Changes in Sitting Time and Cardiovascular Mortality in Older Adults

Verónica Cabanas-Sánchez, PhD,1 Pilar Guallar-Castillón, MD,2,3,4 Sara Higueras-Fresnillo, MSc,1 Fernando Rodríguez-Artalejo, MD,2,3 David Martínez-Gómez, PhD1

Introduction: Prolonged sitting time has demonstrated consistent associations with increased risk of cardiovascular disease and mortality, but most previous studies have analyzed these associations assessing sitting time at one single point and providing scarce evidence on causal links. The main objective of this study was to analyze the association of 2-year changes in sitting time with subsequent long-term cardiovascular disease mortality in older adults.

Methods: The analyses were conducted with 2,657 individuals with complete data. Sitting time and physical activity were assessed by questionnaire. Changes in sitting time were classified into consistently sedentary (high sitting time in 2001 and 2003); newly sedentary (low sitting time in 2001 and high sitting time in 2003); formerly sedentary (high sitting time in 2001 and low sitting time in 2003); and consistently nonsedentary (low sitting time in 2001 and 2003). The associations between change in sitting time and cardiovascular disease mortality were summarized with hazard ratios and their 95% CIs obtained from Cox regression. The combined effect of changes in sitting time and physical activity on cardiovascular disease mortality was also examined.

Results: Compared with consistently sedentary participants, those who were consistently nonsedentary had a 33% (hazard ratio = 0.67, 95% CI = 0.46, 0.96) lower risk of cardiovascular disease death. In combined analyses, consistent nonsedentariness was associated with reduced cardiovascular disease mortality in participants with physical activity less than the median (hazard ratio = 0.62, 95% CI = 0.39, 1.00) and greater than or equal to the median (hazard ratio = 0.49, 95% CI = 0.31, 0.79). Formerly sedentary participants with physical activity greater than or equal to the median had a 48% lower cardiovascular disease mortality.

Conclusions: Among older adults, maintaining low sitting time should be promoted to reduce cardiovascular disease mortality.

INTRODUCTION

The prevalence of excessive sedentary behavior, defined as those activities with an energy expenditure of less than 1.5 METs, including prolonged sitting at work, home, travel, or performing other behaviors that require very low energy expenditure1 is very high in most developed countries, especially among older adults.2 Prolonged time spent in sedentary behaviors, such as sitting time (ST), has demonstrated consistent associations with increased risk of several adverse health outcomes, particularly with cardiovascular disease (CVD) and mortality.3 However, most studies have measured ST only at one single point in time (e.g., at baseline). Using repeated measurements of ST might...
provide better evidence on causal link. Unfortunately, only two previous studies examined the effect of changes in ST on CVD mortality and have obtained mixed results.\(^4\)\(^5\) Accordingly, this study investigates the association of 2-year changes in ST with subsequent long-term CVD mortality in older adults.

**METHODS**

Data were obtained from 4,008 individuals (2,269 women) representative of the non-institutionalized Spanish population aged ≥60 years. Briefly, participants were recruited between October 2000 and February 2001 using probabilistic sampling by multistage clusters. The clusters were stratified according to region of residence and size of municipality. Then, census sections and households were chosen randomly within each cluster. Finally, study participants were selected from 420 census sections in sex and age (60–69, 70–79, and ≥80 years) strata. The information was collected through home-based personal interviews using a structured questionnaire, followed by a physical examination performed by trained and certified personnel.

In 2001 and 2003, participants reported their habitual ST during a weekday and a weekend day. The number of sitting hours per day was calculated as follows: \([\text{weekday ST} \times 5 + \text{weekend day ST} \times 2]/7\). First, as performed in a previous work, \(6 \text{ ST was formed by trained and certified questionnaire, followed by a physical examination performed by trained and certified personnel.}\)

Second, changes in ST were classified as high or low using the sex-specific median in the study sample for each year; that is, the authors standardized ST levels according to the characteristics of the study population. When using specific cut-off points identified in previous studies,\(^7\) the results were inappropriate because they classified a very low proportion of the study participants with high ST. For example, only 12.91% (\(n=343\)) and 14.26% (\(n=379\)) of the sample reported a low ST in 2001 and 2003, respectively, based on the cut-off point identified in a recent meta-analysis on ST and all-cause mortality (≥7 hours/day).\(^7\) Consistently sedentary (high ST in 2001 and 2003); newly sedentary (low ST in 2001 and high ST in 2003); formerly sedentary (high ST in 2001 and low ST in 2003); and consistently nonsedentary (low ST in 2001 and 2003).

Additionally, information on leisure-time PA in 2003 was collected by the Spanish version of the PA questionnaire used in the Nurses’ Health Study and Health Professionals’ Follow-up study.\(^8\) This questionnaire evaluates the participation in 16 activities and provides an estimation of energy expenditure per week. Also, the authors used the sex-specific median of PA in the study sample to classify the participants. CVD mortality from 2003 to the end of follow-up (December 31, 2014) was assessed by linkage with the National Death Index.

The associations between change in ST and CVD mortality were summarized with hazard ratios (HRs) and their 95% CIs obtained from Cox regression. Age was used as the time scale in Cox regression models. The combined effect of changes in ST and PA on CVD mortality was also examined.

The analyses were adjusted for age; sex; education (no formal education/primary/secondary or higher); smoking (never/former/currently); alcohol consumption (never/former/currently); BMI; perceived health (optimal/suboptimal); limitations in mobility (yes/no); limitations in agility (yes/no); and the number (zero, one, two or more) of physician-diagnosed reported diseases from this list: chronic lung disease, heart disease, diabetes mellitus, osteomuscular disease, and cancer. Analyses were performed with Stata, version 14.2, in March 2017.

**RESULTS**

Of the 4,008 participants at baseline, 222 died between 2001 and 2003, and 765 were unable to be contacted again in 2003. Thus, after excluding participants who did not report ST in 2001 or 2003 (\(n=209\)) and who lacked data on other study variables (\(n=155\)), the analyses were performed on 3,011 participants.

**Table 1. CVD Mortality From 2003 to 2014 According to Change in Sitting Time (ST) Between 2001 and 2003**

<table>
<thead>
<tr>
<th></th>
<th></th>
<th></th>
<th></th>
<th></th>
<th></th>
</tr>
</thead>
<tbody>
<tr>
<td>ST in 2001 (h/day), M±SD</td>
<td>6.89±2.48</td>
<td>2.99±0.87</td>
<td>6.20±2.05</td>
<td>2.80±0.95</td>
<td></td>
</tr>
<tr>
<td>ST in 2003 (h/day), M±SD</td>
<td>7.24±2.52</td>
<td>6.67±2.13</td>
<td>3.06±0.97</td>
<td>2.83±1.03</td>
<td></td>
</tr>
<tr>
<td>n (%)</td>
<td>721 (27.14)</td>
<td>561 (21.11)</td>
<td>559 (21.04)</td>
<td>816 (30.71)</td>
<td></td>
</tr>
<tr>
<td>CVD, deaths (%)</td>
<td>149 (20.67)</td>
<td>106 (18.72)</td>
<td>80 (14.31)</td>
<td>75 (9.19)</td>
<td></td>
</tr>
<tr>
<td>Model 1, HR (95% CI)</td>
<td>ref</td>
<td>1.14 (0.84, 1.55)</td>
<td>0.76 (0.55, 1.06)</td>
<td>0.64 (0.45, 0.93)</td>
<td></td>
</tr>
<tr>
<td>Model 2, HR (95% CI)</td>
<td>ref</td>
<td>1.18 (0.87, 1.59)</td>
<td>0.77 (0.56, 1.07)</td>
<td>0.67 (0.46, 0.96)</td>
<td></td>
</tr>
</tbody>
</table>

Note: Boldface indicates statistical significance (\(p<0.05\)). Values are hazard ratios (HRs) and 95% CIs from Cox regression models, unless otherwise indicated. Model 1 was adjusted for age (years); sex (male/female); educational level (no formal studies/Primary studies/Secondary or higher studies); smoking (never smoker/ former smoker/current smoker); alcohol consumption (never drinker/former drinker/current drinker); BMI; comorbidity (0/1/2 diseases); perceived health (optimal/suboptimal); limitations in mobility (no/yes); and limitations in agility (no/yes). Model 2 was adjusted for model 1 variables and physical activity (METs*h*wk\(^{-1}\)).
conducted with 2,657 individuals (1,682 women). The mean follow-up time was 9.23 (SD=3.62) years (median=11.70), corresponding to 24,524 person-years, with a total of 409 CVD deaths. The median ST was 4.00 hours/day (men) and 4.29 hours/day (women) in 2001, and 4.84 hours/day (men) and 5.03 hours/day (women) in 2003. In the period 2001–2003, a total of 27.14% of the participants were consistently sedentary, 21.11% newly sedentary, 21.04% formerly sedentary, and 30.71% consistently non-sedentary (Table 1).

Compared with consistently sedentary participants, and after multiple adjustments, including PA, those who were consistently nonsedentary had a 33% (HR=0.67, 95% CI=0.46, 0.96) lower risk of CVD death, whereas the newly sedentary (HR=1.18, 95% CI=0.87, 1.59) and formerly sedentary (HR=0.77, 95% CI=0.56, 1.07) did now show statistically significant differences in CVD mortality (Table 1). The CVD mortality risk associated with 1 hour/day increase in ST was 6.4% (95% CI=2.1%, 11.1%).

In combined analyses of change in ST and PA (Figure 1) it was observed that compared with the reference group (i.e., individuals below the median level of PA who remained consistently sedentary), consistent non-sedentariness was associated with reduced CVD mortality in participants with PA less than the median (HR=0.62, 95% CI=0.39, 1.00) and greater than or equal to the median (HR=0.49, 95% CI=0.31, 0.79). Moreover, among individuals with PA greater than or equal to the median, those who reduced their ST (i.e., formerly sedentary) had a 48% (HR=0.52, 95% CI=0.32, 0.85) lower CVD mortality. Associations were not significantly modified by age and sex (both p for interaction >0.10).

**DISCUSSION**

The results of this study concur with those of two studies in middle-age adults (aged ≥29 years) and in post-menopausal women in showing that individuals who maintained low ST had lower risk of CVD mortality. However, these two previous studies also reported partially discrepant results. Although Lee et al. found that those who increased ST or decreased ST did not differ in the risk of CVD death from those who maintained high ST, Grunseit and colleagues found a higher CVD mortality risk for those with increasing ST versus those having a consistently low ST. As it was noted in a previous study relative to all-causes mortality, the authors observed a tendency to reduce CVD mortality in those who decrease their ST (formerly sedentary), but this tendency did not reach significance.

Changes in ST might affect CVD mortality differently depending on the PA levels. The authors found that being formerly sedentary was associated with a lower risk of CVD death in active but not in inactive individuals. Maintaining low ST, or reducing ST while maintaining a high PA level, should be promoted to reduce CVD mortality.

**Limitations**

Strengths of this study include the long-term follow-up of a national sample of older adults, the statistical adjustment for many confounders, and the assessment of ST at two points in time, which provides better evidence on causal links. The study also had some limitations, such as the use of self-reported data of ST and PA. Future research should confirm this study’s results using objective assessments (e.g., accelerometers). Moreover, the confounding influence of PA changes during the 2 years of follow-up could not be evaluated because PA was only assessed in 2003.

**CONCLUSIONS**

Maintaining low ST, or reducing ST while maintaining a high PA level, is associated with reduced cardiovascular disease mortality in older adults.
ACKNOWLEDGMENTS
This work was supported by FIS grant 16/609 (Instituto de Salud Carlos III, State Secretary of R+D+I and FEDER/FSE); MINECO R+D+I grant (DEP2013-47786-R); the FRAILOMIC Initiative (Utility of omic-based biomarkers in characterizing older individuals at risk for frailty, its progression to disability and general consequences to health and well-being; European Union FP7-HEALTH-2012-Proposal No. 305483-2); and the ATHLOS project (Ageing Trajectories of Health: Longitudinal Opportunities and Synergies; European project H2020, Project ID: 635316).

No financial disclosures were reported by the authors of this paper.

REFERENCES


