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Original research

Accelerometer-measured sedentary time and physical activity—A 15 year follow-up of mortality in a Swedish population-based cohort

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ABSTRACT

Objectives: To investigate the associations of objectively assessed sedentary time, light intensity physical activity (PA), moderate to vigorous intensity PA (MVPA), and total PA with all-cause mortality and mortality from cardiovascular disease (CVD) or cancer in a Swedish population-based cohort with 15 years follow-up time.
Design: Longitudinal prospective cohort study.
Methods: Data from 851 persons (56% women) ≥35 years at baseline were included. Primary exposure variables were time (min/day) spent sedentary, in light intensity PA and in MVPA, and total counts from an Actigraph 7164 accelerometer. Data on all-cause mortality and mortality from CVD or cancer were obtained from Swedish registers. Cox proportional hazards models estimated hazard ratios (HR) of mortality with 95% confidence intervals (CI).
Results: Compared with the least sedentary participants, those in the most sedentary tertile had an increased risk of all-cause mortality, HR: 2.7 (1.4, 5.3), CVD mortality, HR: 5.5 (1.4, 21.2) and cancer mortality, HR: 4.3 (1.2, 16.0). For all-cause mortality, those in the highest light intensity PA tertile had a HR 0.34 (0.17, 0.67) compared with the lowest tertile. A similar pattern was found for CVD and cancer mortality. More time spent in MVPA was associated with the largest risk reduction for CVD mortality, with an almost 90% lower risk in the tertile with the most time in MVPA.
Conclusions: This study confirms a strong inverse relationship between MVPA and mortality, and adds new insight for the understanding of the associations between sedentary time and light intensity PA and mortality.

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1. Introduction

Physical activity (PA) provides a wide range of health benefits, including reduced risk of many common diseases and improved physical function. The present body of evidence shows an inverse and curvilinear dose–response relationship between moderate-to-vigorous intensity physical activity (MVPA) and all-cause mortality.[1–3] This implies that the largest health benefits will occur at the lowest end of the activity scale, and that longer duration or higher intensity of the PA will confer additional health benefits. Yet, only a small portion of the day is spent in MVPA for most people.[4,5] Sedentary time and light intensity PA, i.e. activities of everyday living, account for the major part of total daily activities for the average person.[4,6,7]

Recent research has shown that sedentary behaviours have detrimental effects on health.[8,9] The mortality risk increases above 7.5 h/day of sedentary time, with a high risk above 10 h,[10,11] but evidence is inconclusive whether the increased risk is independent of time MVPA.[12–14] Even though higher intensities of PA generally have stronger correlations to health outcomes, light intensity PA may be more attainable than MVPA for certain populations, such as older adults or people with chronic conditions. Longitudinal studies suggest that positive health effects can be achieved from activities of low intensity,[15–17] at least among the most sedentary adults, although this needs to be further investigated.

A vast majority of the previous prospective cohort studies have used self-reported PA. Longitudinal data on associations of sedentary time or PA and mortality using objective measures, such as

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accelerometry, are rare. Self-reports are limited by low accuracy, and true levels of PA or sedentary behaviours are often over- or underestimated due to recall bias or social desirability.[4,18] Time spent in light intensity activities is particularly difficult to estimate by self-report, since those activities are mainly unstructured and interspersed over the day.

Koster et al.[12] analysed accelerometer data from the U.S. National Health and Nutrition Examination Survey (NHANES) cohort and found that sedentary behaviour, adjusted for MVPA, was a risk factor for mortality; however, the follow-up time was only 2.8 years. To the best of our knowledge, only three studies have examined accelerometer-measured sedentary time and PA as predictors of mortality with longer (6.5 years) follow-up time.[19–21] These studies have found total PA and light intensity PA to be associated with lower mortality, independent of MVPA.[19,20] Sedentary time was associated with higher mortality only in low active persons.[20,21] Importantly, the data-set used in these four studies all derived from the same NHANES cohort.[12,19–21] Prospective studies on other populations and with longer follow-up periods are required to further clarify these associations. The aim of this study was therefore to investigate the associations of objectively assessed sedentary time, light intensity PA, MVPA, and total PA with all-cause mortality and mortality from cardiovascular disease (CVD) or cancer in a Swedish population-based cohort with 15 years follow-up time.

2. Methods

This prospective cohort study used data from the Sweden Attitude Behavior and Change study (ABC) 2001–2002. A nationally representative sample of 3300 Swedish adults aged 18–75 years (52% women) were contacted, 2262 persons (54% women) were eligible, and 1221 (55% women) persons provided PA data.[22] Data from the 851 persons (56% women) who were 35 years and older at the ABC baseline data collection were combined with register-data of mortality collected in 2016. A detailed description of the ABC-study is provided elsewhere.[22,23] The study was approved by the Regional Ethical Review Board at the Karolinska Institutet, (Dnr 378/02, 2012/707 31/1, 2015 1578/32). All procedures were in accordance with the 1964 Helsinki declaration and its later amendments or comparable ethical standards.

Sedentary time and PA were assessed with the Actigraph 7164 accelerometer (ActiGraph, Ft. Walton Beach, FL, USA), which measures vertical acceleration, expressed as activity counts. Frequency, duration, and intensity of PA can be calculated from number of counts integrated over a user-specified time interval, and sampling was set at counts per 1-min. The accelerometers were delivered to the participants by mail after a telephone call with agreement to participate, and returned in a prepaid envelope. Participants were instructed to wear the accelerometer for seven consecutive days on the lower back using an elastic belt. The device was removed if swimming/bathing/showering, and while sleeping. Non-wear time was excluded and defined as an interval of at least 60 consecutive min of zero counts, with allowance for up to 2 min of 1–100 counts.[5] Participants with at least one valid day of accelerometer data, defined as >10 h of wear time were included.[4,22] Cut-points to estimate time spent in different PA intensities were defined in accordance with previous population-based studies.[4,12,24] Sedentary time was defined as <100 counts/min, light intensity as 100–2019 counts/min, and MVPA as ≥2020 counts/min. Actilife 6 software was used for the analyses.

The primary exposure variables were tertiles of time (in min) spent sedentary, in light intensity PA, and in MVPA. In addition, tertiles of total accelerometer counts were used to investigate associations between total PA and mortality. A dichotomous variable (yes/no) was created for compliance with the recommended level for health-enhancing PA. Participants with at least 22 min/day of MVPA, which corresponds to 150 min/week, were considered to have reached the recommendation. Neither prolonged nor regular MVPA during the week were required.[5,25]

Register data on all-cause mortality and mortality from CVD or cancer were obtained from the National Board of Health and Welfare's Cause of Death Register and the Swedish Cancer Registry for year 2001–2015. The Cause of Death Register contains both cause of death data and underlying cause of death coded according to the international version of the disease classification ICD-10. Demographic and anthropometric data were self-reported and obtained from the baseline questionnaire sent by mail to the participants together with the accelerometer.[22] Covariates included in this study were age (continuous), sex, education (less than high school, high school/equivalent diploma, or university degree), body mass index (BMI), smoking status (never/former or current), and history of chronic disease: hypertension, heart disease, diabetes, or cancer (yes/no).

Descriptive data are presented as means and standard deviations (SD), or frequency and percentage (%). Two sample *t*-test and Chi-squared test were performed to determine potential differences between women and men. A Spearman's correlation was run to assess the relationship between sedentary time, light intensity PA, and MVPA. Cox proportional hazards models were applied to estimate hazard ratios (HR) of mortality with 95% confidence intervals (CI). Follow-up extended from the first day of accelerometer assessment until date of death or censoring in December 31th, 2015, whichever occurred first. Schoenfeld residuals were examined to assess proportional-hazards assumption.[26] Models for total sample were stratified by sex and age tertiles, and sex-specific models were stratified by age tertiles. We examined all covariates as potential confounders by performing separate statistical test for each of the covariates. The covariates included in the two multivariate models were age, education, smoking status, and history of chronic disease, with addition of complying with PA recommendations in model 3. The analyses of sedentary time were additionally adjusted for wear time in all three models. Tests of BMI both as covariate and mediator showed no significant changes of the estimates. Based on these tests and to get the best model fit, we decided not to include BMI in the final models. *P*-values ≤0.05 were considered statistically significant. Statistical analyses were computed in Stata, version 11.0 (StataCorp LP, USA).

3. Results

In this study, 851 adults were followed for a mean of 14.2 years (SD = 1.9) with 12,117 person-years at risk. During that time, 79 deaths occurred from any cause, including 24 deaths from CVD, 27 deaths from cancer, and 28 from other causes (alcohol/drug abuse, lung disease, neurological disease, dementia, sepsis, not specified). The crude, unweighted death rate was 0.65 deaths per 100 person-years. No deaths occurred within 1 year from inclusion and no deaths were coded as accidental. A total of 828 participants (97%) had ≥4 valid days of accelerometer data, and 570 participants (66%) had one week of valid data. Average daily wear time was 14.5 h (SD = 1.3). Baseline characteristics of the total study population and stratified by sex are shown in Table 1.

The major part of total daily activities was sedentary time, with an average of 8 h 12 min/day for the total sample. There was a small but statistically significant ($P = 0.043$) difference in daily sedentary time between women (8 h, 6 min) and men (8 h, 19 min). On average, 5 h 44 min/day were spent in light activities and 31 min/day in MVPA. Women spent more time in light intensity PA and less time in MVPA compared to men, but these

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