Human Kinetics

Joint Associations of Sedentary Time and Intensity-Specific Physical Activity With Cancer Mortality: A Device-Based Cohort Study of 72,458 UK Adults

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Background: There are no studies examining the prospective joint association of device-based measures of sedentary time and physical activity (PA) with cancer mortality. We examined the joint associations of sedentary time and intensity-specific PA with cancer mortality in 72,458 adults from UK Biobank. *Methods:* Participants wore an Axivity AX3 accelerometer on their dominant wrist for at least 3 days (with at least 1 weekend day). Cox regression was performed to estimate hazard ratios (HR) and 95% confidence intervals (CIs) for joint associations of sedentary time and intensity-specific PA (light [LPA], moderate [MPA], and vigorous PA [VPA]) with cancer mortality (reference group: high intensity-specific PA and low sedentary time) adjusted for confounders and mutually adjusted for other PA intensities. *Results:* Associations between sedentary time and cancer mortality were stronger among participants with low PA, irrespective of the intensity. Compared with participants with lower sedentary time (<11 h/d) and high MPA (median of 49 min/d), HR were 1.27 (95% CI, 0.90–1.78) for high sedentary time and high MPA, 1.35 (95% CI, 1.03–1.77) for high sedentary time and medium MPA (49 min/d), and 1.49 (95% CI, 1.15–1.92) for high sedentary time and low MPA (13 min/d). HR for high sedentary time and low light PA (61 min/d) and high sedentary time and low vigorous PA (1 min/d) were 1.25 (95% CI, 1.02–1.59) and 1.57 (95% CI, 1.20–2.06), respectively. *Conclusions:* Relatively large amounts of LPA and MPA and small amounts of VPA appeared to attenuate the association between sedentary time and cancer mortality.

Keywords: sedentary behavior, exercise, neoplasms, epidemiology

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Key Points

- High sedentary time (>13 h/d) was associated with higher risk of cancer mortality.
- Physical activity (PA) attenuated the association between sedentary time and cancer mortality.
- A median of 4 minutes/day of vigorous PA, 49 min/d of moderate PA, or 100 min/d of light PA appeared to attenuate the cancer mortality risks of high sedentary time.

Sedentary time has been associated with higher risk of cancer mortality, independent of physical activity (PA).[1] However, questionnaire-based findings from a harmonized meta-analysis suggested that at least 50 to 65 minutes per day of self-reported moderate to vigorous PA eliminated the association between sedentary time and cancer mortality.[2] Contrary to questionnaires that only capture blocks of PA (eg, 10–15 min of walking), wearable devices capture all movement and allow the differentiation of PA intensities, such as short bouts of vigorous intermittent lifestyle PA[3,4] and light PA (LPA). To our knowledge, no wearable device-based study on the joint association of sedentary time and PA with cancer mortality exists.[5] Understanding the amounts of movement at different intensities that attenuate the association between sedentary time and cancer mortality may help to inform future guidelines. We examined the joint association of sedentary time and intensity-specific PA with cancer mortality in UK adults.

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Methods

This study followed the Strengthening the Reporting of Observational Studies in Epidemiology reporting guideline.[6] The UK Biobank cohort enrolled more than 500,000 adults from 22 centers across the United Kingdom between 2006 and 2010. The study was approved by the institutional review boards of the National Health Service and the National Research Ethics Service (reference 11/NW/0382), and all participants provided consent for access to their national health records. A total of 103,684 participants were mailed and wore an Axivity AX3 accelerometer on their dominant wrist for 24 hours per day for 7 days. The AX3 accelerometers were initialized to collect data with a sampling frequency of 100 Hz and a dynamic range between ±8 g. Monitoring days were considered valid if wear time was greater than 16 hours. As previously,[3,4,7,8] we included participants with at least 3 days (with at least 1 weekend day) of valid accelerometer data between June 2013 and December 2015. We excluded participants diagnosed with cancer, cardiovascular diseases, or respiratory diseases (n = 16,985) prior to the accelerometry baseline. Finally, we excluded participants who died from any cause during the first 2 years of follow-up (n = 481) to mitigate reverse causation bias, producing a final analytical sample of 72,458 participants.

Person time was calculated from the time of collection of accelerometer data (June 2013 and December 2015) until the time of death or the end of the follow-up period (November 2022), whichever occurred first. Our main outcome was total cancer mortality. PA intensity was classified with a validated accelerometer-based activity machine learning scheme[8] covering sedentary time, LPA, moderate (MPA), and vigorous (VPA) activities. Tertiles were used to categorize low, medium, and high sedentary time (0–11, 11–12, and ≥13 h/d) and PA intensities. The median values (minutes per week) in each joint category of PA and sedentary time were used to estimate the amount of intensity-specific PA needed to attenuate the sedentary behavior risk of cancer mortality.[9]

Multivariable Cox proportional hazard regression models estimated the hazard ratio (HR) and 95% confidence intervals (CIs) for the association between sedentary time and cancer mortality adjusted for potential confounder[10,11] (age, sex, education, race/ethnicity, smoking status, alcohol consumption, fruits and vegetables intake, family history of cancer, and sleep duration) and total PA (LPA and moderate to vigorous PA). Joint association of sedentary time and PA intensities (reference group: highest tertile of PA and lowest tertile of sedentary time) with cancer mortality were adjusted for potential confounders[10,11] (listed earlier) and mutually adjusted for other PA intensities.

Results

Participants with high sedentary time were older, more likely to be men and smokers, and had lower alcohol intake and higher BMI, diabetes, and hypertension compared with those with low sedentary time (Table 1). During a median of 8.06 years of follow-up (566,171 person years), we documented 1195 cancer deaths. Sedentary time was associated with higher risk of cancer mortality. Compared with <11 hours per day of sedentary time, HRs for cancer mortality were 1.22 (95% CI, 1.02–1.45) for 11 to 12 hours per day and 1.34 (1.09 to 1.66) for ≥13 hours per day of sedentary time. We found that a median of 4 minutes per day of VPA, 49 minutes per day of MPA, or 100 minutes per day of LPA

appeared to attenuate the cancer mortality risks of high sedentary time (Figure 1 and Supplementary Table S1 [available online]).

Higher MPA attenuated the association between sedentary time and cancer mortality. Compared with participants with low sedentary time and high MPA, multivariable-adjusted HRs for cancer mortality were 1.27 (95% CI, 0.90–1.78) for high sedentary time and high MPA, 1.35 (95% CI, 1.03–1.77) for high sedentary time and medium MPA, and 1.49 (95% CI, 1.15–1.92) for high sedentary time and low MPA. The attenuation pattern was not always clear as results within the medium sedentary time group presented some inconsistencies (Figure 1). Participants with medium sedentary time and high MPA showed a residual increased risk of cancer mortality (HR 1.35; 95% CI, 1.04–1.76), although the magnitude of the association was weaker compared with participants with medium sedentary time and low MPA (HR 1.50; 95% CI, 1.17–1.93).

For LPA and VPA, we found that participants with low activity consistently showed higher risk of cancer mortality. Participants with medium sedentary time and low LPA (HR 1.35; 95% CI, 1.06–1.71) and high sedentary time and low LPA (HR 1.28; 95% CI, 1.02–1.59) showed higher cancer mortality risk. Similarly, medium sedentary time and low VPA (HR 1.41; 95% CI, 1.08–1.84) and high sedentary time and low VPA (HR 1.57; 95% CI, 1.20–2.06) showed higher risks of cancer mortality. Participants with both medium sedentary time and medium VPA showed a residual increased risk of cancer mortality (HR 1.35; 95% CI, 1.04–1.75). Risks in low sedentary time across all PA intensities were similar to the reference group (low sedentary time and high PA).

Discussion

Our wearable device-based cohort study aimed at examining how much of each intensity category is required to attenuate the association between sedentary time and cancer mortality. We found that a median of 49 minutes per day of MPA, 4 minutes per day of VPA, or 100 minutes per day of LPA alone appeared to attenuate most, but not all, cancer mortality risks of high sedentary time. Of note, these findings were based on mutually adjusted PA models, which offers insights on the amount of each PA intensity needed to attenuate the association between sedentary time and cancer mortality independent of other PA intensities. Future studies may further explore the optimum combination of LPA, MPA, and VPA to reduce cancer mortality risks associated with sedentary time.

Our findings are in line with a previous study showing that at least 50 to 65 minutes per day of self-reported moderate to vigorous PA eliminated the association between sedentary time and cancer mortality.[2] However, our novel findings on PA-specific intensities showed that VPA may be a time-efficient means of reducing the cancer mortality risk. These novel PA intensity-specific findings highlight that, depending on the specific population and sedentary time, interventions can use different amounts of PA intensities to mitigate the cancer mortality risks.

Our study has some limitations. First, residual confounding cannot be excluded. Confounders were collected several years before accelerometer evaluation. We did not have data on cancer stage, treatment, or other predictors of cancer outcomes. Sedentary time and PA were measured at a single point in time, and thus, results may be prone to regression dilution bias. The UK Biobank participants are not a representative sample of the UK adult population, but it is unlikely that this has materially influenced our findings.[12]

Table 1 Baseline Characteristics of Participants by Device-Measured Sedentary Time

Variables[a]	Total (N = 72,458)	Sedentary time (tertiles)		
		Low (n = 24,153)	Medium (n = 24,154)	High (n = 24,151)
Sedentary time				
Median (IQR), h/d	11.9 (10.8–12.9)	10.4 (9.7–10.8)	11.9 (11.6–12.3)	13.4 (13.0–14.1)
Range	0–22.0	0–11.2	11.2–12.6	12.6–22.0
Moderate to vigorous physical activity				
Median (IQR), min/d	33.9 (20.1–53.8)	50.9 (33.3–76.1)	33.3 (21.4–49.1)	22.6 (13.5–35.2)
Range	0–369.4	0–353.3	0.5–234.9	0–369.4
Moderate physical activity				
Median (IQR), min/d	28.6 (16.9–45.9)	43.2 (27.8–65.6)	28.0 (17.9–41.5)	19.1 (11.3–30.1)
Range	0–357.1	0–344.7	0.4–233.8	0–357.1
Vigorous physical activity				
Median (IQR), min/d	3.5 (1.6–7.1)	5.2 (2.6–9.8)	3.6 (1.8–7.0)	2.2 (1.0–4.6)
Range	0–129.0	0–95.0	0–129.1	0–103.3
Light physical activity				
Median (IQR), min/d	103.5 (70.0–158.7)	150.8 (93.3–207.2)	105.2 (73.3–150.1)	78.6 (58.1–109.9)
Range	0–471.6	0–471.6	8.4–454.3	0–438.1
Sleep duration (SD), h	7.5 (1.6)	8.2 (1.9)	7.6 (1.0)	6.8 (1.2)
Age (SD), y	61.1 (7.8)	59.5 (7.8)	61.0 (7.8)	62.8 (7.7)
Men, %	43.0	36.8	43.1	49.2
Race/ethnicity, %				
Asian	1.2	1.1	1.1	1.4
Black	0.9	0.8	0.8	1.2
Mixed	0.6	0.5	0.6	0.7
Other	0.9	0.7	0.8	1.1
White	96.5	97.0	97.0	95.7
Educational attainment, %[b]				
College or university degree	44.4	41.7	45.6	45.9
A levels/AS levels or equivalent	13.4	13.9	13.1	13.2
O levels/GSCEs or equivalent	20.3	21.4	20.2	19.2
CSEs or equivalent	4.2	5.3	4.1	3.1
NVQ or HND or HNC or equivalent	5.2	5.3	5.0	5.2
Other	12.6	12.3	12.0	13.5
BMI, mean (SD), kg/m^2	26.5 (4.4)	25.5 (4.0)	26.4 (4.2)	27.7 (4.8)
Smoking status, %				
Current cigarette	6.7	6.1	6.3	7.7
Former cigarette	34.5	33.7	34.5	35.2
Never cigarette	58.8	60.1	59.2	57.1
Alcohol intake				
Never	2.9	2.8	2.5	3.2
Former	2.6	2.4	2.4	2.9
Current, below guideline	57.4	57.0	57.3	57.7
Current, above guideline	37.2	37.8	37.8	36.1
Fruits and vegetables intake, servings/d	8.1 (4.4)	8.3 (4.5)	8.0 (4.3)	7.9 (4.4)
Family history of CVD	53.6	52.2	53.4	55.3
Family history of cancer	24.8	24.1	25.3	25.0
Diabetes, %	0.6	0.4	0.5	0.8
Hypertension, %	13.7	9.8	12.8	18.6

Abbreviations: BMI, body mass index; CVD, cardiovascular disease; IQR, interquartile range. Note: UK Biobank, 2013 and 2015.
[a]Data collected for confounders were obtained during the initial UK Biobank assessment several years prior to the accelerometer evaluation.
[b]NVQ, national vocational qualification or HND, higher national diploma or HNC, higher national certificate or equivalent = 19 years of education; CSE, certificate of secondary education or equivalent = 10 years of education; O levels/GCSE, general certificate of secondary education or equivalent = 10 years of education; A levels/ AS levels or equivalent = 13 years of education; and College or University degree = 20 years of education.
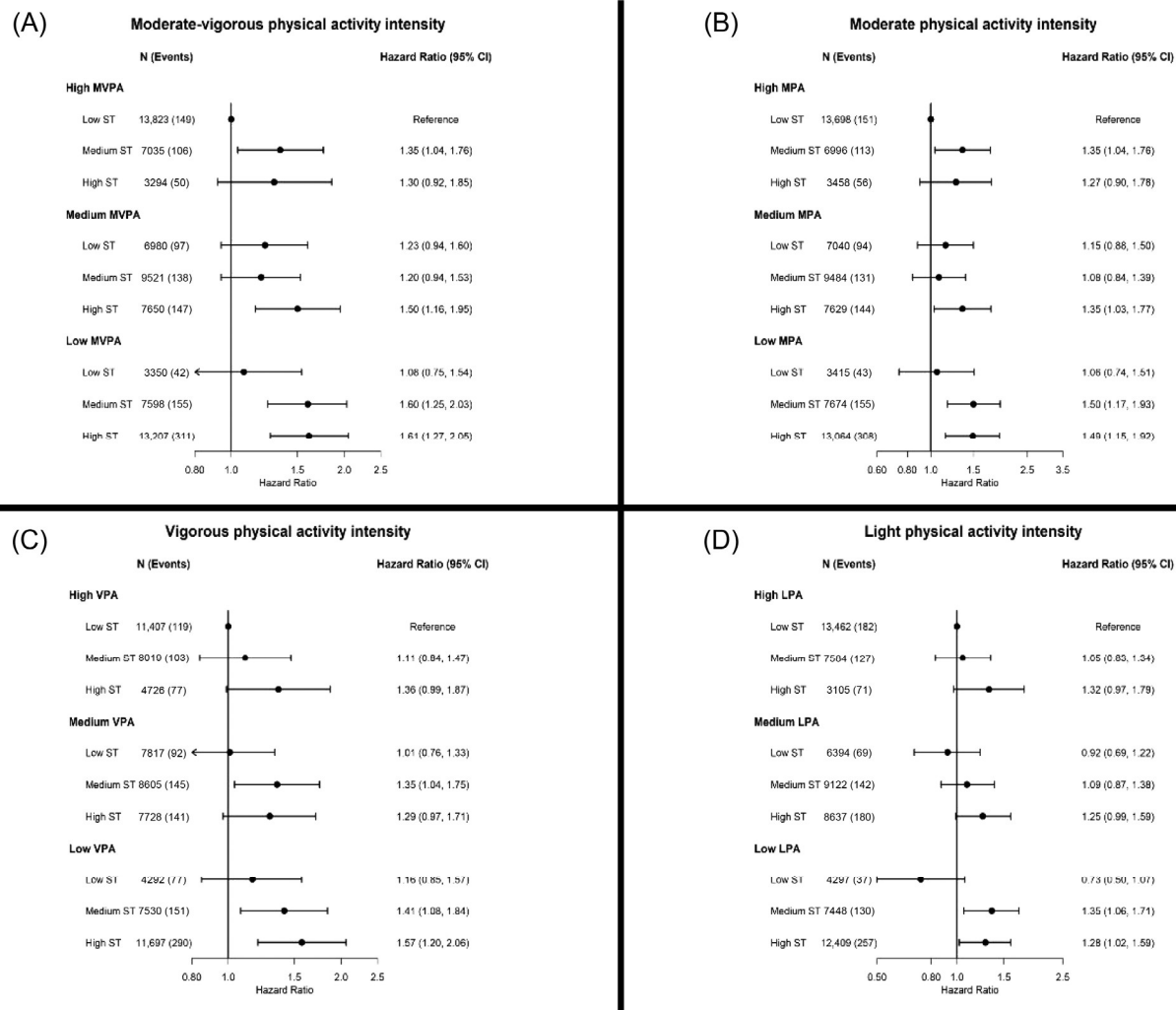
Figure 1 — Joint associations of device-measured sedentary time and intensity-specific physical activity with total cancer mortality. *Note*. Tertiles were used to categorize low, medium, and high sedentary behavior (0–11, 11–13, and >13 h/d), and MVPA (0–24.5, 24.5–45.7, and >45.7 min/d). The median value (minutes per week) in each tertile of intensity-specific physical activity was: MVPA: low, 15.6 minutes per day; medium, 33.9 minutes per day; and high, 64.9 minutes per day. MPA: low, 13.0 minutes per day; medium, 28.6 minutes per day; and high, 55.9 minutes per day. LPA: low, 60.8 minutes per day; medium, 103.5 minutes per day; and high, 184.2 minutes per day. VPA: low, 1.1 minutes per day; medium, 3.5 minutes per day; high, 9.5 minutes per day. Minutes per day: medium, 26.9 minutes per day and high, 63.6 minutes per day. Multivariable model: adjusted for age, sex, education, race/ethnicity, smoking status, alcohol consumption, fruits and vegetables intake, sleep duration, family history of CVD (for ACM and CVD mortality), and family history of cancer (for ACM and cancer mortality); participants with CVD, cancer, and COPD at baseline and less than 2 years of follow-up were excluded. Data collected for confounders were obtained during the initial UK Biobank assessment several years prior to the accelerometer evaluation. ACM indicates all-cause mortality; COPD, chronic obstructive pulmonary disease; CVD, cardiovascular disease; LPA, light physical activity; MPA, moderate physical activity; MVPA, moderate to vigorous physical activity; ST, sedentary time; VPA, vigorous physical activity.

Conclusion

In conclusion, our study showed that relatively large amounts of LPA and MPA, and small amounts of VPA, appeared to attenuate most of the risk of cancer mortality associated with sedentary time. These findings suggest that reducing sedentary time and increasing PA should both be considered as complementary strategies for cancer prevention-focused interventions and public health guidelines.

Acknowledgments

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