Accelerometer-Measured Physical Activity and Sedentary Behavior in Relation to All-Cause Mortality

The Women's Health Study

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Physical inactivity is estimated to cause as many deaths globally each year as smoking.[1] Current guidelines recommend ≥150 min/wk of moderate-intensity aerobic physical activity (PA) and muscle-strengthening exercises on ≥2 d/wk.[2] These guidelines are based primarily on studies using self-reported moderate- to vigorous-intensity PA (MVPA).[2] Technological developments now enable device assessments of light-intensity PA (LPA) and sedentary behavior, and well-designed studies with such assessments that investigate clinical outcomes are needed for updating current guidelines. Here, we present data from the WHS (Women's Health Study). (The data, analytical methods, and study materials will not be made available to other researchers for purposes of reproducing the results or replicating the procedure.)

From 2011 to 2015, 18 289 of 29 494 living women agreed to participate; 1456 were ineligible because they could not walk unassisted outside the home. Women provided written consent to participate, and the study was approved by the institutional review board committee of Brigham and Women's Hospital. Participants were younger and healthier than nonparticipants. Women were mailed a triaxial accelerometer (ActiGraph GT3X+, ActiGraph Corp) and asked to wear it on the hip for 7 days (except during sleep and water-based activities) and then to mail back the device. A total of 17 708 women wore their devices. Of 17 466 devices recording data (242 devices failed), 16 741 (96%) had data from ≥10 h/d on ≥4 days (convention for compliant wear). Women were followed up through December 31, 2015, for mortality, with deaths confirmed with medical records, death certificates, or the National Death Index.

We examined the associations of total volume of PA (total accelerometer counts per day), MVPA (minutes per day), LPA (minutes per day), and sedentary behavior (minutes per day) with mortality using proportional hazards regression. MVPA, LPA, and sedentary behavior were categorized with triaxial accelerometer cut points (MVPA, accelerometer vector magnitude ≥2690 counts per minute; LPA, 200–2689 counts per minute; and sedentary behavior, <200 counts per minute).[3] Initial models were adjusted for age and accelerometer wear time; a second model was additionally adjusted for potential confounders (Figure). Analyses of LPA and sedentary behavior were also adjusted for MVPA because these behaviors were correlated (MVPA and LPA minutes per day, $r = 0.36$; MVPA and sedentary minutes per day, $r=-0.44$).

At baseline, the mean age was 72.0 years (SD, 5.7 years), and mean wear time was 14.9 h/d (1.3 h/d). The median times of MVPA, LPA, and sedentary behavior were 28, 351, and 503 min/d, respectively. During an average follow-up of 2.3 years, 207 women died. Total volume of PA was inversely related to mortality after adjustment for potential confounders (*P* for trend=0.002; Figure). For MVPA, there also was a strong inverse association (*P* for trend=0.0002). This association persisted in sensitivity analyses that excluded women with cardiovascular disease

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Key Words: aging ■ exercise ■ mortality ■ sedentary lifestyle ■ women

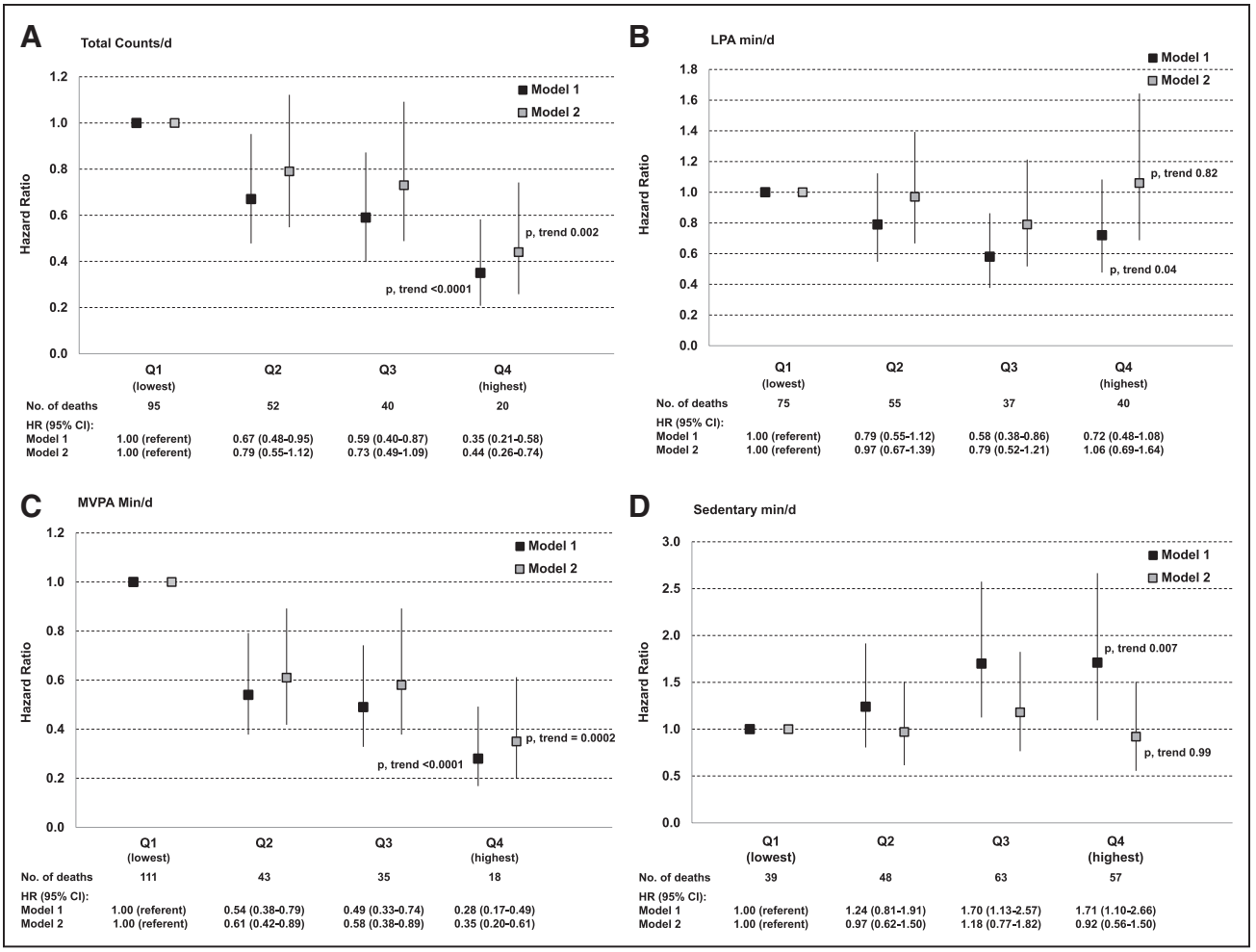

Figure. Hazard ratios (HRs) and 95% confidence intervals (CIs) for all-cause mortality by physical activity (PA) and sedentary behavior.

HRs are for quartiles of triaxial accelerometer-assessed. **A**, Total counts/d (measure of total PA). **B**, Moderate- to vigorous-intensity PA (MVPA) in min/d. **C**, Light-intensity PA (LPA) in min/d. **D**, Sedentary behavior in min/d. Vertical lines represent 95% CIs. Model 1 is adjusted for age and wear time. Model 2 is additionally adjusted for smoking; alcohol; intakes of saturated fat, fiber, fruits, and vegetables; hormone therapy; parental history of myocardial infarction; family history of cancer; general health; history of cardiovascular disease; history of cancer; and cancer screening. Analyses of MVPA and LPA are mutually adjusted; analyses of sedentary behavior also are adjusted for MVPA.

and cancer and those rating their health as fair/poor or deaths in the first year (data not shown).

For LPA, in age- and wear time–adjusted analysis, there was a significant inverse association (*P* for trend=0.04). With adjustment for potential confounders and MVPA, this association was no longer apparent (*P* for trend=0.82). Parallel (but directionally opposite) findings were seen with sedentary behavior (*P* for trend=0.007 in age- and wear-time adjusted analysis; *P* for trend=0.99 in analysis adjusted for potential confounders and MVPA).

In this large study of women with triaxial accelerometer–assessed PA, 3 main findings emerged. First, we observed a strong inverse association between overall volume of PA and all-cause mortality. Although this inverse relation is not novel, the magnitude of risk reduction (≈60%–70%, comparing extreme quartiles) was far larger than that estimated from meta-analyses of studies using self-reported PA (≈20%–30%). Second, the strong inverse association for overall volume of activity was attributable primarily to the strong inverse association between MVPA and mortality. Third, we did not find any associations of LPA or sedentary behavior with mortality after accounting for MVPA.

This study is one of the first investigations of PA and a clinical outcome using newer-generation accelerometers capable of measuring activity along 3 planes. Using triaxial instead of uniaxial data increases the sensitivity for recognizing PA, detecting more time in LPA and less time in sedentary behavior.

A few previous studies of device-assessed PA, using mainly uniaxial devices, and mortality have yielded inconsistent findings.[4] In addition, a large number of studies

have examined device-assessed sedentary behavior in relation to biomarkers. However, the vast majority are cross-sectional studies, limiting the interpretation of findings.[5]

The present study adds meaningfully to existing data because of its large sample size, use of triaxial accelerometer data, and investigation of a clinical outcome. Although the short-term follow-up could raise the possibility of reverse causation as an explanation for the findings, we observed a consistent pattern of results after excluding early deaths within 1 year of PA ascertainment. Although we adjusted for potential confounders, they were self-reported (apart from cardiovascular disease and cancer diagnoses, confirmed with medical records) and may have led to overestimates for MVPA. Finally, the overall participation rate among eligible women was 63%. Although this rate compares favorably with other studies that have used devices to measure PA (eg, 44% in the UK Biobank study), it may limit the generalizability of findings.

This study provides support for the 2008 federal guideline recommendation of MVPA,[2] but it does not support either increasing LPA or decreasing sedentary behavior for mortality risk reduction. As PA guidelines are updated,[2] additional data on other clinical outcomes are needed to fully inform any revisions.

ACKNOWLEDGMENTS

The authors are grateful to the participants and staff of the WHS, particularly Bonnie Church, MS, and Colby Smith, BS, for accelerometer data collection and Eunjung Kim, MS, for data analyses.

SOURCES OF FUNDING

This work is supported by National Institutes of Health grants CA154647, CA047988, CA182913, HL043851, HL080467, and HL099355. Dr Shiroma is supported in part by the Intramural Research Program at the National Institute on Aging. Dr Kamada is supported by a Japan Society for the Promotion of Science Postdoctoral Fellowship for Research Abroad and Young Scientists. The sponsor had no involvement in the design and conduct of the study; collection, management, analysis, and interpretation of the data; preparation, review, or approval of the manuscript; or the decision to submit the manuscript for publication.

DISCLOSURES

None.

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FOOTNOTES

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