



Short Communication

Television viewing, C-reactive protein, and depressive symptoms in older adults

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ABSTRACT

There is emerging evidence for a link between sedentary behavior and mental health, although the mechanisms remain unknown. We tested if an underlying inflammatory process explains the association between sedentary behavior and depressive symptoms. We conducted a two year follow-up of 4964 (aged 64.5 ± 8.9 years) men and women from the English Longitudinal Study of Ageing, a cohort of community dwelling older adults. Self-reported TV viewing time was assessed at baseline as a marker of leisure time sedentary behavior. The eight-item Centre of Epidemiological Studies Depression (CES-D) scale was administered to measure depressive symptoms at follow-up. At baseline, TV time was associated with C-reactive protein (CRP), adjusted geometric mean CRP values were 2.94 mg/L (<2 h/d TV); 3.04 mg/L (2–4 h/d TV); 3.29 mg/L (4–6 h/d TV); 3.23 mg/L (>6 h/d TV). We observed both a direct association of TV time on CES-D score at follow-up ($B = 0.08$, 95% CI, 0.05, 0.10) and indirect effects ($B = 0.07$, 95% CI, 0.05, 0.08). The indirect effects were largely explained through lack of physical activity, smoking, and alcohol, but not by CRP or body mass index.

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1. Introduction

Modern day lifestyles are characterized by large amounts of prolonged sedentary activities that have led researchers to examine sedentary behavior as an independent risk factor. Historically, sedentary behavior has generally been inferred as the bottom end of the physical activity continuum. However, a mounting body of literature has demonstrated that direct measures of sedentary behaviors, such as TV viewing, are associated with an increased risk of cardio-metabolic diseases independently from physical activity (Thorp et al., 2011; Grøntved and Hu, 2011; Rhodes et al., 2012). There is now emerging evidence for a link between sedentary behavior and depressive symptoms (Teychenne et al., 2010a, 2010b; Hamer et al., 2010; Atkin et al., 2012; Sanchez-Villegas et al., 2010; Lucas et al., 2011). Several prospective studies have demonstrated an association between TV/computer time (Sanchez-Villegas et al., 2010) and TV time alone (Lucas et al., 2011) with higher risk of depression, at follow-up. However, the underlying mechanisms remain unknown.

The role of inflammation in depression has gained substantial attention (Dantzer et al., 2008; Dowlati et al., 2010) and could be a potential mechanism in explaining the link between sedentary

behaviour and mental health. Indeed, several studies have documented an association between sedentary time, particularly TV viewing, and inflammatory markers (Pinto Pereira et al., 2012; Stamatakis et al., 2011; Healy et al., 2011) after accounting for confounding factors such as body mass index and physical activity level. We are not aware of any studies that have empirically tested if an underlying inflammatory process explains the association between sedentary behavior and depressive symptoms, which formed the rationale for this study.

2. Methods

2.1. 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 (see ELSA user guide). The ELSA cohort consists of men and women born on or before 29 February 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 (2008–09) were used as the baseline since this was the first occasion that information on TV viewing was gathered. Follow up for depressive symptoms was made two years later at wave 5 (2010–11). The sample initially contained 8,824 participants with complete interview data on variables for the present analyses, although 3,333 did not consent or

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were ineligible (participants with clotting and bleeding disorders, or taking anti-coagulant medication) to give blood, and a further 527 participants were lost to follow-up, leaving a final analytic sample of 4964 (aged 64.5 ± 8.9 years). In comparison with the analytic sample, participants excluded were slightly older (64.5 ± 8.9 vs. 65.7 ± 11.4 years, $p < 0.001$), did not differ in relation to sex distribution (% men; 45.1% vs. 43.6%, $p = 0.21$), but reported a higher prevalence of longstanding illness (50.0% vs. 57.4%, $p < 0.001$). Participants gave full informed written consent to participate in the study and ethical approval was obtained from the London Multi-centre Research Ethics Committee.

2.2. Baseline TV viewing and demographics

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 $\{(\text{weekday TV time} \times 5) + (\text{weekend TV time})\}/7$. Daily TV time was categorized into roughly equal quarters rounded up to the nearest hour (<2 h/d; 2 to <4 h/d; 4 to <6 h/d; ≥ 6 h/d). As previously described (Demakakos et al., 2010), participants were asked how often they took part in three types of physical activity (vigorous, moderate- and low-intensity). Light intensity physical activity was defined as a metabolic equivalent (MET) below three (e.g., dish washing), moderate physical activity for MET values ranging from 3 to 5.9 (e.g., brisk walking, weeding), and vigorous physical activity for MET values of six or greater (e.g., jogging, sports, mowing). The response options were: 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. Other demographic and health-related questions included cigarette smoking (current, previous or non-smoker), frequency of alcohol intake (daily, 5–6/week, 3–4/week, 1–2/week, 1–2/month, once every couple of months, 1–2/year, never) and self-reported chronic illness (yes; no).

2.3. Depressive symptoms at follow-up

Depressive symptoms were assessed 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 (Irwin et al., 1999; Lyness et al., 1997). The items from the CES-D displayed excellent reliability in the present sample (Cronbach $\alpha = 0.92$).

2.4. Baseline clinical variables

At baseline clinical variables were collected during a separate nurse visit. 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 formulae [weight (kilograms)/height (meters) squared]. Blood samples were collected for the analysis of high sensitivity C-reactive protein (hsCRP). The analysis of the blood data was carried out in the Royal Victoria Infirmary (Newcastle-upon-Tyne, UK) as previously described (Hamer et al., 2009). Briefly, the analysis of CRP levels from serum was performed using the N Latex high sensitivity CRP mono immunoassay on the Behring Nephelometer II analyser. The limit of detection was 0.17 mg/L and the coefficient of variation (CV) was less than 6% for this assay.

2.5. Statistical analyses

hsCRP was log transformed to normalise the distribution. For the main analysis we employed a bootstrapping technique (Preacher and Hayes, 2008) to examine mediation of the association of TV time at baseline on CES-D scores at follow up through hsCRP, BMI, alcohol consumption, smoking and physical activity, controlling for age, sex, and chronic illness. All of the independent variables were modeled using baseline data. This multiple mediation Sobel model allowed us to test the total indirect effect of TV viewing on depressive symptoms and the extent to which specific variables mediate this association. All analyses were conducted using SPSS version 21.

3. Results

Average daily TV time was 5.2 ± 4.0 h/d and 26.9% of the sample reported viewing TV more than 6 h/d. TV time was related to a number of covariates in mutually adjusted models, including; sex (women reported more TV time, $B = 0.45$ h/d, 95% CI, 0.22, 0.68), physical activity (moderately or vigorously active participants reported less TV time compared with inactive, $B = -0.66$ h/d, 95% CI, -0.97 , -0.35); obesity (obese reported higher TV time compared with normal weight, $B = 1.22$ h/d, 95% CI, 0.91, 1.51); smoking (smokers reported higher TV time compared with non-smokers, $B = 1.19$ h/d, 95% CI, 0.85, 1.53); alcohol (non-drinkers reported higher TV time compared with regular-drinkers, $B = 0.66$ h/d, 95% CI, 0.29, 1.02). In addition there was a dose–response association between TV time and hsCRP (see Table 1), independent of covariates. The adjusted geometric mean CRP values were 2.94 mg/L, (<2 h/d TV); 3.04 mg/L, (2–4 h/d TV); 3.29 mg/L, (4–6 h/d TV); 3.23 mg/L, (>6 h/d TV). We added waist circumference instead of BMI into the models although the results remained unchanged, (difference in log CRP between <2 h/d vs. >6 h/d TV = 0.09, 95% CI, 0.03, 0.16). Similar patterns were observed in men and women. When we removed 321 participants demonstrating an acute inflammatory response (hsCRP > 10 mg/L) the association with TV time was not altered (difference in log CRP between <2 h/d vs. >6 h/d TV = 0.10, 95% CI, 0.04, 0.15).

Table 1

The association between TV viewing and log transformed C-reactive protein ($N = 4,964$).

Daily TV viewing	N	Model 1 coefficient (95% CI)	Model 2 coefficient (95% CI)
<2 h/d	535	Ref.	Ref.
2–4 h/d	1742	0.11 (0.04, 0.18)	0.04 (–0.03, 0.10)
4–6 h/d	1352	0.27 (0.20, 0.34)	0.12 (0.06, 0.19)
≥ 6 h/d	1335	0.29 (0.22, 0.36)	0.11 (0.04, 0.17)
P-trend		<0.001	<0.001

Model 1: Adjustment for age, sex.

Model 2: Adjustment for age, sex, smoking, physical activity, alcohol, chronic illness, body mass index.

Table 2

Mediation of the effect of baseline TV viewing on CES-D score at follow up through C-reactive protein, body mass index, alcohol consumption, smoking and physical activity, controlling for chronic illness, age and sex (Preacher and Hayes, 2008).

Mediators	Coefficient	SE	Bootstrapping, 95% CI	
			Lower	Upper
Log C-reactive protein	0.003	0.005	−0.004	0.010
Alcohol	0.014	0.003	0.008	0.020
Smoking	0.018	0.004	0.011	0.027
Physical activity	0.024	0.005	0.016	0.034
Body mass index	0.007	0.004	−0.001	0.015
Total indirect	0.066	0.008	0.050	0.082

There was an increase in depressive symptoms score from baseline (estimated marginal mean = 1.17, 95% CI, 1.12, 1.22) to follow-up (1.32, 95% CI, 1.27, 1.37). Several of the mediating variables at baseline were associated with CES-D score at follow-up, including log CRP (per SD, $B = 0.15$, 95% CI, 0.10, 0.20), vigorous physical activity ($B = -0.57$, 95% CI, -0.72 , -0.42), smoking ($B = 0.47$, 95% CI, 0.42, 0.63), alcohol abstinence ($B = 0.51$, 95% CI, 0.35, 0.67), BMI (per 5 kg/m² $B = 0.07$, 95% CI, 0.01, 0.14). TV viewing was associated with CES-D score at follow-up (B coefficient = 0.15, 95% CI, 0.12, 0.17), and this comprised both direct effects (B for direct effect = 0.08, 95% CI, 0.05, 0.10) and indirect effects (B for total indirect effect = 0.07, 95% CI, 0.05, 0.08). As shown in Table 2, the indirect effects were largely explained through lack of physical activity, smoking, and alcohol, but not by hsCRP and BMI. We repeated the analysis after removing 225 participants taking antidepressant medication although none of the results were changed.

4. Discussion

The aim of this study was to test if the association between TV viewing, as a marker of sedentary behavior, and depressive symptoms is partly explained through an inflammatory mechanism. Consistent with prior work (Sanchez-Villegas et al., 2010; Lucas et al., 2011), we observed a longitudinal association between TV viewing and depressive symptoms. We also observed an association between TV viewing time and C-reactive protein at baseline, independently of physical activity and other confounders such as body mass index. In addition, consistent with many prior studies (Howren et al., 2009) we observed an association between CRP and depressive symptoms. However, there was no evidence to suggest that this marker of inflammation explained the association between TV viewing and depressive symptoms. Only 50% of the variance could be explained through lack of physical activity, smoking, and alcohol, thus a large proportion of the association remains unknown.

Sedentary behaviors such as TV viewing are characterised by a lack of muscle contraction. Thus, the association between TV viewing and low grade inflammation is plausible since muscle contraction is known to stimulate the expression of transcriptional co-activators such as PGC1 α , thought to promote anti-inflammatory effects through a transient release of myokines (Pedersen, 2011). Other recent work has shown that prolonged sitting is associated with the expression of various genes linked to inflammatory responses (Latouche et al., 2013). Given the association between obesity and TV viewing that we observed, adipose tissue inflammation might also play an important role (Vieira et al., 2009a). Although our analyses were adjusted for body mass index, direct measures of adiposity were not taken and might explain the differences in CRP (Vieira et al., 2009b).

Other plausible mechanisms might exist to explain the links between TV viewing and depression. 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 (Golden et al., 2009) and cognitive decline (Shankar et al., 2013). Other biological mechanisms, not examined in this study, might include brain derived neurotrophic factor and dysregulation of the hypothalamic pituitary adrenal axis (Hamer, 2012). Forced withdrawal of physical activity in habitual exercisers is a powerful model to induce negative mood states (Kop et al., 2008; Poole et al., 2011). If we assume that habitual exercise is replaced by sedentary activities during exercise withdrawal this provides stronger evidence for a causal effect of sedentary behavior on mental health. However, such studies have also provided little evidence for an underlying inflammatory mechanism.

Our study has some limitations. Our measure of sedentary behavior were limited to TV viewing thus our results cannot be generalized to total sedentary time. The questionnaires used to assess TV viewing in ELSA have not been validated against objective measures, although sedentary time questions focusing on TV viewing have the strongest reliability and validity among non-occupational sedentary behavior questions (Clark et al., 2009). We have not assessed the content of TV viewing, or the context in which people watch TV; both of which might be of interest in future work. We have only collected CRP at one point in time, and repeated testing has been recommended to confirm elevated plasma levels since concentrations can be affected by acute infection. However, removal of participants with possible acute infection (CRP > 10 mg/L) did not appreciably alter any of the results. Also, CRP is thought to be sufficiently stable for use in long term risk prediction, since its stability over 12 years follow up was similar to that of blood pressure and serum cholesterol (Danesh et al., 2004). Although CRP is strongly associated with interleukin (IL)-6 we did not directly assess any of the cytokines that have been more directly associated with depression (Dowlati et al., 2010). Thus, future studies with extensive assessment of inflammatory markers and more sensitive provocation techniques, such as lipopolysaccharide-stimulation of immune cells, may be required to reveal significant mechanistic effects. Despite these limitations, our study also has some notable strengths. These include the longitudinal nature of the study that is an important aspect of the mediation model in order to make inferences about temporality; the use of a large national sample of community-dwelling men and women; and the inclusion of a wide range of potentially important factors, including behavioral, social and clinical variables.

In conclusion, among a sample of older adults we observed both direct and indirect associations of TV viewing on depressive symptoms. The indirect effects were largely explained through lack of physical activity, smoking, and alcohol, but not by CRP or body mass index.

5. Funding sources

The data were made available through the UK Data Archive. The English Longitudinal Study of Ageing (ELSA) was developed by a team of researchers based at University College London, the Institute of Fiscal Studies and the National Centre for Social Research. The funding is provided by the National Institute on Aging in the United States (grants 2R01AG7644-01A1 and 2R01AG017644) and a consortium of UK government departments coordinated by the Office for National Statistics. MH is supported by the British Heart Foundation (RE/10/005/28,296). The funders had no role in the study design; in the collection, analysis and interpretation of data; in writing of the report; or in the decision to submit the paper for publication. The developers and funders of ELSA and the Archive do not bear any responsibility for the analyses or interpretations presented here.

6. Author contributions

MH 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, drafting and critical revision of the manuscript.

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