completed the rapid food screener. This represents a response rate of 74%. Table 1 describes participant characteristics and any noted differences in demographic and biometric variables between men and women. As would be expected there were significant differences between men and women for height, weight, and HDL-cholesterol. Differences were also noted for systolic and diastolic blood pressure and total cholesterol.

Pearson correlations between average cIMT, maximum region cIMT and healthy and unhealthy diet scores are shown in Table 2. Pearson correlations indicated a significant positive correlation for cIMT and a composite unhealthy diet score. When an average score was computed from the 15 unhealthy diet questions and correlated to cIMT, the correlation was significant (r = 0.218, p = .023). The correlation between healthy diet score and cIMT was not significant, however the trend was inverse as would be expected (r = -0.101, p = .180). A significant correlation was also noted for unhealthy diet score and maximum region cIMT (r = 0.197, p = .037). The correlation for maximum region cIMT and healthy diet score was not significant (r = -0.104, p = .172).

Partial correlations indicated significant relationships between unhealthy diet score and average and maximum region cIMT while controlling for certain potential confounding variables but not for others. When controlling for gender the correlation between unhealthy diet score and average cIMT remained significant (r = 0.210, p = .028). Additionally, the correlation with average cIMT remained significant when controlling for total cholesterol (p = .025), diastolic blood pressure (p = .025), and BMI (p = .024). Maximum region partial correlations were similarly significant with the exception of gender. When controlling for gender the maximum region cIMT and unhealthy diet score was not significant (r = .169, p = .063). The correlation with between maximum region cIMT and unhealthy diet scores were significant when controlling for total cholesterol (p = .036), diastolic blood pressure (p = .038), and BMI (p = .037). When controlling for all potential confounding variables simultaneously the unhealthy diet scores were not significantly correlated to average cIMT or maximum region cIMT. See table 2 for other correlation findings.

Data were also analyzed to determine differences in cIMT based on highest and lowest healthy and unhealthy diet scores for diet specific questions related to fruit and vegetable consumption, and red meat and processed meat consumption (Table 3). Analysis of variance of cIMT by high and low fruit and vegetable consumption showed that average cIMT was significantly lower (F (1,30) 4.54, p = .041) among study participants who consumed fruit 2 or more times per day and consumed vegetables 2 or more times per day (cIMT = 0.729mm) when compared to participants who consumed fruits and vegetables less than one time week (cIMT = 0.853mm). Similar results were seen for differences in maximum region cIMT (.864mm vs 1.023mm) when comparing highest vs lowest fruit and vegetable consumers (F (1,30) 5.41, p = .027). Results of analysis of variance for cIMT and red meat and processed meat groups were all non-significant for highest vs lowest frequency consumers, although cIMT means for the groups were in the expected directions.

Discussion

The purpose of this study was to determine if a relationship existed between cIMT and healthy and unhealthy diet patterns in older apparently healthy adults when using a rapid food screener to elucidate healthy and unhealthy patterns of eating, specifically red meat/processed meat and fruit/vegetable consumption. Previous research has indicated that CVD risk and cIMT measurements was lower in persons with healthier diets relative to those who consume less healthy diets.[15-19] Many of the dietary assessment instruments used in previous studies are complicated, lengthy, and in some cases interviewer administered.[15-19]

Previously, the rapid food screener has not been correlated specifically to cIMT. The findings of this study are informative but cause and effect conclusions are not warranted. The rapid food screener designed and validated by Block, et al, 2000 can be self-administered and completed in less than 5 minutes by most individuals.[24] The rapid food screener assesses fat and fruit and vegetable intake with separate sections of questions, including 15 Likert-type questions about meat and snacks, and 7 questions related to fruit and vegetable intake. Based on the results of correlational analysis, significant positive correlations were found between unhealthy diet scores and cIMT suggesting that those with higher intakes of meat/snacks had higher scores for average cIMT and maximum region cIMT. The correlations remained significant even after controlling for certain potentially confounding variables, specifically gender, total cholesterol, diastolic blood pressure, and BMI. However, the correlation between cIMT scores and unhealthy diet scores was no longer significant after controlling for age (average cIMT, $p = .122$ and maximum region cIMT, $p = .135$) and systolic blood pressure (average cIMT, $p = .057$ and maximum region cIMT, $p = .081$).

It is not unexpected that age accounts for much of the variance in cIMT. Past studies have shown linear increases in cIMT with increasing age in young adults to centenarians.[28] When correlating age with average cIMT and maximum region cIMT in this study, age accounted for approximately 10% to 15% of the variance in cIMT (average cIMT, $r = .384$, $p = <.001$; maximum region cIMT, $r = .313$, $p = .002$). Age was also positively correlated with unhealthy diet scores ($r = .258$, $p = .009$). Systolic blood pressure was also significantly positively correlated with unhealthy diet scores ($r = .233$, $p = .016$).

While significant correlations existed between cIMT scores and unhealthy diet scores the correlations between cIMT scores and healthy diet scores were non-significant. Nevertheless, a trend was seen for healthy diet scores that was negatively correlated to both average and maximum region cIMT (Table 2) indicating some importance for healthy eating. Current dietary guidelines for fruits and vegetables based on an average 2000 calorie/day diet, are to consume at least 2 cups of fruits and 2 ½ cups of vegetables daily. Additionally, recommendations for red and processed meats are to consume only modest amounts.[29]

Another valuable finding from this study points to the importance of fruit and vegetable consumption. When participants are categorized by highest and lowest intakes of fruits and vegetables (2+ times/day for fruits and 2+ times/day for vegetables vs consuming fruits and vegetables less than 1 time/week) the high intake group had significantly lower average cIMT (.729mm vs .853mm) and maximum region cIMT (.864mm vs 1.023mm) scores than the low intake group (p = .041 and p = .027 respectively). This suggests that fruit and vegetable consumption may have a cardio-protective benefit at least relative to minimal consumption of fruits and vegetables. Interestingly, ANOVA yielded no significant differences between highest vs lowest consumers of red meat and processed meat for either average or maximum region cIMT score. Other studies have found links to increased cIMT with unhealthy diet including more animal-based diets where red and processed meats are consumed.[30-33]

Conclusion

Overall, the results of this study contribute to increased understanding of the relationship between diet and CVD risk. The study is not without weakness however. The present study is cross-sectional in nature therefore cause-and-effect conclusions are not warranted. Furthermore, the sample size is relatively small. However, generalizability of the findings would be considered good since the study participants come from a national sample.

The findings from this study are similar to the findings of some other studies indicating that healthy diet patterns may have implications for lowering risk of cardiovascular disease where cIMT is the measured outcome. However, the dietary pattern assessment tool used in this study was a validated rapid food screening instrument that is self-administered and brief as opposed to lengthier, complex, interviewer administered tools. This study found that significant positive correlations existed between the unhealthy diet pattern and cIMT, and significant mean differences were found for cIMT scores between high and low fruit and vegetable consumers. Because the rapid food screener is brief and self-administered it may have utility as a basic dietary evaluation tool for providing feedback to individuals relative to potential for CVD risk. Future research might consider the potential for behavior change using self-administered and self-scored diet assessment. Clearly research in the area of CVD risk should continue to explore ways to empower individuals to assess and understand their current risk for CVD, especially as it pertains to modifiable risk factors, such as diet, that are tied to individual choices.

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Table 1. Descriptive Statistics with Differences for Men and Women

	All Subjects (n=84)	Men (n=51)	Women (n=33)		
	Mean (SD)	Mean (SD)	Mean (SD)	F	*p*
Age (y)	67.36 (7.79)	67.45 (7.54)	67.21 (8.28)	.019	.892
Height (in)*	67.75 (4.06)	70.07 (3.16)	64.16 (2.31)	85.75	<.001
Weight (lbs)*	173.74 (31.58)	186.10 (28.24)	154.64 (26.87)	25.81	<.001
BMI	26.52 (3.61)	26.63 (3.39)	26.34 (3.97)	0.13	.720
Systolic BP (mmHg)*	128.44 (17.13)	132.59 (17.41)	122.03 (14.78)	8.28	.005
Diastolic BP (mmHg)*	78.52 (9.94)	80.47 (10.35)	75.52 (8.55)	5.24	.025
Cholesterol (mg/dl)*	196.10 (33.18)	188.57 (31.38)	207.73 (32.98)	7.18	.009
HDL (mg/dl)*	57.36 (16.54)	52.08 (15.20)	65.52 (15.35)	15.54	<.001
LDL (mg/dl)	118.57 (28.36)	116.24 (27.38)	122.18 (29.88)	0.88	.351
VLDL (mg/dl)	20.17 (10.33)	20.26 (10.96)	20.03 (9.44)	0.01	.923
Triglycerides (mg/dl)	100.94 (51.58)	101.26 (54.88)	100.46 (46.83)	0.01	.945
Avg cIMT (mm)	0.736 (.094)	0.741 (.099)	0.729 (.087)	0.32	.574
Max cIMT (mm)	0.870 (.110)	0.882 (.114)	0.852 (.102)	1.57	.214

* = statistically significant differences between males and females

Table 2. Correlations between Healthy and Unhealthy Diet Scores, and cIMT

	Avg cIMT		Max cIMT	
	R	*p*	r	*p*
Healthy Diet Score	-0.101	.180	-0.104	.172
Unhealthy Diet Score	0.218	.023	0.197	.037
Variable Controlled				
Gender				
Healthy Diet Score	-0.098	.190	-0.097	.193
Unhealthy Diet Score	0.210	.028	0.169	.063
Age				
Healthy Diet Score	-0.156	.082	-0.146	.094
Unhealthy Diet Score	0.129	.122	0.122	.135
Total Cholesterol				
Healthy Diet Score	-0.102	.179	-0.105	.174
Unhealthy Diet Score	0.217	.025	0.198	.036
Systolic Blood Pressure				
Healthy Diet Score	-0.106	.171	-0.108	.165
Unhealthy Diet Score	0.175	.057	0.155	.081
Diastolic Blood Pressure				
Healthy Diet Score	-0.105	.173	-0.106	.171
Unhealthy Diet Score	0.216	.025	0.196	.038

Table 2 cont. Correlations between Healthy and Unhealthy Diet Scores, and cIMT

BMI				
Healthy Diet Score	-0.105	.172	-0.113	.156
Unhealthy Diet Score	0.218	.024	0.197	.037
All Confounding Variables				
Healthy Diet Score	-0.145	.103	-0.134	.120
Unhealthy Diet Score	0.049	.337	0.042	.357

Table 3. ANOVA for cIMT in high and low consumers of fruits/vegetables and red meat/processed meat

	Frequency of Consumption			
	High (≥2x/day)	Low (<1x/week)	F	*p*
Fruit/Vegetable Groups				
Avg cIMT (mean)	0.729mm	0.853mm	4.54	.041
Max region cIMT	0.864mm	1.023mm	5.41	.007
Red Meat/Processed Meat Groups				
Avg cIMT (mean)	0.734mm	0.719mm	0.294	.589
Max cIMT (mean)	0.869mm	0.847mm	0.585	.447