Evidence Portfolio – Sedentary Subcommittee, Question 1

Q1. What is the relationship between sedentary behavior and all-cause mortality?

a. Is there a dose-response relationship? If yes, what is the shape of the relationship?
b. Does the relationship vary by age, sex, race/ethnicity, socio-economic status, or weight status?
c. Is the relationship independent of levels of light, moderate, or vigorous physical activity?
d. Is there evidence that bouts or breaks in sedentary behavior change the relationship between sedentary behavior and all-cause mortality?

Sources of Evidence: Existing Systematic Reviews, Meta-Analyses, and Original Research

Conclusion Statements and Grades

Strong evidence demonstrates a significant relationship between greater time spent in sedentary behavior and higher all-cause mortality rates. **PAGAC Grade: Strong.**

Strong evidence demonstrates the existence of a direct, curvilinear dose-response relationship between sedentary behavior and all-cause mortality, with an increasing slope at higher amounts of sedentary behavior. **PAGAC Grade: Strong.**

Limited evidence suggests that the relationship between sedentary behavior and all-cause mortality does not vary by age, sex/ethnicity, or weight status. **PAGAC Grade: Limited.**

Insufficient evidence is available to determine whether the relationship between sedentary behavior and all-cause mortality varies by socioeconomic status. **PAGAC Grade: Not assignable.**

Strong evidence demonstrates that the relationship between sedentary behavior and all-cause mortality varies by amount of moderate-to-vigorous physical activity. **PAGAC Grade: Strong.**

Insufficient evidence is available to determine whether bouts or breaks in sedentary behavior are important factors in the relationship between sedentary behavior and all-cause mortality. **PAGAC Grade: Not assignable.**

Description of the Evidence

An initial search for systematic reviews, meta-analyses, pooled analyses, and reports did not identify sufficient literature to fully answer the research question as determined by the Sedentary Subcommittee. A supplementary search for original research was conducted to capture the most recent literature.

Existing Systematic Reviews and Meta-Analyses

Overview

A total of 9 existing reviews were included: 6 meta-analyses[1-6] and 3 systematic reviews.[7-9] The reviews were published from 2011 to 2016.

The meta-analyses included a range of 3 to 16 studies that addressed all-cause mortality. All meta-analyses covered an extensive timeframe: from inception to one year before publication or during the year of publication,[1, 3, 5, 6] from 1970 to March 2011,[4] and from 1989 to January 2013.[2]

The systematic reviews included a range of 3 to 6 studies that addressed all-cause mortality. Reviews covered the following timeframes: from inception to one year before publication,[7] from 1989 to February 2010,[8] and from 1996 to January 2011.[9]

Exposures

All of the included reviews examined sedentary behavior. The majority of the reviews used a comprehensive definition of sedentary behavior that included any activities requiring low levels of energy expenditure (≤1.5 metabolic equivalents), such as sitting time, television viewing, or screen time.[1-3, 6-9] Two reviews examined television viewing or screen time only.[4, 5]

Outcomes

All included reviews addressed all-cause mortality as an outcome.

Original Research

Overview

Twenty-seven original research studies were included as sources of evidence.[10-36] All of the included studies were prospective cohort studies. The studies were published between 2014 and 2017.

The majority of the studies (n=16) were conducted in the United States,[11-15, 18, 22-25, 27, 28, 30-32, 35] 3 were in the United Kingdom,[17, 29, 36] 2 were in Norway,[16, 21] 2 were in Australia,[10, 33] 1 was in Denmark,[34] 1 was in Japan,[19] 1 was in the Netherlands,[20] and the remaining study was conducted in Spain.[26] The analytic sample size ranged from 1,839 to 423,659.

Exposures

The majority (n=15) of the studies used self-reported data to measure sedentary behavior. Of these studies, 8 assessed participants' sitting per day,[10, 16, 17, 21, 22, 26, 28, 35] 2 studies[18, 32] assessed television viewing time, 2 studies[19, 34] assessed occupational sitting time, 1 study[36] assessed leisure screen time per day, 1 study[29] reported on the number of hours spent sitting per week, and 1 study[33] assessed sitting and screen time per day.

The other 12 studies used objective devices to measure sedentary behaviors. The majority of the studies used accelerometers,[11, 13-15, 20, 23-25, 27, 30, 31] while 1 study[12] used an activity monitor.

Outcomes

All included studies addressed all-cause mortality as an outcome.

Populations Analyzed

The table below lists the populations analyzed in each article.

Table 1. Populations Analyzed by All Sources of Evidence

	Sex	Race/ Ethnicity	Age	Socio-economic Status	Weight Status	Disability Status	Chronic Conditions	Other
Biswas, 2015			Adults					
Chau, 2013			Adults					
de Rezende, 2014			Adults					
Ding, 2015			Adults ≥45					
Edwards, 2016			Adults 20–85					
Ekelund, 2016			Adults					
Ensrud, 2014	Male		Adults ≥65					
Evenson, 2017			Adults ≥40					
Evenson, 2016			Adults ≥40					
Fishman, 2016			Adults 50–79					
Grontved, 2011			Adults					
Grunseit, 2017			Adults ≥20					
Hagger-Johnson, 2016			Adults 37–78					
Keadle, 2015	Male		Adults 50–71					
Kikuchi, 2015	Male		Adults 40–69 (baseline), 50–74 (follow-up)					
Koolhaas, 2017	Male		Adults 45–98					
Krokstad, 2017			Adults 20–69					
Lee, 2016a	Women		Adults 50-59, 60–69, 70–79, 80–89				Diabetes, Congestive Heart Failure	Post-menopausal, Smoking
Lee, 2016b			Adults ≥18					
Loprinzi, 2016a			Adults 20–85			Visually impaired		

Table 1. Populations Analyzed by All Sources of Evidence (Continued)

	Sex	Race/ Ethnicity	Age	Socio-economic Status	Weight Status	Disability Status	Chronic Conditions	Other
Loprinzi, 2016b			Adults 20–85					
Martinez-Gomez, 2016			Adults ≥60			Disability		
Matthews, 2016			Adults ≥40					
Matthews, 2015	Male		Adults 59–82					
Proper, 2011			Adults					
Pulsford, 2015			Adults 35–55					
Schmid, 2016	Male		Adults 50–85					
Schmid, 2015			Adults ≥50					
Shuval, 2015			Adults ≥20					
Stamatakis, 2015			Adults ≥45					
Sun, 2015			Adults					
Thorp, 2011			Adults					
van der Ploeg, 2015	Male		Adults ≥21	Social class (five levels)	Normal/Healthy Weight (BMI: 18.5–24.9), Overweight (BMI: 25–29.9), Obese (BMI: ≥30)			Smoking
Warren Anderson, 2016	Male	White, Black or African American	Adults 40–79	Low income				
Wijndaele, 2017			Adults 40–69					
Wilmot, 2012			Adults					

Supporting Evidence

Existing Systematic Reviews and Meta-Analyses

Table 2. Existing Systematic Reviews and Meta-Analyses Individual Evidence Summary Tables

<table>
<tr><td colspan="2">Meta-Analysis
Citation: Biswas A, Oh PI, Faulkner GE, et al. Sedentary time and its association with risk for disease incidence, mortality, and hospitalization in adults: A systematic review and meta-analysis. Ann Intern Med. 2015;162(2):123-32.</td></tr>
<tr><td>Purpose: To quantify the association between sedentary time and hospitalizations, all-cause mortality, cardiovascular disease (CVD), diabetes, and cancer in adults independent of PA.</td><td rowspan="4">Abstract: BACKGROUND: The magnitude, consistency, and manner of association between sedentary time and outcomes independent of physical activity remain unclear. PURPOSE: To quantify the association between sedentary time and hospitalizations, all-cause mortality, cardiovascular disease, diabetes, and cancer in adults independent of physical activity. DATA SOURCES: English-language studies in MEDLINE, PubMed, EMBASE, CINAHL, Cochrane Library, Web of Knowledge, and Google Scholar databases were searched through August 2014 with hand-searching of in-text citations and no publication date limitations. STUDY SELECTION: Studies assessing sedentary behavior in adults, adjusted for physical activity and correlated to at least 1 outcome. DATA EXTRACTION: Two independent reviewers performed data abstraction and quality assessment, and a third reviewer resolved inconsistencies. DATA SYNTHESIS: Forty-seven articles met our eligibility criteria. Meta-analyses were performed on outcomes for cardiovascular disease and diabetes (14 studies), cancer (14 studies), and all-cause mortality (13 studies). Prospective cohort designs were used in all but 3 studies; sedentary times were quantified using self-report in all but 1 study. Significant hazard ratio (HR) associations were found with all-cause mortality (HR, 1.240 [95% CI, 1.090 to 1.410]), cardiovascular disease mortality (HR, 1.179 [CI, 1.106 to 1.257]), cardiovascular disease incidence (HR, 1.143 [CI, 1.002 to 1.729]), cancer mortality (HR, 1.173 [CI, 1.108 to 1.242]), cancer incidence (HR, 1.130 [CI, 1.053 to 1.213]), and type 2 diabetes incidence (HR, 1.910 [CI, 1.642 to 2.222]). Hazard ratios associated with sedentary time and outcomes were generally more pronounced at lower levels of physical activity than at higher levels. LIMITATION: There was marked heterogeneity in research designs and the assessment of sedentary time and physical activity. CONCLUSION: Prolonged sedentary time was independently associated with deleterious health outcomes regardless of physical activity.</td></tr>
<tr><td>Timeframe: Inception–2014</td></tr>
<tr><td>Total # of Studies: 41</td></tr>
<tr><td>Author's Definition of Sedentary:
A distinct class of waking behaviors characterized by little physical movement and low energy expenditure (≤1.5 metabolic equivalents), including sitting, television watching, and reclined posture.</td></tr>
<tr><td>Outcomes Addressed:
All-cause mortality, CVD mortality, cancer mortality.</td><td></td></tr>
<tr><td>Populations Analyzed:
Adults</td><td>Author-Stated Funding Source: No funding source used</td></tr>
</table>

<table>
<tr><td colspan="2">Meta-Analysis
Citation: Chau JY, Grunseit AC, Chey T, et al. Daily sitting time and all-cause mortality: A meta-analysis. PLoS One. 2013;8(11):e80000. doi:10.1371/journal.pone.0080000.</td></tr>
<tr><td>Purpose: To quantitatively summarize the results of all published prospective cohort studies that have examined the association between daily total sitting time and all-cause mortality, and to examine potential dose-response relationships.</td><td rowspan="5">Abstract: OBJECTIVE: To quantify the association between daily total sitting and all-cause mortality risk and to examine dose-response relationships with and without adjustment for moderate-to-vigorous physical activity. METHODS: Studies published from 1989 to January 2013 were identified via searches of multiple databases, reference lists of systematic reviews on sitting and health, and from authors' personal literature databases. We included prospective cohort studies that had total daily sitting time as a quantitative exposure variable, all-cause mortality as the outcome and reported estimates of relative risk, or odds ratios or hazard ratios with 95% confidence intervals. Two authors independently extracted the data and summary estimates of associations were computed using random effects models. RESULTS: Six studies were included, involving data from 595,086 adults and 29,162 deaths over 3,565,569 person-years of follow-up. Study participants were mainly female, middle-aged or older adults from high-income countries; mean study quality score was 12/15 points. Associations between daily total sitting time and all-cause mortality were not linear. With physical activity adjustment, the spline model of best fit had dose-response HRs of 1.00 (95% CI: 0.98-1.03), 1.02 (95% CI: 0.99-1.05) and 1.05 (95% CI: 1.02-1.08) for every 1-hour increase in sitting time in intervals between 0-3, >3-7 and >7 h/day total sitting, respectively. This model estimated a 34% higher mortality risk for adults sitting 10 h/day, after taking physical activity into account. The overall weighted population attributable fraction for all-cause mortality for total daily sitting time was 5.9%, after adjusting for physical activity. CONCLUSIONS: Higher amounts of daily total sitting time are associated with greater risk of all-cause mortality and moderate-to-vigorous physical activity appears to attenuate the hazardous association. These findings provide a starting point for identifying a threshold on which to base clinical and public health recommendations for overall sitting time, in addition to physical activity guidelines.</td></tr>
<tr><td>Timeframe: 1989–January 2013</td></tr>
<tr><td>Total # of Studies: 6</td></tr>
<tr><td>Author's Definition of Sedentary: Daily sedentary time and sitting time was defined as daily total sitting time. Encompasses a broad range of behaviors that involve sitting or lying down and do not increase energy expenditure substantially during waking time.</td></tr>
<tr><td>Outcomes Addressed: All-cause mortality.</td></tr>
<tr><td>Populations Analyzed: Adults</td><td>Author-Stated Funding Source: Australian National Health and Medical Research Council</td></tr>
</table>

Systematic Review **Citation:** de Rezende LF, Rey-Lopez JP, Matsudo VK, do Carmo Luiz O. Sedentary behavior and health outcomes among older adults: A systematic review. *BMC Public Health*. 2014;14:333. doi:10.1186/1471-2458-14-333.	
Purpose: To look for associations between sedentary behavior and multiple health outcomes in adults over 60 years of age. **Timeframe:** Inception–2013 **Total # of Studies:** 23 **Author's Definition of Sedentary:** Sedentary behaviors are characterized by any waking activity that requires an energy expenditure ranging from a basal metabolic rate of 1.0 to 1.5 and a sitting or reclining posture. **Outcomes Addressed:** All-cause mortality, cardiovascular disease mortality, colorectal cancer mortality.	**Abstract:** BACKGROUND: In the last decade, sedentary behavior has emerged as a new risk factor for health. The elderly spend most of their awake time in sedentary activities. Despite this high exposure, the impact of this sedentary behavior on the health of this population has not yet been reviewed. We systematically reviewed evidence for associations between sedentary behavior and multiple health outcomes in adults over 60 years of age. METHODS: We searched the Medline, Embase, Web of Science, SPORTDiscus, PsycINFO, CINAHL, LILLACS, and Sedentary Research Database for observational studies published up to May 2013. Additionally, we contacted members of the Sedentary Behaviour Research Network to identify articles that were potentially eligible. After inclusion, the methodological quality of the evidence was assessed in each study. RESULTS: We included 24 eligible articles in our systematic review, of which only 2 (8%) provided high-quality evidence. Greater sedentary time was related to an increased risk of all-cause mortality in the older adults. Some studies with a moderate quality of evidence indicated a relationship between sedentary behavior and metabolic syndrome, waist circumference, and overweightness/obesity. The findings for other outcomes such as mental health, renal cancer cells, and falls remain insufficient to draw conclusions. CONCLUSION: This systematic review supports the relationship between sedentary behavior and mortality in older adults. Additional studies with high methodological quality are still needed to develop informed guidelines for addressing sedentary behavior in older adults.
Populations Analyzed: Adults	**Author-Stated Funding Source:** Fundação de Amparo à Pesquisa do Estado de São Paulo (FAPESP, São Paulo Research Foundation)

Meta-Analysis

Citation: Ekelund U, Steene-Johannessen J, Brown WJ, et al. Does physical activity attenuate, or even eliminate, the detrimental association of sitting time with mortality? A harmonised meta-analysis of data from more than 1 million men and women. *Lancet.* 2016;388(10051):1302-1310. doi:10.1016/S0140-6736(16)30370-1.

Purpose: To examine the joint and stratified associations of sedentary behavior and physical activity with all-cause mortality.

Timeframe: Inception–2015

Total # of Studies: 16

Author's Definition of Sedentary: Daily sitting or TV-viewing time.

Outcomes Addressed: All-cause mortality, cardiovascular disease mortality, and cancer mortality.

Abstract: BACKGROUND: High amounts of sedentary behaviour have been associated with increased risks of several chronic conditions and mortality. However, it is unclear whether physical activity attenuates or even eliminates the detrimental effects of prolonged sitting. We examined the associations of sedentary behaviour and physical activity with all-cause mortality. METHODS: We did a systematic review, searching six databases (PubMed, PsycINFO, Embase, Web of Science, Sport Discus, and Scopus) from database inception until October, 2015, for prospective cohort studies that had individual level exposure and outcome data, provided data on both daily sitting or TV-viewing time and physical activity, and reported effect estimates for all-cause mortality, cardiovascular disease mortality, or breast, colon, and colorectal cancer mortality. We included data from 16 studies, of which 14 were identified through a systematic review and two were additional unpublished studies where pertinent data were available. All study data were analysed according to a harmonised protocol, which categorised reported daily sitting time and TV-viewing time into four standardised groups each, and physical activity into quartiles (in metabolic equivalent of task [MET]-hours per week). We then combined data across all studies to analyse the association of daily sitting time and physical activity with all-cause mortality, and estimated summary hazard ratios using Cox regression. We repeated these analyses using TV-viewing time instead of daily sitting time. FINDINGS: Of the 16 studies included in the meta-analysis, 13 studies provided data on sitting time and all-cause mortality. These studies included 1 005 791 individuals who were followed up for 2-18·1 years, during which 84 609 (8·4%) died. Compared with the referent group (ie, those sitting <4 h/day and in the most active quartile [>35·5 MET-h per week]), mortality rates during follow-up were 12-59% higher in the two lowest quartiles of physical activity (from HR=1·12, 95% CI 1·08-1·16, for the second lowest quartile of physical activity [<16 MET-h per week] and sitting <4 h/day; to HR=1·59, 1·52-1·66, for the lowest quartile of physical activity [<2·5 MET-h per week] and sitting >8 h/day). Daily sitting time was not associated with increased all-cause mortality in those in the most active quartile of physical activity. Compared with the referent (<4 h of sitting per day and highest quartile of physical activity [>35·5 MET-h per week]), there was no increased risk of mortality during follow-up in those who sat for more than 8 h/day but who also reported >35·5 MET-h per week of activity (HR=1·04; 95% CI 0·99-1·10). By contrast, those who sat the least (<4 h/day) and were in the lowest activity quartile (<2·5 MET-h per week) had a significantly increased risk of dying during follow-up (HR=1·27, 95% CI 1·22-1·31). Six studies had data on TV-viewing time (N=465 450; 43 740 deaths). Watching TV for 3 h or more per day was associated with increased mortality regardless of physical activity, except in the most active quartile, where mortality was significantly increased only in people who watched TV for 5

	h/day or more (HR=1·16, 1·05-1·28). INTERPRETATION: High levels of moderate intensity physical activity (ie, about 60-75 min per day) seem to eliminate the increased risk of death associated with high sitting time. However, this high activity level attenuates, but does not eliminate the increased risk associated with high TV-viewing time. These results provide further evidence on the benefits of physical activity, particularly in societies where increasing numbers of people have to sit for long hours for work and may also inform future public health recommendations.
Populations Analyzed: Adults	**Author-Stated Funding Source:** No funding source used

Meta-Analysis **Citation:** Grontved A, Hu FB. Television viewing and risk of type 2 diabetes, cardiovascular disease, and all-cause mortality: A meta-analysis. *JAMA*. 2011;305(23):2448-55. doi: 10.1001/jama.2011.812.	
Purpose: To determine the association between TV viewing and type 2 diabetes, nonfatal or fatal cardiovascular disease (CVD), and all-cause mortality, and to quantify the dose-response relationship of TV viewing with the risk of these health outcomes.	**Abstract:** CONTEXT: Prolonged television (TV) viewing is the most prevalent and pervasive sedentary behavior in industrialized countries and has been associated with morbidity and mortality. However, a systematic and quantitative assessment of published studies is not available. OBJECTIVE: To perform a meta-analysis of all prospective cohort studies to determine the association between TV viewing and risk of type 2 diabetes, fatal or nonfatal cardiovascular disease, and all-cause mortality. DATA SOURCES AND STUDY SELECTION: Relevant studies were identified by searches of the MEDLINE database from 1970 to March 2011 and the EMBASE database from 1974 to March 2011 without restrictions and by reviewing reference lists from retrieved articles. Cohort studies that reported relative risk estimates with 95% confidence intervals (CIs) for the associations of interest were included. DATA EXTRACTION: Data were extracted independently by each author and summary estimates of association were obtained using a random-effects model. DATA SYNTHESIS: Of the 8 studies included, 4 reported results on type 2 diabetes (175,938 individuals; 6428 incident cases during 1.1 million person-years of follow-up), 4 reported on fatal or nonfatal cardiovascular disease (34,253 individuals; 1052 incident cases), and 3 reported on all-cause mortality (26,509 individuals; 1879 deaths during 202,353 person-years of follow-up). The pooled relative risks per 2 hours of TV viewing per day were 1.20 (95% CI, 1.14-1.27) for type 2 diabetes, 1.15 (95% CI, 1.06-1.23) for fatal or nonfatal cardiovascular disease, and 1.13 (95% CI, 1.07-1.18) for all-cause mortality. While the associations between time spent viewing TV and risk of type 2 diabetes and cardiovascular disease were linear, the risk of all-cause mortality appeared to increase with TV viewing duration of greater than 3 hours per day. The estimated absolute risk differences per every 2 hours of TV viewing per day were 176 cases of type 2 diabetes per 100,000 individuals per year, 38 cases of fatal cardiovascular disease per 100,000 individuals per year, and 104 deaths for all-cause mortality per 100,000 individuals per year. CONCLUSION: Prolonged TV viewing was associated with increased risk of type 2 diabetes, cardiovascular disease, and all-cause mortality.
Timeframe: 1970–March 2011	
Total # of Studies: 8	
Author's Definition of Sedentary: TV viewing or screen time.	
Outcomes Addressed: All-cause mortality, CVD mortality.	
Populations Analyzed: Adults	**Author-Stated Funding Source:** Danish Heart Foundation, Sygekassernes Helsefond (the Danish Health Fund), Oticon Foundation, Augustinus Foundation, National Institutes of Health

Systematic Review **Citation:** Proper KI, Singh AS, van Mechelen W, Chinapaw MJ. Sedentary behaviors and health outcomes among adults: A systematic review of prospective studies. *Am J Prev Med.* 2011;40(2):174-182. doi:10.1016/j.amepre.2010.10.015.	
Purpose: To systematically review the literature with respect to the relationship between diverse sedentary behaviors and health outcomes among adults, taking into account the methodologic quality of the studies.	**Abstract:** CONTEXT: Nowadays, people spend a substantial amount of time per day on sedentary behaviors and it is likely that the time spent sedentary will continue to rise. To date, there is no review of prospective studies that systematically examined the relationship between diverse sedentary behaviors and various health outcomes among adults. PURPOSE: This review aimed to systematically review the literature as to the relationship between sedentary behaviors and health outcomes considering the methodologic quality of the studies. EVIDENCE ACQUISITION: In February 2010, a search for prospective studies was performed in diverse electronic databases. After inclusion, in 2010, the methodologic quality of each study was assessed. A best-evidence synthesis was applied to draw conclusions. EVIDENCE SYNTHESIS: 19 studies were included, of which 14 were of high methodologic quality. Based on inconsistency in findings among the studies and lack of high-quality prospective studies, insufficient evidence was concluded for body weight-related measures, CVD risk, and endometrial cancer. Further, moderate evidence for a positive relationship between the time spent sitting and the risk for type 2 diabetes was concluded. Based on three high-quality studies, there was no evidence for a relationship between sedentary behavior and mortality from cancer, but strong evidence for all-cause and CVD mortality. CONCLUSIONS: Given the trend toward increased time in sedentary behaviors, additional prospective studies of high methodologic quality are recommended to clarify the causal relationships between sedentary behavior and health outcomes. Meanwhile, evidence to date suggests that interventions aimed at reducing sedentary behavior are needed.
Timeframe: 1989–February 2010	
Total # of Studies: 19	
Author's Definition of Sedentary: Activities that do not increase energy expenditure substantially above the resting level (1.0–1.5 metabolic equivalents); includes activities such as sleeping, sitting, lying down, watching TV, and engaging in other forms of screen-based entertainment.	
Outcomes Addressed: All-cause mortality, cardiovascular disease mortality, cancer mortality.	
Populations Analyzed: Adults	**Author-Stated Funding Source:** Not Reported

Meta-Analysis **Citation:** Sun JW, Zhao LG, Yang Y, Ma X, Wang YY, Xiang YB. Association between television viewing time and all-cause mortality: A meta-analysis of cohort studies. *Am J Epidemiol.* 2015;182(11):908-16. doi:10.1093/aje/kwv164.	
Purpose: To explore the magnitude and shape of the association between TV-viewing time and all-cause mortality.	**Abstract:** Findings on the association between television (TV) viewing and all-cause mortality in epidemiologic studies have been inconsistent. Therefore, we conducted a meta-analysis of data from prospective cohort studies to quantify this association. Relevant articles were identified by searching MEDLINE (PubMed; National Library of Medicine, Bethesda, Maryland) and EMBASE (Elsevier B.V., Amsterdam, the Netherlands) from inception to March 1, 2015, and reviewing the reference lists of retrieved articles. Study-specific results were pooled using a random-effects model. Of 2,578 citations identified by the search strategy, 10 cohort studies (61,494 deaths among 647,475 individuals) met the inclusion criteria. The summary relative risk of all-cause mortality for the highest category of TV viewing time versus the lowest was 1.33 (95% confidence interval: 1.20, 1.47), with heterogeneity among studies (I(2) = 66.7%, P(heterogeneity) = 0.001). In dose-response meta-analysis, TV viewing time was statistically significantly associated with all-cause mortality risk in a J-shaped fashion (P(nonlinearity) = 0.001). These results indicate that prolonged TV viewing time might increase the risk of all-cause mortality. Given the high prevalence of excessive TV viewing, public health recommendations or interventions aimed at decreasing the amount of TV viewing time in modern societies are warranted.
Timeframe: Inception–2015	
Total # of Studies: 10	
Author's Definition of Sedentary: TV-viewing time (including watching TV or video or using a computer).	
Outcomes Addressed: All-cause mortality.	
Populations Analyzed: Adults	**Author-Stated Funding Source:** Shanghai Health Bureau Key Disciplines and Specialties Foundation

<table>
<tr><td colspan="2">Systematic Review
Citation: Thorp AA, Owen N, Neuhaus M, Dunstan DW. Sedentary behaviors and subsequent health outcomes in adults a systematic review of longitudinal studies, 1996-2011. Am J Prev Med. 2011;41(2):207-215. doi:10.1016/j.amepre.2011.05.004.</td></tr>
<tr><td>Purpose: To systematically review and provide an informative synthesis of findings from longitudinal studies published since 1996 reporting on relationships between self-reported sedentary behavior and device-based measures of sedentary time with health-related outcomes in adults.</td><td rowspan="5">Abstract: CONTEXT: To systematically review and provide an informative synthesis of findings from longitudinal studies published since 1996 reporting on relationships between self-reported sedentary behavior and device-based measures of sedentary time with health-related outcomes in adults. EVIDENCE ACQUISITION: Studies published between 1996 and January 2011 were identified by examining existing literature reviews and by systematic searches in Web of Science, MEDLINE, PubMed, and PsycINFO. English-written articles were selected according to study design, targeted behavior, and health outcome. EVIDENCE SYNTHESIS: Forty-eight articles met the inclusion criteria; of these, 46 incorporated self-reported measures including total sitting time; TV viewing time only; TV viewing time and other screen-time behaviors; and TV viewing time plus other sedentary behaviors. Findings indicate a consistent relationship of self-reported sedentary behavior with mortality and with weight gain from childhood to the adult years. However, findings were mixed for associations with disease incidence, weight gain during adulthood, and cardiometabolic risk. Of the three studies that used device-based measures of sedentary time, one showed that markers of obesity predicted sedentary time, whereas inconclusive findings have been observed for markers of insulin resistance. CONCLUSIONS: There is a growing body of evidence that sedentary behavior may be a distinct risk factor, independent of physical activity, for multiple adverse health outcomes in adults. Prospective studies using device-based measures are required to provide a clearer understanding of the impact of sedentary time on health outcomes.</td></tr>
<tr><td>Timeframe: 1996–January 2011</td></tr>
<tr><td>Total # of Studies: 48</td></tr>
<tr><td>Author's Definition of Sedentary: A distinct class of activities that require low levels of energy expenditure in the range of 1.0–1.5 metabolic equivalents and involve sitting during commuting and leisure time and sitting in the workplace and the domestic environment.</td></tr>
<tr><td>Outcomes Addressed: All-cause mortality, cardiovascular disease mortality, cancer mortality.</td></tr>
<tr><td>Populations Analyzed: Adults</td><td>Author-Stated Funding Source: Australian National Health and Medical Research Council, Healthy Lifestyle Research Centre, Queensland Health, Victorian Health Promotion Foundation</td></tr>
</table>

Meta-Analysis **Citation:** Wilmot EG, Edwardson CL, Achana FA, Davies MJ, Gorely T, Gray LJ, et al. Sedentary time in adults and the association with diabetes, cardiovascular disease and death: Systematic review and meta-analysis. *Diabetologia*. 2012;55(11):2895-2905. doi: 10.1007/s00125-012-2677-z.	
Purpose: To quantitatively synthesize existing observational evidence relating sedentary (sitting) time to four key clinical outcomes: diabetes, cardiovascular disease (CVD), cardiovascular mortality, and all-cause mortality.	**Abstract:** AIMS/HYPOTHESIS: Sedentary (sitting) behaviours are ubiquitous in modern society. We conducted a systematic review and meta-analysis to examine the association of sedentary time with diabetes, cardiovascular disease and cardiovascular and all-cause mortality. METHODS: Medline, Embase and the Cochrane Library databases were searched for terms related to sedentary time and health outcomes. Cross-sectional and prospective studies were included. RR/HR and 95% CIs were extracted by two independent reviewers. Data were adjusted for baseline event rate and pooled using a random-effects model. Bayesian predictive effects and intervals were calculated to indicate the variance in outcomes that would be expected if new studies were conducted in the future. RESULTS: Eighteen studies (16 prospective, two cross-sectional) were included, with 794,577 participants. Fifteen of these studies were moderate to high quality. The greatest sedentary time compared with the lowest was associated with a 112% increase in the RR of diabetes (RR 2.12; 95% credible interval [CrI] 1.61, 2.78), a 147% increase in the RR of cardiovascular events (RR 2.47; 95% CI 1.44, 4.24), a 90% increase in the risk of cardiovascular mortality (HR 1.90; 95% CrI 1.36, 2.66) and a 49% increase in the risk of all-cause mortality (HR 1.49; 95% CrI 1.14, 2.03). The predictive effects and intervals were only significant for diabetes. CONCLUSIONS/INTERPRETATION: Sedentary time is associated with an increased risk of diabetes, cardiovascular disease and cardiovascular and all-cause mortality; the strength of the association is most consistent for diabetes.
Timeframe: Inception–2012	
Total # of Studies: 18	
Author's Definition of Sedentary: Time spent in sedentary activities or time spent in the absence of movement.	
Outcomes Addressed: All-cause mortality, CVD mortality.	
Populations Analyzed: Adults	**Author-Stated Funding Source:** Department of Cardiovascular Sciences, University of Leicester

Table 3. Existing Systematic Reviews and Meta-Analyses Quality Assessment Chart

AMSTARExBP: SR/MA	Biswas, 2015	Chau, 2013	de Rezende, 2014	Ekelund, 2016	Grontved, 2011	Proper, 2011	Sun, 2015	Thorp, 2011	Wilmot, 2012
Review questions and inclusion/exclusion criteria delineated prior to executing search strategy.	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes
Population variables defined and considered in methods.	Yes	Yes	Yes	Yes	Yes	No	Yes	Yes	Yes
Comprehensive literature search performed.	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes
Duplicate study selection and data extraction performed.	Yes	No	Yes	Yes	No	Yes	Yes	No	Yes
Search strategy clearly described.	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes
Relevant grey literature included in review.	No	Yes	Yes	Yes	No	No	No	No	No
List of studies (included and excluded) provided.	No	Yes	Yes	No	Yes	No	No	No	No
Characteristics of included studies provided.	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes
FITT defined and examined in relation to outcome effect sizes.	Yes	N/A	N/A	Yes	N/A	N/A	N/A	N/A	N/A
Scientific quality (risk of bias) of included studies assessed and documented.	Yes	Yes	Yes	Yes	No	Yes	No	No	Yes
Results depended on study quality, either overall, or in interaction with moderators.	Yes	Yes	Yes	Yes	N/A	Yes	N/A	N/A	Yes
Scientific quality used appropriately in formulating conclusions.	Yes	Yes	Yes	Yes	N/A	Yes	N/A	N/A	Yes
Data appropriately synthesized and if applicable, heterogeneity assessed.	Yes	Yes	N/A	Yes	Yes	N/A	Yes	N/A	Yes
Effect size index chosen justified, statistically.	Yes	Yes	N/A	Yes	Yes	N/A	No	N/A	Yes
Individual-level meta-analysis used.	No	No	N/A	Yes	Partially Yes	N/A	No	N/A	No
Practical recommendations clearly addressed.	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes
Likelihood of publication bias assessed.	Yes	Yes	No	Yes	Yes	No	Yes	No	Yes
Conflict of interest disclosed.	Yes	Yes	No	Yes	Yes	No	Yes	No	Yes

Original Research

Table 4. Original Research Individual Evidence Summary Tables

<table>
<tr><td colspan="2">Original Research
Citation: Ding D, Rogers K, van der Ploeg H, Stamatakis E, Bauman AE. Traditional and emerging lifestyle risk behaviors and all-cause mortality in middle-aged and older adults: Evidence from a large population-based Australian cohort. PLoS Med. 2015;12(12):e1001917. doi:10.1371/journal.pmed.1001917.</td></tr>
<tr><td colspan="2">Purpose: To examine the association between a lifestyle risk index and all-cause mortality, and to quantify the population-attributable risk associated with the risk score among adults.</td></tr>
<tr><td>Study Design: Prospective cohort study

Location: Australia

Sample: 231,048
Attrition Rate: 12.83%
Sample Power: Not Reported

Exposure Measurement
Self-Reported: Sedentary behavior assessed with a single question adapted from the IPAQ, hours spent sitting in a typical 24-hour day.
Measures Steps: No
Measures Bouts: No</td><td>Abstract: BACKGROUND: Lifestyle risk behaviors are responsible for a large proportion of disease burden worldwide. Behavioral risk factors, such as smoking, poor diet, and physical inactivity, tend to cluster within populations and may have synergistic effects on health. As evidence continues to accumulate on emerging lifestyle risk factors, such as prolonged sitting and unhealthy sleep patterns, incorporating these new risk factors will provide clinically relevant information on combinations of lifestyle risk factors. METHODS AND FINDINGS: Using data from a large Australian cohort of middle-aged and older adults, this is the first study to our knowledge to examine a lifestyle risk index incorporating sedentary behavior and sleep in relation to all-cause mortality. Baseline data (February 2006- April 2009) were linked to mortality registration data until June 15, 2014. Smoking, high alcohol intake, poor diet, physical inactivity, prolonged sitting, and unhealthy (short/long) sleep duration were measured by questionnaires and summed into an index score. Cox proportional hazards analysis was used with the index score and each unique risk combination as exposure variables, adjusted for socio-demographic characteristics. During 6 y of follow-up of 231,048 participants for 1,409,591 person-years, 15,635 deaths were registered. Of all participants, 31.2%, 36.9%, 21.4%, and 10.6% reported 0, 1, 2, and 3+ risk factors, respectively. There was a strong relationship between the lifestyle risk index score and all-cause mortality. The index score had good predictive validity (c index = 0.763), and the partial population attributable risk was 31.3%. Out of all 96 possible risk combinations, the 30 most commonly occurring combinations accounted for more than 90% of the participants. Among those, combinations involving physical inactivity, prolonged sitting, and/or long sleep duration and combinations involving smoking and high alcohol intake had the strongest associations with all-cause mortality. Limitations of the study include self-reported and under-specified measures, dichotomized risk scores, lack of long-term patterns of lifestyle behaviors, and lack of cause-specific mortality data. CONCLUSIONS: Adherence to healthy lifestyle behaviors could reduce the risk for death from all causes. Specific combinations of lifestyle risk behaviors may be more harmful than others, suggesting synergistic relationships among risk factors.</td></tr>
</table>

Refers to Other Materials: Yes **Examine Cardiorespiratory Fitness as Outcome:** No	**Outcomes Examined:** All-cause mortality: ascertained from the NSW Registry of Births, Deaths and Marriages, survival time measured as time lapse (weeks) from baseline data collection to death or censoring.
Populations Analyzed: Adults ≥45	**Author-Stated Funding Source:** National Health and Medical Research Council Early Career Fellowship

<table>
<tr><td colspan="2">Original Research
Citation: Edwards MK, Loprinzi PD. All-cause mortality risk as a function of sedentary behavior, moderate-to-vigorous physical activity and cardiorespiratory fitness. Phys Sportsmed. 2016;44(3):223-30. doi:10.1080/00913847.2016.1221751.</td></tr>
<tr><td colspan="2">Purpose: To evaluate both the independent and combined associations of moderate to vigorous PA, sedentary behavior, and cardiorespiratory fitness with mortality among adults.</td></tr>
<tr><td>Study Design: Prospective cohort study</td><td rowspan="4">Abstract: OBJECTIVE: Emerging work demonstrates individual associations of sedentary behavior, moderate-to-vigorous physical activity (MVPA) and cardiorespiratory fitness (CRF) on mortality risk. Limited research has evaluated all three of these parameters in a model when considering mortality risk, and their potential additive association on mortality risk has not been fully evaluated, which was the purpose of this study. METHODS: Data from the 2003-2006 National Health and Nutrition Examination Survey were used (N = 2,295 adults 20-85 yrs), with follow-up through 2011. Sedentary behavior and MVPA were objectively assessed (accelerometry) with cardiorespiratory estimated from a prediction equation taking into consideration participant demographic, anthropometric and behavioral characteristics. Using the median values, a PACS (Physical Activity Cardiorespiratory Sedentary) score was created that ranged from 0-3, indicating the number of these three positive characteristics. RESULTS: Those with below median sedentary behavior did not have a reduced all-cause mortality risk (HR = 0.59; 95% CI: 0.34-1.04; P = 0.07), but those with above median MVPA (HR = 0.35; 95% CI: 0.15-0.82; P = 0.02) and above median CRF did (HR = 0.20; 95% CI: 0.09-0.43; P < 0.001). Compared to those with a PACS score of 0, those with a PACS score of 1, 2, and 3, respectively, had a 67% (HR = 0.33; 95% CI: 0.17-0.63, P = 0.002), 82% (HR = 0.12; 95% CI: 0.05-0.30; P < 0.001) and 96% (HR = 0.04; 95% CI: 0.02-0.11; P < 0.001) reduced risk of all-cause mortality. CONCLUSION: Cardiorespiratory fitness and MVPA, but not sedentary behavior, were independently associated with reduced mortality risk. Adults with all three characteristics (below median sedentary and above median MVPA and CRF), however, had the lowest mortality risk.</td></tr>
<tr><td>Location: United States</td></tr>
<tr><td>Sample: 2,955
Attrition Rate: 46.61%
Sample Power: Not Reported</td></tr>
<tr><td>Exposure Measurement
Device-Measured: Accelerometer, sedentary time measured for 7 days, defined as counts/min <= 99.
Measures Steps: No
Measures Bouts: No</td></tr>
<tr><td>Refers to Other Materials: Yes
Examine Cardiorespiratory Fitness as Outcome: No</td><td>Outcomes Examined: All-cause mortality: death certificate data from the National Death Index.</td></tr>
<tr><td>Populations Analyzed: Adults 20–85</td><td>Author-Stated Funding Source: No funding source used</td></tr>
</table>

<table>
<tr><td colspan="2">Original Research
Citation: Ensrud KE, Blackwell TL, Cauley JA, et al. Objective measures of activity level and mortality in older men. J Am Geriatr Soc. 2014;62(11):2079-87. doi:10.1111/jgs.13101.</td></tr>
<tr><td colspan="2">Purpose: To comprehensively assess associations of objective measures of activity level with mortality risk in older men.</td></tr>
<tr><td>Study Design: Prospective cohort study</td><td rowspan="4">Abstract: OBJECTIVES: To examine associations between objective measures of activity level and mortality risk in older men. DESIGN: Prospective cohort study. SETTING: Six U.S. sites. PARTICIPANTS: Men aged 71 and older followed an average of 4.5 years (N = 2,918). MEASUREMENTS: Time awake spent in sedentary behavior (metabolic equivalent (MET) level </=1.50), light activity (MET level 1.51-2.99), and at least moderate activity (MET level >/=3.00) measured using an activity monitor worn for 5 days or longer and expressed as quartiles. Deaths were confirmed with death certificates; cause of death was adjudicated by review of certificates and records. RESULTS: During follow-up, 409 (14%) men died. After multivariable adjustment, comparing Q4 with Q1, more time spent in sedentary behavior (Q4 vs Q1, hazard ratio (HR) = 1.51, 95% confidence interval (CI) = 1.10-2.08), less time spent in light activity (Q1 vs Q4, HR = 1.54, 95% CI = 1.06-2.24), and less time spent in at least moderate activity (Q1 vs Q4, HR = 1.56, 95% CI = 1.09-2.25) were similarly associated with greater mortality risk primarily due to higher risks of cardiovascular and noncardiovascular, noncancer death. The association between time spent in sedentary behavior and mortality varied according to time spent at higher activity level. More time spent in sedentary behavior was associated with greater risk of death in men spending 1.2 (median) h/d or more in at least moderate activity (Q4 vs Q1, HR = 2.09, 95% CI = 1.26-3.49) but not in those spending less time (Q4 vs Q1, HR = 1.02, 95% CI = 0.62-1.66) (P = .005 for interaction). CONCLUSION: In older men exceeding current guidelines on physical activity, more time spent in sedentary behavior is associated with greater mortality risk.</td></tr>
<tr><td>Location: United States</td></tr>
<tr><td>Sample: 2,918
Attrition Rate: 51.32%
Sample Power: Not Reported</td></tr>
<tr><td>Exposure Measurement
Device-Measured: Activity monitor, time (minutes/24 hours) spent sleeping, sedentary behavior (metabolic equivalent ≤ 1.50). Compared across quartiles of time spent in sedentary behavior.
Measures Steps: No
Measures Bouts: No</td></tr>
<tr><td>Refers to Other Materials: Yes
Examine Cardiorespiratory Fitness as Outcome: No</td><td>Outcomes Examined: Mortality: participants contacted every four months to ascertain vital status; death certificates and cause of death adjudicated due to cardiovascular disease, cancer, or other cause by central physician review.</td></tr>
<tr><td>Populations Analyzed: Adults ≥65, Male</td><td>Author-Stated Funding Source: National Institutes of Health</td></tr>
</table>

Original Research
Citation: Evenson KR, Herring AH, Wen F. Accelerometry-assessed latent class patterns of physical activity and sedentary behavior with mortality. *Am J Prev Med.* 2017;52(2):135-43. doi:10.1016/j.amepre.2016.10.033.

Purpose: To explore accelerometry-assessed day-to-day patterns of PA and sedentary behavior with all-cause mortality among adults.

Study Design: Prospective cohort study

Location: United States

Sample: 4,510
Attrition Rate: 0
Sample Power: Not Reported

Exposure Measurement
Device-Measured: Accelerometer (counts/minute), sedentary bouts were defined as ≥ 30 minutes with at least 80% of minutes below sedentary threshold.
Measures Steps: No
Measures Bouts: Yes

Abstract: INTRODUCTION: Latent class analysis provides a method for understanding patterns of physical activity and sedentary behavior. This study explored the association of accelerometer-assessed patterns of physical activity/sedentary behavior with all-cause mortality. METHODS: The sample included 4,510 U.S. National Health and Nutrition Examination Survey participants aged >/=40 years enrolled in 2003-2006 with mortality follow-up through 2011. Participants used a hip-worn accelerometer for 1 week that provided minute-by-minute information on physical activity/sedentary behavior. Accelerometry patterns were derived using latent class analysis. Cox proportional hazards models provided adjusted hazard ratios with 95% CIs. Analyses were conducted from 2014 to 2016. RESULTS: During an average of 6.6 years of follow-up, 513 deaths occurred. For average counts/minute, the more-active classes had a lower risk of mortality compared with the lowest (Class 1). Findings were generally similar for percentage of the day in minutes and bouts of moderate to vigorous physical activity, defined two ways. For percentage of the day in sedentary behavior, generally no associations were identified. However, the class with the highest percentage of the day in sedentary bouts (Class 1) had a higher risk of mortality (adjusted hazard ratio, 2.10; 95% CI=1.11, 3.97) versus the class with fewer sedentary bouts (Class 7). CONCLUSIONS: In this national observational study, time spent in physical activity reduced the risk of all-cause mortality and time spent in sedentary bouts increased the risk of all-cause mortality, regardless of how both were accumulated. The latent class analysis contributed to understanding the impact of patterning of physical activity and sedentary behavior on mortality.

Refers to Other Materials: Yes
Examine Cardiorespiratory Fitness as Outcome: No

Outcomes Examined: All-cause mortality: any cause of death, except for deaths related to external causes.

Populations Analyzed: Adults ≥40

Author-Stated Funding Source: National Institutes of Health, National Heart, Lung, and Blood Institute

<table>
<tr><td colspan="2">Original Research
Citation: Evenson KR, Wen F, Herring AH. Associations of accelerometry-assessed and self-reported physical activity and sedentary behavior with all-cause and cardiovascular mortality among US adults. Am J Epidemiol. 2016;184(9):621-32.</td></tr>
<tr><td colspan="2">Purpose: To explore the associations of both accelerometer-assessed and self-reported PA and sedentary behavior with the risks of all-cause and cardiovascular disease mortality among adults.</td></tr>
<tr><td>Study Design: Prospective cohort study</td><td rowspan="4">Abstract: The US physical activity (PA) recommendations were based primarily on studies in which self-reported data were used. Studies that include accelerometer-assessed PA and sedentary behavior can contribute to these recommendations. In the present study, we explored the associations of PA and sedentary behavior with all-cause and cardiovascular disease (CVD) mortality in a nationally representative sample. Among the 2003-2006 National Health and Nutrition Examination Survey cohort, 3,809 adults 40 years of age or older wore an accelerometer for 1 week and self-reported their PA levels. Mortality data were verified through 2011, with an average of 6.7 years of follow-up. We used Cox proportional hazards models to obtain adjusted hazard ratios and 95% confidence intervals. After excluding the first 2 years, there were 337 deaths (32% or 107 of which were attributable to CVD). Having higher accelerometer-assessed average counts per minute was associated with lower all-cause mortality risk: When compared with the first quartile, the adjusted hazard ratio was 0.37 (95% confidence interval: 0.23, 0.59) for the fourth quartile, 0.39 (95% confidence interval: 0.27, 0.57) for the third quartile, and 0.60 (95% confidence interval: 0.45, 0.80) second quartile. Results were similar for CVD mortality. Lower all-cause and CVD mortality risks were also generally observed for persons with higher accelerometer-assessed moderate and moderate-to-vigorous PA levels and for self-reported moderate-to-vigorous leisure, household and total activities, as well as for meeting PA recommendations. Accelerometer-assessed sedentary behavior was generally not associated with all-cause or CVD mortality in fully adjusted models. These findings support the national PA recommendations to reduce mortality.</td></tr>
<tr><td>Location: United States</td></tr>
<tr><td>Sample: 3,809
Attrition Rate: 40.06%
Sample Power: Not Reported</td></tr>
<tr><td>Exposure Measurement
Device-Measured: Accelerometer, sedentary behavior (minutes/day) compared by quartiles (≥588.4, 497–588.3, 413.5–497.6, ≤413.4), sedentary bouts (minutes/day) compared by quartiles (≥518.4, 380.7–518.3, 265.0–380.6, ≤264.9).
Measures Steps: No
Measures Bouts: Yes</td></tr>
<tr><td>Refers to Other Materials: Yes
Examine Cardiorespiratory Fitness as Outcome: No</td><td>Outcomes Examined: All-cause and cardiovascular mortality: National Death Index.</td></tr>
<tr><td>Populations Analyzed: Adults ≥40</td><td>Author-Stated Funding Source: National Heart, Lung, and Blood Institute, National Institutes of Health</td></tr>
</table>

<table>
<tr><td colspan="2">Original Research
Citation: Fishman EI, Steeves JA, Zipunnikov V, et al. Association between objectively measured physical activity and mortality in NHANES. Med Sci Sports Exerc. 2016;48(7):1303-11. doi:10.1249/MSS.0000000000000885.</td></tr>
<tr><td colspan="2">Purpose: To examine accelerometer-measured total, light, and moderate-to-vigorous physical activity of mortality in a nationally representative sample of older adults.</td></tr>
<tr><td>Study Design: Prospective cohort study</td><td rowspan="4">Abstract: PURPOSE: We examined total activity, light activity, and moderate-to-vigorous physical activity (MVPA) as predictors of mortality in a nationally representative sample of older adults. Then we explored the theoretical consequences of replacing sedentary time with the same duration of light activity or MVPA. METHODS: Using accelerometer-measured activity, the associations between total activity, light activity (100-2019 counts per minute), and MVPA (>2019 counts per minute) counts and mortality were examined in adults age 50 to 79 yr in the National Health and Nutrition Examination Survey, 2003-2006 (n = 3029), with mortality follow-up through December 2011. Cox proportional hazard models were fitted to estimate mortality risks. An isotemporal substitution model was used to examine the theoretical consequences of replacing sedentary time with light activity or MVPA on mortality. RESULTS: After adjusting for potential confounders, including age, sex, race/ethnicity, education, BMI, and the presence of comorbid conditions, those in the highest tertile of total activity counts had one fifth the risk of death of those in the lowest tertile (hazard ratio [HR] = 0.21, 95% confidence interval [CI] = 0.12-0.38), and those in the middle tertile had one third the risk of death (HR = 0.36, 95% CI = 0.30-0.44). In addition, replacing 30 min of sedentary time with light activity was associated with significant reduction in mortality risk (after 5 yr of follow-up: HR = 0.80, 95% CI = 0.75-0.85). Replacing 30 min of sedentary time with MVPA was also associated with reduction in mortality risk (HR = 0.49, 95% CI = 0.25-0.97). CONCLUSIONS: Greater total activity is associated with lower all-cause mortality risk. Replacing sedentary time with light activity or MVPA may reduce mortality risk for older adults.</td></tr>
<tr><td>Location: United States</td></tr>
<tr><td>Sample: 3,029
Attrition Rate: 17.08%
Sample Power: Not Reported</td></tr>
<tr><td>Exposure Measurement
Device-Measured:
Accelerometer, sedentary behavior defined as less than 100 counts per minute. Sedentary behavior was not the main exposure of interest but was used as a covariate.
Measures Steps: No
Measures Bouts: No</td></tr>
<tr><td>Refers to Other Materials: Yes
Examine Cardiorespiratory Fitness as Outcome: No</td><td>Outcomes Examined: Mortality: death records from the National Death Index.</td></tr>
<tr><td>Populations Analyzed: Adults 50–79</td><td>Author-Stated Funding Source: National Institute on Aging, National Institutes of Health</td></tr>
</table>

<table>
<tr><td colspan="2">Original Research
Citation: Grunseit AC, Chau JY, Rangul V, Holmen TL, Bauman A. Patterns of sitting and mortality in the Nord-Trondelag health study (HUNT). Int J Behav Nutr Phys Act. 2017;14(1):8. doi:10.1186/s12966-016-0457-8.</td></tr>
<tr><td colspan="2">Purpose: To examine the associations between sitting time, assessed at two time points 11 years apart, and risk of all-cause and cardio-metabolic disease mortality among adults.</td></tr>
<tr><td>Study Design: Prospective cohort study</td><td rowspan="4">Abstract: BACKGROUND: Current evidence concerning sedentary behaviour and mortality risk has used single time point assessments of sitting. Little is known about how changes in sitting levels over time affect subsequent mortality risk. AIM: To examine the associations between patterns of sitting time assessed at two time points 11 years apart and risk of all-cause and cardio-metabolic disease mortality. METHODS: Participants were 25,651 adults aged > =20 years old from the Nord-Trondelag Health Study with self-reported total sitting time in 1995-1997 (HUNT2) and 2006-2008 (HUNT3). Four categories characterised patterns of sitting: (1) low at HUNT2/ low at HUNT3, 'consistently low sitting'; (2) low at HUNT2/high at HUNT3, 'increased sitting'; (3) high at HUNT2/low at HUNT3, 'reduced sitting'; and (4) high at HUNT2 /high at HUNT3, 'consistently high sitting'. Associations of sitting pattern with all-cause and cardio-metabolic disease mortality were analysed using Cox regression adjusted for confounders. RESULTS: Mean follow-up was 6.2 years (158880 person-years); 1212 participants died. Compared to 'consistently low sitting', adjusted hazard ratios for all-cause mortality were 1.51 (95% CI: 1.28-2.78), 1.03 (95% CI: 0.88-1.20), and 1.26 (95% CI: 1.06-1.51) for 'increased sitting', 'reduced sitting' and 'consistently high sitting' respectively. CONCLUSIONS: Examining patterns of sitting over time augments single time-point analyses of risk exposures associated with high sitting time. Whilst sitting habits can be stable over a long period, life events (e.g., changing jobs, retiring or illness) may influence sitting trajectories and therefore sitting-attributable risk. Reducing sitting may yield mortality risks comparable to a stable low-sitting pattern.</td></tr>
<tr><td>Location: Norway</td></tr>
<tr><td>Sample: 25,651
Attrition Rate: 0
Sample Power: Not Reported</td></tr>
<tr><td>Exposure Measurement
Self-Reported: Single question: “How many hours do you usually spend sitting down during a 24-h period?”; classified 8 hours or more as “high sitting,” sitting pattern combined high (≥ 8h/day) and low (<8 h/day) over two surveys. Sitting yielded four categories: “consistently low sitting”; “increased sitting”; “reduced sitting”; and “consistently high sitting.”
Measures Steps: No
Measures Bouts: No</td></tr>
<tr><td>Refers to Other Materials: No
Examine Cardiorespiratory Fitness as Outcome: No</td><td>Outcomes Examined: Mortality from all causes and from cardio-metabolic diseases (diseases of the circulatory system; endocrine, nutritional, and metabolic diseases): linked to Norwegian Causes of Death Registry, causes of death coded based on the International Classification of Diseases.</td></tr>
<tr><td>Populations Analyzed: Adults ≥20</td><td>Author-Stated Funding Source: National Heart Foundation of Australia</td></tr>
</table>

<table>
<tr><td colspan="2">Original Research
Citation: Hagger-Johnson G, Gow AJ, Burley V, Greenwood D, Cade JE. Sitting time, fidgeting, and all-cause mortality in the UK women's cohort study. Am J Prev Med. 2016;50(2):154-60. doi:10.1016/j.amepre.2015.06.025.</td></tr>
<tr><td colspan="2">Purpose: To determine if fidgeting modified the association between longer sitting times and mortality among adult women.</td></tr>
<tr><td>Study Design: Prospective cohort study
Location: United Kingdom
Sample: 10,937
Attrition Rate: 23.22%
Sample Power: Not Reported
Exposure Measurement
Self-Reported: Sitting time per day ([5 x weekday + 2 x weekend hours]/7), divided into three sitting groups: low (<5 hours/day), medium (5 or 6 hours/day), and high (≥ 7 hours/day).
Measures Steps: No
Measures Bouts: No</td><td rowspan="2">Abstract: INTRODUCTION: Sedentary behaviors (including sitting) may increase mortality risk independently of physical activity level. Little is known about how fidgeting behaviors might modify the association. METHODS: Data were from the United Kingdom (UK) Women's Cohort Study. In 1999-2002, a total of 12,778 women (aged 37-78 years) provided data on average daily sitting time, overall fidgeting (irrespective of posture), and a range of relevant covariates including physical activity, diet, smoking status, and alcohol consumption. Participants were followed for mortality over a mean of 12 years. Proportional hazards Cox regression models estimated the relative risk of mortality in high (versus low) and medium (versus low) sitting time groups. RESULTS: Fidgeting modified the risk associated with sitting time (p=0.04 for interaction), leading us to separate groups for analysis. Adjusting for covariates, sitting for >/=7 hours/day (versus <5 hours/day) was associated with 30% increased all-cause mortality risk (hazard ratio [HR]=1.30, 95% CI=1.02, 1.66) only among women in the low fidgeting group. Among women in the high fidgeting group, sitting for 5-6 hours/day (versus <5 hours/day) was associated with decreased mortality risk (HR=0.63, 95% CI=0.43, 0.91), adjusting for a range of covariates. There was no increased mortality risk from longer sitting time in the middle and high fidgeting groups. CONCLUSIONS: Fidgeting may reduce the risk of all-cause mortality associated with excessive sitting time. More detailed and better-validated measures of fidgeting should be identified in other studies to replicate these findings and identity mechanisms, particularly measures that distinguish fidgeting in a seated from standing posture.</td></tr>
<tr><td>Refers to Other Materials: No
Examine Cardiorespiratory Fitness as Outcome: No
Outcomes Examined: All-cause mortality: vital status was monitored using the National Health Service number assigned.</td></tr>
<tr><td>Populations Analyzed: Adults 37–78</td><td>Author-Stated Funding Source: The World Cancer Research Fund, Biotechnology and Biological Sciences Research Council and Medical Research Council, Royal Society of Edinburgh</td></tr>
</table>

<table>
<tr><td colspan="2">Original Research
Citation: Keadle SK, Arem H, Moore SC, Sampson JN, Matthews CE. Impact of changes in television viewing time and physical activity on longevity: A prospective cohort study. Int J Behav Nutr Phys Act. 2015;12:156. doi:10.1186/s12966-015-0315-0.</td></tr>
<tr><td colspan="2">Purpose: To estimate the mortality risk associated with many years of prolonged TV viewing and evaluate the influence of changes in TV-viewing time on mortality risk among older adults.</td></tr>
<tr><td>Study Design: Prospective cohort study
Location: United States
Sample: 165,087
Attrition Rate: 25.36%
Sample Power: Not Reported
Exposure Measurement
Self-Reported: Television-viewing time, separated into categories (<3, 3–4, and 5+ hours per day).
Measures Steps: No
Measures Bouts: No</td><td>Abstract: BACKGROUND: Television viewing is a highly prevalent sedentary behavior among older adults, yet the mortality risks associated with hours of daily viewing over many years and whether increasing or decreasing viewing time affects mortality is unclear. This study examined: 1) the long-term association between mortality and daily viewing time; 2) the influence of reducing and increasing in television viewing time on longevity and 3) combined effects of television viewing and moderate-to-vigorous physical activity (MVPA) on longevity. METHODS: Participants included 165,087 adults in the NIH-AARP Diet and Health (aged 50-71 yrs) who completed questionnaires at two-time-points (Time 1: 1994-1996, and Time 2: 2004-2006) and were followed until death or December 31, 2011. Multivariable-adjusted Cox proportional hazards regression was used to estimate Hazard Ratios and 95% confidence intervals (CI) with self-reported television viewing and MVPA and all-cause mortality. RESULTS: Over 6.6 years of follow-up, there were 20,104 deaths. Compared to adults who watched < 3 h/day of television at both time points, mortality risk was 28% greater (CI:1.21,1.34) those who watched 5+ h/day at both time-points. Decreasing television viewing from 5 + h/day to 3-4 h/d was associated with a 15% reduction in mortality risk (CI:0.80, 0.91) and decreasing to <3 h/day resulted in an 12% lower risk (CI:0.79, 0.97). Conversely, adults who increased their viewing time to 3-4 h/day had an 17% greater mortality risk (CI:1.10, 1.24) and those who increased to 5+ h/day had a 45% greater risk (CI:1.32, 1.58), compared to those who consistently watched <3 h/day. The lowest mortality risk was observed in those who were consistently active and watched < 3 h/day of television. CONCLUSIONS: We confirm that prolonged television viewing time was associated with greater mortality in older adults and demonstrate for the first time that individuals who reduced the amount of time they spent watching television had lower mortality. Our findings provide new evidence to support behavioral interventions that seek to reduce sedentary television viewing in favor of more physically active pursuits, preferably MVPA. Given the high prevalence of physical inactivity and prolonged television viewing in older adults, favorable changes in these two modifiable behaviors could have substantial public health impact.</td></tr>
<tr><td>Refers to Other Materials: Yes
Examine Cardiorespiratory Fitness as Outcome: No</td><td>Outcomes Examined: All-cause mortality: vital status determined through linkage with the Social Security Administration Death Master File and the National Death Index.</td></tr>
<tr><td>Populations Analyzed: Adults 50–71, Male</td><td>Author-Stated Funding Source: Intramural Research Program at the National Cancer Institute, National Institutes of Health</td></tr>
</table>

<table>
<tr><td colspan="2">Original Research
Citation: Kikuchi H, Inoue S, Odagiri Y, et al. Occupational sitting time and risk of all-cause mortality among Japanese workers. Scand J Work Environ Health. 2015;41(6):519-28. doi:10.5271/sjweh.3526.</td></tr>
<tr><td colspan="2">Purpose: To assess the association between occupational sitting time and all-cause mortality, independently from moderate-to-vigorous PA, among Japanese adults.</td></tr>
<tr><td>Study Design: Prospective cohort study</td><td rowspan="4">Abstract: OBJECTIVES: Prolonged sitting is a health risk for cardiovascular diseases and all-cause mortality, independent of moderate-to-vigorous physical activity. Epidemiological evaluation of occupational sitting has received little attention, even though it may have a potential impact on workers' health. We prospectively examined the association between occupational sitting time and all-cause mortality. METHODS: Community-dwelling, Japanese workers aged 50-74 years who responded to a questionnaire in 2000-2003 were followed for all-cause mortality through 2011. Cox proportional hazard models were employed to calculate hazard ratios (HR) of all-cause mortality among middle (1- to <3 hours/day) or longer (>/=3 hours/day) occupationally sedentary subjects by gender or types of engaging industry ("primary industry" and "secondary or tertiary industry"). RESULTS: During 368,120 person-years of follow-up (average follow-up period, 10.1 years) for the 36,516 subjects, 2209 deaths were identified. Among workers in primary industry, longer duration of occupational sitting was significantly or marginally associated with higher mortality [HR 1.23, 95% confidence interval (95% CI) 1.00-1.51 among men; HR 1.34, 95% CI 0.97-1.84 among women]. No associations were found among secondary or tertiary industry workers (men: HR 0.87, 95% CI 0.75-1.01; women: HR 1.03, 95% CI 0.77-1.39). CONCLUSIONS: Occupational sitting time increased all-cause mortality among primary industry workers, however similar relationships were not observed for secondary-tertiary workers. Future studies are needed to confirm detailed dose-response relationships by using objective measures. In addition, studies using cause-specific mortality data would be important to clarify the physiological underlying mechanism.</td></tr>
<tr><td>Location: Japan</td></tr>
<tr><td>Sample: 36,516
Attrition Rate: 63.28%
Sample Power: Not Reported</td></tr>
<tr><td>Exposure Measurement
Self-Reported: Average time of occupational sitting time was determined by multiplying frequency and duration, categorized based on the tertile value: short (<1 hour/day), middle (1 to <3 hours/day), or longer (≥3 hours/day).
Measures Steps: No
Measures Bouts: No</td></tr>
<tr><td>Refers to Other Materials: Yes
Examine Cardiorespiratory Fitness as Outcome: No</td><td>Outcomes Examined: All-cause mortality: death certificates, provided by the Japanese Ministry of Health, Labor and Welfare; cause of death was defined according to the International Classification of Diseases.</td></tr>
<tr><td>Populations Analyzed: Adults 40–69 (baseline), 50–74 (follow-up); Male</td><td>Author-Stated Funding Source: National Cancer Centre Research and Development Fund; Ministry of Health, Labor and Welfare of Japan; Japan Ministry of Education, Culture, Sports, Science and Technology</td></tr>
</table>

<table>
<tr><td colspan="2">Original Research
Citation: Koolhaas CM, Dhana K, van Rooij FJ, et al. Sedentary time assessed by actigraphy and mortality: The Rotterdam Study. Prev Med. 2017;95:59-65. doi:10.1016/j.ypmed.2016.11.021.</td></tr>
<tr><td colspan="2">Purpose: To examine the association between sedentary behavior assessed by actigraphy and all-cause mortality among adults.</td></tr>
<tr><td>Study Design: Prospective cohort study
Location: Netherlands
Sample: 1,839
Attrition Rate: 10.86%
Sample Power: Not Reported
Exposure Measurement
Device-Measured: Actigraph, sedentary time (minutes per day) spent in sedentary behavior determined by count-based intensity threshold value of <199 counts per minute, only waking hours were used, analyzed continuously per 1 hour increase and categorically (<8 h/day, 8–11 h/day, ≥ 11 h/day).
Measures Steps: No
Measures Bouts: No</td><td>Abstract: Research suggests that sedentary behavior is a risk factor for mortality. However, most studies rely on questionnaires, which are prone to reporting error. We examined the association between sedentary time assessed by actigraphy and mortality among 1839 participants, aged 45-98years, from the prospective population-based Rotterdam Study, enrolled between 2004 and 2007. Participants wore an actigraph around the wrist for seven days. Sedentary time was evaluated continuously, per 1h/day increase, and categorically in three groups (<8, 8-11, >/=11h/day). The lowest category was used as reference. Mortality risks were examined using Cox proportional hazard models, adjusted for confounders and biological risk factors. We examined the association between sedentary behavior and mortality over and beyond other activity measures (including physical activity (PA) and activities of daily living (ADL)) in a final model. During 11years of follow-up (median: 7.5years, interquartile range: 6.6-8.3years), 212 participants (11.5%) died. In the multivariable model, the hazard ratio (HR) and 95% confidence interval (95% CI) per 1 more hour/day sedentary time was 1.09 (1.00, 1.18). The HR (95% CI) after adjustment for PA and ADL was 1.04 (0.96, 1.13). Participants sedentary for >/=11h/day had a higher mortality risk (HR: 1.80, 95% CI: 1.14, 2.84) than those sedentary <8h/day, in the multivariable model. After adjusting for PA and ADL, this association was clearly attenuated (HR: 1.50, 95% CI: 0.93, 2.41). In conclusion, our study suggests that sedentary behavior is a risk factor for mortality. Further investigation is needed to examine whether this association is distinct from the effect of other measures of activity.</td></tr>
<tr><td>Refers to Other Materials: Yes
Examine Cardiorespiratory Fitness as Outcome: No</td><td>Outcomes Examined: Mortality: collected through an automated follow-up system with a digital linkage to the study database to all medical records maintained by general practitioners, and registry of the municipality of Rotterdam.</td></tr>
<tr><td>Populations Analyzed: Adults 45–98, Male</td><td>Author-Stated Funding Source: Netherlands Organisation for Scientific Research. The Rotterdam Study is funded by Erasmus Medical Center and Erasmus University Rotterdam; the Netherlands Organisation for Health Research and Development; Research Institute for Diseases in the Elderly; Ministry of Education, Culture and Science; Ministry for Health, Welfare and Sports; and the European Commission.</td></tr>
</table>

Original Research

Citation: Krokstad S, Ding D, Grunseit AC, et al. Multiple lifestyle behaviours and mortality, findings from a large population-based Norwegian cohort study - The HUNT Study. *BMC Public Health.* 2017;17(1):58. doi:10.1186/s12889-016-3993-x.

Purpose: To determine whether sleep, sitting time, and social participation would contribute to the concept of "lifestyle risk," we examined their associations with all-cause and cardio-metabolic mortality among adults.

Study Design: Prospective cohort study

Location: Norway

Sample: 36,911
Attrition Rate: 53.26%
Sample Power: Not Reported

Exposure Measurement
Self-Reported: Question: "How many hours do you usually spend sitting down during a 24 h period?"; classified sitting for more than 7 hours per day as "at risk."
Measures Steps: No
Measures Bouts: No

Abstract: BACKGROUND: Lifestyle risk behaviours are responsible for a large proportion of disease burden and premature mortality worldwide. Risk behaviours tend to cluster in populations. We developed a new lifestyle risk index by including emerging risk factors (sleep, sitting time, and social participation) and examine unique risk combinations and their associations with all-cause and cardio-metabolic mortality. METHODS: Data are from a large population-based cohort study in a Norway, the Nord-Trondelag Health Study (HUNT), with an average follow-up time of 14.1 years. Baseline data from 1995-97 were linked to the Norwegian Causes of Death Registry. The analytic sample comprised 36 911 adults aged 20-69 years. Cox regression models were first fitted for seven risk factors (poor diet, excessive alcohol consumption, current smoking, physical inactivity, excessive sitting, too much/too little sleep, and poor social participation) separately and then adjusted for socio-demographic covariates. Based on these results, a lifestyle risk index was developed. Finally, we explored common combinations of the risk factors in relation to all-cause and cardio-metabolic mortality outcomes. RESULTS: All single risk factors, except for diet, were significantly associated with both mortality outcomes, and were therefore selected to form a lifestyle risk index. Risk of mortality increased as the index score increased. The hazard ratio for all-cause mortality increased from 1.37 (1.15-1.62) to 6.15 (3.56-10.63) as the number of index risk factors increased from one to six respectively. Among the most common risk factor combinations the association with mortality was particularly strong when smoking and/or social participation were included. CONCLUSIONS: This study adds to previous research on multiple risk behaviours by incorporating emerging risk factors. Findings regarding social participation and prolonged sitting suggest new components of healthy lifestyles and potential new directions for population health interventions.

Refers to Other Materials: No
Examine Cardiorespiratory Fitness as Outcome: No

Outcomes Examined: All-cause mortality and cardio-metabolic diseases mortality: linked to the Norwegian Causes of Death Registry by Statistics Norway; causes of death were coded based on the International Classification of Diseases.

Populations Analyzed: Adults 20–69

Author-Stated Funding Source: National Health and Medical Research Council

<table>
<tr><td colspan="2">Original Research
Citation: Lee J, Kuk JL, Ardern CI. The relationship between changes in sitting time and mortality in post-menopausal US women. J Public Health (Oxf). 2016a;38(2):270-8. doi:10.1093/pubmed/fdv055.</td></tr>
<tr><td colspan="2">Purpose: To assess the relationship between sitting time at baseline and year six of follow-up with mortality among post-menopausal women.</td></tr>
<tr><td>Study Design: Prospective cohort study
Location: United States
Sample: 77,801
Attrition Rate: 16.17%
Sample Power: Not Reported
Exposure Measurement
Self-Reported: Total daily sitting time assessed at baseline and at year six of follow-up by questionnaire: 'During a usual day and night, about how many hors do you spend sitting?', participants were initially divided into quartiles of sitting time (<5, 6-9, 10-13, >14) to assess does-response. The sitting time variable at baseline and follow-up was dichotomized as 'low-to-moderate' (<9 h) or 'high' (>10 h).
Measures Steps: No
Measures Bouts: No</td><td>Abstract: BACKGROUND: Prolonged sitting is linked to various deleterious health outcomes. The alterability of the sitting time (ST)-health relationship is not fully established however and warrants study within populations susceptible to high ST. METHODS: We assessed the mortality rates of post-menopausal women from the Women's Health Initiative (WHI) observational study, a 15-year prospective study of post-menopausal women aged 50-79 years, according to their change in ST between baseline and year six. A total of 77 801 participants had information at both times on which to be cross-classified into the following: (i) high ST at baseline and follow-up; (ii) low ST at baseline and follow-up; (iii) increased ST and (iv) decreased ST. Cox regression was used to assess the relationship between all-cause, CVD and cancer mortality with change in ST. RESULTS: At the end of follow-up, there were 1855 deaths. Compared with high ST maintainers, low ST maintainers had a 51 and 48% lower risk of all-cause and cancer mortality, respectively. Reducing sitting also resulted in a protective rate of 29% for all-cause and 27% for cancer mortality. CONCLUSIONS: These results highlight not only the benefit of maintaining minimal ST, but also the utility of decreasing ST in older women, if current levels are high.</td></tr>
<tr><td>Refers to Other Materials: Yes
Examine Cardiorespiratory Fitness as Outcome: No</td><td>Outcomes Examined: Death from all-cause, cardiovascular disease, or cancer: trained physician adjudicators established the end points from hospitalization and emergency room records, death certificates, autopsy reports, and coroner’s reports. Cause-specific mortality categorizations were based on the cause of death rather than the immediate or contributing cause of death.</td></tr>
<tr><td>Populations Analyzed: Women, Adults 50–59, 60–69, 70–79, 80–89; Diabetes; Other; Congestive Heart Failure; Post-menopausal; Smoking</td><td>Author-Stated Funding Source: Canadian Institute of Health Research</td></tr>
</table>

<table>
<tr><td colspan="2">Original Research
Citation: Lee PH. Examining non-linear associations between accelerometer-measured physical activity, sedentary behavior, and all-cause mortality using segmented Cox regression. Front Physiol. 2016b;7:272. doi:10.3389/fphys.2016.00272.</td></tr>
<tr><td colspan="2">Purpose: To examine the interaction effect between accelerometer-measured physical activity and sedentary behaviors, on all-cause mortality among adults.</td></tr>
<tr><td>Study Design: Prospective cohort study</td><td rowspan="4">Abstract: Healthy adults are advised to perform at least 150 min of moderate-intensity physical activity weekly, but this advice is based on studies using self-reports of questionable validity. This study examined the dose-response relationship of accelerometer-measured physical activity and sedentary behaviors on all-cause mortality using segmented Cox regression to empirically determine the break-points of the dose-response relationship. Data from 7006 adult participants aged 18 or above in the National Health and Nutrition Examination Survey waves 2003-2004 and 2005-2006 were included in the analysis and linked with death certificate data using a probabilistic matching approach in the National Death Index through December 31, 2011. Physical activity and sedentary behavior were measured using ActiGraph model 7164 accelerometer over the right hip for 7 consecutive days. Each minute with accelerometer count <100; 1952-5724; and >/=5725 were classified as sedentary, moderate-intensity physical activity, and vigorous-intensity physical activity, respectively. Segmented Cox regression was used to estimate the hazard ratio (HR) of time spent in sedentary behaviors, moderate-intensity physical activity, and vigorous-intensity physical activity and all-cause mortality, adjusted for demographic characteristics, health behaviors, and health conditions. Data were analyzed in 2016. During 47,119 person-year of follow-up, 608 deaths occurred. Each additional hour per day of sedentary behaviors was associated with a HR of 1.15 (95% CI 1.01, 1.31) among participants who spend at least 10.9 h per day on sedentary behaviors, and each additional minute per day spent on moderate-intensity physical activity was associated with a HR of 0.94 (95% CI 0.91, 0.96) among participants with daily moderate-intensity physical activity </=14.1 min. Associations of moderate physical activity and sedentary behaviors on all-cause mortality were independent of each other. To conclude, evidence from this study supported at least 15 min per day of moderate-intensity physical activity and no more than 10.9 h per day of sedentary behaviors as recommendations to reduce all-cause mortality.</td></tr>
<tr><td>Location: United States</td></tr>
<tr><td>Sample: 7,006
Attrition Rate: 24.17%
Sample Power: Not Reported</td></tr>
<tr><td>Exposure Measurement Device-Measured: Accelerometer, sedentary time classified by accelerometer count <100.
Measures Steps: No
Measures Bouts: No</td></tr>
<tr><td>Refers to Other Materials: Yes
Examine Cardiorespiratory Fitness as Outcome: No</td><td>Outcomes Examined: Mortality: linked using a probabilistic matching approach with death certificate data in the National Death Index, classified according to the 10th International Classification of Diseases.</td></tr>
<tr><td>Populations Analyzed: Adults ≥18</td><td>Author-Stated Funding Source: Not reported</td></tr>
</table>

<table>
<tr><td colspan="2">Original Research
Citation: Loprinzi PD, Loenneke JP, Ahmed HM, Blaha MJ. Joint effects of objectively-measured sedentary time and physical activity on all-cause mortality. Prev Med. 2016b;90(Sep):47-51. doi:10.1016/j.ypmed.2016.06.026.</td></tr>
<tr><td colspan="2">Purpose: To examine the joint effects of objectively measured sedentary time and moderate-to-vigorous physical activity on all-cause mortality among adults.</td></tr>
<tr><td>Study Design: Prospective cohort study
Location: United States
Sample: 5,575
Attrition Rate: 0%
Sample Power: Not Reported
Exposure Measurement
Device-Measured: Accelerometer, sedentary time was defined as counts/min ≤ 99, total daily estimates of sedentary time was calculated (continuous).
Measures Steps: No
Measures Bouts: No</td><td>Abstract: OBJECTIVE: Examine the joint effects of objectively-measured sedentary time and moderate-to-vigorous physical activity (MVPA) on all-cause mortality. METHODS: The present study included data from the 2003-2006 National Health & Nutrition Examination Survey, with mortality follow-up data (via National Death Index) through 2011 (N=5575U.S. adults). Sedentary time (activity counts/min between 0 and 99) and MVPA (activity counts/min >/=2020) were objectively measured using the ActiGraph 7164 accelerometer. RESULTS: The median age of the participants was 50yrs; proportion of men was 50.2%; proportion of whites was 53.8%, 18.7% for blacks; median follow-up was 81months; and 511 deaths occurred over the follow-up period. After adjusting for age, gender, race-ethnicity, cotinine, weight status, poverty level, C-reactive protein and comorbid illness (summed score of 0-8 chronic diseases), and for a 1min increase in MVPA and sedentary time, both MVPA (HRadjusted=0.98; 95% CI: 0.96-0.99; P=0.04) and sedentary time (HRadjusted=1.001; 95% CI: 1.0003-1.002; P=0.008) were independently associated with all-cause mortality. Further, MVPA was associated with all-cause mortality among those with greater (above median) sedentary time (HRadjusted=0.95; 95% CI: 0.93-0.97; P<.001). Sedentary time was not associated with all-cause mortality among those engaging in above median levels of MVPA (HRadjusted=0.998; 95% CI: 0.996-1.001; P=.32), but sedentary time was associated with increased mortality risk among those below median levels of MVPA (HR=1.002; 95% CI: 1.001-1.003; P<0.001). CONCLUSIONS: Sedentary time and MVPA are independently associated with all-cause mortality. Above median sedentary time levels did not negate the beneficial effects of MVPA on all-cause mortality risk.</td></tr>
<tr><td>Refers to Other Materials: Yes
Examine Cardiorespiratory Fitness as Outcome: No</td><td>Outcomes Examined: Mortality: participants were linked to death certificate data from the National Death Index.</td></tr>
<tr><td>Populations Analyzed: Adults 20–85</td><td>Author-Stated Funding Source: No funding source used</td></tr>
</table>

<table>
<tr><td colspan="2">Original Research
Citation: Loprinzi PD, Joyner C. Accelerometer-determined physical activity and mortality in a national prospective cohort study: Considerations by visual acuity. Prev Med. 2016(Jun)a;87:18-21. doi:10.1016/j.ypmed.2016.02.005.</td></tr>
<tr><td colspan="2">Purpose: To examine if physical activity has a protective effect on survival among adults with visual impairment.</td></tr>
<tr><td>Study Design: Prospective cohort study</td><td rowspan="4">Abstract: BACKGROUND: Previous research demonstrates that visual impairment (VI) is associated with increased all-cause mortality risk and is also associated with reduced physical activity participation. Although physical activity is reduced among those with VI, no studies have examined the relationship between physical activity and all-cause mortality across different visual function statuses, which is noteworthy of investigation as physical activity is linked with greater survival. METHODS: Data from the 2003-2006 NHANES were employed, with physical activity assessed via accelerometry and visual function assessed using the ARK-760 autorefractor. RESULTS: For those with normal vision, and after adjustments, for every 60min increase in physical activity, normal-sighted adults had an 18% (HR=0.82; 95% CI: 0.72-0.93) reduced risk of all-cause mortality. Similarly, after adjustments and for every 60min increase in physical activity for those with uncorrected refractive error and VI, respectively, there was a 15% (HR=0.85; 95% CI: 0.72-1.00) and 35% (HR=0.65; 95% CI: 0.43-0.98) reduced risk of all-cause mortality. Among all three visual status groups, sedentary behavior was not associated with mortality status. CONCLUSION: Among those with varying degrees of visual loss, sedentary behavior was not associated with mortality, but physical activity demonstrated survival benefits.</td></tr>
<tr><td>Location: United States</td></tr>
<tr><td>Sample: 5,278
Attrition Rate: 0
Sample Power: Not Reported</td></tr>
<tr><td>Exposure Measurement
Device-Measured:
Accelerometer, sedentary behavior was defined as activity counts/min <100.
Measures Steps: No
Measures Bouts: No</td></tr>
<tr><td>Refers to Other Materials: Yes
Examine Cardiorespiratory Fitness as Outcome: No</td><td>Outcomes Examined: Mortality: participants were linked to death certificate data from the National Death Index. Person-months of follow-up were calculated from the date of the interview until date of death or censoring on December 31, 2011, whichever came first.</td></tr>
<tr><td>Populations Analyzed: Adults 20–85, Visually Impaired</td><td>Author-Stated Funding Source: No funding source used</td></tr>
</table>

<table>
<tr><td colspan="2">Original Research
Citation: Martinez-Gomez D, Guallar-Castillon P, Rodriguez-Artalejo F. Sitting time and mortality in older adults with disability: A national cohort study. J Am Med Dir Assoc. 2016;17(10):960.e15-20. doi:10.1016/j.jamda.2016.07.016.</td></tr>
<tr><td colspan="2">Purpose: To examine the association between sitting time and long-term mortality in older adults with disabilities.</td></tr>
<tr><td>Study Design: Prospective cohort study
Location: Spain
Sample: 2,470
Attrition Rate: 9.87%
Sample Power: Not Reported
Exposure Measurement
Self-Reported: Sitting time, estimated by leisure time spent sitting down with the following question: “How much time do you spend sitting down on weekdays?”; the same question was asked for the weekend days, average hours per day seated on a typical week [(weekday sitting time x 5 + weekend sitting time x 2)/7], classified into tertiles (<4 h/d, 4–6 h/d, >6 h/d).
Measures Steps: No
Measures Bouts: No</td><td>Abstract: BACKGROUND: The progressive aging of the population has increased the number of older adults with disabilities. Regular physical activity has shown to improve health among these individuals, but the effects of sedentary behavior are mostly unknown. Thus, this study examined the association between sitting time and mortality in older adults with disability. METHODS: Prospective cohort of 2470 people aged >/=60 years. In 2000-2011, the study participants reported their sitting time and physical activity levels and were subsequently followed up through 2011 to ascertain mortality. RESULTS: During an average follow-up of 8.7 years, 982 deaths occurred. Compared with people who spent seated <4 hours/d, the hazard ratio (95% confidence interval) of mortality was 1.27 (1.07-1.51) in those seated during 4-6 hours/d and 1.55 (1.29-1.87) in those seated for >6 hours/d. Each increment of 1 hour/day in sitting time was linked to a 7% increase in mortality. Compared with active individuals who spent seated <4 hours/day, those who were inactive and spent seated >6 hours/d showed the highest mortality (hazard ratio 1.82, 95% confidence interval 1.37-2.42). CONCLUSIONS: Sitting time is associated with higher mortality in older people with disability. Interventions combining the reduction of sedentary behavior with increased physical activity should be developed and evaluated in this group of population.</td></tr>
<tr><td>Refers to Other Materials: No
Examine Cardiorespiratory Fitness as Outcome: No</td><td>Outcomes Examined: All-cause mortality: number and dates of deaths were obtained by a computerized search of the National Death Index.</td></tr>
<tr><td>Populations Analyzed: Adults ≥ 60, Disability (agility, mobility, restriction of daily activities, instrumental activities of daily living, self-care)</td><td>Author-Stated Funding Source: FIS, MINECO I+D+i, FP7-HEALTH-2012, and by the Catedra UAM de Epidemiologia y Control del Riesgo Cardiovascular</td></tr>
</table>

<table>
<tr><td colspan="2">Original Research
Citation: Matthews CE, Keadle SK, Troiano RP, et al. Accelerometer-measured dose-response for physical activity, sedentary time, and mortality in US adults. Am J Clin Nutr. 2016;104(5):1424-1432.</td></tr>
<tr><td colspan="2">Purpose: To describe dose response for sedentary time and light- and moderate- to vigorous-intensity activity and estimate the mortality benefits associated with replacing sedentary time with physical activity among adults.</td></tr>
<tr><td>Study Design: Prospective cohort study
Location: United States
Sample: 4,840
Attrition Rate: 23.84%
Sample Power: Not Reported
Exposure Measurement Device-Measured: Accelerometer, sedentary time was defined as wear time with activity count <100.
Measures Steps: No
Measures Bouts: No</td><td>Abstract: BACKGROUND: Moderate-to-vigorous-intensity physical activity is recommended to maintain and improve health, but the mortality benefits of light activity and risk for sedentary time remain uncertain. OBJECTIVES: Using accelerometer-based measures, we 1) described the mortality dose-response for sedentary time and light- and moderate-to-vigorous-intensity activity using restricted cubic splines, and 2) estimated the mortality benefits associated with replacing sedentary time with physical activity, accounting for total activity. DESIGN: US adults (n = 4840) from NHANES (2003-2006) wore an accelerometer for </=7 d and were followed prospectively for mortality. Proportional hazards models were used to estimate adjusted HRs and 95% CIs for mortality associations with time spent sedentary and in light- and moderate-to-vigorous-intensity physical activity. Splines were used to graphically present behavior-mortality relation. Isotemporal models estimated replacement associations for sedentary time, and separate models were fit for low- (<5.8 h total activity/d) and high-active participants to account for nonlinear associations. RESULTS: Over a mean of 6.6 y, 700 deaths occurred. Compared with less-sedentary adults (6 sedentary h/d), those who spent 10 sedentary h/d had 29% greater risk (HR: 1.29; 95% CI: 1.1, 1.5). Compared with those who did less light activity (3 h/d), those who did 5 h of light activity/d had 23% lower risk (HR: 0.77; 95% CI: 0.6, 1.0). There was no association with mortality for sedentary time or light or moderate-to-vigorous activity in highly active adults. In less-active adults, replacing 1 h of sedentary time with either light- or moderate-to-vigorous-intensity activity was associated with 18% and 42% lower mortality, respectively. CONCLUSIONS: Health promotion efforts for physical activity have mostly focused on moderate-to-vigorous activity. However, our findings derived from accelerometer-based measurements suggest that increasing light-intensity activity and reducing sedentary time are also important, particularly for inactive adults.</td></tr>
<tr><td>Refers to Other Materials: Yes
Examine Cardiorespiratory Fitness as Outcome: No</td><td>Outcomes Examined: Mortality: the National Death Index.</td></tr>
<tr><td>Populations Analyzed: Adults ≥ 40</td><td>Author-Stated Funding Source: No funding source used</td></tr>
</table>

<table>
<tr><td colspan="2">Original Research
Citation: Matthews CE, Moore SC, Sampson J, et al. Mortality benefits for replacing sitting time with different physical activities. Med Sci Sports Exerc. 2015;47(9):1833-40. doi:10.1249/MSS.0000000000000621.</td></tr>
<tr><td colspan="2">Purpose: To determine the marginal effects of hours of sedentary behavior, exercise, and non-exercise activity on overall mortality.</td></tr>
<tr><td>Study Design: Prospective cohort study</td><td rowspan="4">Abstract: PURPOSE: Prolonged sitting has emerged as a risk factor for early mortality, but the extent of benefit realized by replacing sitting time with exercise or activities of everyday living (i.e., nonexercise activities) is not known. METHODS: We prospectively followed 154,614 older adults (59-82 yr) in the National Institutes of Health-AARP Diet and Health Study who reported no major chronic diseases at baseline and reported detailed information about sitting time, exercise, and nonexercise activities. Proportional hazard models were used to estimate adjusted hazard ratios and 95% confidence intervals (HR (95% confidence interval)) for mortality. An isotemporal modeling approach was used to estimate associations for replacing sitting time with specific types of physical activity, with separate models fit for less active and more active participants to account for nonlinear associations. RESULTS: During 6.8 yr (SD, 1.0) of follow-up, 12,201 deaths occurred. Greater sitting time (>/=12 vs < 5 h.d(-1)) was associated with increased risk for all-cause and cardiovascular mortality. In less active adults (<2 h.d(-1) total activity), replacing 1 h.d(-1) of sitting with an equal amount of activity was associated with lower all-cause mortality for both exercise (HR, 0.58 (0.54-0.63)) and nonexercise activities (HR, 0.70 (0.66-0.74)), including household chores, lawn and garden work, and daily walking. Among more active participants (2+ h.d(-1) total activity), replacement of sitting time with purposeful exercise was associated with lower mortality (HR, 0.91 (0.88-0.94)) but not with nonexercise activity (HR, 1.00 (0.98-1.02)). Similar results were noted for cardiovascular mortality. CONCLUSIONS: Physical activity intervention strategies for older adults often focus on aerobic exercise, but our findings suggest that reducing sitting time and engaging in a variety of activities is also important, particularly for inactive adults.</td></tr>
<tr><td>Location: United States</td></tr>
<tr><td>Sample: 154,614
Attrition Rate: 0
Sample Power: Not Reported</td></tr>
<tr><td>Exposure Measurement
Self-Reported: Three sitting questions were asked about the number of hours spent in a typical 24-hour period during the last 12 months.
Measures Steps: No
Measures Bouts: No</td></tr>
<tr><td>Refers to Other Materials: Yes
Examine Cardiorespiratory Fitness as Outcome: No</td><td>Outcomes Examined: All-cause mortality, mortality from cardiovascular disease, and mortality from cancer determined through linkage with the Social Security Administration Death Master File and the National Death Index.</td></tr>
<tr><td>Populations Analyzed: Adults 59–82, Male</td><td>Author-Stated Funding Source: National Institutes of Health, National Cancer Institute</td></tr>
</table>

Original Research

Citation: Pulsford RM, Stamatakis E, Britton AR, Brunner EJ, Hillsdon M. Associations of sitting behaviours with all-cause mortality over a 16-year follow-up: The Whitehall II study. *Int J Epidemiol.* 2015;44(6):1909-16. doi:10.1093/ije/dyv191.

Purpose: To enhance the evidence base by examining the type-specific associations of four different sitting behaviors as well as total sitting with the risk of all-cause mortality among United Kingdom adults.

Study Design: Prospective cohort study

Location: United Kingdom

Sample: 5,132
Attrition Rate: 50.21%
Sample Power: Not Reported

Exposure Measurement
Self-Reported: Participants reported on average how many hours per week they spent: sitting at work, including driving or commuting, and sitting at home, by selecting from eight response categories (none, 1h, 2–5, 6–10, 11–20, 21–30, 31–40, >40); five sitting indicators were computed (work sitting, TV viewing time, non-TV leisure time sitting, total leisure time sitting, and total sitting time).
Measures Steps: No
Measures Bouts: No

Abstract: BACKGROUND: Sitting behaviours have been linked with increased risk of all-cause mortality independent of moderate to vigorous physical activity (MVPA). Previous studies have tended to examine single indicators of sitting or all sitting behaviours combined. This study aims to enhance the evidence base by examining the type-specific prospective associations of four different sitting behaviours as well as total sitting with the risk of all-cause mortality. METHODS: Participants (3720 men and 1412 women) from the Whitehall II cohort study who were free from cardiovascular disease provided information on weekly sitting time (at work, during leisure time, while watching TV, during leisure time excluding TV, and at work and during leisure time combined) and covariates in 1997-99. Cox proportional hazards models were used to investigate prospective associations between sitting time (h/week) and mortality risk. Follow-up was from date of measurement until (the earliest of) death, date of censor or July 31 2014. RESULTS: Over 81 373 person-years of follow-up (mean follow-up time 15.7 +/- 2.2 years) a total of 450 deaths were recorded. No associations were observed between any of the five sitting indicators and mortality risk, either in unadjusted models or models adjusted for covariates including MVPA. CONCLUSIONS: Sitting time was not associated with all-cause mortality risk. The results of this study suggest that policy makers and clinicians should be cautious about placing emphasis on sitting behaviour as a risk factor for mortality that is distinct from the effect of physical activity.

Refers to Other Materials: No
Examine Cardiorespiratory Fitness as Outcome: No

Outcomes Examined: Mortality: established through the national mortality register kept by the National Health Service Central Registry.

Populations Analyzed: Adults 35–55

Author-Stated Funding Source: Medical Research Council, British Heart Foundation, Stroke Association, National Heart Lung and Blood Institute, and National Institute on Aging

<table>
<tr><td colspan="2">Original Research
Citation: Schmid D, Ricci C, Baumeister SE, Leitzmann MF. Replacing sedentary time with physical activity in relation to mortality. Med Sci Sports Exerc. 2016;48(7):1312-9. doi:10.1249/MSS.0000000000000913.</td></tr>
<tr><td colspan="2">Purpose: To explore whether reallocating 30 min*d^{-1} from one activity behavior to an equal amount of time spent in another activity behavior is associated with mortality from any cause, cardiovascular disease, or cancer among adults.</td></tr>
<tr><td>Study Design: Prospective cohort study</td><td rowspan="4">Abstract: INTRODUCTION: Data evaluating mortality benefit from replacing sedentary time with physical activity are sparse. We explored reallocating time spent in sedentary behavior to physical activity of different intensities in relation to mortality risk. METHODS: Women and men age 50-85 yr from the National Health and Nutrition Examination Survey 2003-2004 and 2005-2006 cycles with follow-up through December 31, 2011, were included. Sedentary time and physical activity were assessed using an ActiGraph accelerometer. Isotemporal substitution models were used to estimate the effect of replacing one activity behavior with another activity behavior for the same amount of time while holding total accelerometer wear time constant. RESULTS: During a mean follow-up of 6.35 yr, 697 deaths from any cause occurred. Replacing 30 min of sedentary time with an equal amount of light activity was associated with 14% reduced risk of mortality (multivariable-adjusted hazard ratio (HR), 0.86; 95% confidence interval (CI), 0.83-0.90). Replacement of sedentary time with moderate to vigorous activity was related to 50% mortality risk reduction (HR, 0.50; 95% CI, 0.31-0.80). We also noted a 42% reduced risk of mortality when light physical activity was replaced by moderate to vigorous activity (HR, 0.58; 95% CI, 0.36-0.93). CONCLUSION: Replacing sedentary time with an equal amount of physical activity may protect against preterm mortality. Replacement of light physical activity with moderate to vigorous activity is also associated with protection from premature mortality.</td></tr>
<tr><td>Location: United States</td></tr>
<tr><td>Sample: 3,702
Attrition Rate: 0.19%
Sample Power: Not Reported</td></tr>
<tr><td>Exposure Measurement
Device-Measured:
Accelerometer, sedentary time defined as <100 counts per minute.
Measures Steps: No
Measures Bouts: No</td></tr>
<tr><td>Refers to Other Materials: Yes
Examine Cardiorespiratory Fitness as Outcome: No</td><td>Outcomes Examined: Mortality: based on probabilistic match between the National Health and Nutrition Examination Survey and death certificate records of the National Death Index.</td></tr>
<tr><td>Populations Analyzed: Adults 50–85, Male</td><td>Author-Stated Funding Source: No funding source used</td></tr>
</table>

<table>
<tr><td colspan="2">Original Research
Citation: Schmid D, Ricci C, Leitzmann MF. Associations of objectively assessed physical activity and sedentary time with all-cause mortality in US adults: The NHANES study. PLoS One. 2015;10(3):e0119591. doi:10.1371/journal.pone.0119591.</td></tr>
<tr><td colspan="2">Purpose: To examine whether higher levels of PA can alleviate the apparent adverse effect of sedentary time on early mortality from any cause among adults.</td></tr>
<tr><td>Study Design: Prospective cohort study</td><td rowspan="4">Abstract: BACKGROUND: Sedentary behavior is related to increased mortality risk. Whether such elevated risk can be offset by enhanced physical activity has not been examined using accelerometry data. MATERIALS AND METHODS: We examined the relations of sedentary time and physical activity to mortality from any cause using accelerometry data among 1,677 women and men aged 50 years or older from the National Health and Nutrition Examination Survey (NHANES) 2003-2004 cycle with follow-up through December 31, 2006. RESULTS: During an average follow-up of 34.67 months and 4,845.42 person-years, 112 deaths occurred. In multivariate Cox proportional hazard models, greater sedentary time (>/= median of 8.60 hours/day) was associated with increased risk of mortality from any cause (relative risk (RR) = 2.03; 95% confidence interval (CI) = 1.09-3.81). Low level of moderate to vigorous physical activity (< median of 6.60 minutes/day) was also related to enhanced all-cause mortality risk (RR = 3.30; 95% CI = 1.33-8.17). In combined analyses, greater time spent sedentary and low levels of moderate to vigorous physical activity predicted a substantially elevated all-cause mortality risk. As compared with the combination of a low sedentary level and a high level of moderate to vigorous physical activity, the risks of mortality from all causes were 4.38 (95% CI = 1.26-15.16) for low levels of both sedentary time and physical activity, 2.79 (95% CI = 0.77-10.12) for greater time spent sedentary and high physical activity level, and 7.79 (95% CI = 2.26-26.82) for greater time spent sedentary and low physical activity level. The interaction term between sedentary time and moderate to vigorous physical activity was not statistically significant (p = 0.508). CONCLUSIONS: Both high levels of sedentary time and low levels of moderate to vigorous physical activity are strong and independent predictors of early death from any cause. Whether a high physical activity level removes the increased risk of all-cause mortality related to sedentariness requires further investigation.</td></tr>
<tr><td>Location: United States</td></tr>
<tr><td>Sample: 1,677
Attrition Rate: 33.19%
Sample Power: Not Reported</td></tr>
<tr><td>Exposure Measurement Device-Measured: Accelerometer, sedentary time was defined as <100 counts per minute.
Measures Steps: No
Measures Bouts: No</td></tr>
<tr><td>Refers to Other Materials: No
Examine Cardiorespiratory Fitness as Outcome: No</td><td>Outcomes Examined: Mortality: sources included the Social Security Administration, Centers for Medicare & Medicaid Services, and death certificates.</td></tr>
<tr><td>Populations Analyzed: Adults ≥50</td><td>Author-Stated Funding Source: No funding source used</td></tr>
</table>

Original Research

Citation: Shuval K, Finley CE, Barlow CE, Nguyen BT, Njike VY, Gabriel KP. Independent and joint effects of sedentary time and cardiorespiratory fitness on all-cause mortality: The Cooper Center Longitudinal Study. *BMJ Open.* 2015;5(10):e008956.

Purpose: To examine the independent and joint effects of sedentary time and fitness on all-cause mortality among adults.

Study Design: Prospective cohort study

Location: United States

Sample: 3,141
Attrition Rate: 14.55%
Sample Power: Not Reported

Exposure Measurement
Self-Reported: Sedentary behavior, reported time spent viewing TV and commuting in a car; hours of car driving and TV viewing per week were considered separate exposure variables; combined amount of sedentary time (sum of TV viewing and car commuting time) was regarded as an additional exposure variable; quartile cut-points for the combined sedentary time are: 11, 16, 23 h/week, car time (0–4, 5–7, 8–10, and
≥ 11h/week), TV viewing time (0–3, 4–7,
8–12, ≥13 h/week).
Measures Steps: No
Measures Bouts: No

Abstract: OBJECTIVES: To examine the independent and joint effects of sedentary time and cardiorespiratory fitness (fitness) on all-cause mortality. DESIGN, SETTING, PARTICIPANTS: A prospective study of 3141 Cooper Center Longitudinal Study participants. Participants provided information on television (TV) viewing and car time in 1982 and completed a maximal exercise test during a 1-year time frame; they were then followed until mortality or through 2010. TV viewing, car time, total sedentary time and fitness were the primary exposures and all-cause mortality was the outcome. The relationship between the exposures and outcome was examined utilising Cox proportional hazard models. RESULTS: A total of 581 deaths occurred over a median follow-up period of 28.7 years (SD=4.4). At baseline, participants' mean age was 45.0 years (SD=9.6), 86.5% were men and their mean body mass index was 24.6 (SD=3.0). Multivariable analyses revealed a significant linear relationship between increased fitness and lower mortality risk, even while adjusting for total sedentary time and covariates (p=0.02). The effects of total sedentary time on increased mortality risk did not quite reach statistical significance once fitness and covariates were adjusted for (p=0.05). When examining this relationship categorically, in comparison to the reference category (</=10 h/week), being sedentary for >/=23 h weekly increased mortality risk by 29% without controlling for fitness (HR=1.29, 95% CI 1.03 to 1.63); however, once fitness and covariates were taken into account this relationship did not reach statistical significance (HR=1.20, 95% CI 0.95 to 1.51). Moreover, spending >10 h in the car weekly significantly increased mortality risk by 27% in the fully adjusted model. The association between TV viewing and mortality was not significant. CONCLUSIONS: The relationship between total sedentary time and higher mortality risk is less pronounced when fitness is taken into account. Increased car time, but not TV viewing, is significantly related to higher mortality risk, even when taking fitness into account, in this cohort.

Refers to Other Materials: Yes
Examine Cardiorespiratory Fitness as Outcome: No

Outcomes Examined: All-cause mortality: National Death Index was the primary source of mortality information.

Populations Analyzed: Adults ≥20

Author-Stated Funding Source: National Institutes of Health

<table>
<tr><td colspan="2">Original Research
Citation: Stamatakis E, Rogers K, Ding D, et al. All-cause mortality effects of replacing sedentary time with physical activity and sleeping using an isotemporal substitution model: A prospective study of 201,129 mid-aged and older adults. Int J Behav Nutr Phys Act. 2015;12(Sep):121. doi: 10.1186/s12966-015-0280-7.</td></tr>
<tr><td colspan="2">Purpose: To examine the estimated replacement effects of sedentary behavior and other time-dependent behaviors on all-cause mortality among adults.</td></tr>
<tr><td>Study Design: Prospective cohort study</td><td rowspan="4">Abstract: BACKGROUND: Sedentary behaviour, sleeping, and physical activity are thought to be independently associated with health outcomes but it is unclear whether these associations are due to the direct physiological effects of each behaviour or because, across a finite 24-hour day, engagement in one behavior requires displacement of another. The aim of this study was to examine the replacement effects of sedentary behaviour (total sitting, television/computer screen time combined), sleeping, standing, walking, and moderate-to-vigorous physical activity on all-cause mortality using isotemporal substitution modelling. METHODS: Longitudinal analysis (4.22 +/- 0.9 years follow-up/849,369 person-years) of 201,129 participants of the 45 and Up study aged >/=45 years from New South Wales, Australia. RESULTS: Seven thousand four hundred and sixty deaths occurred over follow-up. There were beneficial associations for replacing total sitting time with standing (per-hour HR: 95 % CI: 0.95, 0.94-0.96), walking (0.86, 0.81-0.90), moderate-to-vigorous physical activity (0.88, 0.85-0.90), and sleeping in those sleeping </= 7 h/day (0.94, 0.90-0.98). Similar associations were noted for replacing screen time. Replacing one hour of walking or moderate-to-vigorous physical activity with any other activity class was associated with an increased mortality risk by 7-18%. Excluding deaths in the first 24 months of the follow up and restricting analyses to those who were healthy at baseline did not materially change the above observations. CONCLUSION: Although replacing sedentary behaviour with walking and moderate-to-vigorous physical activity are associated with the lowest mortality risk, replacements with equal amounts of standing and sleeping (in low sleepers only) are also linked to substantial mortality risk reductions.</td></tr>
<tr><td>Location: Australia</td></tr>
<tr><td>Sample: 201,129
Attrition Rate: 24.70%
Sample Power: Not Reported</td></tr>
<tr><td>Exposure Measurement
Self-Reported: 45 and Up Study baseline questionnaire: sitting, screen time (watching television or using a computer), standing and sleeping variables, sitting time per day (0–2, 3–4, 5–6, ≥7 hours).
Measures Steps: No
Measures Bouts: No</td></tr>
<tr><td>Refers to Other Materials: Yes
Examine Cardiorespiratory Fitness as Outcome: No</td><td>Outcomes Examined: All-cause mortality: linked to the baseline data from the 45 and Up Study by the Centre for Health Record Linkage.</td></tr>
<tr><td>Populations Analyzed: Adults ≥45</td><td>Author-Stated Funding Source: Australian National Health and Medical Research Council, UK National Institute for Health Research</td></tr>
</table>

Original Research

Citation: van der Ploeg HP, Moller SV, Hannerz, H, van der Beek AJ, Holtermann A. Temporal changes in occupational sitting time in the Danish workforce and associations with all-cause mortality: Results from the Danish work environment cohort study. *Int J Behav Nutr Phys Act.* 2015;12:71. doi:10.1186/s12966-015-0233-1.

Purpose: To determine temporal changes in occupational sitting time between 1990 and 2010 and the association and possible dose-response relationship between occupational sitting time and all-cause mortality among adults.

Study Design: Prospective cohort study

Location: Denmark

Sample: N/A
Attrition Rate: 0
Sample Power: Not Reported

Exposure Measurement
Self-Reported: Occupational sitting time, assessed in the Danish Work Environment Cohort Study using the question "Does your job involve sitting?" with pre-set answer categories ("Almost all the time"; "approximately 3/4 of the time"; "approximately 1/2 of the time"; "approximately 1/4 of the time"; "rarely"; "never"); combined with self-reported actual working hours by multiplying by coefficients 0.875, 0.75, 0.5, 0.25, 0.125, 0. Separated into sedentary workers (≥ 24 hr/wk) and less sedentary workers (<24 hr/wk).
Measures Steps: No
Measures Bouts: No

Abstract: BACKGROUND: Prolonged sitting has been negatively associated with a range of non-communicably diseases. However, the role of occupational sitting is less clear, and little is known on the changes of occupational sitting in a working population over time. The present study aimed to determine 1) temporal changes in occupational sitting time between 1990 and 2010 in the Danish workforce; 2) the association and possible dose-response relationship between occupational sitting time and all-cause mortality. METHODS: This study analysed data from the Danish Work Environment Cohort Study (DWECS), which is a cohort study of the Danish working population conducted in five yearly intervals between 1990 and 2010. Occupational sitting time is self-reported in the DWECS. To determine the association with all-cause mortality, the DWECS was linked to the Danish Register of Causes of Death via the Central Person Register. RESULTS: Between 1990 and 2010 the proportion of the Danish workforce who sat for at least three quarters of their work time gradually increased from 33.1 to 39.1%. All-cause mortality analyses were performed with 149,773 person-years of observation and an average follow-up of 12.61 years, during which 533 deaths were registered. None of the presented analyses found a statistically significant association between occupational sitting time and all-cause mortality. The hazard ratio for all-cause mortality was 0.97 (95% CI: 0.79; 1.18) when >/=24 hr/wk occupational sitting time was compared to <24 hr/wk for the 1990-2005 waves. CONCLUSIONS: Occupational sitting time increased by 18% in the Danish workforce, which seemed to be limited to people with high socio-economic status. If this increase is accompanied by increases in total sitting time, this development has serious public health implications, given the detrimental associations between total sitting time and mortality. The current study was inconclusive on the specific role that occupational sitting might play in the increased all-cause mortality risk associated with the total volume of sitting.

Refers to Other Materials: No
Examine Cardiorespiratory Fitness as Outcome: No

Outcomes Examined: All-cause mortality: linked to the Danish Register of Causes of Death via the Central Person Register.

Populations Analyzed: Adults ≥ 21; Social Class I (highest), Social Class II, Social Class III, Social

Author-Stated Funding Source: Not reported

Class IV, Social Class V (lowest); Normal/Healthy Weight (BMI: 18.5–24.9), Overweight (BMI: 25-29.9), Obese (BMI: 30 and above); Smoking; Male	

<table>
<tr><td colspan="2">Original Research
Citation: Warren Andersen S, Zheng, W, Sonderman, J, et al. Combined Impact of Health Behaviors on Mortality in Low-Income Americans. Am J Prev Med. 2016;51(3):344-55.</td></tr>
<tr><td colspan="2">Purpose: To examine the combined association of modifiable lifestyle factors with all-cause and cause-specific mortality among adults.</td></tr>
<tr><td>Study Design: Prospective cohort study</td><td rowspan="4">Abstract: INTRODUCTION: African Americans and low-income whites have higher mortality than the U.S. general population. This study prospectively investigated the combined influence of major lifestyle factors and poverty on mortality in this vulnerable population. METHODS: Data were collected in 2002-2009 from 79,101 Southern Community Cohort Study participants, of which 67% were African American and 55% had household incomes <$15,000. Mortality outcomes were identified from the National Death Index though December 31, 2011 (data analyzed in 2014-2015). Healthy behavior scores were created based on tobacco smoking, alcohol intake, diet, physical activity, and sedentary time. The primary analysis was performed based on the score created by counting each participant as having met/not met public health guidelines for each behavior. RESULTS: Healthy behavior scores were associated with reduced cancer, cardiovascular disease, and all-cause mortality. Associations were stronger for whites than African Americans: hazard ratios for all-cause mortality comparing participants meeting four or five guidelines versus participants meeting zero were 0.41 (95% CI=0.30, 0.55) for African American men; 0.36 (95% CI=0.24, 0.55) for white men; 0.46 (95% CI=0.36, 0.59) for African American women; and 0.27 (95% CI=0.18, 0.43) for white women. The association between healthy lifestyle and all-cause mortality was weaker among those with incomes <$15,000 than those with higher income, particularly in men (p<0.05 for interaction). CONCLUSIONS: This study demonstrates the importance of health behaviors on mortality among all groups, but highlights the need for additional research to identify factors contributing to high risk of mortality among low-income and African American populations.</td></tr>
<tr><td>Location: United States</td></tr>
<tr><td>Sample: 79,101
Attrition Rate: 6.64%
Sample Power: Not Reported</td></tr>
<tr><td>Exposure Measurement
Self-Reported: Sedentary behavior, assessed by asking about amount of time/day spent sitting. Summary sedentary behavior variable was created as the average sitting time/day over the course of the week.
Measures Steps: No
Measures Bouts: No</td></tr>
<tr><td>Refers to Other Materials: Yes
Examine Cardiorespiratory Fitness as Outcome: No</td><td>Outcomes Examined: Mortality: obtained via linkage to the Social Security Administration’s Death Master File. Cause of death was ascertained from the National Death Index and grouped according to the ICD-10 codes as cardiovascular diseases, cancer, and all other causes.</td></tr>
<tr><td>Populations Analyzed: White; Black or African American; Adults 40–79; Low-Income; Male</td><td>Author-Stated Funding Source: National Cancer Institute at National Institutes of Health (including special allocations from the American Recovery and Reinvestment Act), Vanderbilt Molecular and Genetic Epidemiology of Cancer</td></tr>
</table>

<table>
<tr><td colspan="2">Original Research
Citation: Wijndaele K, Sharp SJ, Wareham NJ, Brage S. Mortality risk reductions from substituting screen-time by discretionary activities. Med Sci Sports Exerc. 2017;Jan 19. doi: 10.1249/MSS.0000000000001206.</td></tr>
<tr><td colspan="2">Purpose: To estimate the differential mortality risk reductions associated with substituting leisure screen time with different discretionary PA types among adults.</td></tr>
<tr><td>Study Design:
Prospective cohort study</td><td rowspan="4">Abstract: PURPOSE: Leisure-screen-time, including TV viewing, is associated with increased mortality risk. We estimated the all-cause mortality risk reductions associated with substituting leisure-screen-time with different discretionary physical activity types, and the change in mortality incidence associated with different substitution scenarios. METHODS: 423,659 UK Biobank participants, without stroke, myocardial infarction or cancer history, were followed for 7.6 (1.4) (median (IQR)) years. They reported leisure-screen-time (TV watching and home computer use) and leisure/home activities, categorised as daily-life activities (walking for pleasure; light DIY; heavy DIY) and structured exercise (strenuous sports; other exercises). Iso-temporal substitution modelling in Cox regression provided hazard ratios (95% confidence intervals) for all-cause mortality when substituting screen-time (30 minutes/day) with different discretionary activity types of the same duration. Potential impact fractions (PIFs) estimated the proportional change in mortality incidence associated with different substitution scenarios. RESULTS: During 3,202,105 person-years of follow-up, 8,928 participants died. Each 30 minute/day difference in screen-time was associated with lower mortality hazard when modelling substitution of screen-time by an equal amount of daily-life activities (0.95 (0.94-0.97)), as well as structured exercise (0.87 (0.84-0.90)). Re-allocations from screen-time into specific activity subtypes suggested different reductions in mortality hazard (walking for pleasure (0.95 (0.92-0.98)), light DIY (0.97 (0.94-1.00)), heavy DIY (0.93 (0.90-0.96)), strenuous sports (0.87 (0.79-0.95)), other exercises (0.88 (0.84-0.91))). The lowest hazard estimates were found when modelling replacement of TV viewing. PIFs ranged from 4.3% (30 minute/day substitution of screen-time into light DIY) to 14.9% (TV viewing into strenuous sports). CONCLUSION: Substantial public health benefits could be gained by replacing small amounts of screen-time with daily-life activities and structured exercise. Daily-life activities may provide feasible screen-time alternatives, if structured exercise is initially too ambitious.</td></tr>
<tr><td>Location: United Kingdom</td></tr>
<tr><td>Sample: 423,659
Attrition Rate: 16.28%
Sample Power: Not Reported</td></tr>
<tr><td>Exposure Measurement Self-Reported: Questionnaire, number of hours spent watching TV and number of hours spent using the computer (not including occupational use) on a typical day. The sum of both estimates was calculated to estimate average daily screen time (hours/day). Screen time was truncated at 9 hours/day.
Measures Steps: No
Measures Bouts: No</td></tr>
<tr><td>Refers to Other Materials: No
Examine Cardiorespiratory Fitness as Outcome: No</td><td>Outcomes Examined: Mortality: followed up for vital status by linkage to national datasets (NHS Information Centre and Scottish Morbidity Record).</td></tr>
<tr><td>Populations Analyzed: Adults 40–69</td><td>Author-Stated Funding Source: British Heart Foundation and the Medical Research Council</td></tr>
</table>

Table 5. Original Research Bias Assessment Chart

Nutrition Evidence Library (NEL) Bias Assessment Tool (BAT): Original Research							
	Ding, 2015	Edwards, 2016	Ensrud, 2014	Evenson, 2017	Evenson, 2016	Fishman, 2016	Grunseit, 2017
(???) = Can't Determine							
Inclusion/exclusion criteria similar across study groups.	Yes	Yes	Yes	Yes	Yes	Yes	Yes
Strategy for recruiting or allocating participants similar across study groups.	Yes	Yes	Yes	Yes	Yes	Yes	Yes
Allocation sequence randomly generated.	N/A	N/A	N/A	N/A	N/A	N/A	N/A
Group allocation concealed (i.e., assignments could not be predicted).	N/A	N/A	N/A	N/A	N/A	N/A	N/A
Distribution of critical confounding factors similar across study groups at baseline, or analysis controlled for differences between groups.	???	Yes	Yes	Yes	Yes	Yes	Yes
Accounted for variations in execution of study from proposed protocol or research plan.	N/A	N/A	N/A	N/A	N/A	N/A	N/A
Adherence to study protocols similar across study groups.	Yes	Yes	Yes	Yes	Yes	Yes	Yes
Investigators accounted for unintended concurrent exposures that were differentially experienced by study groups and might bias results.	Yes	Yes	Yes	Yes	Yes	Yes	Yes
Participants blinded to their intervention or exposure status.	N/A	N/A	N/A	N/A	N/A	N/A	N/A
Investigators blinded to participants' intervention or exposure status.	N/A	N/A	N/A	N/A	N/A	N/A	N/A
Outcome assessors blinded to participants' intervention or exposure status.	N/A	N/A	N/A	N/A	N/A	N/A	N/A
Valid and reliable measures used consistently across study groups to assess inclusion/exclusion criteria, exposures, outcomes, and confounders.	Yes	Yes	Yes	Yes	Yes	Yes	No
Length of follow-up similar across study groups.	Yes	Yes	Yes	Yes	Yes	Yes	Yes
In cases of high or differential loss to follow-up, impact assessed through sensitivity analysis or other adjustment.	N/A	Yes	Yes	Yes	Yes	Yes	N/A
Other sources of bias taken into account in design and/or analysis of study through matching or other statistical adjustment.	Yes	Yes	Yes	Yes	Yes	Yes	Yes
Adequate statistical methods used to assess primary outcomes.	Yes	Yes	Yes	Yes	Yes	Yes	Yes

Nutrition Evidence Library (NEL) Bias Assessment Tool (BAT): Original Research							
	Hagger-Johnson, 2016	Keadle, 2015	Kikuchi, 2015	Koolhaas, 2017	Krokstad, 2017	Lee, 2016a	Lee, 2016b
(???) = Can't Determine							
Inclusion/exclusion criteria similar across study groups.	Yes	Yes	Yes	Yes	Yes	Yes	N/A
Strategy for recruiting or allocating participants similar across study groups.	Yes	Yes	Yes	Yes	Yes	Yes	N/A
Allocation sequence randomly generated.	N/A	N/A	N/A	N/A	N/A	N/A	N/A
Group allocation concealed (i.e., assignments could not be predicted).	N/A	N/A	N/A	N/A	N/A	N/A	N/A
Distribution of critical confounding factors similar across study groups at baseline, or analysis controlled for differences between groups.	Yes	Yes	Yes	Yes	Yes	Yes	N/A
Accounted for variations in execution of study from proposed protocol or research plan.	Yes	N/A	Yes	N/A	N/A	N/A	N/A
Adherence to study protocols similar across study groups.	Yes	Yes	Yes	Yes	Yes	Yes	N/A
Investigators accounted for unintended concurrent exposures that were differentially experienced by study groups and might bias results.	Yes	Yes	Yes	Yes	No	Yes	N/A
Participants blinded to their intervention or exposure status.	N/A	N/A	N/A	N/A	N/A	N/A	N/A
Investigators blinded to participants' intervention or exposure status.	N/A	N/A	N/A	N/A	N/A	N/A	N/A
Outcome assessors blinded to participants' intervention or exposure status.	N/A	N/A	N/A	N/A	N/A	N/A	N/A
Valid and reliable measures used consistently across study groups to assess inclusion/exclusion criteria, exposures, outcomes, and confounders.	No	No	No	Yes	No	No	N/A
Length of follow-up similar across study groups.	Yes	Yes	Yes	Yes	Yes	Yes	N/A
In cases of high or differential loss to follow-up, impact assessed through sensitivity analysis or other adjustment.	Yes	Yes	Yes	N/A	Yes	Yes	No
Other sources of bias taken into account in design and/or analysis of study through matching or other statistical adjustment.	Yes	Yes	Yes	Yes	Yes	Yes	Yes
Adequate statistical methods used to assess primary outcomes.	Yes	Yes	Yes	Yes	Yes	Yes	Yes

Nutrition Evidence Library (NEL) Bias Assessment Tool (BAT): Original Research							
	Loprinzi, 2016a	Loprinzi, 2016b	Martinez-Gomez, 2016	Matthews, 2016	Matthews, 2015	Pulsford, 2015	Schmid, 2016
(???) = Can't Determine							
Inclusion/exclusion criteria similar across study groups.	N/A	N/A	Yes	Yes	Yes	Yes	Yes
Strategy for recruiting or allocating participants similar across study groups.	N/A	N/A	Yes	Yes	Yes	Yes	Yes
Allocation sequence randomly generated.	N/A	N/A	N/A	N/A	N/A	N/A	N/A
Group allocation concealed (i.e., assignments could not be predicted).	N/A	N/A	N/A	N/A	N/A	N/A	N/A
Distribution of critical confounding factors similar across study groups at baseline, or analysis controlled for differences between groups.	N/A	N/A	Yes	Yes	Yes	Yes	Yes
Accounted for variations in execution of study from proposed protocol or research plan.	N/A	Yes	N/A	N/A	N/A	N/A	Yes
Adherence to study protocols similar across study groups.	N/A	N/A	Yes	Yes	Yes	Yes	Yes
Investigators accounted for unintended concurrent exposures that were differentially experienced by study groups and might bias results.	N/A	N/A	Yes	Yes	Yes	Yes	Yes
Participants blinded to their intervention or exposure status.	N/A	N/A	N/A	N/A	N/A	N/A	N/A
Investigators blinded to participants' intervention or exposure status.	N/A	N/A	N/A	N/A	N/A	N/A	N/A
Outcome assessors blinded to participants' intervention or exposure status.	N/A	N/A	N/A	N/A	N/A	N/A	N/A
Valid and reliable measures used consistently across study groups to assess inclusion/exclusion criteria, exposures, outcomes, and confounders.	N/A	Yes	No	Yes	No	Yes	Yes
Length of follow-up similar across study groups.	N/A	N/A	Yes	Yes	Yes	Yes	Yes
In cases of high or differential loss to follow-up, impact assessed through sensitivity analysis or other adjustment.	N/A	N/A	N/A	Yes	N/A	Yes	Yes
Other sources of bias taken into account in design and/or analysis of study through matching or other statistical adjustment.	Yes	Yes	Yes	Yes	Yes	Yes	Yes
Adequate statistical methods used to assess primary outcomes.	Yes	Yes	Yes	Yes	Yes	Yes	Yes

Nutrition Evidence Library (NEL) Bias Assessment Tool (BAT): Original Research						
	Schmid, 2015	Shuval, 2015	Stamatakis, 2015	van der Ploeg, 2015	Warren 2016	Wijndaele, 2017
(???) = Can't Determine						
Inclusion/exclusion criteria similar across study groups.	Yes	Yes	Yes	Yes	Yes	Yes
Strategy for recruiting or allocating participants similar across study groups.	Yes	Yes	Yes	Yes	Yes	Yes
Allocation sequence randomly generated.	N/A	N/A	N/A	N/A	N/A	N/A
Group allocation concealed (i.e., assignments could not be predicted).	N/A	N/A	N/A	N/A	N/A	N/A
Distribution of critical confounding factors similar across study groups at baseline, or analysis controlled for differences between groups.	Yes	Yes	Yes	Yes	Yes	Yes
Accounted for variations in execution of study from proposed protocol or research plan.	N/A	N/A	N/A	Yes	N/A	Yes
Adherence to study protocols similar across study groups.	Yes	Yes	Yes	Yes	Yes	Yes
Investigators accounted for unintended concurrent exposures that were differentially experienced by study groups and might bias results.	Yes	No	Yes	Yes	Yes	Yes
Participants blinded to their intervention or exposure status.	N/A	N/A	N/A	N/A	N/A	N/A
Investigators blinded to participantsâ€™ intervention or exposure status.	N/A	N/A	N/A	N/A	N/A	N/A
Outcome assessors blinded to participantsâ€™ intervention or exposure status.	N/A	N/A	N/A	N/A	N/A	N/A
Valid and reliable measures used consistently across study groups to assess inclusion/exclusion criteria, exposures, outcomes, and confounders.	Yes	No	Yes	Yes	No	No
Length of follow-up similar across study groups.	Yes	Yes	Yes	Yes	Yes	Yes
In cases of high or differential loss to follow-up, impact assessed through sensitivity analysis or other adjustment.	Yes	N/A	Yes	Yes	N/A	Yes
Other sources of bias taken into account in design and/or analysis of study through matching or other statistical adjustment.	Yes	Yes	Yes	Yes	Yes	Yes
Adequate statistical methods used to assess primary outcomes.	Yes	Yes	Yes	Yes	Yes	Yes

Appendices

Appendix A: Analytical Framework

Analytical Framework

Sedentary Behavior

Systematic Review Questions

What is the relationship between sedentary behavior and all-cause mortality?

a. Is there a dose-response relationship? If yes, what is the shape of the relationship?
b. Does the relationship vary by age, sex, race/ethnicity, socio-economic status, or weight status?
c. Is the relationship independent of levels of light, moderate, or vigorous physical activity?
d. Is there evidence that bouts or breaks in sedentary behavior change the relationship between sedentary behavior and all-cause mortality?

Population

Adults, 18 years and older

Exposure

Sedentary behavior

- Total sitting time
- Screen time
- Leisure-time sitting
- Occupational sitting time
- Objective measures of sedentary time

Comparison

Adults who participate in varying levels and types of sedentary behavior

Endpoint Health Outcomes

Incidence of:

- All-cause mortality

Key Definition:

Sedentary Behavior: In general, it is any waking behavior characterized by an energy expenditure ≤1.5 METs while in a sitting or reclining posture (Sedentary Behaviour Research Network. Standardized use of the terms "sedentary" and "sedentary behaviours." Appl Physiol Nutr Metab 2012;37:540-542).

Appendix B: Final Search Strategy[1]

Research Questions

Q1. What is the relationship between sedentary behavior and all-cause mortality?
Q2. What is the relationship between sedentary behavior and mortality from cardiovascular disease?
Q3. What is the relationship between sedentary behavior and mortality from cancer?

Search Strategy: PubMed Q1-3 (Systematic Reviews, Meta-Analyses, Pooled Analyses, and High-Quality Reports)

Database: PubMed; Date of Search: 12/5/2016; 164 results

Set	Search Terms
Limit: Language	(English[lang])
Limit: Exclude animal only	NOT ("Animals"[Mesh] NOT ("Animals"[Mesh] AND "Humans"[Mesh]))
Limit: Exclude child only	NOT (("infant"[Mesh] OR "child"[mesh] OR "adolescent"[mh]) NOT (("infant"[Mesh] OR "child"[mesh] OR "adolescent"[mh]) AND "adult"[Mesh]))
Limit: Publication Date Systematic Reviews/Meta-Analyses	AND ("2000/01/01"[PDAT] : "3000/12/31"[PDAT])
Limit: Publication Type Include Systematic Reviews/Meta-Analyses	AND (systematic[sb] OR meta-analysis[pt] OR “systematic review”[tiab] OR “systematic literature review”[tiab] OR metaanalysis[tiab] OR "meta analysis"[tiab] OR metanalyses[tiab] OR "meta analyses"[tiab] OR "pooled analysis"[tiab] OR “pooled analyses”[tiab] OR "pooled data"[tiab])
Limit: Publication Type Exclude Systematic Reviews/Meta-Analyses	NOT (“comment”[Publication Type] OR “editorial”[Publication Type])
Sedentary	AND (("Sedentary lifestyle"[mh] OR "Computer time"[tiab] OR "Computer use"[tiab] OR "Screen time"[tiab] OR "Sitting"[tiab] OR "Television"[tiab] OR "TV viewing"[tiab] OR "TV watching"[tiab] OR "Video game"[tiab] OR "Video gaming"[tiab]) OR (("Sedentary"[tiab] OR "Inactivity"[tiab] OR "Physically inactive"[tiab] OR "Sedentarism"[tiab]) NOT medline[sb]))
Mortality OR Cardiovascular Disease OR Cancer	AND (("Death"[mh] OR "Death"[tiab] OR "Dying"[tiab] OR Fatal*[tiab] OR Mortalit*[tiab] OR "Postmortem"[tiab] OR "Mortality"[mh] OR "Arteriosclerosis"[mh] OR "Death, sudden, cardiac"[mh] OR "Heart failure"[mh] OR "Myocardial ischemia"[mh] OR "myocardial infarction"[mh] OR "Stroke"[mh] OR "Subarachnoid hemorrhage"[mh] OR "Aortic Aneurysm, Thoracic"[mh] OR

[1] One search was conducted to answer Q1, Q2, and Q3.

Set	Search Terms
	"Intracranial hemorrhages"[mh] OR myocardial ischemia[mh]OR "neoplasms"[mh]) OR ((Arteriosclero*[tiab] OR Atherosclero*[tiab] OR "Cerebral infarction"[tiab] OR "Cerebrovascular diseases"[tiab] OR "Cerebrovascular disease"[tiab] OR "Coronary heart disease"[tiab] OR "Intracerebral Hemorrhage"[tiab] OR "Intracerebral Hemorrhages"[tiab] OR "Intracranial hemorrhage"[tiab] OR "Intracranial hemorrhages"[tiab] OR "ischemic"[tiab] OR "myocardial infarction"[tiab] OR "Stroke"[tiab] OR "Subarachnoid hemorrhages"[tiab] OR "Subarachnoid hemorrhage"[tiab] OR "Cancer"[tiab] OR "Neoplasm"[tiab] OR "Tumor"[tiab] OR "Carcinogenesis"[tiab] OR "Leukemia"[tiab] OR "Lymphoma"[tiab] OR "Malignan*"[tiab] OR "Blastoma"[tiab] OR "Tumour"[tiab] OR "Melanoma"[tiab] OR "Myeloma"[tiab] OR "Carcinoma"[tiab] OR "Neoplasia"[tiab] OR "Sarcoma"[tiab] OR "Tumors"[tiab] OR "Tumours"[tiab] OR "Neoplasms"[tiab] OR "Adenosarcoma"[tiab] OR "Angiosarcoma"[tiab] OR "Astrocytoma"[tiab] OR "Cholangiocarcinoma"[tiab] OR "Chondrosarcoma"[tiab] OR "Craniopharyngioma"[tiab] OR "Ependymoma"[tiab] OR "Fibrosarcoma"[tiab] OR "Glioma"[tiab] OR "Langerhans Cell Histiocytosis"[tiab] OR "Hodgkin's Disease"[tiab] OR "Leiomyosarcoma"[tiab] OR "Medulloblastoma"[tiab] OR "Mesothelioma"[tiab] OR "Neuroblastoma"[tiab] OR "Rhabdomyosarcoma"[tiab] OR "Osteosarcoma"[tiab]) NOT medline[sb]))

Search Strategy: CINAHL Q1-3 (Systematic Reviews, Meta-Analyses, Pooled Analyses, and High-Quality Reports)

Database: CINAHL; Date of Search: 12/1/2016; 4 unique results
Terms searched in title or abstract

Set	Search Terms
Sedentary	Title OR Abstract: ("Sedentary" OR "Sedentary lifestyle" OR "Inactivity" OR "Physically inactive" OR "Sedentarism" OR "Computer time" OR "Computer use" OR "Screen time" OR "Sitting" OR "Television" OR "TV viewing" OR "TV watching" OR "Video game" OR "Video gaming")
Mortality OR Cardiovascular Disease OR Cancer	AND Title OR Abstract: ("Death" OR "Dying" OR Fatal* OR Mortalit* OR "Postmortem" OR Arteriosclero* OR Atherosclero* OR "Cerebral infarction" OR "Cerebrovascular diseases" OR "Cerebrovascular disease" OR "Coronary heart disease" OR "Heart failure" OR "Intracerebral Hemorrhage" OR "Intracerebral Hemorrhages" OR "Intracranial hemorrhage" OR "Intracranial hemorrhages" OR "ischemic" OR "myocardial infarction" OR "Stroke" OR "Subarachnoid hemorrhages" OR "Subarachnoid hemorrhage" OR "Cancer" OR "Neoplasm" OR "Tumor" OR "Carcinogenesis" OR "Leukemia" OR "Lymphoma" OR "Malignan*" OR "Blastoma" OR "Tumour" OR "Melanoma" OR "Myeloma" OR "Carcinoma" OR "Neoplasia" OR "Sarcoma" OR "Tumors" OR "Tumours" OR "Neoplasms" OR "Adenosarcoma" OR "Angiosarcoma" OR "Astrocytoma" OR "Cholangiocarcinoma" OR "Chondrosarcoma" OR "Craniopharyngioma" OR "Ependymoma" OR "Fibrosarcoma" OR "Glioma" OR "Langerhans Cell Histiocytosis" OR "Hodgkin's Disease" OR "Leiomyosarcoma" OR "Medulloblastoma" OR "Mesothelioma" OR "Neuroblastoma" OR "Rhabdomyosarcoma" OR "Osteosarcoma")
Systematic Reviews and Meta-Analyses	AND (“systematic review” OR “systematic literature review” OR metaanalysis OR "meta analysis" OR metanalyses OR "meta analyses"" OR "pooled analysis"[tiab] OR “pooled analyses”[tiab] OR "pooled data"[tiab])
Limits	2000-present English language Peer reviewed Exclude Medline records Human

Search Strategy: Cochrane Q1-3 (Systematic Reviews, Meta-Analyses, Pooled Analyses, and High-Quality Reports)

Database: Cochrane; Date of Search: 12/5/16; 37 Results
Terms searched in title, abstract, or keywords

Set	Search Terms
Sedentary	Title, Abstract, Keywords: ("Sedentary" OR "Sedentary lifestyle" OR "Inactivity" OR "Physically inactive" OR "Sedentarism" OR "Computer time" OR "Computer use" OR "Screen time" OR "Sitting" OR "Television" OR "TV viewing" OR "TV watching" OR "Video game" OR "Video gaming")
Mortality OR Cardiovascular Disease OR Cancer	AND ("Death" OR "Dying" OR Fatal* OR Mortalit* OR "Postmortem" OR Arteriosclero* OR Atherosclero* OR "Cerebral infarction" OR "Cerebrovascular diseases" OR "Cerebrovascular disease" OR "Coronary heart disease" OR "Heart failure" OR "Intracerebral Hemorrhage" OR "Intracerebral Hemorrhages" OR "Intracranial hemorrhage" OR "Intracranial hemorrhages" OR "ischemic" OR "myocardial infarction" OR "Stroke" OR "Subarachnoid hemorrhages" OR "Subarachnoid hemorrhage" OR "Cancer" OR "Neoplasm" OR "Tumor" OR "Carcinogenesis" OR "Leukemia" OR "Lymphoma" OR "Malignan*" OR "Blastoma" OR "Tumour" OR "Melanoma" OR "Myeloma" OR "Carcinoma" OR "Neoplasia" OR "Sarcoma" OR "Tumors" OR "Tumours" OR "Neoplasms" OR "Adenosarcoma" OR "Angiosarcoma" OR "Astrocytoma" OR "Cholangiocarcinoma" OR "Chondrosarcoma" OR "Craniopharyngioma" OR "Ependymoma" OR "Fibrosarcoma" OR "Glioma" OR "Langerhans Cell Histiocytosis" OR "Hodgkin's Disease" OR "Leiomyosarcoma" OR "Medulloblastoma" OR "Mesothelioma" OR "Neuroblastoma" OR "Rhabdomyosarcoma" OR "Osteosarcoma")
Limits	2000-present Cochrane Reviews and Other Reviews Word variations not searched

Search Strategy: PubMed Q1-3 (Original Research)

Database: PubMed; Date of Search: 1/30/17; 953 results

Set	Search Terms
Limit: Language	(English[lang])
Limit: Exclude animal only	NOT ("Animals"[Mesh] NOT ("Animals"[Mesh] AND "Humans"[Mesh]))
Limit: Exclude child only	NOT (("infant"[Mesh] OR "child"[mesh] OR "adolescent"[mh]) NOT (("infant"[Mesh] OR "child"[mesh] OR "adolescent"[mh]) AND "adult"[Mesh]))
Limit: Exclude subheadings	NOT (ad[sh] OR aa[sh] OR ai[sh] OR ci[sh] OR cn[sh] OR dh[sh] OR de[sh] OR dt[sh] OR em[sh] OR en[sh] OR es[sh] OR eh[sh] OR ge[sh] OR hi[sh] OR is[sh] OR ip[sh] OR lj[sh] OR ma[sh] OR mi[sh] OR og[sh] OR ps[sh] OR py[sh] OR pk[sh] OR pd[sh] OR po[sh] OR re[sh] OR rt[sh] OR rh[sh] OR st[sh] OR sd[sh] OR tu[sh] OR th[sh] OR tm[sh] OR tr[sh] OR ut[sh] OR ve[sh] OR vi[sh])
Limit: Publication Date (Original)	AND ("2014/01/01"[PDAT] : "3000/12/31"[PDAT])
Limit: Publication Type Exclude (Original)	NOT (“comment”[Publication Type] OR “editorial”[Publication Type] OR “review”[Publication Type] OR systematic[sb] OR "meta-analysis"[publication type] OR “systematic review”[tiab] OR “systematic literature review”[tiab] OR metaanalysis[tiab] OR "meta analysis"[tiab] OR metanalyses[tiab] OR "meta analyses"[tiab] OR "pooled analysis"[tiab] OR “pooled analyses”[tiab] OR "pooled data"[tiab])
Sedentary	AND (("Sedentary lifestyle"[mh] OR "Computer time"[tiab] OR "Computer use"[tiab] OR "Screen time"[tiab] OR "Sitting"[tiab] OR "Television"[tiab] OR "TV viewing"[tiab] OR "TV watching"[tiab] OR "Video game"[tiab] OR "Video gaming"[tiab]) OR (("Sedentary"[tiab] OR "Inactivity"[tiab] OR "Physically inactive"[tiab] OR "Sedentarism"[tiab]) NOT medline[sb]))
Mortality OR Cardiovascular Disease OR Cancer	AND (("Death"[mh] OR "Death"[tiab] OR "Dying"[tiab] OR Fatal*[tiab] OR Mortalit*[tiab] OR "Postmortem"[tiab] OR "Mortality"[mh] OR "Arteriosclerosis"[mh] OR "Death, sudden, cardiac"[mh] OR "Heart failure"[mh] OR "Myocardial ischemia"[mh] OR "myocardial infarction"[mh] OR "Stroke"[mh] OR "Subarachnoid hemorrhage"[mh] OR "Aortic Aneurysm, Thoracic"[mh] OR "Intracranial hemorrhages"[mh] OR "neoplasms"[mh]) OR ((Arteriosclero*[tiab] OR Atherosclero*[tiab] OR "Cerebral infarction"[tiab] OR "Cerebrovascular diseases"[tiab] OR "Cerebrovascular disease"[tiab] OR "Coronary heart disease"[tiab] OR "Heart failure"[tiab] OR "Intracerebral Hemorrhage"[tiab] OR "Intracerebral Hemorrhages"[tiab] OR "Intracranial hemorrhage"[tiab] OR "Intracranial hemorrhages"[tiab] OR "ischemic"[tiab] OR "myocardial infarction"[tiab] OR "Stroke"[tiab] OR "Subarachnoid hemorrhages"[tiab] OR "Subarachnoid hemorrhage"[tiab] OR "Cancer"[tiab] OR "Neoplasm"[tiab] OR "Tumor"[tiab] OR "Carcinogenesis"[tiab] OR "Leukemia"[tiab] OR "Lymphoma"[tiab] OR "Malignan*"[tiab] OR "Blastoma"[tiab] OR "Tumour"[tiab] OR "Melanoma"[tiab] OR "Myeloma"[tiab] OR "Carcinoma"[tiab] OR "Neoplasia"[tiab] OR "Sarcoma"[tiab] OR "Tumors"[tiab] OR

Set	Search Terms
	"Tumours"[tiab] OR "Neoplasms"[tiab] OR "Adenosarcoma"[tiab] OR "Angiosarcoma"[tiab] OR "Astrocytoma"[tiab] OR "Cholangiocarcinoma"[tiab] OR "Chondrosarcoma"[tiab] OR "Craniopharyngioma"[tiab] OR "Ependymoma"[tiab] OR "Fibrosarcoma"[tiab] OR "Glioma"[tiab] OR "Langerhans Cell Histiocytosis"[tiab] OR "Hodgkin's Disease"[tiab] OR "Leiomyosarcoma"[tiab] OR "Medulloblastoma"[tiab] OR "Mesothelioma"[tiab] OR "Neuroblastoma"[tiab] OR "Rhabdomyosarcoma"[tiab] OR "Osteosarcoma"[tiab]) NOT medline[sb]))

Search Strategy: CINAHL Q1-3 (Original Research)

Database: CINAHL; Date of Search: 1/27/17; 49 results
Terms searched in title or abstract

Set	Search Terms
Sedentary	Title and Abstract: ("Sedentary" OR "Sedentary lifestyle" OR "Inactivity" OR "Physically inactive" OR "Sedentarism" OR "Computer time" OR "Computer use" OR "Screen time" OR "Sitting" OR "Television" OR "TV viewing" OR "TV watching" OR "Video game" OR "Video gaming")
Mortality OR Cardiovascular Disease OR Cancer	AND ("Death" OR "Dying" OR Fatal* OR Mortalit* OR "Postmortem" OR Arteriosclero* OR Atherosclero* OR "Cerebral infarction" OR "Cerebrovascular diseases" OR "Cerebrovascular disease" OR "Coronary heart disease" OR "Heart failure" OR "Intracerebral Hemorrhage" OR "Intracerebral Hemorrhages" OR "Intracranial hemorrhage" OR "Intracranial hemorrhages" OR "ischemic" OR "myocardial infarction" OR "Stroke" OR "Subarachnoid hemorrhages" OR "Subarachnoid hemorrhage" OR "Cancer" OR "Neoplasm" OR "Tumor" OR "Carcinogenesis" OR "Leukemia" OR "Lymphoma" OR "Malignan*" OR "Blastoma" OR "Tumour" OR "Melanoma" OR "Myeloma" OR "Carcinoma" OR "Neoplasia" OR "Sarcoma" OR "Tumors" OR "Tumours" OR "Neoplasms" OR "Adenosarcoma" OR "Angiosarcoma" OR "Astrocytoma" OR "Cholangiocarcinoma" OR "Chondrosarcoma" OR "Craniopharyngioma" OR "Ependymoma" OR "Fibrosarcoma" OR "Glioma" OR "Langerhans Cell Histiocytosis" OR "Hodgkin's Disease" OR "Leiomyosarcoma" OR "Medulloblastoma" OR "Mesothelioma" OR "Neuroblastoma" OR "Rhabdomyosarcoma" OR "Osteosarcoma")
Original Research	NOT (“systematic review” OR “systematic literature review” OR metaanalysis OR "meta analysis" OR metanalyses OR "meta analyses" OR "pooled analysis" OR “pooled analyses” OR "pooled data")
Limits	Title or abstract 2014-present English language Peer reviewed Exclude Medline records Human

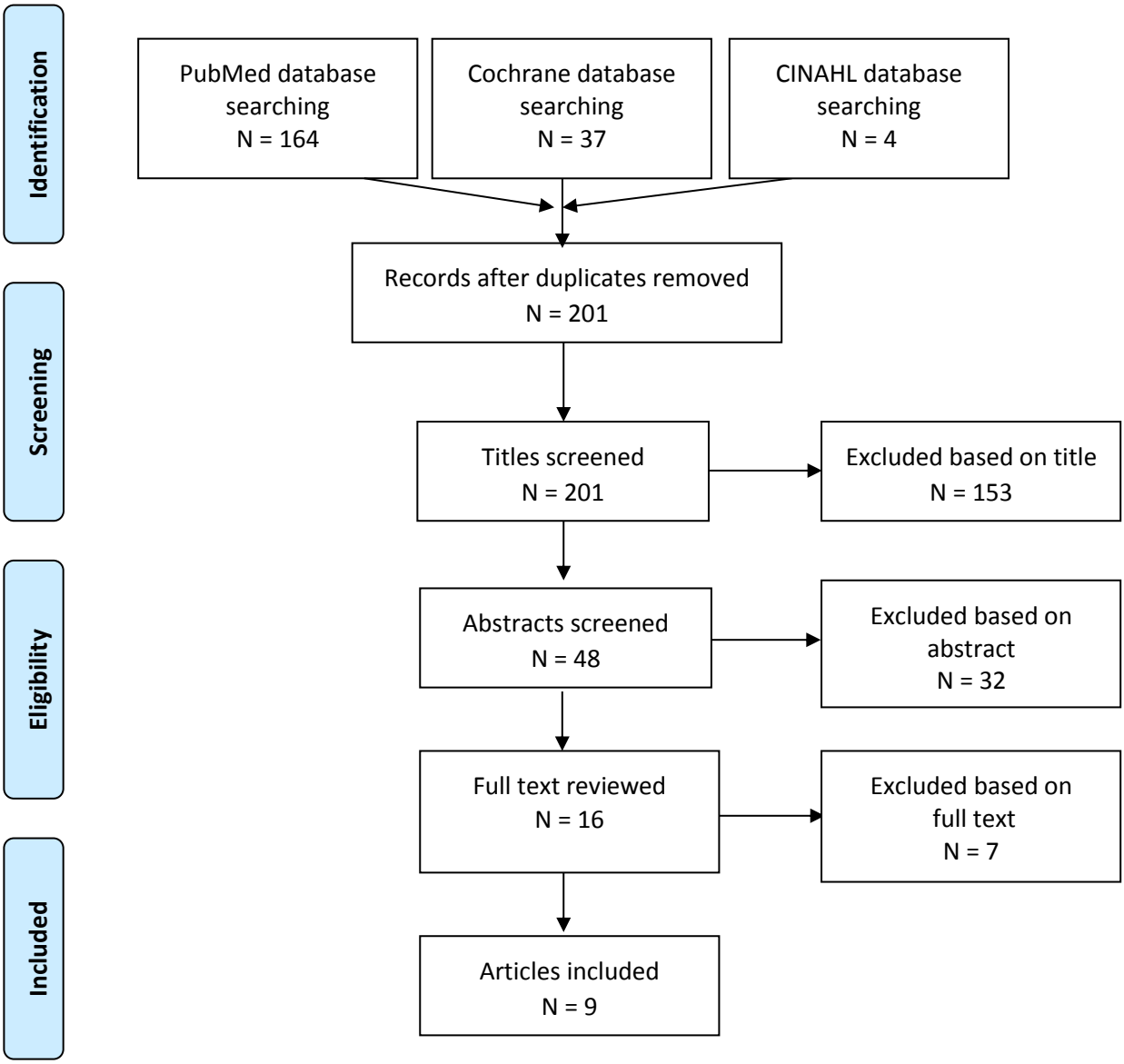
Search Strategy: Cochrane Q1-3 (Original Research)

Database: Cochrane; Date of Search: 1/27/17; 325 Results
Terms searched in title, abstract, or keywords

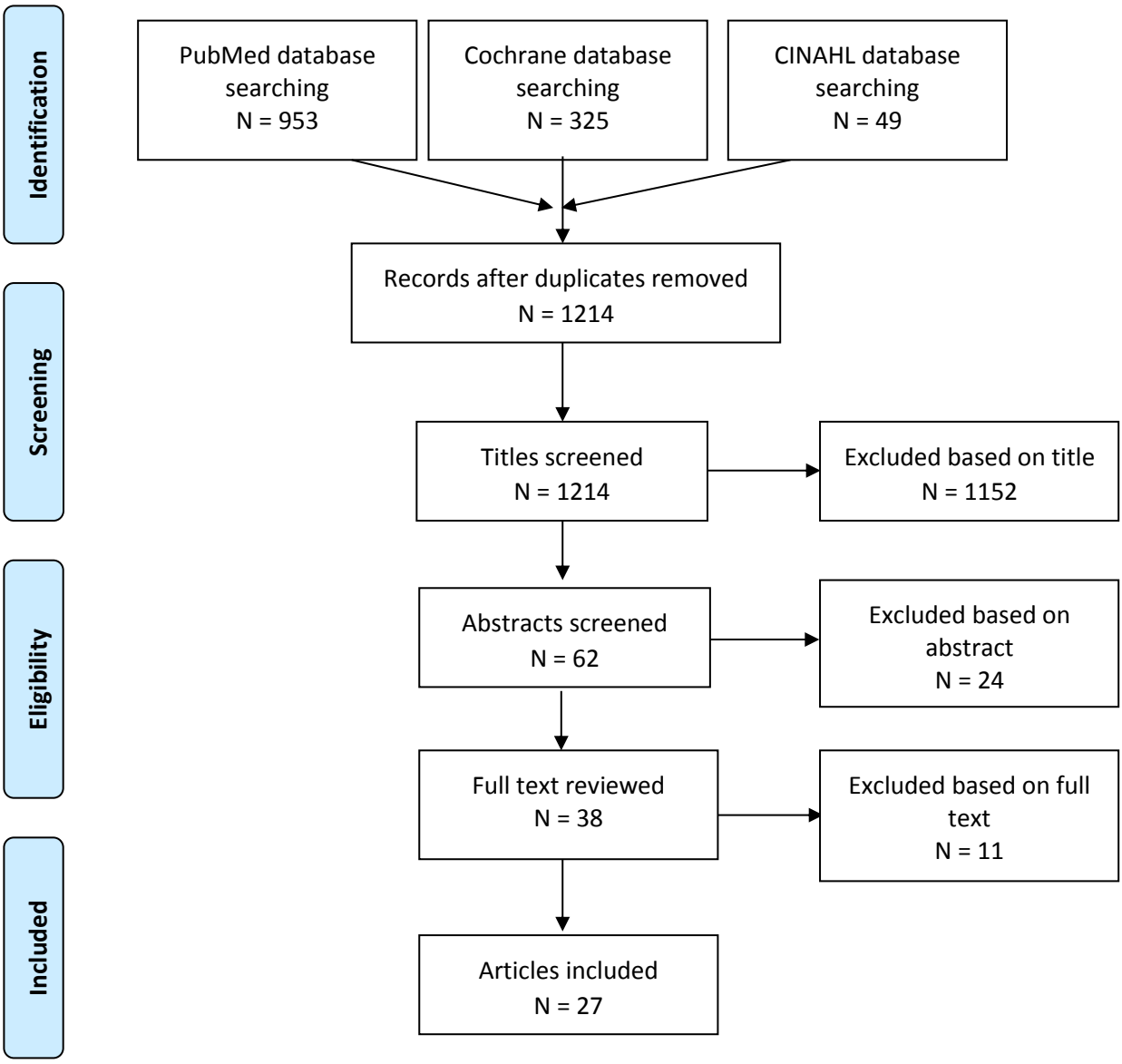
Set	Search Terms
Sedentary	Title, Abstract, Keywords: ("Sedentary" OR "Sedentary lifestyle" OR "Inactivity" OR "Physically inactive" OR "Sedentarism" OR "Computer time" OR "Computer use" OR "Screen time" OR "Sitting" OR "Television" OR "TV viewing" OR "TV watching" OR "Video game" OR "Video gaming")
Mortality OR Cardiovascular Disease OR Cancer	AND ("Death" OR "Dying" OR Fatal* OR Mortalit* OR "Postmortem" OR Arteriosclero* OR Atherosclero* OR "Cerebral infarction" OR "Cerebrovascular diseases" OR "Cerebrovascular disease" OR "Coronary heart disease" OR "Heart failure" OR "Intracerebral Hemorrhage" OR "Intracerebral Hemorrhages" OR "Intracranial hemorrhage" OR "Intracranial hemorrhages" OR "ischemic" OR "myocardial infarction" OR "Stroke" OR "Subarachnoid hemorrhages" OR "Subarachnoid hemorrhage" OR "Cancer" OR "Neoplasm" OR "Tumor" OR "Carcinogenesis" OR "Leukemia" OR "Lymphoma" OR "Malignan*" OR "Blastoma" OR "Tumour" OR "Melanoma" OR "Myeloma" OR "Carcinoma" OR "Neoplasia" OR "Sarcoma" OR "Tumors" OR "Tumours" OR "Neoplasms" OR "Adenosarcoma" OR "Angiosarcoma" OR "Astrocytoma" OR "Cholangiocarcinoma" OR "Chondrosarcoma" OR "Craniopharyngioma" OR "Ependymoma" OR "Fibrosarcoma" OR "Glioma" OR "Langerhans Cell Histiocytosis" OR "Hodgkin's Disease" OR "Leiomyosarcoma" OR "Medulloblastoma" OR "Mesothelioma" OR "Neuroblastoma" OR "Rhabdomyosarcoma" OR "Osteosarcoma")
Limits	2014-present Word variations not searched Trials

Appendix C: Literature Tree

Existing Systematic Reviews, Meta-Analyses, Pooled Analyses, and Reports Literature Tree



Original Research Literature Tree



Appendix D: Inclusion/Exclusion Criteria

Sedentary Subcommittee

Q1. What is the relationship between sedentary behavior and all-cause mortality?

a. Is there a dose-response relationship? If yes, what is the shape of the relationship?
b. Does the relationship vary by age, sex, race/ethnicity, or socio-economic status?
c. Is the relationship independent of levels of light, moderate, or vigorous physical activity?
d. Is there evidence that bouts or breaks in sedentary behavior change the relationship between sedentary behavior and all-cause mortality?

Category	Inclusion/Exclusion Criteria	Notes/Rationale
Publication Language	**Include:** • Studies published with full text in English	
Publication Status	**Include:** • Studies published in peer-reviewed journals • Reports determined to have appropriate suitability and quality by PAGAC **Exclude:** • Grey literature, including unpublished data, manuscripts, abstracts, conference proceedings	
Research Type	**Include:** • Original research • Meta-analyses • Systematic reviews • Reports determined to have appropriate suitability and quality by PAGAC	
Study Subjects	**Include:** • Human subjects	
Age of Study Subjects	**Include:** • Adults ages 18 and older	Sedentary behavior in youth will be address by youth subcommittee
Health Status of Study Subjects	**Exclude:** • Nonambulatory adults • Hospitalized patients	
Date of Publication	**Include:** • Original research, systematic reviews, and meta-analyses published from 2000 to 2016	
Study Design	**Include:** • Prospective cohort studies • Systematic reviews • Meta-analyses • Reports determined to have appropriate suitability and quality by PAGAC **Exclude:** • Randomized controlled trials	

	• Non-randomized controlled trials • Retrospective cohort studies • Case-control studies • Narrative reviews • Commentaries • Editorials • Cross-sectional studies • Before-and-after studies	
Exposure	**Include studies in which the exposure is:** • All types of sedentary behavior **Exclude:** • Studies that use sedentary behavior solely as a confounding variable	
Outcome	**Include studies in which the outcome is:** • All-cause mortality	

Appendix E: Rationale for Exclusion at Abstract or Full-Text Triage for Existing Systematic Reviews, Meta-Analyses, Pooled Analyses, and Reports

The table below lists the excluded articles with at least one reason for exclusion, but may not reflect all possible reasons.

Citation	Outcome	Study Design	Exposure	Not ideal fit for replacement of de novo search
Biddle SJ, Bennie JA, Bauman AE, et al. Too much sitting and all-cause mortality: is there a causal link? *BMC Public Health*. 2016;16:635. doi:10.1186/s12889-016-3307-3.	X			
Boyle T, Fritschi L,Kobayashi LC, et al. Sedentary work and the risk of breast cancer in premenopausal and postmenopausal women: a pooled analysis of two case-control studies. *Occup Environ Med*. 2016;73(11):735-741. doi:10.1136/oemed-2015-103537.	X			
Brenner DR. Cancer incidence due to excess body weight and leisure-time physical inactivity in Canada: implications for prevention. *Prev Med*. 2014;66:131-139. doi:10.1016/j.ypmed.2014.06.018.	X			
Buckley JP, Hedge A, Yates T, et al. The sedentary office: an expert statement on the growing case for change towards better health and productivity. *Br J Sports Med.* 2015;49:1357-1362. doi:10.1136/bjsports-2015-094618.	X			
Cannioto RA, LaMonte MJ, Kelemen LE, et al. Recreational physical inactivity and mortality in women with invasive epithelial ovarian cancer: evidence from the Ovarian Cancer Association Consortium. *Br J Cancer.* 2016;115(1):95-101. doi:10.1038/bjc.2016.153.			X	
Charansonney OL, Despres JP. Disease prevention--should we target obesity or sedentary lifestyle? *Nat Rev Cardiol*. 2010;7(8):468-472. doi:10.1038/nrcardio.2010.68.		X		
Cong YJ, Gan Y, Sun HL, et al. Association of sedentary behaviour with colon and rectal cancer: a meta-analysis of observational studies. *Br J Cancer*. 2014;110:817-826. doi:10.1038/bjc.2013.709.	X			
de Rezende LF, Rodrigues Lopes M, Rey-Lopez JP, Matsudo VK, Luiz Odo C. Sedentary behavior and health outcomes: an overview of systematic reviews. *PLoS One*. 2014;9:e105620. doi:10.1371/journal.pone.0105620.		X		
Dempsey PC, Owen N, Biddle SJ, Dunstan DW. Managing sedentary behavior to reduce the risk of diabetes and cardiovascular disease. *Curr Diab Rep*. 2014;14(9):522. doi:10.1007/s11892-014-0522-0.	X	X		
English C, Manns PJ, Tucak C, Bernhardt J. Physical activity and sedentary behaviors in people with stroke living in the community: a systematic review. *Phys Ther.* 2014;94(2):185-196. doi:10.2522/ptj.20130175.	X			
Haney EM, Huffman LH, Bougatsos C, et al. *U.S. Preventive Services Task Force Evidence Syntheses, formerly Systematic Evidence Reviews.* Screening for lipid disorders in children and adolescents. 2007;Jul(Report No. 07-0598).	X			
Henson J, Dunstan DW, Davies MJ, Yates T. Sedentary behaviour as a new behavioural target in the prevention and treatment of type 2 diabetes. *Diabetes Metab Res Rev*. 2016;32(suppl 1):213-220. doi:10.1002/dmrr.2759.		X		
Hughes J, Kee F, O'Flaherty M, et al. Modelling coronary heart disease mortality in Northern Ireland between 1987 and 2007:		X		

Citation	Outcome	Study Design	Exposure	Not ideal fit for replacement of de novo search
broader lessons for prevention. *Eur J Prev Cardiol*. 2013;20(2):310-321. doi:10.1177/2047487312441725.				
Jaworski CA. Latest clinical research published by ACSM. *Curr Sports Med Rep.* 2015;14(1):351-352. doi:10.1249/JSR.0b013e3182750106.		X		
Katzmarzyk PT, Lee IM. Sedentary behaviour and life expectancy in the USA: a cause-deleted life table analysis. *BMJ Open.* 2012;2e000828. doi:10.1136/bmjopen-2012-000828.	X			
Keum N, Cao Y, Oh H, et al. Sedentary behaviors and light-intensity activities in relation to colorectal cancer risk. *Int J Cancer*. 2016;138(9):2109-2117. doi:10.1002/ijc.29953.	X			
Lin JS, Eder M, Weinmann S, et al. *U.S. Preventive Services Task Force Evidence Syntheses, formerly Systematic Evidence Reviews.* Behavioral counseling to prevent skin cancer: systematic evidence review to update the 2003 U.S. Preventive Services Task Force Recommendation. 2011;82(Report No.11-05152-EF-1).	X			
Lynch BM. Sedentary behavior and cancer: a systematic review of the literature and proposed biological mechanisms. *Cancer Epidemiol Biomarkers Prev*. 2010;19(11):2691-2709. doi:10.1158/1055-9965.EPI-10-0815.	X			
Milton K, Macniven R, Bauman A. Review of the epidemiological evidence for physical activity and health from low- and middle-income countries. *Glob Public Health.* 2014;9(4):369-381. doi:10.1080/17441692.2014.894548.			X	
Molmenti CL, Hibler EA, Ashbeck EL, et al. Sedentary behavior is associated with colorectal adenoma recurrence in men. *Cancer Causes Control*. 2014;25(10):1387-1395. doi:10.1007/s10552-014-0444-9.	X			
Moore SC, Gierach GL, Schatzkin A, Matthews CE. Physical activity, sedentary behaviours, and the prevention of endometrial cancer. *Br J Cancer*. 2010;103(7):933-938. doi:10.1038/sj.bjc.6605902.	X			
Nelson SH, Marinac CR, Patterson RE, et al. Impact of very low physical activity, BMI, and comorbidities on mortality among breast cancer survivors. *Breast Cancer Res Treat*. 2016;155(3):551-557. doi:10.1007/s10549-016-3694-2.		X		
Oczkowski W. Complexity of the relation between physical activity and stroke: a meta-analysis. *Clin J Sport Med*. 2005;15(5):399.	X			
Pandey A, Salahuddin U, Garg S, et al. Continuous dose-response association between sedentary time and risk for cardiovascular disease: a meta-analysis. *JAMA Cardiol*. 2016;1(5):575-583. doi:10.1001/jamacardio.2016.1567.				X
Park S, Kim Y, Shin HR, et al. Population-attributable causes of cancer in Korea: obesity and physical inactivity. *PLoS One*. 2014;9(7):e90871. doi:10.1371/journal.pone.0090871.	X			
Pizot C, Boniol M, Mullie P, et al. Physical activity, hormone replacement therapy and breast cancer risk: a meta-analysis of prospective studies. *Eur J Cancer*. 2016;52:138-154. doi:10.1016/j.ejca.2015.10.063.	X			
Rezende LF, Sa TH, Mielke GI, Viscondi JY, Rey-Lopez JP, Garcia LM. All-cause mortality attributable to sitting time: analysis of 54 countries worldwide. *Am J Prev Med*. 2016;51(2):253-263. doi:10.1016/j.amepre.2016.01.022.				X

Citation	Outcome	Study Design	Exposure	Not ideal fit for replacement of de novo search
Schmid D, Leitzmann MF. Television viewing and time spent sedentary in relation to cancer risk: a meta-analysis. *J Natl Cancer Inst*. 2014;106(7). pii: dju098. doi:10.1093/jnci/dju098.	X			
Shen D, Mao W, Liu T, et al. Sedentary behavior and incident cancer: a meta-analysis of prospective studies. *PLoS One.* 2014;9(8):e105709. doi:10.1371/journal.pone.0105709.	X			
Sluik D, Buijsse B, Muckelbauer R, et al. Physical activity and mortality in individuals with diabetes mellitus: a prospective study and meta-analysis. *Arch Intern Med*. 2012;172(17):1285-1295. doi:10.1001/archinternmed.2012.3130.			X	
Solomon TP, Thyfault JP. Type 2 diabetes sits in a chair. *Diabetes Obes Metab.* 2013;15(11): 987-992. doi:10.1111/dom.12105.		X		
Stamatakis E, Chau JY, Pedisic Z, et al. Are sitting occupations associated with increased all-cause, cancer, and cardiovascular disease mortality risk? A pooled analysis of seven British population cohorts. *PLoS One*. 2013;8(9):e73753. doi:10.1371/journal.pone.0073753.		X		
Tarraga Lopez PJ, Albero JS, Rodriguez-Montes JA. Primary and secondary prevention of colorectal cancer. *Clin Med Insights Gastroenterol*. 2014;7:33-46. doi:10.4137/CGast.S14039.			X	
van Uffelen JG, Wong J, Chau JY, et al. Occupational sitting and health risks: a systematic review. *Am J Prev Med.* 2010;39(4):379-388. doi:10.1016/j.amepre.2010.05.024.			X	
Vancampfort D, Firth J, Schuch F, et al. Physical activity and sedentary behavior in people with bipolar disorder: a systematic review and meta-analysis. *J Affect Disord*. 2016;201:145-152. doi:10.1016/j.jad.2016.05.020.	X			
Wahid A, Manek N, Nichols M, et al. Quantifying the association between physical activity and cardiovascular disease and diabetes: a systematic review and meta-analysis. *J Am Heart Assoc*. 2016;5(9). pii: e002495. doi:10.1161/JAHA.115.002495.			X	
Wilson LF, Page AN, Dunn NA, Pandeya N, Protani MM, Taylor RJ. Population attributable risk of modifiable risk factors associated with invasive breast cancer in women aged 45-69 years in Queensland, Australia. *Maturitas*. 2013;76(4):370-376. doi:10.1016/j.maturitas.2013.09.002.	X			
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Zhou Y, Zhao H, Peng C. Association of sedentary behavior with the risk of breast cancer in women: update meta-analysis of observational studies. *Ann Epidemiol.* 2015;25(9):687-697. doi:10.1016/j.annepidem.2015.05.007.	X			

Rationale for Exclusion at Abstract and/or Full-Text Triage for Original Research

The table below lists the excluded articles with at least one reason for exclusion, but may not reflect all possible reasons.

Citation	Outcome	Study Design	Exposure
Beddhu S, Wei G, Marcus RL, Chonchol M, Greene T. Light-intensity physical activities and mortality in the United States general population and CKD subpopulation. *Clin J Am Soc Nephrol*. 2015;10(7):1145-1153. doi:10.2215/CJN.08410814.		X	
Behrend SW. Television viewing and time spent sedentary in relation to cancer risk. *Oncol Nurs Forum*. 2014;41(6):695-696. doi:10.1188/14.ONF.695-696.	X		
Bjork Petersen C, Bauman A, Gronbaek M, Wulff Helge J, Thygesen LC, Tolstrup JS. Total sitting time and risk of myocardial infarction, coronary heart disease and all-cause mortality in a prospective cohort of Danish adults. *Int J Behav Nutr Phys Act*. 2014;11:13. doi:10.1186/1479-5868-11-13.	X		
Bol O, Cebicci H, Koyuncu S, Şarlı B, Günay N. A hidden household danger: television. *Ulus Travma Acil Cerrahi Derg.* 2016;22(3):265-268. doi:10.5505/tjtes.2015.42078.			X
Borodulin K, Karki A, Laatikainen T, Peltonen M, Luoto R. Daily sedentary time and risk of cardiovascular disease: the National FINRISK 2002 Study. *J Phys Act Health*. 2015;12(7):904-908. doi:10.1123/jpah.2013-0364.	X		
Borrell LN. The effects of smoking and physical inactivity on advancing mortality in U.S. adults. *Ann Epidemiol*. 2014;24(6):484-487. doi:10.1016/j.annepidem.2014.02.016.			X
Brown JC, Harhay MO, Harhay MN. Physical activity, diet quality, and mortality among community-dwelling prefrail and frail older adults. *J Nutr Gerontol Geriatr.* 2016;35(4):253-266.	X		
Brown JC, Harhay MO, Harhay MN. Physical activity, diet quality, and mortality among sarcopenic older adults. *Aging Clin Exp Res*. 2017;29(2):257-263. doi:10.1007/s40520-016-0559-9.	X		
Chau JY, Grunseit A, Midthjell K, et al. Sedentary behaviour and risk of mortality from all-causes and cardiometabolic diseases in adults: evidence from the HUNT3 population cohort. *Br J Sports Med*. 2015;49(11):737-742.	X		
Converse LJ. Sitting with death. *Am J Nurs*. 2016;116(12):72.		X	
Coombs N, Stamataki E, Lee IM. Physical inactivity among older adults: implications for life expectancy among non-overweight and overweight or obese individuals. *Obes Res Clin Pract*. 2015;9(2):175-179. doi:10.1016/j.orcp.2014.11.004.			X
de Rezende LF, Rabacow FM, Viscondi JY, Luiz Odo C, Matsudo VK, Lee IM. Effect of physical inactivity on major noncommunicable diseases and life expectancy in Brazil. *J Phys Act Health*. 2015;12(3):299-306. doi:10.1123/jpah.2013-0241.			X
Eijsvogels TM, George KP, Thompson PD. Cardiovascular benefits and risks across the physical activity continuum. *Curr Opin Cardiol.* 2016;31(5):566-571. doi:10.1097/HCO.0000000000000321.		X	
Everson-Hock ES, Green MA, Goyder EC, et al. Reducing the impact of physical inactivity: evidence to support the case for targeting people with chronic mental and physical conditions. *J Public Health (Oxf).* 2016;38(2):343-351. doi:10.1093/pubmed/fdv036.	X		X

Citation	Outcome	Study Design	Exposure
Fassier P, Zelek L, Partula V, et al. Variations of physical activity and sedentary behavior between before and after cancer diagnosis: results from the prospective population-based NutriNet-Sante cohort. *Medicine (Baltimore).* 2016;95(40):e4629.	X		
Fazel-Tabar Malekshah A, Zaroudi M, Etemadi A, et al. The combined effects of healthy lifestyle behaviors on all-cause mortality: the Golestan Cohort Study. *Arch Iran Med.* 2016;19(11):752-761.			X
Fox KR, Ku PW, Hillsdon M, et al. Objectively assessed physical activity and lower limb function and prospective associations with mortality and newly diagnosed disease in UK older adults: an OPAL four-year follow-up study. *Aging*. 2015;44(2):261-268. doi:10.1093/ageing/afu168.			X
Grace MS, Lynch BM, Dillon F, Barr EM, Owen N, Dunstan DW. Joint associations of smoking and television viewing time on cancer and cardiovascular disease mortality. *Int J Cancer*. 2017;140(7):1538-1544. doi:10.1002/ijc.30580.	X		
Hayashi R, Iso H, Cui R, Tamakoshi A; JACC Study Group. Occupational physical activity in relation to risk of cardiovascular mortality: the Japan Collaborative Cohort Study for Evaluation for Cancer Risk (JACC Study). *Prev Med.* 2016;89:286-291. doi:10.1016/j.ypmed.2016.06.008.			X
Holme I, Anderssen SA. Increases in physical activity is as important as smoking cessation for reduction in total mortality in elderly men: 12 years of follow-up of the Oslo II study. *Br J Sports Med.* 2015;49(11):743-748. doi:10.1136/bjsports-2014-094522.			X
Holme I, Tonstad S. Increased predictive ability of BMI but not other risk factors with time in men: 39-year follow-up of total mortality in the Oslo Study. *Obes Facts.* 2014;7(5):311-321. doi:10.1159/000368567.			X
Holtermann A, Mork PJ, Nilsen TI. Hours lying down per day and mortality from all-causes and cardiovascular disease: the HUNT Study, Norway. *Eur J Epidemiol.* 2014;29(8):559-565. doi:10.1007/s10654-014-9939-7.			X
Ikehara S, Iso H, Wada Y; JACC Study Group. Television viewing time and mortality from stroke and coronary artery disease among Japanese men and women—the Japan Collaborative Cohort Study. *Circ J.* 2015;79(11):2389-2395. doi:10.1253/circj.CJ-14-1335.	X		
Klenk J, Dallmeier D, Denkinger MD, Rapp K, Koenig W, Rothenbacher D; ActiFE Study Group. Objectively measured walking duration and sedentary behaviour and four-year mortality in older people. *PLoS One*. 2016;11(4):e0153779. doi:10.1371/journal.pone.0153779.	X		
Llamas-Velasco S, Villarejo-Galende A, Contador I, Pablos DL, Hernández-Gallego J, Bermejo-Pareja F. Physical activity and long-term mortality risk in older adults: a prospective population based study (NEDICES). *Prev Med Rep*. 2016;4:546-550. doi:10.1016/j.pmedr.2016.10.002.			X
Loprinzi PD, Edwards MK, Sng E, Addoh O. Sedentary behavior and residual-specific mortality. *Health Promot Perspect*. 2016;6(4):196-201. doi:10.15171/hpp.2016.32.	X		
Menotti A, Puddu PE, Lanti M, Maiani G, Catasta G, Fidanza AA. Lifestyle habits and mortality from all and specific causes of			X

Citation	Outcome	Study Design	Exposure
death: 40-year follow-up in the Italian Rural Areas of the Seven Countries Study. *J Nutr Health Aging.* 2014;18(3):314-321. doi:10.1007/s12603-013-0392-1.			
Nandi A, Glymour MM, Subramanian SV. Association among socioeconomic status, health behaviors, and all-cause mortality in the United States. *Epidemiology*. 2014;25(2):170-177. doi:10.1097/EDE.0000000000000038.			X
Papandreou C, Tuomilehto H. Coronary heart disease mortality in relation to dietary, lifestyle and biochemical risk factors in the countries of the Seven Countries Study: a secondary dataset analysis. *J Hum Nutr Diet*. 2014;27(2):168-175. doi:10.1111/jhn.12187.		X	
Pavey TG, Peeters GG, Brown WJ. Sitting-time and 9-year all-cause mortality in older women. *Br J Sports Med*. 2015;49(2):95-99. doi: 10.1136/bjsports-2012-091676.	X		
Shaw BA, Agahi N. Smoking and physical inactivity patterns during midlife as predictors of all-cause mortality and disability: a 39-year prospective study. *Eur J Ageing*. 2014;11(3):195-204.			X
Stenholm S, Head J, Kivimaki M, et al. Smoking, physical inactivity and obesity as predictors of healthy and disease-free life expectancy between ages 50 and 75: a multicohort study. *Int J Epidemiol*. 2016;45(4):1260-1270.	X		X
Xiao Q, Keadle SK, Hollenbeck AR, Matthews CE. Sleep duration and total and cause-specific mortality in a large US cohort: interrelationships with physical activity, sedentary behavior, and body mass index. *Am J Epidemiol*. 2014;180(10):997-1006. doi:10.1093/aje/kwu222.			X
Xu G, Sui X, Liu S, et al. Effects of insufficient physical activity on mortality and life expectancy in Jiangxi province of China, 2007-2010. *PLoS One*. 2014;9(10):e109826. doi:10.1371/journal.pone.0109826.			X

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mortality, and hospitalization in adults: A systematic review and meta-analysis. *Ann Intern Med*. 2015;162(2):123-132.

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