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ORIGINAL RESEARCH ARTICLE

Relationship of physical activity and healthy eating with mortality and incident heart failure among community-dwelling older adults with normal body mass index

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Abstract

Aims Normal body mass index (BMI) is associated with lower mortality and may be achieved by physical activity (PA), healthy eating (HE), or both. We examined the association of PA and HE with mortality and incident heart failure (HF) among 2040 community-dwelling older adults aged ≥ 65 years with baseline BMI 18.5 to 24.99 kg/m^2 during 13 years of follow-up in the Cardiovascular Health Study.

Methods and results Baseline PA was defined as ≥500 weekly metabolic equivalent task-minutes and HE as ≥5 daily servings of vegetable and fruit intake. Participants were categorized into four groups: (i) PA−/HE− (*n* = 384); (ii) PA−/HE+ (*n* = 162); (iii) PA+/HE− (*n* = 992); and (iv) PA+/HE+ (*n* = 502). Participants had a mean age of 74 (±6) years, mean BMI of 22.6 (±1.5) kg/m^2, 61% were women, and 4% African American. Compared with PA−/HE−, age-sex-race-adjusted hazard ratios and 95% confidence intervals for all-cause mortality for PA−/HE+, PA+/HE−, and PA+/HE+ groups were 0.96 (0.76–1.21), 0.61 (0.52–0.71), and 0.62 (0.52–0.75), respectively. These associations remained unchanged after multivariable adjustment and were similar for cardiovascular and non-cardiovascular mortalities. Respective demographic-adjusted hazard ratios (95% confidence intervals) for incident HF among 1954 participants without baseline HF were 1.21 (0.81–1.81), 0.71 (0.54–0.94), and 0.71 (0.51–0.98). These latter associations lost significance after multivariable adjustment.

Conclusion Among community-dwelling older adults with normal BMI, physical activity, regardless of healthy eating, was associated with lower risk of mortality and incident HF, but healthy eating had no similar protective association in this cohort.

Keywords Physical activity; Healthy eating; Incident heart failure; Older adults

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Normal body mass index (BMI) has been shown to be associated with lower mortality and incident cardiovascular (CV) events.[1–5] Normal BMI maybe achieved by physical activity (PA), healthy eating (HE), or both.[6] However, it is unclear which has a stronger association with lower mortality. In the current analysis, we examined the association of PA and HE with mortality and incident heart failure (HF) among older adults with a normal BMI.

Methods

We used de-identified data from the Cardiovascular Health Study (CHS) obtained from the National Heart, Lung and Blood Institute, which also sponsored the study. CHS is an ongoing, prospective, community-based epidemiologic study of CV disease risk factors in older adults.[7–9] The 5888 CHS participants were a random sample of Medicare-eligible older adults recruited from four US counties in two phases. The rationale and design of the CHS have been previously reported.[7] The current analysis is based on 5795 participants in the public-use copy of the CHS data. Of the CHS participants, 93 did not consent to be included in the de-identified public-use data. The current analysis was restricted to 2040 community-dwelling older adults aged ≥65 years with BMI 18.5 to 24.99 kg/m^2 who had data on baseline PA and HE. PA was estimated by weekly metabolic equivalent task-minutes (MET-minutes) and HE as measured by daily vegetable and fruit intake.[10] Baseline leisure-time PA was assessed using a modified Minnesota Leisure-Time Activities questionnaire, which evaluated frequency and duration of 15 different activities during a 2 week period and was used to estimate kilocalories of energy expended per week.[11] MET-minutes were calculated as total kilocalories per week = total MET-minutes per week × 0.0175 × body weight in kilogrammes. Based on the MET-minutes cutoffs used in the 2008 Physical Activity Guidelines for Americans,[12] we categorized those with MET-minutes ≥ 500 as PA+. At baseline, study participants were asked 'How many fruits do you usually eat per day or per week not counting juices?' and 'About how many servings of vegetables do you eat per day of the week not counting salads or potatoes?' Based on the US Department of Agriculture Dietary Guidelines, we categorized consumption of ≥5 daily servings of vegetable and fruits as HE+. Participants were then categorized into four groups: (i) PA−/HE− (n = 384); (ii) PA−/HE+ (n = 162); (iii) PA+/HE− (n = 992); and (iv) PA+/HE+ (n = 502).

Outcomes of interest in the current analysis were centrally adjudicated all-cause, CV and non-CV mortality and incident HF during over 13 years of follow-up.[13] For descriptive analyses, we used Pearson's chi-square test for categorical variables and analyses of variance for continuous variables. Hazard ratios (HRs) and 95% confidence intervals (CIs) for outcomes were estimated using two different Cox proportional hazard models: (i) adjusting for age, sex, and race and (ii) with additional adjustment for income, pack-years of smoking, weekly alcohol consumption, body mass index, self-reported general health, instrumental activities of daily living, depression, dementia, heart failure, hypertension, prior myocardial infarction, diabetes, atrial fibrillation, stroke, peripheral arterial disease, chronic obstructive pulmonary disease, cancer, left ventricular systolic dysfunction, serum creatinine, haemoglobin, serum cholesterol, and serum C-reactive protein. The analyses for incident HF was based on a subgroup of 1954 participants free of prevalent HF at baseline.

Results

Participants (n = 2040) had a mean (±SD) age of 74 (±6) years, a mean BMI of 22.6 (±1.5) kg/m^2, 61% were women, and 4% were African American. Participants with higher levels of baseline PA and HE were more likely to be younger, Caucasians, and more likely to have a lower prevalence of CV risk factors such as hypertension, diabetes, and coronary artery disease (*Table 1*).

Compared with PA−/HE−, age-sex-race-adjusted hazard ratios (HRs) and 95% confidence intervals (CIs) for all-cause mortality associated with PA−/HE+, PA+/HE−, and PA+/HE+ were 0.96 (0.76–1.21), 0.61 (0.52–0.71), and 0.62 (0.52–0.75), respectively (*Table 2* and *Figure 1*). These associations remained unchanged after multivariable adjustment. Similar associations were observed for cardiovascular and non-cardiovascular mortalities (*Table 2*).

Among the 1954 participants without baseline HF, compared with PA−/HE−, age-sex-race-adjusted HRs and 95% CIs for incident HF associated with PA−/HE+, PA+/HE−, and PA+/HE+ were 1.21 (0.81–1.81), 0.71 (0.54–0.94), and 0.71 (0.51–0.98), respectively (*Table 3*). These associations remained unchanged after multivariable adjustment.

Discussion

Findings from the current study demonstrate that among community-dwelling older adults with a normal BMI, a total weekly PA in the range of 500 MET-minutes or higher were associated with lower risk of all-cause, cardiovascular and non-cardiovascular mortalities, regardless of HE as defined by consumption of five or more daily servings of vegetables and fruits. These protective associations were independent of other risk factors. Consumption of five or more daily servings of vegetables and fruits, on the other hand, had no association with mortality, regardless of PA. HE also had no association with incident HF. However, as previously observed by us, PA had a weak association with incident HF.[10] These findings suggest that for older adults with a normal BMI, PA maybe more beneficial than HE, although bias due to confounding or misclassification of HE is possible.

Both PA and HE have been shown to be associated with lower mortality and cardiovascular events.[1–5,14–18] It is not clear why in our study, HE had no association with outcomes. In CHS, both PA and HE were self-reported. However, findings from our baseline characteristics suggest that baseline characteristics that are markers of PA such as activities of daily living, walking, and time to walk correlated well with PA so that those in PA group performed them better. Although we had no such variables reflective HE habit, self-reports of never eating chicken skin, a potential surrogate for HE, was not statistically different between those with and without HE. This suggests that self-reports of HE may not be as reliable as self-reports of PA, which may potentially explain the lack of association of HE with better outcomes. Also, in our study, the prevalence of coronary artery disease was lower in the PA group than in the HE group. If one assumes that both PA and HE preceded baseline coronary artery disease,

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Table 1. Baseline characteristics

Mean (±SD) or *n* (%)	PA−/HE− (*n* = 384)	PA−/HE+ (*n* = 162)	PA+/HE− (*n* = 992)	PA+/HE+ (*n* = 502)	*P*-value
Age, years	76 (±6)	75 (±6)	74 (±6)	73 (±6)	<0.001
Women	240 (63%)	98 (61%)	589 (59%)	310 (62%)	0.686
African American	25 (7%)	10 (6%)	31 (3%)	12 (2%)	0.003
Education, college or higher	178 (46%)	71 (44%)	463 (47%)	256 (51%)	0.283
Income >25 000	150 (39%)	67 (41%)	382 (39%)	227 (45%)	0.084
Alcohol, drinks per week	2.6 (±7)	3.1 (±7)	2.7 (±7)	2.6 (±7)	0.837
Smoke, pack-years	19 (±28)	19 (±28)	15(±28)	17 (±28)	0.026
Never eat chicken skin	277 (73%)	119 (74%)	754 (76%)	383 (76%)	0.255
Body mass index, kg/m^2	22.5 (±2)	22.8 (±2)	22.5 (±2)	22.7 (±2)	0.115
Systolic blood pressure, mmHg	135 (±23)	137 (±24)	134 (±22)	133 (±22)	0.167
Diastolic blood pressure, mmHg	70 (±11)	69 (±11)	69 (±11)	68 ((±11)	0.460
Medical problems					
Coronary heart diseases	104 (27%)	36 (22%)	167 (17%)	86 (17%)	<0.001
Acute myocardial infarction	51 (13%)	20 (12%)	84 (9%)	43 (9%)	0.025
Angina pectoris	91 (24%)	28 (17%)	132 (13%)	74 (15%)	<0.001
Hypertension	209 (54%)	89 (55%)	488 (49%)	236 (47%)	0.085
Diabetes mellitus	53 (14%)	28 (17%)	84 (9%)	37 (7%)	<0.001
Stroke	25 (7%)	6 (4%)	23 (3%)	17 (3%)	0.002
Atrial fibrillation	15 (4%)	6 (4%)	26 (3%)	15 (3%)	0.612
Chronic obstructive pulmonary disease	67 (17%)	25 (15%)	125 (13%)	54 (11%)	0.022
Arthritis	193 (50%)	87 (54%)	461 (47%)	226 (45%)	0.149
Cancer	68 (18%)	25 (15%)	142 (14%)	73 (15%)	0.449
Left ventricular hypertrophy	13 (3%)	10 (6%)	39 (4%)	27 (5%)	0.280
Left ventricular ejection fraction >55%	348 (91%)	928 (94%)	146 (90%)	461 (92%)	0.177
Geriatric problems					
Activity of daily living	0.17 (±0.06)	0.15 (±0.06)	0.04 (±0.06)	0.03 (±0.06)	<0.001
Instrumental activity of daily living	0.67 (±1)	0.52 (±1)	0.26 (±1)	0.20 (±1)	<0.001
Blocks walked last week	18.80 (±59)	21.58 (±59)	50.09 (±59)	52.52 (±59)	<0.001
Time to walk 15 ft	6.9 (±3.3)	5.9 (±2.2)	5.5 (±1.6)	5.4 (±1.5)	<0.001
Mini-mental state examination score	27 (±3)	27 (±2)	28 (±3)	28 (±2)	0.001
Depression score	5.3 (±5)	5.3 (±5)	4.3 (±5)	4.2 (±5)	<0.001
Laboratory measures					
Serum cholesterol, mg/dL	212 (±41)	206 (±41)	209 (±41)	209 (±41)	0.557
Serum triglyceride, mg/dL	126 (±69)	137 (±69)	124 (±69)	120 (±69)	0.026
Serum creatinine, mg/dL	0.98 (±1)	1.01 (±1)	0.92 (±1)	0.93 (±1)	0.002
Serum potassium, mEq/L	4.16 (±0.4)	4.2 (±0.4)	4.21 (±0.4)	4.18 (±0.4)	0.156
Serum albumin, g/dL	3.9 (±0.3)	4.0 (±0.3)	4.0 (±0.3)	4.0 (±0.3)	0.417
Serum uric acid, mg/dL	5.4 (±2)	5.5 (±2)	5.2 (±2)	5.1 (±2)	<0.001
Serum C-reactive protein, mg/dL	4.5 (±7)	4.6 (±7)	3.6 (±7)	3.4 (±7)	0.014
Serum interleukin-6, pg/mL	2.5 (±2)	2.4 (±2)	1.9 (±2)	1.8 (±2)	<0.001
Serum insulin, µIU/mL	12.6 (±34)	16.1 (±34)	12.6 (±34)	11.9 (±34)	0.034
Fibrinogen, mg/dL	326 (±70)	318 (±70)	311 (±70)	313 (±70)	0.002

HE, healthy eating; PA, physical activity.

then one might conclude that the beneficial health effect of PA was stronger than that of HE. However, no such correlation was observed for diabetes, the incidence of which may also be affected by PA and HE. In contrast, we observed that the prevalence of chronic obstructive pulmonary disease, the incidence of which is not known to be affected by PA or HE, varied across PA and HE subgroups, suggesting that baseline chronic obstructive pulmonary disease had a more profound impact on PA than on HE.

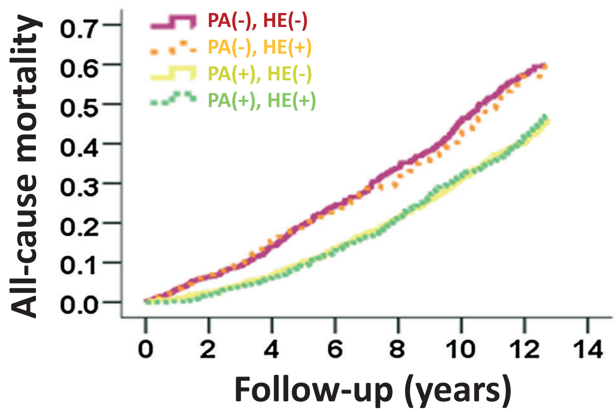
Another potential explanation is that health benefits of HE maybe attenuated among older adults as prior studies demonstrating associations of PA and HE with lower mortality and cardiovascular events were based on children and younger adults.[1–5,14–18] For example, findings from the United States National Health and Nutrition Examination Survey 2003–06 suggest that PA and HE were associated with lower cardiovascular biomarkers.[14] However, participants in that study were children 6–17 years, and the authors of that study used a more comprehensive Healthy Eating Index, a measure of diet quality in terms of conformance to United States federal dietary guidance. Similarly, the Indonesia Nutrition and Health Surveillance System study suggesting an association of fruits and vegetable consumption with lower odds of mortality was based on children under the age of 5 years.[15] In contrast, the Finnish Kuopio Ischemic Heart Disease Risk Factor study that demonstrated an association between high fruit and vegetable intake and lower risk of mortality was among middle-aged (mean age, 53 years) men. Findings from a study of patients with apparent treatment-resistant hypertension (mean age, 67 years) also have suggested that higher PA may have stronger association with lower risk for cardiovascular events and mortality than dietary factors such as moderate alcohol consumption, high Dietary Approaches to Stop Hypertension diet score, and low sodium-to-potassium

Table 2. Mortality by physical activity and healthy eating

	% (Events)	Unadjusted hazard ratio (95% Confidence interval)	Age-sex-race-adjusted hazard ratio (95% Confidence interval)	Multivariable-adjusted hazard ratio[a] (95% Confidence interval)
All-cause mortality				
PA−/HE−(*n* = 384)	64% (245)	1.00 (Reference)	1.00 (Reference)	1.00 (Reference)
PA−/HE+ (*n* = 162)	61% (98)	0.90 (0.71–1.13); $P = 0.358$	0.96 (0.76–1.21); $P = 0.719$	0.97 (0.76–1.23); $P = 0.779$
PA+/HE− (*n* = 992)	46% (452)	0.56 (0.48–0.66); $P < 0.001$	0.61 (0.52–0.71); $P < 0.001$	0.76 (0.65–0.90); $P = 0.001$
PA+/HE+ (*n* = 502)	44% (219)	0.53 (0.44–0.63); $P < 0.001$	0.62 (0.52–0.75); $P < 0.001$	0.75 (0.62–0.91); $P = 0.003$
Cardiovascular mortality				
PA−/HE− (*n* = 384)	24% (93)	1.00 (Reference)	1.00 (Reference)	1.00 (Reference)
PA−/HE+ (*n* = 162)	25% (40)	0.97 (0.67–1.41); $P = 0.888$	1.04 (0.72–1.51); $P = 0.839$	0.98 (0.67–1.44); $P = 0.926$
PA+/HE− (*n* = 992)	17% (169)	0.56 (0.44–0.73); $P < 0.001$	0.59 (0.46–0.77); $P < 0.001$	0.79 (0.60–1.03); $P = 0.083$
PA+/HE+ (*n* = 502)	15% (76)	0.49 (0.36–0.66); $P < 0.001$	0.57 (0.42–0.78); $P < 0.001$	0.70 (0.51–0.97); $P = 0.031$
Non-cardiovascular mortality				
PA−/HE− (*n* = 384)	39% (151)	1.00 (Reference)	1.00 (Reference)	1.00 (Reference)
PA−/HE+ (*n* = 162)	35% (57)	0.84 (0.62–1.14); $P = 0.263$	0.90 (0.66–1.22); $P = 0.502$	0.94 (0.69–1.28); $P = 0.701$
PA+/HE− (*n* = 992)	28% (282)	0.57 (0.47–0.69); $P < 0.001$	0.62 (0.50–0.75); $P < 0.001$	0.75 (0.61–0.93); $P = 0.007$
PA+/HE+ (*n* = 502)	29% (143)	0.56 (0.44–0.70); $P < 0.001$	0.66 (0.52–0.83); $P < 0.001$	0.79 (0.62–1.00); $P = 0.053$

HE, healthy eating; PA, physical activity.
[a]Adjusted with age, sex, race, education, income, alcohol, smoking, body mass index, coronary artery disease, acute myocardial infarction, hypertension, diabetes, stroke, atrial fibrillation, left ventricular hypertrophy, left ventricular systolic dysfunction, systolic blood pressure, diastolic blood pressure, depression score, mini-mental state examination score, serum cholesterol, serum albumin, serum creatinine, and serum C-reactive protein.

Figure 1 Age-sex-race-adjusted survival plots. PA, physical activity; HE, healthy eating.



intake ratio.[19] In contrast to these studies, CHS participants were older (mean age, 75 years), and in addition, participants in our study had a normal BMI. Although participants in the Massachusetts Health Care Panel Study were also older adults, it only examined the association of consumption of carotene-containing fruits and vegetables with lower cardiovascular mortality.[17]

Our study has several limitations. Despite attempts to adjust for confounding, risk factors using multivariable modelling, residual bias, and bias due to unmeasured confounders are possible. We had no data on PA and HE during follow-up, and a higher degree of misclassification of HE than PA would result in a higher degree of regression dilution that could potentially result in the loss of association between HE and mortality benefit. We also had no data on duration and severity of the baseline risk factors such as CAD or diabetes, the incidence of which was affected by PA and HE and vice versa. Finally, we had no data on left ventricular ejection fraction for those with incident HF, which limited our ability to study whether the associations of PA and HE with mortality would vary between incident systolic vs. diastolic HF.

In conclusion, we observed that among community-dwelling older adults with normal BMI, ≥500 MET-minutes

Table 3. Incident heart failure by physical activity and healthy eating

	% (events/total)	Unadjusted hazard ratio (95% confidence interval)	Age-sex-race adjusted hazard ratio (95% confidence interval)	Multivariable-adjusted hazard ratio[a] (95% confidence interval)
PA–/HE–(n=356)	21% (73)	1.00 (Reference)	1.00 (Reference)	1.00 (Reference)
PA–/HE+ (n=152)	24% (37)	1.16 (0.78–1.73); p=0.458	1.21 (0.81–1.80); p=0.351	1.26 (0.84–1.89); p=0.266
PA+/HE– (n=961)	17% (164)	0.67 (0.51–0.89); p=0.005	0.71 (0.54–0.94); p=0.017	0.92 (0.67–1.21); p=0.486
PA+/HE+ (n=485)	16% (78)	0.62 (0.45–0.85); p=0.003	0.71 (0.51–0.98); p=0.037	0.88 (0.63–1.23); p=0.450

HE, healthy eating; PA, physical activity.
[a]Adjusted with age, sex, race, education, income, alcohol, smoking, body mass index, coronary artery disease, acute myocardial infarction, hypertension, diabetes, stroke, atrial fibrillation, left ventricular hypertrophy, left ventricular systolic dysfunction, systolic blood pressure, diastolic blood pressure, depression score, Mini-mental state examination score, serum cholesterol, serum albumin, serum creatinine and serum C-reactive protein

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of PA weekly was associated with lower risk of mortality, regardless of HE, while HE alone had no such association. These hypotheses-generating findings need to be prospectively examined other populations.

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Declaration of interest

None declared.

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