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Brief Original Report

Accelerometer-determined physical activity and mortality in a national prospective cohort study: Considerations by visual acuity

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ABSTRACT

Background. Previous research demonstrates that visual impairment (VI) is associated with increased all-cause mortality risk and is also associated with reduced physical activity participation. Although physical activity is reduced among those with VI, no studies have examined the relationship between physical activity and all-cause mortality across different visual function statuses, which is noteworthy of investigation as physical activity is linked with greater survival.

Methods. Data from the 2003–2006 NHANES were employed, with physical activity assessed via accelerometry and visual function assessed using the ARK-760 autorefractor.

Results. For those with normal vision, and after adjustments, for every 60 min increase in physical activity, normal-sighted adults had an 18% (HR = 0.82; 95% CI: 0.72–0.93) reduced risk of all-cause mortality. Similarly, after adjustments and for every 60 min increase in physical activity for those with uncorrected refractive error and VI, respectively, there was a 15% (HR = 0.85; 95% CI: 0.72–1.00) and 35% (HR = 0.65; 95% CI: 0.43–0.98) reduced risk of all-cause mortality. Among all three visual status groups, sedentary behavior was not associated with mortality status.

Conclusion. Among those with varying degrees of visual loss, sedentary behavior was not associated with mortality, but physical activity demonstrated survival benefits.

Introduction

Research demonstrates that visual impairment (VI) is associated with all-cause mortality risk (Christ et al., 2008). The health effects of VI are substantial as impaired vision can lead to a decline in functional status. With a combined decline in physical function and VI, this may be a reflection of biological aging and disease processes, which may be associated with an increased mortality risk (Pedula et al., 2006). Regular participation in physical activity is associated with greater survival in the general population as well as various morbid populations (Kokkinos, 2012). Physical activity in visually impaired individuals is especially important because this population tends to display a high prevalence of hypokinetic conditions, such as obesity, multi-morbidities, and limitations in daily functioning (Holbrook et al., 2013). These limitations may lead to reduced levels of physical activity and thus contribute to an increase in all-cause mortality risk. Further, among those with VI, physical activity may also be restricted due to increased fear of falling, high level of social isolation, and limited opportunities in leisure activities (Holbrook et al., 2013). Although physical activity is reduced among those with VI (Loprinzi et al., 2013a, 2014a, 2015), the potential protective effect of physical activity on mortality among those with VI has yet to be explored. With physical inactivity being associated with further health complications, those with VI may display benefits of leading an active lifestyle (Holbrook et al., 2009). In order to identify evidence-based strategies to prolong survival among this population at risk of early mortality, it is important to examine the relationship between physical activity and mortality among those with varying degrees of visual function. Therefore, the primary purpose of this brief study was to examine if physical activity has a protective effect on survival among those with VI. Based on emerging research suggesting an independent effect of sedentary behavior on health (Owen et al., 2010; Tremblay et al., 2010; Loprinzi, 2015a, 2015b, 2015c; Loprinzi and Ford, 2015; Loprinzi and Kohli, 2013), a secondary objective of this study was to evaluate the association between sedentary behavior and all-cause mortality risk, with considerations by visual function.

Methods

Design and participants

Data were extracted from the 2003–2006 National Health and Nutrition Examination Survey (NHANES; only available cycles with accelerometry data). Data from participants in these cycles were linked

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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 5278 adults (20–85 years) who provided complete data for the study variables.

The NHANES is an ongoing survey conducted by the Centers for Disease Control and Prevention that uses a representative sample of non-institutionalized United States civilians selected by a complex, multistage, stratified, clustered probability design. The multistage design consists of 4 stages, including the identification of counties, segments (city blocks), random selection of households within the segments, and random selection of individuals within the households. Procedures were approved by the National Center for Health Statistics review board. Consent was obtained from all participants prior to data collection. Further information on NHANES methodology and data collection is available on the NHANES website (http://www.cdc.gov/nchs/nhanes.htm).

Visual acuity

Detailed methodology of the vision assessment is described elsewhere (Loprinzi et al., 2013a, 2014a, 2015). Briefly, presenting visual acuity was assessed for each eye. In subjects who had presenting visual acuity worse than 20/30, corrected lenses were removed (if worn) and objective refraction was measured using an ARK-760 autorefractor (Nidek Co Ltd., Tokyo, Japan). Visual acuity of the better-seeing eye was used to classify participants as having normal sight, uncorrected refraction error (URE), or visual impairment (VI). Participants with presenting visual acuity of 20/40 or better in either eye were classified as having normal sight. Participants with presenting visual acuity worse than 20/40, but postrefraction visual acuity in either eye were 20/40 or better, were classified as having URE. Participants with visual acuity worse than 20/40 after autorefraction, or who self-reported not being able to see light with both eyes open, were classified as having VI. Participants with missing data for presenting acuity in both eyes, or with visual acuity worse than 20/40 in both eyes with no autorefraction in either eye, were excluded from the analysis as they were considered to have incomplete visual acuity data.

Objectively-measured physical activity

Physical activity was assessed using the ActiGraph 7164 accelerometer; further details on accelerometry assessment can be found elsewhere (Chen and Bassett, 2005). SAS (version 9.2) was used to reduce accelerometry data to those with ≥4 days of ≥10 h/day of monitored data and integrate it into 1 min time intervals. Non-wear time was identified as ≥60 consecutive minutes of zero activity counts, with allowance for 1–2 min of activity counts between 0 and 100. Activity counts/min ≥100 was used as the threshold to determine time spent at total physical activity across the valid days (i.e., days with at least 10 + h of monitoring) (Loprinzi et al., 2014b). Sedentary behavior was defined as activity counts/min <100 (Matthews et al., 2008). Moderate-to-vigorous physical activity (MVPA) was defined as activity counts/min ≥2020 (Troiano et al., 2008). The average physical activity level across these valid days was calculated for each participant (Loprinzi and Brosky, 2014).

Covariates

Covariates included in the models were based on previous research demonstrating their association with physical activity, vision and mortality risk. Covariates included *age* (continuous; years) (Troiano et al., 2008), gender (Troiano et al., 2008), race-ethnicity (Mexican American, non-Hispanic white, non-Hispanic black, and other) (Congdon et al., 2004), serum cotinine (marker of active/passive smoking status; continuous; ng/mL) (Wells et al., 1998; Wagenknecht et al., 1992; Zhang et al., 2011), poverty-to-income ratio (continuous) (Lee et al., 2012), C-reactive protein (continuous; mg/L) (Loprinzi et al., 2013b), blood pressure/cholesterol medication use (yes/no) (Hirooka and Shiraga, 2007), physician-diagnosed diabetes (Saaddine et al., 1999), a summed non-diabetic comorbid illness index (ordinal variable) (Crews et al., 2006), and accelerometer-assessed sedentary behavior (Katzmarzyk et al., 2009; Patel et al., 2010; Matthews et al., 2012). As a measure of socioeconomic status, the poverty-to-income ratio was assessed (Lee et al., 2012). The poverty-to-income ratio is calculated by dividing the family income by the poverty guidelines, which is specific to the family size, year assessed, and state of residence (Lee et al., 2012). The comorbid illness variable indicated the summed number of morbidities for each participant, based on physician diagnosis of: arthritis, chronic obstructive pulmonary artery disease, coronary artery disease, congestive heart failure, heart attack, hypertension, and stroke. Additionally, overweight/obese was included as a comorbid illness but it was evaluated based on measured body mass index (≥25 kg/m^2).

Analysis

Statistical analyses were performed via procedures from survey data using Stata (v.12). To account for oversampling, non-response, non-coverage, and to provide nationally representative estimates, all analyses included the use of survey sample weights, clustering and primary sampling units. For example, a sample weight is assigned to each participant, which is a measure of the number of people in the population represented by that sample person in NHANES, reflecting the unequal probability of selection and non-response adjustment. Further, the complex survey analyses accounted for the potential intra-cluster correlation that may exist among participants sampled in the same primary sampling unit. Cox proportional hazard models were used to examine the association between physical activity and all-cause mortality, with models stratified by normal vision, URE, and VI. Schoenfeld's residuals were used to verify the proportional hazards assumption, as a key assumption in Cox models is that the effect of any predictor variable on mortality is constant over time. Thus, a non-zero slope is an indication of a violation of the proportional hazard assumption. Statistical significance was established as $P \leq 0.05$.

Results

Among the 5278 participants, 464 died over the follow-up period (8.79%; unweighted); among those with normal vision ($n = 4846$), 389 died (8.0%); among those with URE ($n = 312$), 37 died (11.86%); and among those with VI ($n = 120$), 38 died (31.67%). The unweighted median follow-up period was 81 months/6.8 years (IQR = 68–93 months). In the sample, 420,730 person-months occurred with an incidence rate of 1.10 deaths per 1000 person-months.

Mean accelerometer wear time was similar across the three groups; normal vision, 14.3 h/day (95% CI: 14.2–14.4); URE, 14.3 h/day (95% CI: 14.0–14.5); and VI, 14.4 h/day (95% CI: 14.0–14.7). Table 1 displays the baseline characteristics of the participants stratified by mortality status at follow-up. Those who were alive at follow-up, compared to those who were deceased, had higher physical activity at baseline, engaged in less sedentary behavior, were younger, more likely to be female, less likely to be non-Hispanic white, had a higher poverty-to-income ratio (higher SES), had lower CRP levels, fewer comorbidities, less likely to be on blood pressure or cholesterol medication and less likely to have vision impairment.

With regard to the main findings, in an unadjusted model, for a 60 min/day increase in physical activity, participants with normal vision had a 46% reduced risk of all-cause mortality (HR = 0.54; 95% CI: 0.47–0.61); unadjusted results were similar for those with URE (HR = 0.62; 95% CI: 0.53–0.73) and VI (HR = 0.49; 95% CI: 0.38–0.64). Table 2 displays the weighted adjusted Cox proportion hazard results examining the association between physical activity/sedentary behavior and all-