Health behavior characteristics and all-cause mortality

Paul D. Loprinzi

Jackson Heart Study Vanguard Center of Oxford, Department of Health, Exercise Science and Recreation Management, Physical Activity Epidemiology Laboratory, The University of Mississippi, 229 Turner Center, University MS, 38677 Oxford, MS, United States

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ABSTRACT

Objective. To examine the potential dose–response relationship between four positive health characteristics (i.e., normal body mass index, physically active, healthy diet and non-smoker) and all-cause mortality.

Methods. Data from the 2003–2006 NHANES were used (20 + years; N = 5844), with follow-up through 2011. Participants wore an ActiGraph 7164 accelerometer over a period of up to 7 days to assess physical activity. Dietary behavior and smoking were assessed via self-report. Body mass index was measured using standard procedures.

Results. There was a clear dose–response relationship between the number of positive health characteristics and all-cause mortality. After adjusting for age, gender, race-ethnicity and comorbid illness, and compared to those with 0 positive health characteristics, those with 1, 2, 3, and 4, respectively, had a 39% (HR = 0.61; 95% CI: 0.40–0.94), 48% (HR = 0.52; 95% CI: 0.34–0.80), 62% (HR = 0.38; 95% CI: 0.22–0.64) and 88% (HR = 0.12; 95% CI: 0.05–0.29) reduced risk of all-cause mortality.

Conclusions. Adoption of more positive health characteristics is associated with greater survival.

1. Introduction

In alignment with the American Heart Association's Strategic Impact Goal for 2020 and Beyond, normal body fat percent and health enhancing behaviors, including adequate physical activity, not smoking, and eating healthily, play a pivotal role in reducing the risk for cardiovascular disease, Type 2 diabetes, and some cancers (Lim et al., 2012). These four health characteristics (normal weight, physical activity, healthy diet, and smoking avoidance) are all independently associated with health (Mokdad et al., 2004), with less research examining their additive effects on health. van Dam et al. (2008) used data from the Nurses' Health study and evaluated self-reported cigarette smoking, self-reported BMI, self-reported physical activity, and self-reported healthy diet, and showed that greater adoption of these health characteristics was associated with lower cardiovascular, cancer, and all-cause mortality. These findings are in alignment with those of Ahmed et al. (2013) who, using data from the Multi-Ethnic Study of Atherosclerosis, demonstrated a dose–response association of self-reported smoking, self-reported diet, BMI, and self-reported physical activity on mortality risk. The purpose of this *brief report* is to extend the findings of Van Dam et al. and Ahmed et al. by examining this exact topic (dose–response relationship of health characteristics on mortality (Mokdad et al., 2004)) while employing an objective measure of physical activity in a representative sample of U.S. adults.

E-mail address: pdloprin@olemiss.edu.

2. Methods

2.1. Study design and participants

The present study includes data from the 2003–2006 National Health and Nutrition Examination Survey (only cycles at the time of this writing with objectively-measured physical activity data), which is a nationally representative sample (Centers for Disease Control and Prevention). Data from participants in these cycles were linked to death certificate data from the National Death Index. Person-months of follow-up were calculated from the date of the interview until date of death or censoring on December 31, 2011, whichever came first. Analyses are based on data from 5,844 adults (20–85 yrs) who provided complete data for the study variables. NHANES study procedures were approved by the National Center for Health Statistics ethics review board, with informed consent obtained from all participants prior to data collection.

2.2. Measurement of health characteristics

2.2.1. Physical activity

While attending the mobile examination center, participants were instructed to wear an ActiGraph 7164 accelerometer during all activities, except water-based activities and while sleeping. The accelerometer measured the frequency, intensity, and duration of physical activity by generating an activity count proportional to the measured acceleration. Detailed information on the ActiGraph accelerometer can be

found elsewhere (Chen and Bassett, 2005). Estimates for moderate-to-vigorous physical activity were summarized in 1-minute time intervals. Activity counts/min greater than or equal to 2020 were classified as moderate-to-vigorous physical activity intensity (Troiano et al., 2008). To determine the amount of time the monitor was worn, nonwear was defined by a period of a minimum of 60 consecutive minutes of zero activity counts, with the allowance of 1–2 minutes of activity counts between 0 and 100 (Troiano et al., 2008).

For the analyses described here, and to represent habitual physical activity patterns, only those participants with activity patterns for at least 4 days of 10 or more hours per day of monitoring data were included in the analyses (Troiano et al., 2008). Notably, previous NHANES work from this dataset demonstrates that excluding these invalid participants may introduce bias as those with invalid accelerometer data are demographically and biologically different than those with valid accelerometry data (Loprinzi et al., 2013). As thoroughly described elsewhere (Loprinzi et al., 2013), the exclusion of these participants with invalid accelerometry data may attenuate the evaluated associations. In an attempt to minimize the attenuation of the evaluated associations, sampling weights were used to produce a nationally representative sample of those with valid accelerometer data (Troiano et al., 2008; National Cancer Institute).

Participants were classified as sufficiently active if they engaged in at least 150 min a week of moderate-to-vigorous physical activity. The SAS (version 9.2) was used to reduce the accelerometry data using the SAS code provided the National Cancer Institute. Using the SAS code, the average time each participant spent per day in physical activity was analyzed from valid individual data.

2.2.2. Dietary behavior

Two 24-hour recall assessments of food and fluid intake were collected during participant visits to a mobile examination center. To capture intake on all days of the week, the 24 h recalls were collected on every day of the week across the participant pool (e.g., participant 1 may have been assessed on Monday and Thursday; participant 2 on Tuesday and Friday; etc.). The dietary interviewers used the Dietary Data Collection (DDC) system, which is an automated standardized interactive dietary interview and coding system. The Healthy Eating Index (HEI) 2005 was developed by the USDA as an indicator of dietary quality (Guenther et al., 2007) and is based on the 2005 Dietary Guidelines for Americans (U.S. Department of Health and Human Services and U.S. Department of Agriculture, 2005). The HEI is comprised of 12 components (total fruit; whole fruit; total vegetable; dark green, orange vegetable and legumes; total grain; whole grain; milk; meat and beans; oil; saturated fats; sodium; and calories from solid fats, alcoholic beverages, and added sugars) with each component individually scored, with a maximum total score of 100. A higher score reflects closer adherence to the dietary guidelines for Americans. The HEI was derived for each of the 24 h recall days using the MyPyramid Equivalents Database and following the methods and SAS code established by the USDA Center for Nutrition Policy and Promotion (United States Department of Agriculture; Bowman et al., 2008; United States Department of Agriculture; National Cancer Institute).

Using the average of the two-day HEI scores, participants at or above the 60th percentile (i.e. top 40%) of HEI scores in the population were categorized as adhering to the dietary guidelines or consuming a healthy diet (Ford et al., 2012; Loprinzi et al., 2014).

2.2.3. Smoking

Participants were classified as smokers if they self-reported smoking every day or some days; otherwise, classified as non-smoker. Previous research demonstrates evidence of validity for self-reported smoking assessment (Yeager and Krosnick, 2010).

2.2.4. Weight status

Measured height and weight were used to calculate body mass index (kg/m^2), with normal weight defined as 18.5–24.9 kg/m^2.

2.3. Calculation of summed positive health characteristics

Given that 4 positive health characteristics were assessed (i.e., sufficiently active, healthy diet, non-smoker, and normal body mass index), participants were classified as having 0–4 positive health characteristics by summing the number of health characteristics they had.

2.4. Analysis

Statistical analyses were performed via procedures from survey data using Stata (v.12). Cox proportional hazard models were used to examine the association of the number of health characteristics on all-cause mortality. Covariates included age, gender, race-ethnicity and comorbid illness. The comorbid illness variable included the summed number of the following physician-diagnosed morbidities: arthritis, coronary artery disease, congestive heart failure, heart attack, stroke, diabetes, emphysema and chronic bronchitis. Schoenfeld's residuals were used to verify the proportional hazards assumption. The proportional hazards assumption was not violated (chi-square = 15.66, $P = 0.15$), with the Harrell's C concordance statistic being 0.85.

3. Results

In the analyzed sample of 2003–2006 NHANES participants, which included 5,844 adult participants, 565 died over the follow-up period; unweighted mean follow-up period was 79.4 months (6.6 yrs). In the sample, 464,227 person-months occurred with an incidence rate of 1.21 deaths per 1000 person-months. Weighted characteristics of the study variables are shown in Table 1.

Table 1
Weighted characteristics of the study variables.

Variables	Mean/proportion	95% CI
Age, mean years	46.5	45.5–47.5
% female	51.7	
Race-ethnicity, %		
Mexican American	7.8	
Other Hispanic	3.4	
Non-Hispanic White	72.7	
Non-Hispanic Black	11.0	
Other	5.1	
# comorbidities[a], mean	0.51	0.46–0.55
Follow-up, mean months	80.5	77.9–83.0
% died	5.6	
% non-smoker[b]	78.6	
% healthy diet[c]	37.2	
% Meeting Physical Activity Guidelines[d]	43.2	
% Normal weight[e]	32.2	
% underweight (<18.5 kg/m2)	1.6	
% overweight/obese (25+ kg/m2)	66.2	
Health Characteristics, %		
0	6.4	
1	28.7	
2	37.8	
3	21.4	
4	5.6	

[a] The comorbid illness variable included the summed number of the following physician-diagnosed morbidities: arthritis, coronary artery disease, congestive heart failure, heart attack, stroke, diabetes, emphysema and chronic bronchitis.
[b] Based on self-report and defined as not currently smoking.
[c] Defined as a healthy eating index score at or above the 60th percentile.
[d] Defined as at least 150 min/week of accelerometer-assessed moderate-to-vigorous physical activity.
[e] Defined as a body mass index of 18.5–24.9 kg/m^2.

There was a clear dose–response relationship between the number of positive health characteristics and all-cause mortality. After adjusting for age, gender, race-ethnicity and comorbid illness, and compared to those with 0 positive health characteristics, those with 1, 2, 3, and 4, respectively, had a 39% (HR = 0.61; 95% CI: 0.40–0.94), 48% (HR = 0.52; 95% CI: 0.34–0.80), 62% (HR = 0.38; 95% CI: 0.22–0.64) and 88% (HR = 0.12; 95% CI: 0.05–0.29) reduced risk of all-cause mortality.

4. Discussion

The present brief report provides confirmatory evidence of a dose–response relationship between positive health characteristics and mortality. These findings complement previous work (van Dam et al., 2008; Ahmed et al., 2013) on this topic by employing an objective measure of physical activity and utilizing a national sample of American adults. These findings also highlight the need for the promotion of concurrent health behaviors. Such a task, however, may prove challenging as only 5% of this American sample had all 4 positive health characteristics. Given that the data analyzed herein is over a decade old, future confirmatory work using more recent epidemiological data is warranted.

Acknowledgment

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