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THE ALTERNATIVE HEALTHY EATING INDEX AND PHYSICAL FUNCTION IMPAIRMENT IN MEN

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Abstract: *Objectives:* Physical function is increasingly recognized as integral to healthy aging, in particular as a core component of mobility and independent living in older adults. Thus, it is important to identify strategies for the prevention of physical function decline. *Design:* Longitudinal cohort study. *Setting and Participants:* A total of 12,658 men from the Health Professionals Follow-Up Study were followed from 2008-2012. *Measurements:* We examined the association between the Alternative Healthy Eating Index-2010 (AHEI), a measure of diet quality combining 11 dietary components (vegetables, fruits, nuts and legumes, red and processed meats, sugar-sweetened beverages and fruit juices, alcohol, whole grains, omega-3 fatty acids, polyunsaturated fatty acids, trans fatty acids, sodium), and impairment in physical function, as measured by the SF-36. Multivariable logistic regression models were used to estimate the odds ratios (OR) and 95% confidence intervals (CI) of impairment in physical function. *Results:* In the multivariable-adjusted model, each 10-point increase in total AHEI score was associated with a 10% lower odds of impairment in physical function (OR=0.90, 95% CI: 0.86,0.95), and in the categorical analysis, men with AHEI scores in the top quintile had a 26% lower odds (OR=0.74, 95% CI:0.63,0.86) compared with men in the bottom quintile. For individual AHEI components, higher intake of vegetables (p-trend=0.01), nuts and legumes (p-trend<0.01), polyunsaturated fatty acids (p-trend<0.01) and lower intake of red and processed meats (p-trend=0.03) and sugar-sweetened beverages (p-trend=0.01) were significantly associated with lower odds of physical impairment. For specific foods, higher consumption of lettuce, broccoli, blueberries, peanuts, walnuts and other nuts were associated with lower odds of impairment. *Conclusions:* In this large cohort of older men, better overall diet quality was significantly associated with a lower odds of impairment in physical function. Given the value of physical function to healthy aging and quality of life, this may represent a particularly compelling public health rationale for older men to improve their diet.

Key words: Diet Quality, physical function, aging, longitudinal cohort study, epidemiology.

Abbreviations: AHEI: Alternative Healthy Eating Index-2010; BMI: Body Mass Index; CI: Confidence Interval; FFQ: Food Frequency Questionnaire; HPFS: Health Professionals Follow-Up Study; OR: Odds Ratio; SF-36: Medical Outcomes Short Form-36.

Introduction

Physical function, which is the ability to perform both basic and instrumental activities of daily living, is increasingly recognized as integral to healthy aging. Physical function is related to hospitalization (1), long-term nursing home care (2, 3), and increased mortality (3, 4). With the proportion of the U.S. population age 65 years or older expected to more than double to 89 million people by 2050 (5), identifying modifiable factors that may help to prevent or delay physical function decline among older adults is of critical public health importance.

Prior research has found that women with a healthier diet, as measured by the Alternative Healthy Eating Index-2010 (AHEI), had a lower risk of developing impairments in physical function (6). However, it is unknown whether this association is consistent in men and prior studies have indicated significant sex differences in physical function patterns in older adults (7-9). Thus, we used data from 12,658 men from the Health Professionals Follow-Up Study to examine the association between diet quality and impairment in physical function.

Methods

The Health Professionals Follow-up Study (HPFS) began in January 1986 with the enrollment of 51,529 male dentists, veterinarians, pharmacists, optometrists, podiatrists, and osteopaths who were 40 years of age and older and living throughout the US. On the initial questionnaire, participants provided a medical history and information on lifestyle and risk factors potentially related to cancer, cardiovascular disease and other medical conditions. Follow-up questionnaires have been mailed every two years to update individual characteristics and to identify incident diagnoses. A food frequency questionnaire (FFQ) was included on the initial questionnaire and every four years thereafter. The 2008 and 2012 questionnaires included the Medical Outcomes Study Short Form-36 (SF-36), a 36-item questionnaire that evaluates eight health concepts, including physical functioning. The study was approved by the Institutional Review Boards of Brigham and Women's Hospital and the Harvard T.H. Chan School of Public Health.

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Diet Assessment

On the FFQ, participants reported their average frequency of food consumption during the previous year based on the units or portion sizes specified on the questionnaire. Frequency is reported using nine possible responses ranging from "never or less than once per month" to "6 or more times per day". The FFQ has been validated in the HPFS men against 7-day diet records and good reproducibility of the dietary questionnaires has been documented (10, 11).

The AHEI criteria and methods for calculating the score have been previously described in detail (12). Briefly, the AHEI consists of 11 components: 6 components for which higher intakes are better (vegetables, fruit, whole grains, nuts and legumes, long-chain omega-3 fatty acids, and polyunsaturated fatty acids); 1 component for which moderate intake is better (alcohol: 3.5 or more drinks/day is assigned 0 points, nondrinkers are assigned 2.5 points, and 0.5-2.0 drinks/day is assigned 10 points); and 4 components for which lower intake is better (sugar-sweetened beverages and fruit juice, red and processed meats, trans fatty acids, and sodium). Each component is given a minimum score of zero for the worst level of intake and a maximum score of 10 for the best level, with intermediate values scored proportionally. The "best" levels of intake were determined a priori and based on a combination of the current dietary guidelines and the scientific literature regarding the dietary factor and chronic disease risk. All the component scores are summed to obtain the total AHEI scores, with a range from 0 (non-adherence) to 110 (perfect adherence).

Physical Function

Information on physical function was collected on the SF-36 questionnaire, a widely used and validated instrument (13). The physical function domain of the SF-36 is a consistent and reliable predictor of morbidity and mortality in a variety of populations (4, 14, 15). The physical function component of the SF-36 is comprised of 10 questions regarding physical limitations in performing the following activities: bathing/dressing yourself, walking one block, walking several blocks, walking more than one mile, bending/kneeling, climbing one flight of stairs, climbing several flights of stairs, lifting groceries, moderate activities, and vigorous activities. Each question has the same three response choices; each answer of "Yes, limited a lot" is assigned one point, an answer of "Yes, limited a little" is assigned two points, and an answer of "No, not limited at all" is assigned three points. A raw score is derived from the set of 10 questions and ranges from a minimum of 10 points to a maximum of 30 points. The raw score is then transformed to a 100-point score, with a score of 100 considered highest physical function. A score of 80 or less has been established to represent clinically meaningful physical impairment (16); this cutoff point has been used in other epidemiologic studies (16, 17).

Statistical Analysis

To evaluate the association between AHEI and incident impairment in physical function, we calculated AHEI as the mean of the scores from the 2002, 2006 and 2010 FFQs to reduce measurement error and to represent longer-term diet. Incident physical impairment was assessed from 2008 to 2012; in 2008, we excluded men with a physical function score <80, and identified incident cases in 2012. Thus, for the study population, we excluded men who died before 2008 (n=18,820), did not respond to the physical function questions in 2008 (n=2,693) or 2012 (n=10,998), had physical function impairment in 2008 (n=5,884), or did not respond to at least two of the three FFQs (n=477), leaving a study population of 12,658 men.

We used logistic regression models to calculate the odds ratio and 95% confidence intervals for physical impairment across five categories of diet quality and per a 10-unit increase in the total AHEI score. The categories were constructed to be equally spaced and to include approximately equal percentages of the population. The basic model was adjusted for age (continuous) and total energy intake (continuous, mean of caloric intake in 2002, 2006 and 2010). The multivariable model included primary, a priori risk factors for physical impairment; to mirror the diet assessments, we averaged potential confounding factors from 2002 through 2010: BMI (continuous, mean of 5 assessments), physical activity (<18, 18-29, 30-41, 42-53, ≥ 54 MET-h/week, mean of 3 assessments) smoking status in 2010 (never, past, current), pack-years of smoking as of 2010 (zero, <10, 10-19, 20-29, ≥ 30, 5% missing), Geriatric Depression score (18) in 2008 (0, 1, 2-4, 5-15), and history of diagnoses (yes/no) of cancer, myocardial infarction, stroke, diabetes, hypertension, and high cholesterol as of 2010.

We also examined associations between the individual AHEI components and physical impairment using the same basic and multivariable models, plus an additional model further adjusted for the other components (the total AHEI score minus the score from the component of interest). Odds ratios were calculated within five a priori categories (0-1.9, 2-3.9, 4-5.9, 6-7.9, 8-10 points) and per a 2-point increase in the AHEI component score. This analysis was not conducted for the trans fatty acid component because all of the men had scores within the top two categories.

We also conducted analyses in which we investigated associations between the top 5 contributors to the food component groups based on caloric intake in the study population: vegetables, fruit, nuts and legumes, red and processed meats, and sugar-sweetened beverages and fruit juice. The foods were categorized into servings of never or < 1/month, 1-3/month, 1/week, 2-4/week, and ≥5/week. These are the response categories provided on the FFQ, with the top categories collapsed into one category due to small numbers. Tests for trend across AHEI score categories and score components were calculated by treating the categories

Table 1
Age-standardized characteristics[a] in 2008 of the study population[b], according to quintiles of the Alternative Health Eating Index score

	AHEI Total Score[c]				
	< 54	**54-59.9**	**60-65.9**	**66-71.9**	**≥ 72**
Age, years [d]	69.4 (6.4)	69.5 (6.4)	70.0 (6.6)	70.1 (6.5)	70.3 (6.6)
Total energy intake, kcal/day	2097 (540)	2017 (562)	2037 (557)	1995 (542)	1990 (511)
Body mass index, kg/m^2	26.3 (3.3)	26.2 (3.1)	26.0 (3.2)	25.6 (3.1)	24.8 (2.9)
Physical activity, MET-h/week [e]	34.6 (24.2)	37.9 (24.9)	39.8 (25.7)	42.3 (25.9)	46.0 (26.3)
Never Smoker, %	53	51	52	53	55
Pack-years of smoking [f]	20.1 (18.5)	15.9 (14.5)	14.9 (14.2)	13.0 (11.9)	11.9 (11.5)
Geriatric Depression Scale [g]	1.3 (1.7)	1.1 (1.6)	1.0 (1.4)	1.1 (1.5)	0.9 (1.4)
Cancer, %	20	21	21	21	21
Myocardial infarction, %	7	6	7	6	6
Stroke, %	2	2	2	1	2
Diabetes, %	8	7	9	9	6
Hypertension, %	54	53	52	49	44
High cholesterol, %	62	66	68	65	61

AHEI, Alternative Healthy Eating Index; a. Values are means (SD) or percentages; b. Values were standardized to the age distribution of the study population; c. The AHEI total score ranges from 0 (worst) to 110 (best); d. Value is not age adjusted; e. Physical activity was assessed in metabolic equivalents (1 MET-hour is equivalent to 1 hour of sitting) and includes only recreational activities; f. Pack-years of smoking was calculated among former and current smokers; g. The Geriatric Depression Scale ranges from 0 to 15 (most depressed).

as an ordinal variable in the logistic regression models and assigning the median value for that category.

In additional analyses to test the robustness of the cutoff for physical function impairment, we tested alternative cutoffs for impairment (75, 70, and 65). Lastly, we conducted analyses to examine effect modification by age, BMI, and physical activity. All analyses were performed in SAS 9.3 (SAS Institute Inc., Cary, NC). All statistical tests were two sided and $P < 0.05$ was considered statistically significant.

Results

Characteristics of the study population in 2008 according to categories of the total AHEI score are shown in Table 1. Men with the highest AHEI scores, indicating a healthier diet pattern, tended to have a lower BMI, report higher levels of physical activity, and a lower prevalence of hypertension compared to men with lower AHEI scores.

The total AHEI score was strongly and linearly associated with decreased odds of physical impairment after adjusting for age and energy intake ($P_{trend} < 0.001$), and this association remained significant after controlling for all covariates (Table 2). In the multivariable model, each 10-point increase in the total AHEI score was associated with 10% lower odds of physical impairment (OR=0.90, 95% CI 0.86-0.95), and in the categorical analysis, comparing extreme categories, men with AHEI scores ≥ 72 (the highest group) had a 26% lower likelihood (OR=0.74, 95% CI 0.63-0.86) compared with men in the lowest group (AHEI scores < 54).

For the AHEI components, after controlling for potential confounding factors, relations were all fairly modest, and few individual components had significant relations with risk of physical function impairment (Table 2). Overall, when we considered each component score as a continuous variable (ranging from 0-10), we found no relation of consumption of fruit, alcohol, whole grains, omega-3 fatty acids, or sodium with onset of physical function impairment. Each 2-point increase in score (representing an increasingly healthy intake of each component) was associated with significantly lower odds of physical impairment for vegetables (OR=0.94, 95% CI 0.90-0.99), nuts and legumes (OR=0.93, 95% CI 0.90-0.97), red and processed meats (OR=0.96, 95% CI 0.92-0.99), sugar-sweetened beverages and fruit juice (OR=0.96, 95% CI 0.93-0.99), and polyunsaturated fatty acids (OR=0.91, 95% CI=0.86-0.97). With additional adjustment for the other component scores, the results for vegetables and for red and processed meats were further attenuated and the associations were no longer significant. For the extreme comparisons of "best" versus "worst" intake of nuts and legumes, sugar-sweetened beverages/fruit juice, and polyunsaturated fatty acids (those components that maintained significant linear associations, the odds ratio associated with a component score of 8-10 compared to a component score of 0-1.9, was 0.94 (95% CI 0.77-1.15) for nuts and legumes, 0.80 (95% CI 0.67-0.96) for sugar-sweetened beverages and fruit juice, and 0.79 (95% CI 0.64-0.97) for polyunsaturated fatty acids.

Table 2
Odds ratios (95% confidence intervals) of physical function impairment in 2012, as measured by the Physical Function scale of SF-36, within categories and per unit increase in the total and component AHEI scores among HPFS men

	Categories of Increasingly Better Diet Quality Scores						
AHEI Total Score	< 54	54-59.9	60-65.9	66-71.9	≥ 72	Ptrend[a]	per 10 points
cases/noncases	578/2074	526/1906	517/2208	430/1917	375/2127		
age + energy adjusted	1.00	0.98 (0.86-1.13)	0.78 (0.68-0.89)	0.74 (0.64-0.85)	0.56 (0.48-0.65)	< 0.001	0.83 (0.79-0.86)
multivariable adjusted[b]	1.00	1.05 (0.91-1.21)	0.87 (0.75-1.00)	0.86 (0.74-1.00)	0.74 (0.63-0.86)	< 0.001	0.90 (0.86-0.95)
	Categories of Increasingly Healthier Consumption of Each Diet Component[c]						
AHEI Component Scores[d]	0-1.9	2-3.9	4-5.9	6-7.9	8-10	Ptrend[a]	per 2 points
Vegetables							
cases/noncases	36/144[e]	284/1089	554/2362	667/2722	885/3915		
age + energy adjusted		1.00	0.91 (0.78-1.07)	0.90 (0.77-1.05)	0.78 (0.66-0.91)	< 0.001	0.92 (0.88-0.96)
multivariable adjusted[b]		1.00	0.98 (0.83-1.16)	0.98 (0.83-1.16)	0.86 (0.73-1.02)	0.01	0.94 (0.90-0.99)
Fruits							
cases/noncases	453/1846	819/3405	601/2705	349/1467	204/809		
age + energy adjusted	1.00	0.86 (0.75-0.98)	0.71 (0.61-0.82)	0.69 (0.58-0.81)	0.68 (0.55-0.83)	< 0.001	0.88 (0.85-0.92)
multivariable adjusted[b]	1.00	0.99 (0.86-1.14)	0.89 (0.77-1.03)	0.94 (0.79-1.12)	1.00 (0.81-1.24)	0.34	0.98 (0.94-1.02)
Nuts and Legumes							
cases/noncases	221/945	482/1774	531/2152	511/2195	681/3166		
age + energy adjusted	1.00	1.14 (0.95-1.37)	1.01 (0.84-1.22)	0.90 (0.75-1.09)	0.76 (0.63-0.91)	< 0.001	0.91 (0.87-0.94)
multivariable adjusted[b]	1.00	1.17 (0.97-1.42)	1.07 (0.89-1.29)	0.98 (0.81-1.19)	0.86 (0.71-1.05)	< 0.001	0.93 (0.90-0.97)
Red and Processed Meats							
cases/noncases	668/2477	548/2097	509/2274	429/2000	272/1384		
age + energy adjusted	1.00	0.91 (0.79-1.04)	0.74 (0.65-0.85)	0.68 (0.58-0.79)	0.59 (0.50-0.70)	< 0.001	0.87 (0.84-0.91)
multivariable adjusted[b]	1.00	1.00 (0.87-1.15)	0.90 (0.78-1.04)	0.88 (0.75-1.03)	0.86 (0.72-1.04)	0.03	0.96 (0.92-0.99)
Sugar-sweetened Beverages and Fruit Juice							
cases/noncases	1315/5348	371/1518	304/1285	238/1069	198/1012		
age + energy adjusted	1.00	1.06 (0.93-1.21)	1.06 (0.92-1.22)	1.04 (0.89-1.22)	0.93 (0.78-1.10)	0.95	1.00 (0.97-1.03)
multivariable adjusted[b]	1.00	0.97 (0.85-1.11)	0.95 (0.82-1.10)	0.89 (0.75-1.05)	0.79 (0.66-0.95)	0.01	0.96 (0.93-0.99)
Alcohol							
cases/noncases	96/358	593/2305	575/2280	345/1522	817/3767		
age + energy adjusted	1.00	0.80 (0.62-1.03)	0.83 (0.64-1.07)	0.73 (0.56-0.95)	0.71 (0.56-0.91)	0.002	0.95 (0.92-0.98)
multivariable adjusted[b]	1.00	0.93 (0.71-1.21)	0.98 (0.75-1.27)	0.85 (0.65-1.11)	0.87 (0.68-1.13)	0.11	0.97 (0.94-1.01)
Whole Grains							
cases/noncases	271/1004	877/3773	883/3635	324/1406	71/414		
age + energy adjusted	1.00	0.84 (0.72-0.99)	0.83 (0.71-0.97)	0.75 (0.62-0.90)	0.53 (0.39-0.71)	< 0.001	0.90 (0.86-0.95)
multivariable adjusted[b]	1.00	0.91 (0.77-1.07)	0.99 (0.84-1.17)	0.97 (0.80-1.18)	0.79 (0.58-1.07)	0.93	1.00 (0.95-1.05)
Omega-3 Fatty Acids							
cases/noncases	80/339	167/622	281/1037	440/1705	1458/6529		
age + energy adjusted	1.00	1.30 (0.95-1.77)	1.28 (0.96-1.71)	1.26 (0.95-1.66)	1.07 (0.83-1.39)	0.01	0.95 (0.92-0.99)
multivariable adjusted[b]	1.00	1.16 (0.85-1.60)	1.16 (0.86-1.56)	1.18 (0.90-1.57)	1.05 (0.80-1.38)	0.12	0.97 (0.93-1.01)
Polyunsaturated Fatty Acids							
cases/noncases	11/35[e]	323/1282	1125/4571	763/3264	204/1080		
age adjusted		1.00	0.99 (0.86-1.15)	0.96 (0.83-1.12)	0.74 (0.61-0.91)	0.002	0.92 (0.87-0.97)
multivariable adjusted[b]		1.00	0.96 (0.83-1.11)	0.91 (0.78-1.06)	0.74 (0.61-0.91)	0.002	0.91 (0.86-0.97)
Sodium							
cases/noncases	392/1537	530/2178	545/2372	543/2255	416/1890		
age + energy adjusted	1.00	0.86 (0.73-1.02)	0.78 (0.64-0.93)	0.74 (0.60-0.92)	0.63 (0.50-0.81)	< 0.001	0.90 (0.85-0.95)
multivariable adjusted[b]	1.00	1.02 (0.86-1.21)	1.03 (0.85-1.25)	1.08 (0.87-1.35)	0.98 (0.76-1.27)	0.74	1.01 (0.95-1.08)

AHEI, Alternative Healthy Eating Index; SF-36, Medical Outcomes Short Form-36; a. linear trend over continuous scores; b. adjusted for age (continuous), total energy intake (except for polyunsaturated fatty acid component) (continuous), body mass index (continuous), pack-years of smoking (never smoker, < 10, 10-19, 20-29, ≥30, missing), current smoker (no,yes), physical activity (< 18, 18-29, 30-41, 42-53, ≥ 54 MET-h/week, missing), Geriatric Depression Score (0, 1, 2-4, 5-15, missing), cancer (no,yes), myocardial infarction (no,yes), stroke (no,yes), diabetes (no,yes), hypertension (no,yes), and high cholesterol (no,yes); c. Component scores categorized such that higher score always indicates healthier consumption patterns; for example, higher fruit score indicates more fruit intake, and higher sodium score indicates less intake of sodium; d. Analyses were not conducted for the trans fatty acid component because all men had scores in the top two categories; e. Reference categories with fewer than 50 cases were combined with the next higher category.

Table 3

Multivariable odds ratios[a] (95% confidence intervals) of physical function impairment in 2012, as measured by the Physical Function scale of SF-36, by consumption of the top food contributors to the AHEI food components in HPFS men

Foods (serving size [b])	mean servings/week	never or < 1/month [c]	1-3/month	1/week	2-4/week	≥5/week [c]	P_{trend} [d]
Vegetables							
Lettuce, leaf or head (1 cup)	4.1	1.00		0.93 (0.76-1.15)	0.85 (0.71-1.03)	0.76 (0.62-0.92)	0.007
Tomatoes (2 slices)	3.4	1.00		1.01 (0.84-1.20)	0.91 (0.78-1.06)	0.90 (0.76-1.07)	0.19
Onions, raw (1 slice) or cooked (½ cup)	3.0	1.00	1.22 (0.97-1.53)	1.07 (0.87-1.33)	1.11 (0.91-1.37)	1.07 (0.86-1.33)	0.63
Carrots, raw (½) or cooked (½ cup)	2.6	1.00	1.25 (0.95-1.66)	1.25 (0.95-1.64)	1.23 (0.93-1.62)	1.07 (0.79-1.44)	0.16
Broccoli (½ cup)	1.6	1.00	1.02 (0.84-1.23)	1.06 (0.88-1.29)	0.93 (0.76-1.13)	0.71 (0.49-1.05)	0.02
Fruits							
Bananas (1)	2.9	1.00	0.99 (0.80-1.23)	1.08 (0.87-1.33)	1.02 (0.84-1.23)	0.97 (0.79-1.20)	0.56
Apples or pears, fresh (1)	2.3	1.00	1.13 (0.92-1.37)	1.01 (0.82-1.24)	1.05 (0.86-1.27)	1.05 (0.83-1.33)	0.67
Oranges (1)	1.6	1.00	1.07 (0.93-1.24)	1.08 (0.93-1.27)	1.04 (0.90-1.21)	1.16 (0.92-1.46)	0.48
Raisins (1 oz) or grapes (½ cup)	1.2	1.00	0.99 (0.88-1.12)	0.98 (0.84-1.14)	0.89 (0.76-1.03)	1.05 (0.82-1.35)	0.60
Blueberries (½ cup)	1.0	1.00	1.00 (0.90-1.11)	0.92 (0.79-1.07)	0.82 (0.70-0.95)		0.005
Nuts and Legumes							
Peanut butter (1 tablespoon)	1.9	1.00	1.16 (1.02-1.33)	1.12 (0.96-1.30)	1.03 (0.90-1.18)	1.02 (0.85-1.23)	0.48
Peanuts (1 oz)	1.5	1.00	1.09 (1.00-1.24)	1.05 (0.89-1.23)	0.97 (0.84-1.14)	0.82 (0.65-1.04)	0.02
Walnuts (1 oz)	0.7	1.00	1.07 (0.96-1.19)	0.97 (0.82-1.16)	0.80 (0.68-0.94)		0.01
Other nuts (1 oz)	1.5	1.00	0.92 (0.81-1.04)	0.82 (0.71-0.96)	0.80 (0.69-0.92)	0.76 (0.61-0.96)	0.003
Beans or lentils (½ cup)	1.1	1.00	0.94 (0.81-1.10)	1.01 (0.85-1.19)	0.88 (0.73-1.06)		0.31
Red and Processed Meats							
Beef or lamb (4-6 oz)	1.9	1.00	1.00 (0.79-1.26)	1.02 (0.82-1.27)	1.07 (0.86-1.34)	1.19 (0.87-1.63)	0.12
Hamburger (1 patty)	1.0	1.00	1.08 (0.93-1.26)	1.18 (1.00-1.39)	1.25 (1.03-1.51)		0.006
Hot dog (1)	0.7	1.00	1.00 (0.90-1.12)	1.09 (0.94-1.26)	1.14 (0.96-1.36)		0.26
Bacon (2 slices)	0.7	1.00	1.07 (0.95-1.19)	1.20 (1.04-1.39)	1.17 (0.99-1.39)		0.03
Pork (4-6 oz)	0.6	1.00	1.10 (0.97-1.24)	1.10 (0.94-1.28)	1.18 (0.90-1.54)		0.17
Sugar-sweetened Beverages and Fruit Juice							
Orange juice (small glass)	1.7	1.00	1.00 (0.87-1.16)	0.95 (0.81-1.11)	1.01 (0.89-1.14)	0.95 (0.81-1.12)	0.63
Carbonated beverages (1 glass/bottle/can)	1.1	1.00	1.17 (1.04-1.33)	1.17 (1.01-1.36)	1.18 (1.01-1.37)	1.23 (0.99-1.53)	0.03
Grapefruit juice (small glass)	0.8	1.00	0.91 (0.81-1.02)	0.86 (0.74-1.01)	0.86 (0.73-1.01)	1.01 (0.75-1.36)	0.28
Other juices (small glass)	1.0	1.00	1.25 (1.11-1.41)	1.13 (0.97-1.30)	0.97 (0.83-1.12)	1.14 (0.87-1.48)	0.85
Punch, lemonade, iced tea, other non-carbonated drinks (1 glass/bottle/can)	0.8	1.00	1.06 (0.94-1.19)	1.13 (0.97-1.32)	1.10 (0.93-1.30)	1.12 (0.84-1.48)	0.24

AHEI, Alternative Healthy Eating Index; SF-36, Medical Outcomes Short Form-36; a. adjusted for age (continuous), total energy intake (continuous), body mass index (continuous), pack-years of smoking (never smoker, < 10, 10-19, 20-29, ≥30, missing), current smoker (no,yes), physical activity (< 18, 18-29, 30-41, 42-53, ≥ 54 MET-h/week, missing), Geriatric Depression Score (0, 1, 2-4, 5-15, missing), cancer (no,yes), myocardial infarction (no,yes), stroke (no,yes), diabetes (no,yes), hypertension (no,yes), and high cholesterol (no,yes); b. 1 cup = 240 mL; 1 tablespoon = 15 mL; 1 fl oz = 30 mL; 1 oz = 28 g; 1 small glass = 120 mL; 1 glass/bottle/can = 360 mL; c. A reference category with fewer than 50 cases was combined with the next higher category, and a top category with fewer than 50 cases was combined with the next lower category; d. linear trend using median food intakes per category

Associations between the top food contributors to each food-based AHEI component and physical impairment are shown in Table 3. In these analyses, we considered absolute intake categories rather than devising a score representing better and worse levels of intake. Higher consumption of lettuce (OR=0.76, 95% CI=0.62-0.92 comparing top versus bottom category of intake, P_{trend} =0.007), broccoli (OR=0.71, 95% CI 0.49-1.05, P_{trend} =0.02), blueberries (OR=0.82, 95% CI 0.70-0.95, P_{trend} =0.005), peanuts (OR=0.82, 95% CI 0.65-1.04, P_{trend} =0.02), walnuts (OR=0.80, 95% CI 0.68-0.94, P_{trend} =0.01) and other nuts (OR=0.76, 95% CI 0.61-0.96, P_{trend} =0.003) were associated with lower odds of impairment. In contrast, higher intakes of hamburger (OR=1.25, 95% CI 1.03-1.51, P_{trend} =0.006), bacon (OR=1.17, 95% CI 0.99-1.39, P_{trend} =0.03), and sugar-sweetened carbonated beverages (OR=1.23, 95% CI 0.99-1.53, P_{trend} =0.03) were associated with higher odds of physical function impairment.

In additional analyses, we tested definitions of physical impairment that were stricter than the ≤ 80 physical function score used to define impairment in our primary analysis; results remained very similar. Using a physical function score of ≤ 70, the OR per 10-point increase in total AHEI score was 0.88 (95% CI 0.84-0.92), and using a score of ≤ 60, the OR was 0.92 (95% CI 0.87-0.96). We also examined total AHEI and physical impairment within strata of age (≤ 75 and ≥ 75 years), BMI (≤ 25 and ≥ 25 kg/m^2) and physical activity (≤ 35 and ≥ 35 MET-hours/week) and found significant inverse associations in all six strata (data not shown).

Discussion

In this large, cohort study, a healthier diet pattern was associated with approximately a 25% lower likelihood of developing impairment in physical function with aging. Overall, the AHEI diet pattern appeared more strongly associated with physical function than the individual components or individual foods, although greater intake of vegetables, nuts and legumes, and polyunsaturated fats, and lower intake of red/processed meats, and sugar-sweetened beverages was associated with modestly lower odds of physical function impairment. Similarly, when we considered specific foods, greater intakes of lettuce, broccoli, peanuts, walnuts and other nuts were associated with reduced odds of physical function impairment.

Our results are consistent with prior studies supporting an association between diet quality and physical function. This association has been observed across a range of dietary patterns including the Mediterranean diet (19-21), Diet Quality Index Revised (22), Prudent Diet Score (23), and the Healthy Eating Index (24) and across different self-reported (19, 23, 25) and in-person assessments (20, 22, 26, 27) of physical function. However, much of this prior work has been limited by cross-sectional study designs, with only one measure of physical function; thus it cannot be determined whether better diet leads to better physical function or the reverse. Our prospective design was a major strength of the current study, including exclusion at baseline of men with poor physical function, thus minimizing the likelihood of reverse causation bias.

When we investigated the individual components of the AHEI score in relation to physical function, we found that greater intake of vegetables, nuts and legumes, and polyunsaturated fats were associated with modestly lower odds of physical function impairment. This finding is also consistent with prior work that has found increased vegetable (26, 28, 29) and nut/legume (6) intake to be association with better physical function. There are clear biological rationales for these findings. First, dietary patterns characterized by higher intakes of fruit, vegetables, legumes, fish, poultry and whole grains are inversely associated with plasma concentrations of inflammation markers (30). Secondly, antioxidants found in fruits and vegetables may reduce the accumulation of oxidative damage, and therefore decrease the risk of oxidative-related chronic diseases, such as cardiovascular disease, cancer, and neurodegenerative diseases (31, 32). Additionally, increased nut intake is associated with a reduction in the incidence of cardiovascular disease (33). Inflammation, oxidative stress and related chronic diseases are all strongly related to physical function (28, 34, 35), supporting the findings observed in this study.

Our study had numerous strengths including the multiple measures of diet and physical function, the ability to control for multiple potential confounders, and the large sample size. Potential limitations also need to be considered. Residual confounding cannot be ruled out in an observational study, and thus results should be interpreted with caution. However, associations between diet quality and physical function remained strong and significant after adjustment for a wide array of health and lifestyle factors. Also, there is potential for measurement error in both the dietary assessment and the outcome measurement. However, both assessment instruments are validated, and averages of diet were used to reduce measurement error of the exposure. Additionally, dietary intake was collected prospectively, and thus any misreporting of diet is expected to be random and would result in bias toward the null, suggesting that our results may underestimate true associations. Additionally, the SF-36 has been found to correlate well with in-person physical performance measures such as grip strength, longer timed-up-and-go, chair rises, three-minute walk test, and the six-minute walk test (36-38).

In summary, we found that better diet quality as measured by the AHEI was associated with lower odds of incident physical function impairment among older men. We also identified several food groups and foods associated with better physical function, such as vegetables (e.g., lettuce, broccoli) and nuts and legumes (e.g., peanuts, walnuts and other nuts). Given the value of physical function to health and quality of life, this may represent a particularly compelling public health rationale for improved focus on a healthy diet with aging.

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Ethical standards: The study was approved by the Institutional Review Boards of Brigham and Women's Hospital and the Harvard T.H. Chan School of Public Health.

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