Prospective Study of Sedentary Behavior, Risk of Depression, and Cognitive Impairment

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ABSTRACT

HAMER, M., and E. STAMATAKIS. Prospective Study of Sedentary Behavior, Risk of Depression, and Cognitive Impairment. *Med. Sci. Sports Exerc.*, Vol. 46, No. 4, pp. 718–723, 2014. **Introduction**: Modern-day lifestyles are characterized by large amounts of prolonged sedentary activities, which may pose a risk to health in its own right, although little is known about their effects on mental health. We examined the association between several types of common sedentary behaviors (TV viewing, Internet use, reading) and different aspects of mental health. **Methods**: We conducted a 2-yr follow-up of 6359 (age 64.9 ± 9.1 yr) men and women from the English Longitudinal Study of Ageing, a cohort of community-dwelling older adults. Self-reported TV viewing time, reading, and use of the Internet was assessed at baseline. Mental health was assessed using the eight-item Centre of Epidemiological Studies Depression scale to measure depressive symptoms and neuropsychological tests of memory and verbal fluency to assess cognitive function. **Results**: At baseline, TV viewing time (≥6 vs. <2 $h \cdot d^{-1}$) was associated with higher depressive symptoms (coefficient = 0.49, 95% confidence interval [CI] = 0.63 to 0.35) and poorer global cognitive function (coefficient = −1.16, 95% CI = −1.00 to −1.31). Conversely, participants using the Internet reported lower depressive symptoms (coefficient = −0.58, 95% CI = −0.50 to −0.66) and higher global cognitive function (coefficient = 1.27, 95% CI = 1.37 to 1.18). There was no association between any sedentary behaviors at baseline and change in mental health measures over follow-up, suggesting that the difference in scores persisted but did not increase over time. **Conclusions**: Some, but not all sedentary behaviors, are linked to adverse mental health. It is likely that these associations are being driven by the contrasting environmental and social contexts in which they occur. **Key Words:** SEDENTARY, DEPRESSION, AGING, COGNITION, EPIDEMIOLOGY

EPIDEMIOLOGY

The three main activities carried out by people in Great Britain in 2005 were sleeping, working in their main job, and watching TV and videos/DVDs or listening to music (18). Prolonged sedentary behaviors, particularly watching TV, have been associated with a range of adverse health outcomes independently from physical activity (11,25,31,33). Thus, sedentary behavior is now considered a distinct domain of behavior, which may pose a risk to health in its own right. Sedentary behavior is particularly prevalent in the elderly, and recent data have shown that adults aged 65 yr and older, on average, spend 4 $h \cdot d^{-1}$ watching television (18); thus, even small adverse health effects of this behavior may have profound effects at the population level.

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Several observational studies (1,12,21,26,34,35) have demonstrated an association between excess sedentary behavior and worse mental health. There are, however, several questions that remain unanswered. First, most existing data are from cross-sectional studies, making it difficult to support causal inferences. Only two existing studies have used a longitudinal design, and both demonstrated an association of TV/computer time (26) and TV time alone (21), with higher risk of mental disorders, including depression and anxiety, at follow-up. Second, not all types of sedentary behaviors seem to be related with adverse mental health; thus, it is unclear if the effects are being driven by physiological processes linked to excessive sitting or the contrasting environmental and social contexts in which they occur. Lastly, the literature in this area has focused on common mood disorders such as depressive symptoms, although other aspects of mental health, for example, cognitive function, have not been examined. Cognitive decline is a serious threat to older people's independence and quality of life and underlies conditions such as dementia that is characterized by increasing loss of memory, confusion, and personality changes as well as problems with verbal or written expression, spatial orientation, and other everyday activities (2). Dementia is more common in older age and prevalent in more than 36 million individuals worldwide, with the numbers expected

to nearly double by 2030 and rise as high as 115.4 million by 2050 (2).

The aim of this study was to examine the association between several types of sedentary behaviors (TV viewing, Internet use, and reading) and different aspects of mental health over 2 yr of follow-up in a representative sample of older participants.

METHODS

Study sample and procedures. The English Longitudinal Study of Ageing (ELSA) is an ongoing cohort study that contains a nationally representative sample of the English population living in households (8). The ELSA cohort consists of men and women born on or before February 29, 1952, using multistage stratified probability sampling with postcode sectors selected at the first stage and household addresses selected at the second stage. For the purposes of the present analyses, data collected at wave 4 (2008–2009) were used as the baseline because this was the first occasion that information on sedentary behaviors was gathered. Follow-up for depressive symptoms and cognitive function was made 2 yr later at wave 5 (2010–2011). Participants gave full informed written consent to participate in the study, and ethical approval was obtained from the London Multicentre Research Ethics Committee.

Sedentary and physical activity at baseline. Participants were asked to recall, "How many hours of television do you watch on an ordinary day or evening, that is, Monday to Friday?" and "How many hours of television do you normally watch in total over the weekend, that is, Saturday and Sunday?" Average daily time spent watching TV was calculated as ([weekday TV time $\times$ 5] + [weekend TV time])/7. Daily TV time was categorized into four roughly equal groups rounded up to the nearest hour (<2, 2 to <4, 4 to <6, and $\geq$6 h·d^{-1}). In addition, participants were asked if they used a computer for Internet or e-mail and if they read a daily newspaper, although time spent in these activities was not quantified. We have described the ELSA physical activity measurements in detail previously (7). In brief, participants were asked how often they took part in three different types of physical activity: vigorous-, moderate-, and low-intensity physical activity. The response options were as follows: more than once a week, once a week, one to three times a month, and hardly ever/never. Physical activity was further categorized into three groups: inactive (no moderate or vigorous activity on a weekly basis), moderate activity at least once a week, and vigorous activity at least once a week.

Depressive symptoms and cognitive function outcomes. Depressive symptoms were assessed at baseline and follow-up using the eight-item Centre of Epidemiological Studies Depression (CES-D) scale, which is highly validated for use in older adults and displays excellent psychometric properties (14,22,27,37). Participants were asked to respond to eight items by providing a dichotomous answer (no = 0, yes = 1). Five of the eight CES-D items (i.e., felt depressed, was happy, felt lonely, enjoyed life, felt sad) were depressed mood items, while the remaining three (i.e., everything was an effort, restless sleep, and could not get going) were somatic complaints items. We derived a summary CES-D score by adding responses to all eight dichotomous questions using reverse scores for positive items (possible range = 0–8).

At baseline and follow-up, three neuropsychological tests were administered to assess cognitive function that have been widely used and validated through clinical–pathologic studies (36). Participants were presented with a list of 10 words that were read out by a computer at a rate of one word every 2 s. A total of four such lists were available, and these were randomly allocated by the computer. After presentation of the words, participants were asked to recall as many words as they could (immediate recall). Participants were also asked to recall these words after an interval during which they completed other cognitive function tests (delayed recall). The number of correctly recalled words was used as a measure of memory. Verbal fluency was used as a measure of executive function. Participants were asked to name as many members of a specific category (in this case, animals) as they could in 1 min. The number of animals named was used as a measure of executive function. A global cognitive function score was calculated from the sum of standardized scores on each test, as previously described (28,36). To provide a more representative estimate, the standardized scores were derived from the total sample providing cognitive data (n = 10,531) and not simply from the present analytic sample.

Covariates. Demographic and health-related questions included cigarette smoking (current, previous, or nonsmoker), frequency of alcohol intake (daily, 5–6 wk^{-1}, 3–4 wk^{-1}, 1–2 wk^{-1}, 1–2 per month, once every couple of months, 1–2 yr^{-1}, or never), and self-reported chronic illness (yes or no). Socioeconomic status was based on the last/most recent occupation and categorized into three groups (managerial/professional, intermediate, or routine/manual occupations). We assessed disability based on participants' responses to questions on perceived difficulties in basic (e.g., difficulty dressing, including putting on shoes and socks) (16) and instrumental (e.g., difficulty preparing a hot meal) activities of daily living (19). Participants with difficulties in one or more activities were considered to have some degree of disability. Nurses collected anthropometric data (weight and height). Participants' body weight was measured using Tanita electronic scales without shoes and in light clothing, and height was measured using a stadiometer with the Frankfort plane in the horizontal position. Body mass index (BMI) was calculated using the standard formula (weight [kg]/height^2 [m^2]).

Statistical analyses. Since the CES-D scale is designed to assess depressive symptoms on a continuum, we retained the raw scores and used a linear modeling approach. To examine associations between sedentary behaviors and

TABLE 1. Characteristics of the study population at baseline.

Characteristic	
Age (yr)	64.9 ± 9.1
Men (%)	45.2
Depressive symptoms (CES-D) score	1.2 ± 1.8
Daily TV viewing time (%)	
<2 h·d^{-1}	10.4
2 to <4 h·d^{-1}	34.6
4 to <6 h·d^{-1}	27.3
≥6 h·d^{-1}	27.7
Users of Internet (%)	58.5
Read a daily newspaper (%)	59.9
Current smokers (%)	12.3
Alcohol intake, frequency (%)	
At least 5 wk^{-1}	23.4
1–2 wk^{-1}	40.0
Monthly	18.8
Never/rarely	17.8
Physical activity (%)	
Inactive	18.2
Moderate at least 1 wk^{-1}	49.3
Vigorous at least 1 wk^{-1}	32.6
Social status (%)	
Professional/managerial	36.6
Intermediate	26.1
Routine/manual	37.3
Body mass index categories (%)	
Normal weight	26.9
Overweight	42.6
Obese	31.1
Chronic illness (%)	52.0
Disability (% any impairment in ADLs/IADLs)	22.3

change in depressive symptoms and cognitive function between waves 4 and 5, we adopted a linear mixed-models approach and fitted the intercept as a random effect. The model included terms for baseline sedentary behavior, time (wave 4 corresponds to time 0, wave 5 to time 1, so that coefficients associated with time correspond to a 2-yr change), and an interaction term between sedentary behavior and time to estimate the association between baseline sedentary behavior and change in depressive symptoms and cognitive function over the follow-up. This model also included the following covariates: age, sex, smoking, alcohol, physical activity, social status, disability, chronic illness, and BMI. This modeling strategy was planned *a priori* based on existing data linking these covariates with sedentary behavior and mental health (1,12). All analyses were conducted using SPSS version 20.

RESULTS

The sample size was 11,050 at wave 4, although 7149 participants had complete data. A further 790 participants were lost to follow-up, leaving a final analytic sample of 6359 (age 64.9 ± 9.1 yr). In comparison with the analytic sample, participants excluded were slightly older (64.9 ± 9.1 vs. 65.5 ± 11.9 yr, $P = 0.001$), were similar in terms of TV viewing (27.7% vs. 33.4% viewed TV >6 h·d^{-1}) but were less likely to use the Internet (59% vs. 49.2%, $P < 0.001$), and were less physically active (81.8% vs. 68.1% reported any moderate or vigorous activity, $P < 0.001$). The characteristics of the sample are displayed in Table 1. Average daily TV time was 5.3 ± 4.1 h·d^{-1} and 58.4% of the sample reported using the Internet. TV time was related to a number of covariates in mutually adjusted models, including sex (women reported more TV time, $\beta = 0.25$ h·d^{-1}, 95% confidence interval [CI] = 0.05 to 0.45), physical activity (moderately or vigorously active participants reported less TV time compared with inactive, $\beta = -0.41$ h·d^{-1}, 95% CI = −0.68 to −0.15), obesity (obese reported higher TV time compared with normal weight, $\beta = 1.11$ h·d^{-1}, 95% CI = 0.85 to 1.37), social status (routine/manual occupations reported higher TV time compared with professional/managerial, $\beta = 1.64$ h·d^{-1}, 95% CI = 1.40 to 1.88), smoking (smokers reported higher TV time compared with nonsmokers, $\beta = 0.78$ h·d^{-1}, 95% CI = 0.48 to 1.08), disability (people with disabilities reported higher TV time, $\beta = 0.28$ h·d^{-1}, 95% CI = 0.02 to 0.53), and Internet use (people using the Internet reported lower TV time, $\beta = -1.30$ h·d^{-1}, 95% CI = −1.53 to −1.07).

Sedentary behavior and risk of depression. At baseline, longer time spent viewing TV was associated with higher depressive symptoms scores, and this association remained after adjustment for other covariates although a clear dose–response association was not observed (Table 2). In contrast, use of the Internet and reading were associated with lower depressive symptoms (Table 2). There was an increase in depressive symptoms from baseline (estimated marginal mean = 1.22, 95% CI = 1.18–1.27) to follow-up (estimated marginal mean = 1.36, 95% CI = 1.32–1.41).

TABLE 2. Linear mixed models to examine the association between sedentary behaviors at baseline on depressive symptoms scores over waves 4 to 5.

Sedentary Exposure	Model 1 Coefficient (95% CI)	Model 2 Coefficient (95% CI)	Interaction Term[a] Coefficient (95% CI)
Daily TV viewing			
≥6 h·d^{-1}	Ref	Ref	Ref
4 to <6 h·d^{-1}	−0.37 (−0.47 to −0.27)	−0.15 (−0.25 to −0.05)	−0.04 (−0.16 to 0.07)
2 to <4 h·d^{-1}	−0.59 (−0.68 to −0.48)	−0.20 (−0.29 to −0.11)	−0.004 (−0.11 to 0.11)
<2 h·d^{-1}	−0.49 (−0.63 to −0.35)	−0.09 (−0.23 to 0.04)	−0.07 (−0.23 to 0.09)
Use of Internet			
Yes	Ref	Ref	Ref
No	0.58 (0.50 to 0.66)	0.15 (0.05 to 0.25)	0.06 (−0.03 to 0.15)
Reading daily newspaper			
Yes	Ref	Ref	
No	0.35 (0.27 to 0.43)	0.22 (0.14 to 0.31)	−0.05 (−0.13 to 0.04)

[a]Interaction term calculated from relevant sedentary categories and time (wave 4 corresponds to time 0, wave 5 to time 1).
Model 1: adjustment for age, sex.
Model 2: adjustment for age, sex, smoking, physical activity, alcohol, social class, disability, chronic illness, body mass index, and mutually for each sedentary behavior.

There was, however, no association between any of the baseline sedentary behaviors and change in depressive symptoms over follow-up, suggesting that the difference in depressive symptoms scores persisted but did not increase over time.

Physical activity was also associated with depressive symptoms independently of sedentary behaviors; for example, participating in vigorous activity at least once per week was associated with a lower CES-D score (covariate adjusted coefficient = −0.60, 95% CI = −0.47 to −0.73) in comparison to inactive participants.

Sedentary behavior and cognitive function. There was a linear inverse association between TV viewing time and global cognitive function score after adjustment for covariates, including baseline depressive symptoms score (Table 3). In contrast, use of the Internet was associated with higher cognitive function scores in fully adjusted models (Table 3). There was a decrease in global cognitive function score from baseline (estimated marginal mean = 0.39, 95% CI = 0.33–0.45) to follow-up (estimated marginal mean = 0.25, 95% CI = 0.19–0.31), but there was no association between any baseline sedentary behaviors and change in cognitive function, suggesting that the difference in scores persisted but did not increase over time.

Physical activity was also independently associated with cognitive function, for example, participating in vigorous activity at least once per week was associated with a higher global score (covariate adjusted coefficient = 0.41, 95% CI = 0.26–0.56) in comparison to inactive participants. In addition, inactive participants demonstrated a greater rate in decline over time (coefficient for time interaction = −0.22, 95% CI = −0.36 to −0.09) compared to vigorously active.

DISCUSSION

The main aim of this study was to assess the prospective association between several types of sedentary behavior and different aspects of mental health. Our findings largely confirm previous work showing a link between passive sedentary behavior (TV viewing) and depressive symptoms (1,12,21,26). Conversely, we demonstrated that other forms of sedentary behavior, including Internet use and reading, were associated with less depressive symptoms, which is consistent with some prior work (1). This is one of the first studies to demonstrate an association between sedentary behavior and cognitive function. Previous work has described associations between physical activity and better cognitive function in older adults (13), and the present data further develop this literature by showing that prolonged passive sedentary behavior was adversely associated with cognitive function independently from physical activity. Only one previous study has examined the association between sedentary behaviors and cognitive function in older adults (17), which showed a negative association between TV viewing and executive functioning at baseline but not longitudinally. Consistent with our data, they also showed that participants who used the computer for >1 $h \cdot d^{-1}$ displayed better verbal memory and executive functioning compared with nonusers (17). From our data, it is difficult to determine whether sedentary behavior was responsible for driving poorer mental health outcomes or the converse since differences in trajectories over time were not observed. Our 2-yr follow-up may have been insufficient to detect longitudinal changes and the relationships might have been established before our baseline assessments.

TV viewing is arguably the most prevalent form of sedentary behavior in older adults (18) and is thought to be the most important indicator of nonoccupational sitting behavior (6). Our data confirm previous reports (18) as over a quarter of our sample reported watching TV over 6 $h \cdot d^{-1}$. Our recent work (29) has shown discrepancies in results when using objectively assessed total sedentary time compared with self-reported TV time to predict cardiometabolic outcomes, thus suggesting that TV viewing carries its own health risks over and above sitting. Consistent with the present study, previous data have shown that not all types of sedentary behaviors are related with adverse mental health. For example, studies that include computer/Internet use as the exposure variable were more likely to report null or inverse associations with risk of depression (34). Older adults using the computer for >1 $h \cdot d^{-1}$ displayed better verbal memory and executive functioning compared with nonusers (17). Other data suggest that social sitting time is associated with better mental health (1). Thus, the highest risk for

TABLE 3. Linear mixed models to examine the association between sedentary behaviors at baseline on global cognitive function scores over waves 4 to 5.

Sedentary Exposure	Model 1 Coefficient (95% CI)	Model 2 Coefficient (95% CI)	Interaction Term[a] Coefficient (95% CI)
Daily TV viewing			
≥6 $h \cdot d^{-1}$	Ref	Ref	Ref
4 to <6 $h \cdot d^{-1}$	0.46 (0.34 to 0.57)	0.20 (0.07 to 0.33)	0.02 (−0.10 to 0.14)
2 to <4 $h \cdot d^{-1}$	0.86 (0.75 to 0.97)	0.39 (0.26 to 0.51)	−0.04 (−0.16 to 0.08)
<2 $h \cdot d^{-1}$	1.16 (1.00 to 1.31)	0.60 (0.41 to 0.78)	−0.10 (−0.26 to 0.07)
Use of Internet			
Yes	Ref	Ref	Ref
No	−1.27 (−1.37 to −1.18)	−0.87 (−0.99 to −0.76)	−0.07 (−0.16 to 0.03)
Reading daily newspaper			
Yes	Ref	Ref	Ref
No	−0.11 (−0.20 to −0.01)	−0.06 (−0.16 to 0.04)	0.002 (−0.09 to 0.09)

[a]Interaction term calculated from relevant sedentary categories and time (wave 4 corresponds to time 0, wave 5 to time 1).
Model 1: adjustment for age, sex.
Model 2: adjustment for age, sex, smoking, physical activity, alcohol, social class, disability, chronic illness, body mass index, baseline CES-D score, and mutually for each sedentary behavior.

adverse mental health seems to be linked with engagement in passive sedentary activities (such as TV viewing) but not those that are cognitively stimulating, suggesting that the contrasting environmental and social contexts in which sedentary behaviors occur is important. In the present sample, Internet use was inversely associated with TV time; thus, Internet use might favorably displace TV time in terms of mental health.

The association between TV time and adverse cognitive function that we observed in this study is plausible for a number of reasons. First, cognitive function has been related to cardiovascular disease risk factors (9,15). There are numerous data showing associations between excess TV viewing time and cardiometabolic risk factors (11,30,31); thus, the links we observed might be partly through cardiovascular mechanisms. It is also possible that the association between excessive sitting and mental health reflects a range of general symptoms in older adults such as breathing difficulties, chest pain, and tiredness (23), although this seems unlikely in the present study since our analyses were adjusted for chronic illness and perceived difficulties in basic and instrumental activities of daily living. Many of the risk factors that drive depressive symptoms are also linked to cognitive function. For example, passive sedentary activities such as TV viewing might encourage social isolation and limit the development of social support networks, known to be linked with both depression (10) and cognitive decline (3,32). In light of the present findings, these psychosocial mechanisms seem particularly relevant as use of the Internet might encourage social interaction, thus preventing the risk of deteriorating mental health in older age.

Our study has some limitations. We were only able to assess three types of sedentary behavior, and therefore, our results cannot be generalized to total sedentary time. The measures of Internet use and reading were crude, and we were unable to examine dose–response associations. Thus, our findings might be explained by the fact people watch TV for more prolonged periods of time as data from the UK time use survey showed that computer users spend, on average, 2 $h \cdot d^{-1}$ on a computer (18). The questionnaires used to assess sedentary behaviors in ELSA have not been validated against objective measures, although a recent review (6) concluded that sedentary time questions focusing on TV viewing have the strongest reliability and validity among nonoccupational sedentary behavior questions. A number of the covariates were based on self reported data that might have introduced bias, although we have previously demonstrated the validity of measures such as self reported illness in ELSA (24). The measures of cognitive function in this study were somewhat limited by the time constraints present in a large-scale multipurpose study like ELSA. The measures were similar to those used in other population-based surveys of older adults such as the Whitehall II study (15,28). In addition, the cognitive variables have been shown to be relevant to the everyday functioning of older adults in ELSA, being associated with low health literacy (4), investment decisions following retirement (5), and stroke (20). Participants retained in our analysis were younger and more physically active than those excluded; thus, our results may have underestimated the true effects of sedentary behavior. Lastly, since evidence for longitudinal associations was lacking, we cannot rule out the possibility of reverse causation. Despite these limitations, our study also has some notable strengths. These include the longitudinal nature of the study allowing us to model prospective associations, the use of a large national sample of community-dwelling men and women, and the ability to adjust for a wide range of potentially important confounding factors, including behavioral, social, and clinical variables.

In conclusion, prolonged passive sedentary behavior in older age is associated with increased risk of depressive symptoms and worse cognitive function, although sedentary behavior that is cognitively stimulating seems to be associated with better mental health. This study supports public health initiatives designed to reduce passive sedentary behavior in older adults.

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M.H. had full access to the data and takes responsibility for the integrity and accuracy of the results. Both authors contributed to the concept and design of study and in drafting and critical revision of the article.

None of the authors have any competing interests to declare.

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