The Dietary Quality of Persons with Heart Failure in NHANES 1999–2006

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BACKGROUND: Dietary quality may impact heart failure outcomes. However, the current status of the dietary quality of persons with heart failure has not been previously reported.

OBJECTIVE: To describe sodium intake, patient factors associated with sodium intake and overall dietary quality in a national sample of persons with heart failure.

DESIGN: Analysis of repeated cross-sectional probability sample surveys using data from National Health and Nutrition Examination Surveys (NHANES) of 1999–2000, 2001–2002, 2003–2004 and 2005–2006.

PARTICIPANTS: The study sample consisted of 574 persons with self-reported heart failure (mean age= 70 years; 52% women).

MEASUREMENTS: Diet of each survey participant was assessed using single 24 hour recall. Dietary nutrients of interest included sodium, the mainstay of heart failure dietary recommendations, and additionally potassium, calcium, magnesium, fish oils, saturated fat and fiber. Specific dietary goals were based on established guidelines.

RESULTS: Mean sodium intake was 2,719 mg, with 34% consuming less than 2,000 mg per day. Patient factors associated with greater sodium intake included male gender, lower education, lower income and no reported diagnosis of hypertension. Mean potassium intake was 2,367 mg/day, with no differences by type of diuretic used or renal disease status. Adherence rates to established guidelines for other nutrients were 13% for calcium, 10% for magnesium, 2% for fish oils, 13% for saturated fat and 4% for fiber.

CONCLUSIONS: Dietary quality of persons with self-reported heart failure was poor. Public health approaches and clinical dietary interventions are needed for persons with this increasingly prevalent clinical syndrome.

KEY WORDS: dietary quality; heart failure; clinical dietary interventions; sodium intake.

Received November 12, 2008
Revised July 29, 2009
Accepted September 18, 2009
Published online October 31, 2009

J Gen Intern Med 25(2):135–40
DOI: 10.1007/s11606-009-1139-x

INTRODUCTION

Heart failure is associated with considerable morbidity and mortality in the U.S.[1] There is a growing body of evidence attesting to the importance of dietary factors in heart failure progression and outcomes.[2–8] The American College of Cardiology/American Heart Association (ACC/AHA) joint guidelines recommend restricted sodium intake for patients with symptomatic, non-end-stage heart failure.[9] These guidelines also endorse adherence to dietary guidelines for common underlying and comorbid conditions in chronic heart failure, including coronary heart disease, hypertension, hypercholesterolemia, and diabetes. The results of several recent studies have suggested that nutrients consistent with Dietary Approaches to Stop Hypertension (DASH) eating plan influence heart failure progression and associated outcomes.[2–8] Additionally, omega-3 fish oil intake has been associated with a beneficial effect on heart failure outcomes.[10]

Despite the influence of dietary factors in determining disease outcomes in patients with heart failure, there is little understanding of the current dietary quality of persons with heart failure.[11] The primary purpose of this analysis is to describe sodium intake and patient factors associated with sodium intake in community-dwelling persons with heart failure.[9] The secondary purpose is to describe the overall dietary quality of persons with heart failure, based on additional nutrients documented as being beneficial to non-end-stage heart failure and its underlying conditions.[2–8,12] These include nutrients listed in the DASH recommendations: potassium, calcium, magnesium, fiber, saturated fat, protein and cholesterol,[13] as well as omega-3 fish oil.[10]

METHODS

Data Source and Population

The NHANES is a series of repeated cross-sectional studies conducted by the Centers for Disease Control and Prevention to provide health information representative of the civilian, non-institutionalized, U.S. population. NHANES uses a multistage, stratified sampling design to ensure adequate represen-

tation of the U.S. population. It consists of a questionnaire, physical examination and dietary assessment at a mobile examination center.[14] Beginning in 1999, NHANES has collected data in contiguous 2-year cycles. The current analyses compiled data from the 1999–2000, 2001–2002, 2003–2004 and 2005–2006 cycles.

The population investigated in this study consisted of adults 50 years or older who reported ever being diagnosed having heart failure by a health care provider. Persons under age 50 were excluded because heart failure is uncommon among younger persons.[15] Of the 8,825 adults age 50 years and over, 574 (6.5%) reported having been diagnosed with heart failure.

Dietary Assessments

A single 24-hour dietary recall was administered to each participant by trained NHANES staff using the Food Intake Analysis System (FIAS).[16] This consists of an automated computer-assisted interview which uses a five-step process with standardized wording to elicit recall of all foods and ingredients consumed. Prompts are provided to ensure complete descriptions of foods, preparation methods and portions. The database includes approximately 7,300 foods including brand names, ethnic foods and recipes, which allows calculation of nutrient information for 52 food components.

Dietary Measures

The primary nutrient of interest was sodium. This analysis used the heart failure-specific sodium intake recommendations from the American College of Cardiology/American Heart Association (ACC/AHA).[9] Additional nutrients promoted by the DASH diet, which documented associations with impact on heart failure outcomes, were also assessed.[2–8] The DASH diet promotes a high quality diet that includes consumption of fruits, vegetables, whole grains, low-fat and fat-free dairy products, lean meats, poultry and fish, and sparse intake of fats, oils, sweets, and added sugars.[13,17] Nutrients included in the DASH diet are potassium, calcium, magnesium, fiber, saturated fat, protein and cholesterol. Omega-3 fish oil intake, using the AHA benchmark[18], was also assessed because of evidence supporting its benefit among persons with heart failure.[10,19]

The ACC/AHA recommends that persons with heart failure follow a low sodium diet, defined as less than 2000 mg per day.[9] Other components of the DASH diet include potassium (.≥4700 mg/day), calcium (≥1240 mg/day), magnesium (>500 mg/day), fiber (>30 gm/day) and cholesterol (<150 mg/day). The DASH diet recommends that adults consume less than 6% of their energy intake from saturated fat and ≥18% of total energy intake from protein. These were calculated as number of saturated fat calories (9 calories/gm) or protein calories (4 calories/gm) consumed divided by total number of calories consumed. The AHA guidelines for persons with cardiovascular disease also recommend consumption one gram or more per day of eicosapentaenoic acid and docosahexaenoic acids, the omega 3 fatty acids in fish oils.[18]

Co-variates

Information was collected on socio-demographic characteristics including age, gender, race/ethnicity, education and income level. Body mass index (BMI) was calculated from measured height and weight (kg/m^2) taken during the mobile examination. Current smoking status was created from first asking whether the participant had ever smoked 100 cigarettes in their lifetime, and if so, whether they currently smoked. NHANES survey year was also considered a potential covariate to account for potential differences across time periods. Common medical conditions known to contribute to heart failure development, coronary heart disease, hypertension, high cholesterol, and renal disease, were assessed by self-report. Self-reported length of time since heart failure diagnosis was also assessed.

Diuretic use was classified into four categories according to potential biologic effect upon potassium: 1) thiazide, loop and carbonic acid inhibitor diuretics, which may cause hypokalemia; 2) potassium-sparing , aldosterone antagonist diuretics, and the combination of hydrochlorothiazide with triamterene, which may cause hyperkalemia; 3) other combinations with diuretics, which may be unpredictable with regard to effect upon potassium; and 4) no diuretic.[20]

Statistical Analysis

Frequency distributions were used to describe the population. Means (SE) for each dietary factor were computed. Percentages of persons with heart failure achieving each dietary goal were estimated. The associations of patient factors with sodium intake were analyzed using survey linear regression modeling. Each patient factor was first included in an unadjusted model. Variables significantly associated ($p \leq 0.05$) were entered into a multivariable model. Variables that remained statistically significant were retained in the final model. Analyses were carried out using Stata SE 10 (Stata Corp., College Station, Texas) and weighted using probability weights provided in the NHANES datasets as derived from estimates for the year 2000 population with respect to age, gender and race/ethnicity.[14]

RESULTS

Study Population

The study population consisted of an approximately equal proportion of men and women, with the majority (70%) being greater than or equal to 65 years. The majority (80%) were non-Hispanic white. Approximately one-third (34%) had attained greater than a high school degree, and 53% had been diagnosed with heart failure less than five years prior to the study interview. Table 1.

Sodium

Table 2 presents a summary of sodium intake. Average intake was 2,728.5 (SE=93.5) mg/day. Only 33% achieved the AHA goal for persons with heart failure of less than 2,000 mg/day. This intake was similar across diuretic categories: 2,756.0 mg/day (SE=96.3) for those taking diuretic associated with potassium loss, 2,605.7 mg/day (SE=202.8) for those taking a potassium-sparing diuretic, 2642.4 mg/day (SE=149.5) for those taking a combination of diuretics, and 2,732.5 mg/day (SE=90.7) for those not taking diuretics. Patient factors

Table 1. Description of Persons Age 50 and Over with Self-reported Heart Failure, NHANES 1999–2000, 2001–2002, 2003–2004 and 2005–2006[a]

Characteristic	Mean (SE) or %
Age, mean (SE)	70.3 (0.64)
Female gender	52.0%
Race/ethnicity	
Non-Hispanic white	79.8%
Non-Hispanic black	11.4%
Hispanic	6.6%
Other	2.2%
Education	
< High school degree	41.8%
High school degree	24.3%
> High school degree	33.9%
Annual income	
<$25,000	47.7%
$25,000–$55,000	33.8%
>=$55,000	18.5%
Body mass index	
< 18.5 kg/m^2	0.6%
18.5–24.9 kg/m^2	20.0%
25.0–29.9 kg/m^2	36.3%
≥ 30.0 kg/m^2	43.1%
Current smoker	17.3%
Number of years since told had heart failure	
0–2	28.3%
3–5	24.5%
6–10	18.2%
11+	28.9%
Provider ever told had coronary heart disease	66.1%
Provider ever told had hypertension	70.0%
Provider ever told had high cholesterol	61.4%
Provider ever told had diabetes	35.4%
Provider ever told had kidney/renal disease	5.6%
Diuretic use	
Taking diuretic that can cause potassium loss	41.4%
Taking potassium-sparing diuretic	4.1%
Taking combination of diuretics	10.1%
No diuretic	44.0%
Total calories per day, (SE)	1714 (38)

[a]*Data weighted to represent the total U.S. population with heart failure*

Table 2. Description of Sodium Intake and Factors Associated with Increased Sodium Intake Among Persons Age 50+ with Heart Failure in NHANES 1999–2000, 2001–2002, 2003–2004, 2005–2006[a]

Daily sodium intake		
Mean daily intake (SE)	2,728.5 (93.5)	
Sodium category	% of population	
<1500 mg	18.7%	
1500–1999 mg	15.3%	
2000–2499 mg	18.4%	
2500–2999 mg	15.6%	
3000–3999 mg	16.6%	
4000+ mg	15.4%	
Multivariable linear regression model of factors associated with increasing daily sodium intake		
Characteristic	β (unit = mg/day) (SE)	P-value
Female gender	−577.1 (119.2)	<0.0001
Education		
< High school degree	Referent	
High school degree	−187.8 (134.5)	0.16
> High school degree	−309.4 (159.3)	0.05
Annual income		
< $25,000	Referent	
$25,000–$55,000	−241.5 (134.8)	0.07
>=$55,000	−839.7 (175.6)	<0.0001
Provider ever told had high blood pressure	−196.2 (121.2)	0.05

[a]*Data weighted to represent the total U.S. population with heart failure*

associated with sodium intake in the linear regression model are presented in Table 2. Female gender, higher education, higher income and self-reported diagnosis of hypertension were associated with lower sodium intake.

Additional Nutrients

Table 3 presents mean (SE) nutrient intake and the percentage of persons that met each additional dietary goal. Overall, 3.1% reported intake of 4,700 mg/day or more of potassium. There were non-significant differences in potassium intake according to use of diuretics associated with potassium loss (mean=2,315.8, SE=72.4), use of potassium-sparing diuretics (mean=2,439.3, SE=282.7), combination of diuretics (mean=2,407.5, SE=112.5) or not taking any diuretic (mean=2,396.7, SE=73.2).

The percentages of participants that met the intake goals for calcium and magnesium were 11.6% and 2.5%, respectively. Less than four percent (3.8%) met the fiber intake goal. The adherence rate for saturated fat was 13.6% and for fish oil was 2.3%. Approximately one-quarter (26.7%) met the protein goal, while 40.4% met the cholesterol goal.

DISCUSSION

High quality dietary patterns, characterized by adherence to sodium restriction and nutrients promoted in the DASH eating plan and consumption of omega-3 fish oils, have been associated with decreased risk and improved management of cardiovascular disease risk factors and conditions, including heart failure.[2–8,11,12] This analysis demonstrates that the dietary quality of U.S. adults living in the community with heart failure is poor. It is likely the poor dietary patterns observed in the population began many years before diagnosis of heart failure, and in fact contributed to the development of heart failure.[21] Indeed, studies examining adherence to DASH diet recommendations in populations at increased risk for developing heart failure (i.e. hypertension and atherosclerosis) have observed poor dietary quality.[22,23] This study extends previous results by documenting that among persons with a severe chronic illness, namely heart failure, poor dietary habits

Table 3. Mean (SE) Dietary Intake of Additional Nutrients and Percentage Meeting Dietary Goals of Persons Age 50 and Over with Self-reported Heart Failure, NHANES 1999–2000, 2001–2002, 2003–2004 and 2005–2006[a]

Dietary nutrient	Daily goal	Mean (SE)	% Meeting goal
Potassium	≥ 4700 mg/day	2373,2 (47.3)	3.1%
Calcium	≥ 1240 mg/day	705.6 (21.0)	11.6%
Magnesium	≥ 500 mg/day	236.9 (4.8)	2.5%
Fiber	≥ 30 g/d	13.6 (0.4)	3.8%
Fish oil±	≥ 1 gm/day	0.11 (0.01)	2.3%
Saturated fat	≤ 6% of total energy	11.0 (0.18)	13.6%
Protein	≥ 18% of total energy	15.8 (0.22)	26.9%
Cholesterol	≤ 150 mg/d	262.4 (11.7)	40.4%

[a]*Data weighted to represent the total U.S. population with heart failure*
± *Not included in DASH diet*

persist. Our findings reinforce the need for primary prevention efforts aimed at improving dietary quality for cardiovascular disease risk reduction.

Sodium restriction is the mainstay of heart failure dietary recommendations,[9] yet adherence to established guidelines was poor. Because of impaired neurohormonal regulation of sodium excretion, patients with heart failure must attain a dietary sodium intake that is less than that of the general population.[5] The average daily sodium intake among persons with heart failure in this analysis was 2,728.5 mg/day, with 34% achieving the 2,000 mg/day benchmark. The average daily sodium intake in the adult 1999–2006 NHANES sample age 50 and over without heart failure was 3,073.1 mg/day (data not shown). Results suggest that even though sodium intake among persons with heart failure remains high, there has been some success in decreasing sodium intake among persons with heart failure at the population-level.

Sodium restriction is challenging because it limits restaurant fare and convenience foods. Further, it requires careful label reading and food preparation. This analysis found that persons with hypertension consumed approximately 200 mg/day less than those without it, suggesting modest success of clinical and public health efforts to decrease sodium consumption in this at-risk group. Men and persons of lower education and income level had high sodium intake whereas persons of higher educational attainment and persons with higher income levels had lower sodium intake in this analysis. Educational attainment may be associated with better ability to read and understand food labels, while persons with higher income are allowed more choices about the foods that they purchase and consume. Targeted clinical efforts may be required to address differences in sodium intake according to socio-economic status indicators (education and income) and gender. However, given the widespread use of sodium in the food supply, any meaningful strategy to reduce sodium intake must rely upon a public and professional demand that manufacturers and restaurants reduce the amount of salt added during food preparation.

Potassium intake is of concern in heart failure. Low serum potassium has been shown to increase disease progression and increase all-cause mortality in persons with heart failure.[24] Heart failure and its associated medications may alter serum potassium through changes in renal clearance and in the amounts and impact of aldosterone, renin-angiotensin and catecholamine secretions. Potassium deficiency in heart failure may result from a poor diet, anorexia, hyperaldosteronism, or through the use of loop or thiazide diuretics.[25] Thus, eating high-potassium foods is recommended for many patients with heart failure. However, due to the risk of hyperkalemia in patients on potassium-sparing diuretics and those with renal failure, dietary potassium intake needs vary considerably, making it difficult to establish a universal goal. The results of this study demonstrate that overall, dietary potassium intake in persons with heart failure is low and that intake does not differ according to diuretic use. Because potassium has a narrow range and delicate physiological balance, potassium levels should be closely monitored for physicians to make individualized recommendations.

Calcium intake in this study was also inadequate. Calcium is essential for many regulatory functions affecting heart health, including coagulation/hemostasis, endocrine, exocrine, and neuroendocrine cell secretions, and actions of cardiac and skeletal muscles.[26] Dietary calcium is implicated for its beneficial role in heart failure, as part of electrolyte balance to help maintain optimal heart contractility and rhythm, and blood pressure measures.[27] Calcium appears to have a stabilizing effect on muscle contraction to prevent vasoconstriction in "calcium sensitive" hypertensives.[27] Calcium may also directly inhibit renal sodium reabsorption, and/or lower the activity of the renin-angiotensin system to benefit hypertension.[28] Unfortunately, loop diuretics may cause hypocalcemia.[29] Thus, insufficient intake of calcium, flagged by the 2005 Dietary Guidelines for Americans (DGA 2005) as a nutrient of concern for most Americans,[30] is of particular concern among persons with heart failure.

The DGA 2005 also named magnesium a nutrient of concern.[30] Magnesium primarily affects cardiovascular, neuromuscular, and renal tissues. Magnesium intake may temper the increased arrhythmic risk and vasoconstriction experienced by many heart failure patients.[6,31] Magnesium deficiency can lead to increased sodium retention, decreased potassium uptake, and affect essential intracellular calcium concentrations, all of which further complicate the management of heart failure. Persons taking loop and/or thiazide diuretic treatments for heart failure may need an even higher magnesium intake to address increased urinary excretion of magnesium caused by these medications.

Fiber intake was also inadequate. Fiber can impact inflammation, weight, blood pressure, glycemic control, and other cardiovascular disease biomarkers.[32] Because fiber can be a dietary addition, rather than a restriction, adherence to this goal may be enhanced if routinely recommended.

Omega-3 fatty acids, specifically eicosapentaenoic acid (EPA) and docosahexaenoic acid (DHA) derived from fish, have been shown to suppress inflammatory markers and increase adiponectin for patients with heart failure.[18,19] Since fish is a source of protein, potassium, and omega-3 fatty acids, following the AHA recommendation to eat at least two fatty fish meals per week may increase adherence to several nutrient goals. Only a small percentage of the NHANES study sample met intake goals for saturated fat. A cornerstone of dietary recommendations for persons with cardiovascular disease, excess intake of saturated fat has been directly correlated with increased LDL cholesterol,[33] and increased levels of proinflammatory cytokines.[7,34–37] A low saturated fat diet is particularly important in heart failure, to address a markedly increased risk for cardiovascular disease complications.

Protein energy malnutrition is generally not of concern in the U.S. population,[38] yet 27% of this population did not achieve the DASH benchmark of 18% of total calories. Because common protein sources include foods that are also high in saturated fat (e.g. red meats) and sodium (e.g. processed meats), public health messages should reinforce the importance of obtaining protein from food sources that are otherwise beneficial.

Cholesterol presents an interesting case among dietary recommendations. It has not been definitively linked, as has saturated fat, with a detrimental lipidemic effect, because it tends to raise both LDL and HDL cholesterol.[39] Studies suggest that the association between dietary cholesterol and occurrence of heart disease is small;[40,41] and of the nutrients listed above, cholesterol is probably the least important. However, given that patients appear to be at least somewhat (40%) adherent to this recommendation, it may present an opportunity to impact other beneficial nutrients since lowering dietary cholesterol might reduce the intake of foods that also contain saturated fat.

This study has several limitations. The sample size (n=574) was relatively small. Self-reported diagnosis may under-estimate the true proportion of the population that has chronic heart failure.[42] It is possible that the dietary status of persons who do not report having heart failure, either by choice or because they do not know or understand that they have the disease, is even poorer than what was observed. This study is cross-sectional, so change in dietary habits as a result of diagnosis is unknown. Dietary recall data have limitations. People tend to under-report consumption of calories and certain nutrients, including saturated fat and sodium, which would point to even poorer intake.[43,44] Diet was assessed by a single 24-hour dietary recall. Though a single 24-hour dietary recall is not suitable for assessing individual intake, it is appropriate for determining group means.[45] Doses and timing of dose changes were not available, nor were blood levels of potassium, sodium or other nutrients, so diuretic influence upon physiological status could not be determined. Data were not available for supplemental potassium and calcium consumption, over-the-counter calcium supplements or salt-substitutes with potassium. Thus, the results presented likely under-estimate total consumption and represent intake through diet. Data were also not available for heart failure symptoms. The fact that almost half of patients were not on a diuretic implies that they did not have symptoms. However, sodium consumption did not differ by diuretic status, suggesting that intake did not differ by symptom status.

CONCLUSIONS

The results of this study suggest that the dietary quality of persons with heart failure is poor, which has strong potential for detrimental effect on disease progression and underlying conditions. Numerous approaches will likely be required to address this issue. Patients need clear and simple dietary prescriptions for specific foods and food groups from health care providers. Moreover, effective, large-scale intervention strategies are needed[11] because making dietary changes, even in the presence of life threatening illness, is extremely difficult.[46] Such strategies should address both primary and secondary prevention. Results also support the need for public health approaches. In particular, since non-discretionary sodium added to foods is so prevalent, increased public and political pressure is needed to make changes to the food supply to improve the diet of persons with heart failure and the population in general.

Acknowledgement: *This work was presented at the Society of Behavioral Medicine 2009 annual conference.*

Conflict of Interest: *None disclosed.*

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