Original research

Sedentary leisure-time in relation to mortality and survival time

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ABSTRACT

Objective: To examine the association between sedentary leisure-time and all-cause mortality and differences in survival time.
Design: Prospective cohort study.
Methods: Information on sedentary leisure-time, defined as TV viewing and/or sitting reading, was collected from 72 003 Swedish adults who were 45–83 (median 60) years of age and completed a self-administered questionnaire at baseline and were followed up for 17 years through linkage with the Swedish Death Register.
Results: The association between sedentary leisure-time and all-cause mortality was modified by age with a more pronounced association in middle-aged (<60 years of age) than in older adults ($\geq$60 years of age) (p-interaction < 0.001). During follow-up, 3358 and 15 217 deaths occurred in the middle-aged and older age group, respectively. The multivariable-adjusted hazard ratios for the highest (>6 h/day) versus lowest category (<1 h/day) of sedentary leisure-time were 1.72 (95% confidence interval [CI] 1.29–2.30) in middle-aged adults and 1.19 (95% CI 1.05–1.36) in older adults. This corresponded to a difference in survival time of respectively 2.4 (95% CI −4.1 to −0.8) years and 1.5 (95% CI −2.2 to −0.7) years.
Conclusions: Prolonged sedentary leisure-time was associated with a significantly decreased survival time up to 2.4 years in middle-aged adults.

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Practical implications

- Individuals with a sedentary leisure-time, defined as TV viewing and/or sitting reading >6 h per day, had higher mortality and shorter survival time than those viewing TV and/or sitting reading <1 h per day.
- The association between sedentary leisure-time and mortality was more pronounced among individuals who also had a sedentary work.
- This study highlights the importance of reducing sedentary behaviors for a longer life.

1. Introduction

Accruing observational data indicate that prolonged sedentary leisure-time, such as television (TV) viewing, is associated with deleterious health outcomes, such as obesity[1], type 2 diabetes[1–3], cardiovascular disease[2,3], cancer[3], and all-cause mortality.[3–5] Hitherto, data on sedentary time in relation to health outcomes were often presented only in terms of relative measures (e.g., hazard ratios), and results from individual studies of the association between sedentary time and all-cause mortality have been inconclusive with not all studies showing an association. For example, a meta-analysis of 13 prospective studies found an overall hazard ratio of 1.22 (95% confidence interval 1.08–1.38) for high versus low self-reported sedentary time, but there was significant heterogeneity among study-specific results with hazard ratio estimates ranging from 0.91 to 3.26.[3] The reasons for these inconsistent results are unclear but may be related to different adjustment for confounders and population characteristics across studies.

Besides the uncertain relationship between sedentary time and relative risk of all-cause mortality, the association between sedentary time and differences in survival time is unclear. We therefore sought to quantify the differences in survival time according to sedentary-leisure time, defined as hours per day viewing TV and/or sitting reading. For this purpose, we used data from two population-based cohorts of middle-aged and older Swedish adults followed up for 17 years. To be able to compare our findings with previous studies, we also report results in terms of hazard ratios. Furthermore, we examined whether the association was modified by age,

sex, body mass index (BMI), smoking, exercise, work activity, and employment status.

2. Methods

We used data from the Cohort of Swedish Men (COSM) and the Swedish Mammography Cohort (SMC). These cohorts are registered at ClinicalTrials.gov (Identifier NCT01127711 and NCT01127698) and are part of the Swedish Infrastructure for Medical Population-based Life-course Environmental Research (SIMPLER). COSM was established in the late autumn of 1997 when all men who were born between 1918 and 1952 and living in Västmanland and Örebro counties of central Sweden received a mailed questionnaire that solicited information on lifestyle and other potential risk factors for chronic diseases. A total of 48 850 men (49% response rate) returned a completed questionnaire and agreed to participate in the study. SMC was established in 1987–1990, when all women who were born between 1914 and 1948 and residing in Västmanland and Uppsala counties of central Sweden received an invitation to participate in a mammography-screening program. In the autumn of 1997, participants of the SMC were mailed a questionnaire that was identical, except for some sex-specific questions, to the questionnaire completed by men in the COSM; 39 227 women (70% response rate) returned a completed questionnaire and agreed to participate in the study. Ethical approval was obtained from the Regional Ethical Review Board at Karolinska Institutet in Stockholm.

Participants with a missing personal identification number (a unique number assigned to all Swedish citizens) on the baseline questionnaire, those who died or had a diagnosis of cancer or cardiovascular disease before baseline, and those with missing data on sedentary leisure-time were excluded, leaving 72 003 participants (38 284 men and 33 719 women), aged 45–83 years, for analysis (Fig. 1). Complete follow up for deaths was accomplished through linkage to the Swedish Death Register, using the personal identification number. In Sweden, 100% of all deaths are reported to the Swedish Death Register within 30 days.[6] Participants were followed up from 1 January 1998 through 31 December 2014 or date of death.

Information on sedentary leisure-time, physical activity, weight, height, smoking status, number of cigarettes smoked per day at different ages, education, employment status, history of hypertension, hypercholesterolemia, and diabetes, alcohol consumption, and diet was collected through a self-administered questionnaire in the autumn of 1997. Participants were asked to report their usual time spent on different activities, including TV viewing and/or sitting reading (defined as sedentary leisure-time in this study) as well as work activity, housework, walking/bicycling, and exercise in the last year prior to baseline. For the question on TV viewing and/or sitting reading time, participants could choose from five predefined categories: <1 h/day, 1–2 h/day, 3–4 h/day, 5–6 h/day, and >6 h/day. The questions about specific types of activities have been validated in random samples of women participating in the SMC[7] and men from the study area.[8] The correlation coefficient comparing activity records with the questionnaire was 0.5 for TV viewing and/or sitting reading.[7,8]

Participants were defined as having a history of hypertension or diabetes if they reported in the questionnaire that they had these diseases or if they had a diagnosis of these diseases in the Swedish National Patient or Diabetes Registers. Pack-years of smoking history were calculated by multiplying the number of packs of cigarettes smoked per day by the number of years of smoking. BMI was calculated as weight (in kg) divided by height (in m) squared. Diet was assessed with a validated food-frequency questionnaire[9] which inquired about the average consumption of 96 foods/food items and beverages during the last year. For most items, participants could select from eight frequency categories, ranging from never to three or more times per day. A modified Dietary Approaches to Stop Hypertension (mDASH) diet score, as a measure of an overall healthy diet, was created based on reported intake of vegetables, fruits, legumes and nuts, whole-grain and fiber-rich products, reduced-fat dairy products, red meat and processed meat, and sweetened beverages, as described in detail elsewhere.[10] Snack foods included in the questionnaire were chocolate, sweets (excluding chocolate), potato chips/popcorn/cheese puffs, and nuts/almonds.

Hazard ratios (HR) and 95% confidence intervals (CI) of all-cause mortality by categories of sedentary leisure-time were derived from Cox proportional hazards regression models with age as the time scale. Tests for trend were conducted by modeling the categories of sedentary leisure-time as a continuous variable. The proportional hazards assumption was tested using Schoenfeld residuals. The assumption was violated for the whole study sample due to effect modification by age (p-interaction < 0.001). All analyses were therefore performed stratified by baseline age (<60 and ≥60 years of age [median age]). No violation of the proportional hazards assumption was observed in the two age groups. Laplace regression[11–13] was used to estimate differences in survival time by age group and categories of sedentary leisure-time. We modeled the 10th, 25th, and 40th survival percentiles, that is, the time points at which the first 10%, 25%, and 40%, respectively of participants had died. The 25th survival percentile was used for the primary analysis because about 25% of participants died during follow-up. All multivariable Cox and Laplace regression models were adjusted for age, sex, education, employment status, work activity, housework, walking/bicycling, exercise, BMI, smoking status and pack-years of smoking, history of hypertension, hypercholesterolemia, and diabetes, alcohol consumption, and mDASH diet score. Adjustment for consumption of snack foods did not materially change the results and therefore snack foods were not included in the final multivariable models.

We assessed effect modification by sex, BMI (<25 kg/m^2 or ≥25 kg/m^2), smoking (current smoker or nonsmoker), employment status (employed or unemployed/other), work activity (mostly sitting down [considered a sedentary work] or sitting down half the time to heavy manual work [non-sedentary work]), housework (<1 h/day or ≥1 h/day), walking/bicycling (<40 min/day or ≥40 min/day), and exercise (<2 h/week or ≥2 h/week) by stratified analysis. In these stratified analyses the two highest categories for sedentary-leisure time was collapsed (5–6 h/day and >6 h/day) due to small number of participants in the highest category. The significance of the interactions was tested using the likelihood ratio test that compared models with and without interaction terms. To evaluate potential reverse causation bias, a sensitivity analysis that omitted the first 5 years of follow-up was performed. All tests were two sided and considered statistically significant at p values < 0.05. The statistical analyses were performed using SAS (version 9.3, SAS Institute, Cary, NC) and Stata (version 14.1, StataCorp, College Station, TX).

3. Results

From January 1998 through December 2014, 18 575 (25.8%) of participants died. These included 3358 deaths (8.9%) during 621 223 person-years of follow-up of 37 782 participants in the middle-aged (45–59 years) group and 15 217 deaths (44.5%) during 481 975 person-years of follow-up of 34 221 participants in the older (60–83 years) age group (Fig. 1). Baseline characteristics of participants by age group and categories of sedentary leisure-time are presented in Table 1. In both age groups, compared with those in the lowest category of sedentary leisure-time (<1 h/day), those in the high-

Table 1
Baseline characteristics by age group and sedentary leisure-time.

Characteristics[*]	Sedentary leisure-time (TV viewing and/or sitting reading), hours/day									
	Participants <60 years of age (n = 37 782)					Participants ≥60 years of age (n = 34 221)				
	<1 (n = 6934)	1–2 (n = 20 841)	3–4 (n = 9106)	5–6 (n = 678)	>6 (n = 223)	<1 (n = 2074)	1–2 (n = 13 467)	3–4 (n = 15 715)	5–6 (n = 2359)	>6 (n = 606)
Age in years, mean (SD)	52.4 (3.6)	52.8 (3.7)	53.2 (3.7)	53.1 (3.7)	53.0 (3.8)	66.7 (5.8)	67.6 (5.7)	69.3 (5.6)	70.6 (5.6)	69.9 (5.7)
Body mass index (kg/m^2), mean (SD)	25.0 (3.5)	25.1 (3.5)	25.8 (3.8)	26.9 (4.9)	26.6 (4.6)	25.4 (3.7)	25.3 (3.5)	25.5 (3.6)	26.2 (4.0)	26.6 (4.6)
High-school or university education, %	31.7	26.4	18.6	19.7	25.2	12.2	11.3	9.7	9.5	13.5
Employment status, % employed	91.9	89.6	76.1	45.3	30.5	26.6	19.9	12.1	5.0	3.7
Sedentary work, %[a]	27.3	25.4	24.4	32.7	47.7	15.6	12.2	14.4	23.0	41.7
Household work ≥1 hour/day, %	65.1	71.1	74.1	73.0	60.1	69.6	79.1	84.6	84.6	74.7
Walking/cycling ≥40 min/day, %	27.4	29.5	31.3	34.4	35.3	35.9	38.9	40.5	39.4	37.9
Leisure-time exercise ≥2 h/week, %	49.7	52.6	51.4	45.3	44.0	56.4	64.6	66.8	62.3	52.4
Current smoker, %	24.5	26.2	32.1	39.2	44.7	21.6	19.6	20.3	24.6	30.7
Hypertension, %	13.9	14.2	17.3	24.1	24.2	24.9	26.4	28.1	29.9	28.8
Hypercholesterolemia, %	8.8	9.7	10.9	10.6	9.6	11.4	11.7	11.1	13.6	14.8
Diabetes, %	2.7	2.5	3.6	7.5	7.1	9.1	9.0	8.5	10.3	13.5
Alcohol intake in drinks/week, mean (SD)[b]	7.1 (11.1)	7.3 (8.9)	8.3 (12.4)	9.8 (18.7)	14.3 (9.3)	5.6 (13.8)	5.2 (8.0)	5.4 (7.9)	6.3 (10.2)	10.6 (7.5)
mDASH diet score, mean (SD)	21.9 (4.4)	21.7 (4.3)	21.1 (4.4)	20.3 (4.5)	19.8 (4.9)	21.3 (4.6)	21.7 (4.4)	21.7 (4.4)	21.5 (4.3)	21.0 (4.5)
Snack food intake in servings/week, mean (SD)										
Chocolate	0.9 (1.2)	1.0 (1.3)	1.0 (1.4)	1.1 (1.8)	1.1 (2.5)	0.8 (1.5)	0.9 (1.5)	1.0 (1.6)	1.1 (1.9)	1.3 (2.5)
Sweets (not including chocolate)	0.8 (1.2)	0.8 (1.2)	0.9 (1.4)	0.9 (1.7)	0.9 (2.3)	0.5 (1.3)	0.6 (1.4)	0.7 (1.5)	0.9 (2.0)	0.9 (2.4)
Potato chips/popcorn/cheese puffs	0.3 (0.5)	0.4 (0.6)	0.4 (0.7)	0.4 (1.0)	0.5 (1.1)	0.1 (0.5)	0.2 (0.6)	0.2 (0.5)	0.2 (0.7)	0.3 (1.2)
Nuts/almonds	0.4 (0.8)	0.3 (0.7)	0.3 (0.8)	0.3 (0.7)	0.4 (0.8)	0.2 (0.8)	0.2 (0.8)	0.2 (0.8)	0.2 (0.7)	0.3 (1.4)

SD = standard deviation.

[*] Age-standardized to the age distribution of the study population at baseline. *p* for trend across categories of sedentary leisure-time is <0.05 for all baseline characteristics, except sedentary work (*p* = 0.98), leisure-time exercise (*p* = 0.74), and mDASH diet score (*p* = 0.27) in the middle-aged group.

[a] Mostly sitting down at work.

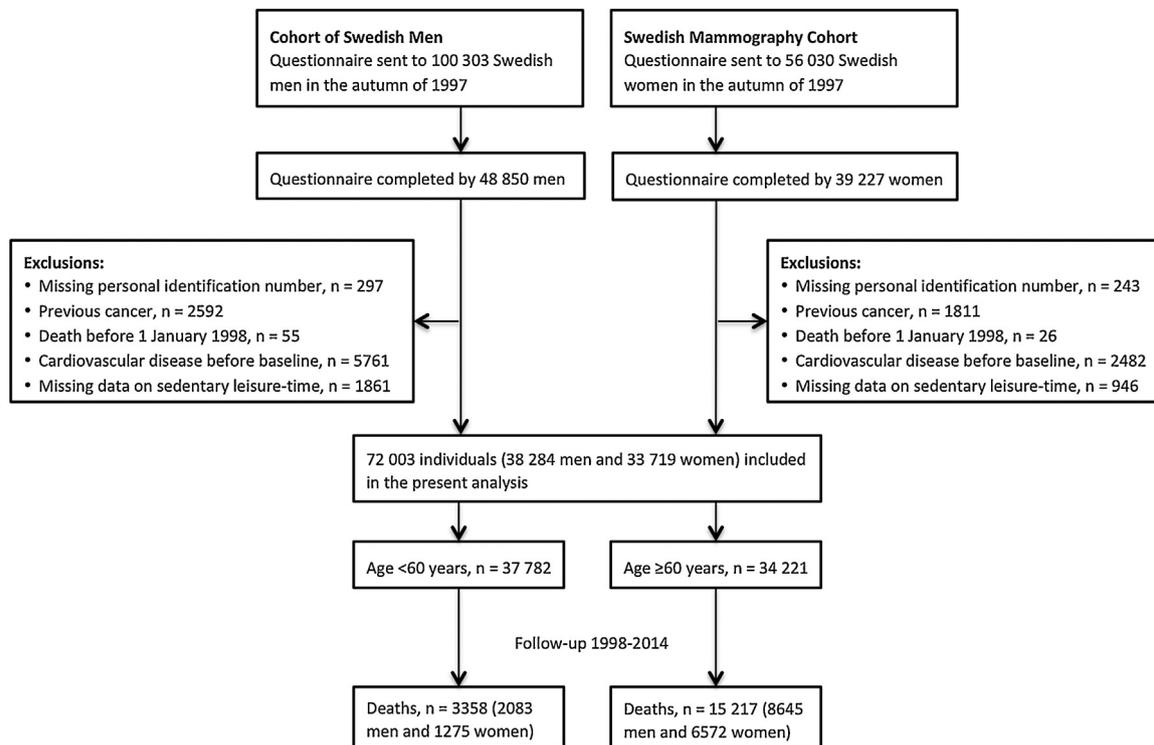[b] Among current drinkers; one drink corresponds to 12 g of alcohol.

Fig. 1. Participant flow chart and number of deaths in the two age groups.

Table 2
Hazard ratios of all-cause mortality and survival percentile differences in years by age group and categories of sedentary leisure-time (TV viewing and/or sitting reading), 1998–2014.

| Sedentary leisure-time, hours/day	No. of cases	Person-years	Mortality rate[a]	Hazard ratio (95% confidence interval)		Survival percentile difference in years (95% confidence interval)		
				Age- and sex-adjusted	Multivariable-adjusted[b]	10th, multivariable-adjusted[b]	25th, multivariable-adjusted[b]	40th, multivariable-adjusted[b]
<60 years (n = 37 782)								
<1	501	114 750	4.4	Reference	Reference	Reference	Reference	Reference
1–2	1705	343 991	5.0	1.09 (0.98 to 1.20)	1.06 (0.96 to 1.17)	−0.2 (−0.9 to 0.4)	−0.3 (−0.9 to 0.3)	−0.4 (−0.9 to 0.4)
3–4	988	148 392	6.7	1.44 (1.29 to 1.60)	1.14 (1.02 to 1.28)	−0.2 (−1.6 to −0.1)	−0.7 (−1.4 to −0.0)	−0.8 (−2.0 to −0.5)
5–6	110	10 716	10.3	2.26 (1.84 to 2.78)	1.29 (1.04 to 1.59)	−2.5 (−3.9 to −1.2)	−1.6 (−3.2 to −0.0)	−1.4 (−5.1 to −1.9)
>6	54	3374	16.0	3.50 (2.65 to 4.64)	1.72 (1.29 to 2.30)	−3.2 (−5.8 to −0.6)	−2.4 (−4.1 to −0.8)	−2.9 (−4.2 to −1.7)
p for trend				<0.001	<0.001	–	–	–
≥60 years (n = 34 221)								
<1	772	30 033	25.7	Reference	Reference	Reference	Reference	Reference
1–2	5436	193 676	28.1	0.97 (0.90 to 1.05)	1.02 (0.94 to 1.10)	−0.2 (−0.8 to 0.5)	−0.1 (−0.6 to 0.3)	−0.1 (−0.6 to 0.3)
3–4	7346	219 512	33.5	0.99 (0.92 to 1.07)	1.03 (0.95 to 1.11)	−0.1 (−0.8 to 0.6)	−0.1 (−0.6 to 0.4)	−0.2 (−0.6 to 0.3)
5–6	1305	31 129	41.9	1.14 (1.04 to 1.25)	1.12 (1.02 to 1.23)	−0.9 (−1.7 to −0.1)	−0.5 (−1.0 to 0.1)	−0.7 (−1.3 to −0.2)
>6	358	7625	47.0	1.35 (1.19 to 1.53)	1.19 (1.05 to 1.36)	−0.9 (−1.9 to 0.1)	−1.5 (−2.2 to −0.7)	−1.3 (−2.1 to −0.5)
p for trend				<0.001	0.001	–	–	–

[a] Per 1000 person-years.
[b] Adjusted for age, sex, education (less than high school, high school, or university), work activity (four categories), housework (four categories), walking/bicycling (four categories), exercise (four categories), BMI (in kg/m2; <25, 25–<30, or ≥30), smoking status and pack-years of smoking (never, former <20, former ≥20, current <20, or current ≥20), history of hypertension (yes or no), history of hypercholesterolemia (yes or no), diabetes (yes or no), alcohol consumption (never drinker, former drinker, or current drinker of <1, 1–6, 7–14, 15–21, or >21 drinks/week), and mDASH diet score (quartiles).

est category (>6 h/day) were more likely to have a sedentary work, walk/bicycle for at least 40 min/day, be current smoker, and to have a history of hypertension and diabetes. On average, they also had higher BMI and consumed more alcohol and slightly more snack foods (except nuts/almonds). In the middle-aged and older age groups, 85.5% and 16.5%, respectively, were employed.

The associations of sedentary leisure-time with all-cause mortality and survival time by age group are shown in Table 2. In the middle-aged group, the multivariable HR of all cause mortality was 1.72 (95% CI 1.29–2.30) when comparing those in the highest category of sedentary leisure-time (>6 h/day) with those in the lowest

category (<1 h/day). This corresponded to a difference in survival time of 2.4 (95% CI −4.1 to −0.8) years for the highest versus lowest category of sedentary leisure-time. In the older age group, those in the highest category of sedentary leisure-time, compared with the lowest category, had a multivariable HR of 1.19 (95% CI 1.05–1.36) and 1.5 (95% CI −2.2 to −0.7) years shorter survival time. Further adjustment for snack food consumption did not change the results materially (HRs of 1.74 [95% CI 1.30–2.33] in the middle-aged group and 1.19 [95% CI 1.05–1.36] in the older age group). The results persisted after excluding the first five years of follow-up; the multivariable HRs for the highest versus lowest category of sedentary

Middle-aged adults (<60 years)

Older adults (≥60 years)
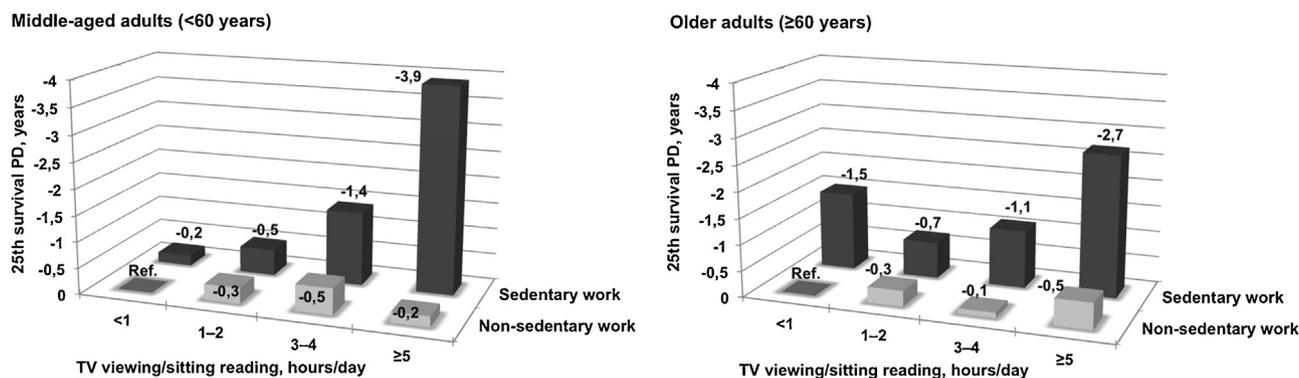
Fig. 2. Joint association of sedentary leisure-time (TV viewing and/or sitting reading) and sedentary work with survival time, presented in terms of 25th survival percentile difference. Adjusted for age, sex, education (less than high school, high school, or university), work activity (four categories), housework (four categories), walking/bicycling (four categories), exercise (four categories), BMI (in kg/m^2; <25, 25–< 30, or ≥30), smoking status and pack-years of smoking (never, former <20, former ≥20, current <20, or current ≥20), history of hypertension (yes or no), history of hypercholesterolemia (yes or no), diabetes (yes or no), alcohol consumption (never drinker, former drinker, or current drinker of <1, 1–6, 7–14, 15–21, or >21 drinks/week), and mDASH diet score (quartiles). Sedentary work was defined as mostly sitting down at work; non-sedentary work was defined as sitting down half the time to heavy manual work. The 25th survival percentile differences (95% confidence interval) in the middle-aged group were 0 (reference), −0.3 (−1.0 to 0.4), −0.5 (−1.3 to 0.3), −0.2 (−2.3 to 1.8), −0.2 (−1.4 to 1.0), −0.5 (−1.4 to 0.4), −1.4 (−2.4 to −0.5), and −3.9 (−6.2 to −1.7); the corresponding 25th survival percentile differences (95% confidence interval) in the older age group were 0 (reference), −0.3 (−0.8 to 0.2), −0.1 (−0.6 to 0.4), −0.5 (−1.1 to 0.1), −1.5 (-2.5 to −0.4), −0.7 (−1.4 to 0.0), −1.1 (−1.7 to −0.5), and −2.7 (−3.6 to −1.8).

leisure-time were 1.58 (95% CI 1.14–2.20) in middle-aged individuals and 1.21 (95% CI 1.05–1.39) in the older age group.

The association of sedentary leisure-time with all-cause mortality was modified by work activity (p-interaction = 0.007 in the middle-aged group and <0.001 in the older age group). In the middle-aged group, the multivariable HR of mortality was 1.99 (95% CI 1.55–2.56) for those with a sedentary leisure-time (≥5 h/day) and a sedentary work (mostly sitting down) compared with those in the lowest category of sedentary leisure-time (<1 h/day) and a non-sedentary work (sitting down half the working time to heavy manual work). This corresponded to −3.9 (95% CI −6.2 to −1.7) years shorter survival time (Fig. 2). In the older age group, the corresponding HR was 1.54 (95% CI 1.36 to 1.74) and this corresponded to −2.7 (95% CI −3.6 to −1.8) years shorter survival time (Fig. 2). There was no interaction by sex, BMI, smoking, housework, walking/bicycling, exercise, or employment status in either age group (all p-interaction > 0.05).

4. Discussion

In this prospective study of middle-aged and older adults, prolonged sedentary leisure-time (TV viewing and/or sitting reading) was associated with a markedly shorter survival time. The association was more pronounced in middle-aged adults among whom sedentary leisure-time for more than 6 h per day was associated with 72% increased all-cause mortality risk and 2.4 years shorter survival time. The association was even more pronounced among those with a sedentary work. In middle-aged adults with a sedentary work, prolonged sedentary leisure-time was associated with 3.9 years shorter survival time.

Our findings are consistent with those from previous studies of TV viewing or sedentary time in relation to mortality reported in terms of relative measures.[2,3,5] Results from a recent prospective cohort of 851 Swedish adults in which sedentary time was objectively measured (using accelerometer) showed that those in the most sedentary tertile had a 2.7-fold increased risk of all-cause mortality compared with the least sedentary individuals.[5]

The association of prolonged sedentary leisure-time time with increased mortality may be mediated by chronic diseases, such as type 2 diabetes mellitus, cardiovascular disease, and cancer,[1–3] all of which are associated with increased mortality. Furthermore, the association may be explained by metabolic abnormalities. Data from cross-sectional studies indicate that objectively measured

sedentary time and self-reported TV viewing time are associated with abnormal glucose metabolism, insulin resistance, increased fasting insulin and triglyceride concentrations, and decreased high-density lipoprotein cholesterol concentrations.[14–17] A prospective study of 8451 English adults indicated that inflammatory markers may partially account for the association between TV viewing time and increased mortality rate.[4] Another prospective study of 8933 Australian adults showed that TV viewing time was significantly associated with increased risk of inflammatory-related but not non-inflammatory-related mortality.[18] TV viewing may be associated with higher snack food consumption, which may increase mortality risk. In the present study consumption of snack foods, except nuts/almonds, slightly increased across categories of sedentary leisure-time but adjustment for snack food consumption did not change the results, suggesting that the observed association between sedentary leisure-time and all-cause mortality is not explained by higher snack food consumption.

Our study extends the evidence regarding the deleterious health outcomes associated with sedentary leisure-time by showing that daily long-time TV viewing and/or sitting reading time is significantly associated with a shorter survival, particularly in middle-aged adults and in those who also have a sedentary work. The reason for the stronger association in middle-aged than in older individuals is unclear but a possibility is that sedentary leisure-time has more adverse effects on cardiometabolic risk factors in younger individuals.

The chief strengths of this study include the large number of deaths and the complete and objective follow up of participants by linkage with the Swedish Death Register. A limitation is that TV viewing and/or reading time was assessed with a self-administered questionnaire and only once (at baseline). Moreover, there was moderate correlation between self-reported sedentary leisure-time and estimates from activity records,[7,8] and this may have affected the results. Another potential shortcoming is that we could only assess sedentary leisure-time, rather than total sedentary time, in relation to all-cause mortality. Nonetheless, we examined the combined association of TV viewing and/or reading time and sedentary time at work with all-cause mortality, and these two measures combined likely account for a major part of sedentary time. Another limitation is the observational design and that sedentary leisure-time was related to other behaviors linked to premature mortality, such as smoking, alcohol intake, and history of hypertension and diabetes. Despite adjustment for those and

other potential confounders we cannot completely rule out that the observed associations may be explained by residual confounding.

5. Conclusions

This study showed that prolonged sedentary leisure-time is associated with increased all-cause mortality and markedly shorter survival time. These results underscore the importance of reducing sedentary behaviors for a longer life.

Acknowledgments

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