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Research Article

Independent Associations Between Sedentary Behaviors and Mental, Cognitive, Physical, and Functional Health Among Older Adults in Retirement Communities

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Abstract

Background. We examined the relationships between objective and self-reported sedentary time and health indicators among older adults residing in retirement communities.

Methods. Our cross-sectional analysis used data from 307 participants who completed baseline measurements of a physical activity trial in 11 retirement communities in San Diego County. Sedentary time was objectively measured with devices (accelerometers) and using self-reports. Outcomes assessed included emotional and cognitive health, physical function, and physical health (eg, blood pressure). Linear mixed-effects models examined associations between sedentary behavior and outcomes adjusting for demographics and accelerometer physical activity.

Results. Higher device-measured sedentary time was associated with worse objective physical function (Short Physical Performance Battery, balance task scores, 400-m walk time, chair stand time, gait speed), self-reported physical function, and fear of falling but with less sleep disturbance (all ps < .05). TV viewing was positively related to 400-m walk time ($p < .05$). Self-reported sedentary behavior was related to better performance on one cognitive task (trails A; $p < .05$).

Conclusions. Sedentary time was mostly related to poorer physical function independently of moderate-to-vigorous physical activity and may be a modifiable behavior target in interventions aiming to improve physical function in older adults. Few associations were observed with self-reported sedentary behavior measures.

Key Words: Exercise—Sleep—Cognition—Falls and mobility problems—Oldest-old—Retirement—Well-being

Sedentary behavior refers to any waking activity characterized by low energy expenditure (<1.5 metabolic equivalents) and a sitting or reclining posture (1). Sedentary behavior is linked to a higher risk of cardiovascular disease, metabolic syndrome, obesity, and other negative health outcomes, independent of physical activity levels, among older adults (2,3). Accelerometer data indicate that older adults in the United States spend well over 8 hours per day sedentary with some studies showing average sedentary time at over 9.5 hours per day (2,4).

There are two key limitations to our current understanding of the health effects of sedentary time. One limitation is that research has focused on disease outcomes (3). Little is known about the associations of sedentary time with variables that are important for successful aging including mental, cognitive, functional, and physical health indicators. The other limitation is that the majority of studies rely on self-reported measures of sedentary behavior (3). A recent review suggested that more research to understand the health correlates of objectively measured sedentary behavior is imperative among older populations in order to build an evidence base that can support future interventions for reducing older adult sedentary behavior (3).

Regarding mental and cognitive health, self-reported sedentary behaviors (eg, total sitting time or TV time) have been related to greater depression in older adults in cross-sectional (5,6) and prospective studies (7). Relationships with quality of life are mixed (8–10). Cognitive function has been related detrimentally to TV viewing and sitting time (5,11).

In regard to physical health, physical function has more consistently been related to objective and self-reported sedentary time in older adults (12–14). Studies have yielded conflicting findings on whether blood pressure is related to sedentary behavior in older adults (3). Few known studies have examined the relationships between sedentary behavior and patient-reported outcomes such as sleep quality, pain, fear of falling, and stress in older adulthood. In adults, several studies have indicated that screen time may adversely affect sleep quality (15).

A major limitation of previous studies is that self-reported sitting time is difficult for older adults to recall (16). In addition, studies have not examined the oldest age groups. No known studies have examined the relationships between device-measured sedentary time and mental, physical, functional, and cognitive health among the oldest old nor contrasted these relationships to associations with self-reported television viewing and sedentary behavior. Finally, most studies in older adults focus on healthier, community-dwelling older adults. Thus, the primary aim of our study was to examine, among very old adults living in continuing care retirement communities, whether device-based and self-reported measures of sedentary time are related to mental, cognitive, functional, and physical health.

Methods

Participants

Participants (*N* = 307) were older adults living in 11 continuing care retirement communities in San Diego County who completed a baseline measurement as part of a randomized controlled trial (Multilevel Intervention for Physical Activity in Retirement Communities (17). Details of the trial can be found elsewhere (17). The study was approved by the University of California, San Diego Institutional Review Board. Eligibility criteria included: age 65 years and above; ability to speak and read English; ability to complete written assessments; no history of falls within the past 12 months that resulted in hospitalization; ability to walk 20 m without human assistance; completion of the Timed Up & Go Test in less than 30 seconds; ability to read survey questions; and completion of a post-consent comprehension test.

Procedures

Baseline measurements occurred on-site at the retirement communities by trained research staff. After informed consent was obtained, participants completed a survey and were given accelerometers to wear. Participants wore the accelerometer device on a belt over the suprailiac crest of their right hip for 6 days. They were asked to remove the device when sleeping, showering, or swimming. Participants then attended another on-site measurement visit where they returned their accelerometer device and completed objective measures of physical and cognitive function.

Measures

Self-reported sedentary behavior was assessed using a modified version of the Sedentary Behavior Questionnaire (18). Participants reported time spent during a typical weekday and weekend day in nine sedentary behaviors including sitting/lying while watching television/DVDs, computer/internet use, reading, talking, in a car or bus, doing hobbies, doing group activities, napping, and other activities. Participants responded to each item by selecting one of 11 response categories, ranging from "None" to "More than 8 hours." The midpoint of each time category (eg, 2.5 hours if the category was 2–3 hours) was used as the time spent sedentary for each item. Total weekday and weekend sedentary behavior was calculated as the sum of all items. Daily time spent watching television and total sedentary behavior was multiplied by 5 (for weekday estimates) and 2 (for weekend estimates). The weekly estimates were then divided by 7 to obtain average daily estimates. For 5 participants, total daily self-reported sedentary behaviors added up to more than 24 hours because categories of sedentary behavior were not mutually exclusive (eg, people can use a computer while watching TV).

Device-measured sedentary time and moderate-to-vigorous physical activity were measured with the ActiGraph GT3X+ accelerometer (ActiGraph, LLC; Pensacola, FL). The GT3X+ is a lightweight, triaxial solid-state accelerometer. The ActiGraph device has been validated and calibrated to measure physical activity and sedentary behavior (19) in samples of older adults (4). The device was set to sample at 30 Hz with the low frequency extension enabled. Device data were processed using ActiLife software v6.3. Standard procedures identified nonwear time as periods of ≥90 consecutive minutes of zero counts (indicating no lateral movement), with a 2-minute tolerance allowing for artifactual movement of the unworn device (20). Minimum wear standards for assessing sedentary time are not available. Therefore, we included participants with at least 1 valid day and 600 minutes of accelerometer data. Sedentary time was assessed using the standard cutpoint of less than 100 counts per minute (21). The same methods were used to measure moderate-to-vigorous physical activity using the standard measure moderate-to-vigorous physical activity cutpoint of 1,951 counts per minute and higher (22).

Mental health. The 10-item Center for Epidemiological Studies Depression Scale (CES-D-10) (23) measured depressive symptoms; scores range from 0 to 30 with scores of 10 or higher indicating clinically significant depressive symptoms (23,24). Quality of life was measured with a 12-item adaptation of the Perceived Quality of Life Scale (25). The scale assesses satisfaction with physical, social, and cognitive health. All items are summed and then averaged with total scores ranging from 1 to 5. Fear of falling was measured with the 16-item Falls Efficacy Scale International (26). Scores on the Falls Efficacy Scale International range from 16 to 64 with scores of 23 or higher indicating a high concern of falling. Finally, stress was measured with an adaptation of the 4-item Cohen Perceived Stress Scale with scores ranging from 0 to 16 (27). Higher scores indicate more perceived stress.

Cognitive function. The Trail Making Test A & B measured cognitive function. Trails A was completed first, followed by Trails B. Both items were scored using completion time in seconds and scores for participants who were unable to complete the exam were set to the maximum value (300 seconds). Trails A estimates visual search and perceptual speed while Trails B examines working memory and task switching abilities. Based on prior research, we estimated executive function by subtracting the completion time of Trails A from Trails B (Trails B time – Trails A time) (28).

Physical function. The 400 Meter Walk Test (400 MWT) (29) and Short Physical Performance Battery (SPPB) (30) were used to objectively measure physical function. Participants had to complete the 400 MWT within 15 minutes but were allowed to rest (without sitting down) during the task. The SPPB consists of three tasks to assess balance, strength (time to rise from a chair five times), and time to walk 4 m. We used the SPPB total score, balance task score, walk completion time (gait speed), and time to complete five chair stands (for participants who were able to complete them). SPPB scores are predictive of disability (31). Ten items from the Late-Life Function and Disability Instrument (32) measured self-reported physical function. Response options range from 1 (cannot do) to 5 (no difficulty) and a total score was created by summing all items such that higher scores indicate higher function.

Physical health indicators. Pain interference and sleep disturbance were measured with 6-item short forms from the Patient-Reported Outcomes Measurement Information System (PROMIS) (33,34). Raw scores were transformed into *t*-scores according to the standard procedures for PROMIS measures. Higher *t*-scores on both measures indicate more pain interference and sleep disturbance. Blood pressure was measured using an automatic upper arm sphygmomanometer; of the three readings taken, the average of the two closest readings were used.

Analysis Plan

Linear mixed-effects models were employed to analyze the association between device-measured sedentary time, self-reported sedentary behaviors, or time spent watching TV and mental, cognitive, functional, or physical health indicators. Clustering by residential site was modeled as a random effect. Covariates included age, gender, marital and educational status, and device-measured physical activity (to understand the independent effects of sedentary behavior). Potential bias due to participants wearing accelerometer devices for different lengths of time was addressed by including accelerometer wear time in all models that assessed device-measured sedentary time. When the model residuals suggested a nonnormal distribution, the dependent variable was log transformed (Trails A, Trails B, Trails B – Trails A and fear of falling). For all models, we used complete case analysis resulting in different sample sizes for each analysis. To preserve the psychometric properties of self-reported scales, participants with one or more missing item were classified as missing on that scale. Those who were unable to complete the 400 m walk or chair stands were classified as missing. All data processing and analyses were carried out using SPSS v22 software and R software (35) with significance set at $p < .05$.

Results

Participant (N = 307) characteristics are described in Table 1. Participants were on average 84 years old and predominantly female (72%). On average, participants wore the accelerometer device for 5.7 days (1.48 *SD*) and 13.6 hours per day (1.3 *SD*). Participants spent 8.6 hours per day (1.0 *SD*) in device-measured sedentary time, 11 hours per day (4.9 *SD*) engaging in total self-reported sedentary behavior, and 2.4 hours per day (1.5 *SD*) watching television. About 17% reported depressive symptoms consistent with mild to moderate depression.

Mental and Cognitive Health

Higher device-measured sedentary time was associated with higher fear of falling scores ($p < .001$; see Table 2). Higher total self-reported sedentary behavior was significantly related to taking less time to complete Trails A (representing better cognitive functioning). No sedentary behavior measures (self-report or device-measured) were related to depressive symptoms, quality of life, stress, Trails B, or Trails B – Trails A scores.

Functional Health

Higher self-reported TV viewing was related to longer 400 MWT times ($p < .05$; see Table 2).No other self-reported sedentary behavior measures were related to functional health indicators. Higher device-measured sedentary time was related to longer 400 MWT times ($p < .001$), more time to complete five chair stands ($p < .001$), more time to walk 4 m ($p < .001$), worse SPPB total ($p < .001$) and balance scores ($p < .05$), and poorer self-reported physical function ($p < .001$).

Physical Health

Self-reported sedentary behavior was unrelated to measures of physical health (see Table 2). Device-measured sedentary time was beneficially related to sleep quality with more sedentary time associated with less sleep disturbance ($p < .05$). There were no other relationships between indicators of physical health and sedentary behaviors.

Discussion

The main aim of our investigation was to explore whether indicators of mental, cognitive, functional, and physical health were related to sedentary behavior measured in various ways. We consistently found that higher levels of device-measured sedentary time were deleteriously associated with physical function, consistent with previous studies (12). Very few other relationships were observed across health domains and different types of measurement. The patterns observed with device-measured sedentary time were not detected using self-reports of sedentary behavior for nearly all health outcomes. Virtually no relationships were observed between mental and cognitive health and sedentary behaviors regardless of measurement method.

Faster completion of the Trails A task (ie, better cognitive function) was related to higher self-reported sedentary behavior. This opposite finding suggests that some types of sedentary behavior could relate to better cognitive function (eg, reading, computer time) (36). The size of this effect was small and may not be clinically meaningful (a 1% decrease in time to complete Trails A for every 1-hour increase in self-reported sedentary behavior). In contrast to other studies (5,6), we did not find TV time to be associated with mental or cognitive health indicators.

The strength of the associations between device-measured sedentary behavior and physical function indicates a potentially clinically meaningful effect. For example, for every 1-hour increase in sedentary time, we observed a 21-second increase in time to complete the 400 MWT and a 0.55 decrease in SPPB scores. Kwon found that a minimally significant change in the 400 MWT was between 20–30 seconds and 0.3–0.8 points for SPPB scores (37). Our findings are within these ranges suggesting that these could be considered meaningful but small effects.

Table 1. Baseline Sample Characteristics of Participants From Retirement Communities in San Diego County

	N or % or Mean (*SD*)	Sample Range	Possible Range on the Measure
Age (*N* = 307)	83.6 (6.4)	67–100	n/a
Female (*N* = 307)	222 (72.3%)	n/a	n/a
Married (*N* = 302)	123 (40.7%)	n/a	n/a
College education or higher (*N* = 298)	106 (35.6%)	n/a	n/a
White (*N* = 300)	278 (92.7%)	n/a	n/a
Hispanic or Latino origin (*N* = 296)	4 (1.4%)	n/a	n/a
TV viewing (h/d; *N* = 299)	2.4 (1.5)	0–8.5	n/a
Self-reported sedentary behavior (h/d; *N* = 280)*	11.0 (4.9)	2.3–31.5	n/a
Sedentary time by accelerometer (h/d; *N* = 302)	8.6 (1.0)	5.8–10.9	0–12
Moderate-to-vigorous physical activity (MVPA) by accelerometer (min/d; *N* = 302)	8.7 (12.2)	0–88	n/a
Center for Epidemiological Studies Depression Scale Depression Score (*N* = 293)	5.5 (4.1)	0–18	0–30
Quality of Life (*N* = 299)	3.9 (.6)	1.5–5	1–5
Falls Efficacy Scale (*N* = 285)	26.0 (8.4)	16–64	16–64
Perceived stress score (*N* = 298)	4.2 (2.5)	0–10	0–16
Trails A (time in seconds; *N* = 302)	54.4 (21.9)	19–155	0–180
Trails B (time in seconds; *N* = 299)	148.6 (72.2)	49.3–300	0–300
Trails B – Trails A (time in seconds; *N* = 298)	94.1 (62.0)	−13 to 275.8	n/a
Late-Life Function and Disability Scale (*N* = 282)	38.4 (8.9)	10–50	10–50
400-m walk (time in seconds; *N* = 277)	447.8 (116.6)	269–858	0–900
Short Physical Performance Batter (SPPB) Total Score (*N* = 303)	8.6 (2.8)	1–12	0–12
SPPB balance score (*N* = 303)	3 (1.2)	0–4	0–4
SPPB gait speed (s; *N* = 303)	4.8 (1.4)	2.7–12.9	n/a
SPPB chair stands (s; *N* = 232)	13.0 (3.4)	5.4–25.8	n/a
PROMIS sleep disturbance scores (*N* = 299)	53.1 (4.2)	46.4–76.1	>40
PROMIS pain interference scores (*N* = 298)	49.6 (7.9)	41–67.4	>40
Systolic blood pressure (*N* = 304)	131.4 (19.1)	84–206	n/a
Diastolic blood pressure (*N* = 304)	68.1 (10.1)	44.5–105	n/a

Notes: n/a = not applicable; PROMIS = Patient-Reported Outcomes Measurement Information System.
*Can add up to more than 24 h/d due to response bias and behavior categories are not mutually exclusive.

Better sleep quality was related to higher device-measured sedentary time among our sample. No known prior studies have examined relationships between sleep quality and sedentary time in older adults. We also found that higher fear of falling was associated with higher sedentary behavior. One prior study found that fear of falling was related to self-reported sitting time in older adults with chronic pain (38). Our findings suggest that sedentary behavior could also contribute to a constellation of factors, including life space constriction, deconditioning, and physical inactivity, that can lead to frailty, falls, and loss of independence (39). Future research could further elucidate whether sedentary time is related prospectively to falls and other important aging-related health indicators.

Of note, all of our results were adjusted for measure moderate-to-vigorous physical activity. This indicates that the relationships between sedentary behavior and health are independent from measure moderate-to-vigorous physical activity in very old adults. Because sedentary behavior is independent of physical activity, that is, people can be both highly active and highly sedentary during the day, it is vital to assess both sedentary time and physical activity and examine separately the health associations of each.

Study limitations include the cross-sectional nature of our study and a sample that had low self-reported TV time, high education, low depressive symptoms, and high quality of life. There may have been ceiling effects limiting our ability to detect relationships for some variables. Accelerometers are limited in that they do not measure posture (standing time can be captured as sedentary), nonwear is estimated by algorithms, and no standard for the number of valid days needed to approximate "typical" sedentary patterns are available. We conducted sensitivity analyses including those with ≥4 valid days of accelerometer wear time and (separately) ≥5 days of valid days. There were no changes in the results using ≥4 days. Using ≥5 days, sleep disturbance became nonsignificant and Trails B scores became significant (the effect size was small indicating a 5% faster time with every 1-hour increase in sedentary time).

Study strengths include objective measures of sedentary time, physical activity, physical function, and cognitive function in contrast to prior studies. Our investigation was novel in examining sedentary time among a very old age group with multiple indicators of sedentary time. The unique setting of retirement communities may provide an excellent setting for sedentary behavior reduction interventions.

The findings highlight important relationships between physical function and sedentary time as well as high sedentary time and fear of falling. While we did not find significant consistent associations between sedentary behavior and other emotional, cognitive, and physical health indicators, intervention trials are needed to determine whether improvements in sedentary behavior could result in beneficial improvements. Our findings particularly warrant explorations to determine whether sedentary behavior reduction strategies could improve physical function or vice versa.

Table 2. Estimates From Linear Mixed-effects Models of Mental, Cognitive, Functional, and Physical Health and Three Measures of Sedentary Behavior Among 307 Retirement Community-Dwelling Older Adults in San Diego County*

	Self-reported Behaviors			TV Viewing			Sedentary Time†		
Dependent Variables	β	*SE* (β)	*p* Value	β	*SE* (β)	*p* Value	β	*SE* (β)	*p* Value
Mental and Cognitive Health Indicators:									
CES-D 10	0.03	0.05	0.60	−0.02	0.16	0.91	0.26	0.23	0.26
Quality of life	0.00	0.01	0.73	−0.02	0.02	0.45	−0.03	0.04	0.36
Falls Efficacy Scale‡	0.00	0.00	0.56	0.00	0.01	0.80	0.05	0.02	<0.001
Perceived stress score	0.03	0.03	0.39	−0.05	0.10	0.63	0.04	0.15	0.80
Trails A‡	−0.01	0.00	<0.01	−0.01	0.01	0.49	−0.02	0.02	0.33
Trails B‡	−0.01	0.01	0.08	−0.01	0.02	0.72	−0.03	0.02	0.18
Trails A − B‡	−0.01	0.01	0.63	−0.01	0.03	0.79	−0.05	0.04	0.17
Functional Health Indicators:									
Late-Life Function and Disability Scale	−0.15	0.10	0.15	−0.49	0.30	0.10	−1.80	0.42	<0.001
400-m walk (s)	1.08	1.38	0.44	9.18	4.08	0.03	20.72	5.79	<0.001
Total SPPB score	0.04	0.03	0.24	−0.01	0.09	0.88	−0.55	0.13	<0.001
SPPB balance score	0.00	0.01	0.73	−0.04	0.04	0.32	−0.15	0.06	0.01
SPPB chair stands (s)	−0.06	0.04	0.19	0.11	0.14	0.41	1.02	0.21	<0.001
SPPB gait speed (s)	−0.02	0.02	0.13	0.02	0.05	0.72	0.23	0.07	<0.001
Physical Health Indicators:									
PROMIS pain interference	0.06	0.10	0.57	0.35	0.31	0.25	0.81	0.45	0.07
PROMIS sleep disturbance	−0.04	0.06	0.47	0.05	0.17	0.75	−0.66	0.24	0.01
Systolic blood pressure (mm Hg)	0.07	0.24	0.78	0.17	0.75	0.82	0.78	1.10	0.48
Diastolic blood pressure (mm Hg)	0.01	0.14	0.96	0.09	0.40	0.82	0.77	0.58	0.19

Notes: PROMIS = Patient-Reported Outcomes Measurement Information System.

*All models adjust for age, gender, marital status, educational status, and moderate-to-vigorous physical activity.

†Models including accelerometer-measured sedentary time were adjusted for time spent wearing activity monitors.

‡Variables were log transformed. The log transformed scores for the three participants with negative Trails A − B times we set equal to 0.

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Conflict of Interest

There are no conflicts of interest.

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