CSP CADERNOS DE SAÚDE PÚBLICA
REPORTS IN PUBLIC HEALTH

ARTIGO
ARTICLE

Sedentary behaviors and risk of depression in the Seguimiento Universidad de Navarra cohort: the SUN Project

Comportamientos sedentarios y riesgo de depresión en la cohorte de Seguimiento Universidad de Navarra: el Proyecto SUN

Comportamentos sedentários e risco de depressão na coorte Seguimiento Universidad de Navarra: o Projeto SUN

Adriano Marçal Pimenta [1]
Raquel de Deus Mendonça [2]
Francisca Lahortiga-Ramos [3]
Cesar I. Fernandez-Lazaro [4]
Miguel Angel Martínez-González [4]
Almudena Sánchez-Villegas [5]

doi: 10.1590/0102-311X00076621

Abstract

The study aimed to prospectively examine the association between different sedentary behaviors and the risk of depression. We included 12,691 Spanish university graduates (mean age: 36.7 year; SD: 11.5), participants of the Seguimiento Universidad de Navarra cohort (the SUN Project), initially free of depression who were followed-up for a median of 10.9 years. Based on items presented in our baseline questionnaire, time spent in four sedentary behaviors (hours/day) were evaluated: overall sitting time; TV-viewing; computer use; and driving. Participants were classified as incident cases of depression if they reported a physician diagnosis of depression in at least one of the follow-up assessments conducted after the first two years of follow-up. Cox regression models were used to assess the relationship between sedentary behaviors and depression. A total of 560 incident cases of depression were identified during follow-up. We found no significant association between overall sitting time, TV-viewing or driving and risk of depression. On the other hand, computer use was directly associated with the risk of developing depression during the follow-up (p-value for trend = 0.020), with the participants in the highest quartile of computer use (3.64 to 10 hours/week) having a higher risk of developing depression (HR = 1.33; 95%CI: 1.05-1.70) than those in the lowest quartile (0 to 0.25 hours/week) after adjusting for potential confounders. Prolonged use of computer was independently associated with an increased risk of developing depression among young middle-aged adult university graduates from a Spanish cohort.

Depression; Sedentary Behavior; Computers; Adult; Cohort Studies

Correspondence
A. M. Pimenta
Departamento de Enfermagem, Setor de Ciências da Saúde, Universidade Federal do Paraná.
Av. Prefeito Lothário Meissner 632, Curitiba, PR
80210-170, Brasil.
adriano.pimenta@ufpr.br

[1] Departamento de Enfermagem, Universidade Federal do Paraná, Curitiba, Brasil.
[2] Escola de Nutrição, Universidade Federal de Ouro Preto, Ouro Preto, Brasil.
[3] Clínica Universidad de Navarra, Pamplona, España.
[4] Universidad de Navarra, Pamplona, España.
[5] Universidad Pública de Navarra, Pamplona, España.

Introduction

Depression is an important public health concern worldwide, being one of the leading causes of global disability (over 54 million years lived with disability – YLDs; 7.5% of all YLDs) and affecting 322 million people (4.4%) [1].

Moreover, depression has social-economic and epidemiological relevance due to its relationship with decreasing quality of life and productivity, and to its impact on other diseases and mortality [2]. Regarding the latter association, depression is the major contributor to suicide attempts, accounting for roughly 800,000 deaths per year (1.5% of all deaths), becoming an alarming problem worldwide [1].

Systematic reviews and meta-analyses have demonstrated that physical activity is a prospective factor to prevent depression [3,4,5,6]. On the other hand, the association between sedentary behaviors – defined as an energy expenditure ≤ 1.5 metabolic equivalent of task (METs), while in a sitting or reclining posture during waking hours [7] – and depression is not totally clear.

A meta-analysis found that higher levels of sedentary behaviors were associated with depression (relative risk – RR = 1.25; 95% confidence interval – 95%CI: 1.16-1.35) [8], however, the diagnosis of depression was confirmed by a physician only in 4 out of 23 studies included in that analysis. Moreover, these studies were conducted with older women [9] and adolescents [10] or had cross-sectional designs [10,11], characteristics that limit the interpretation and generalizability of the outcomes.

An updated meta-analysis of 14 prospective studies found a significant association between TV-viewing and risk of clinician-diagnosed depression (RR = 1.08; 95%CI: 1.03-1.14), but the authors did not find a significant association with computer use [12].

Passive sedentary behaviors, such as TV-viewing, might be related to depression, while more cognitive and mentally stimulating sedentary behaviors, such as computer and internet use, could be associated with depression to a lesser extent [13]. Thus, analyses have identified associations between sedentary behaviors and depression, but the available evidence is incipient and inconclusive.

Therefore, our study aimed to prospectively examine the association between different sedentary behaviors and the risk of depression in participants of the Seguimiento Universidad de Navarra cohort (the SUN Project).

Materials and methods

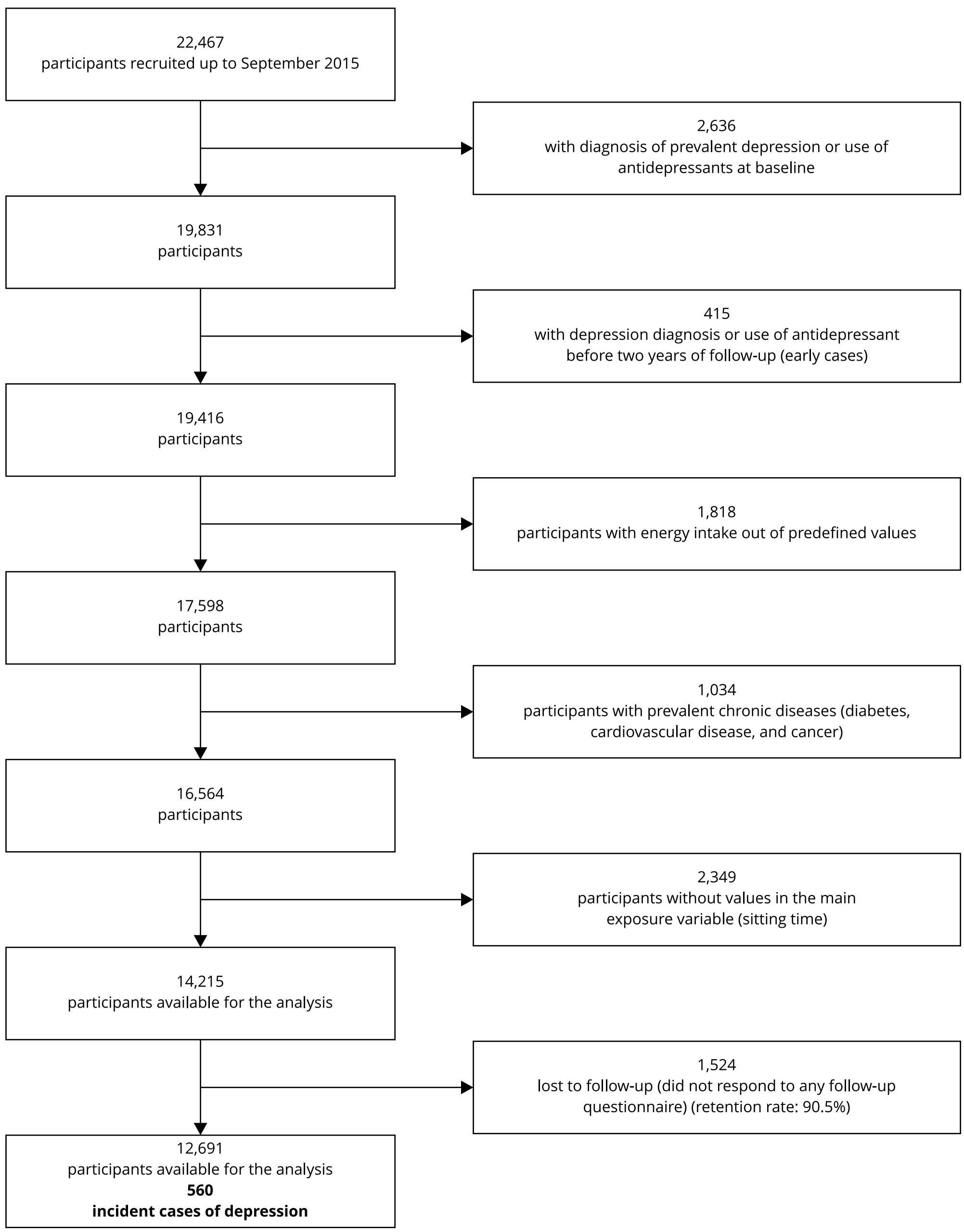
The SUN Project is a dynamic prospective cohort study with permanently open recruitment, conducted in Spain among university graduates since December 1999. Information is gathered by mail or e-mail questionnaires collected biennially.

In the baseline questionnaire, information on sociodemographic characteristics, lifestyle aspects, anthropometric variables, and medical history are collected. After baseline assessment, participants receive follow-up questionnaires every two years to evaluate changes in lifestyle and health-related behaviors, anthropometric measures, incident diseases, and medical conditions. Previous publication described additional details on its objectives, design, and methods [14].

Up to June 2018, 22,790 participants had completed the baseline questionnaire of the SUN Project. For our analysis, we included only participants recruited before September 2015 to allow a minimum follow-up period of two years and nine months, to give them the opportunity to complete at least the 2-year follow-up assessment. Among 22,467 participants, those who reported a previous history of clinical diagnosis of depression or use of antidepressants at baseline were excluded for analyses of a new-onset depression (n = 2,636). To allay the threat of reverse causality bias, those with a depression diagnosis during the first two years of follow-up (early cases) (n = 415) were excluded. Participants with the following characteristics were also excluded: total energy intake outside of predefined limits (< 800Kcal/day or > 4,000Kcal/day in men, and < 500Kcal/day or > 3,500Kcal/day in women, n = 1,818) according to published recommendations [15], those with prevalent chronic diseases (diabetes, cardiovascular disease, and cancer, n = 1,034), those with missing values in the main exposure variable (overall sitting time, n = 2,349), and those who were lost to follow-up (did not complete at least one follow-up questionnaire, n = 1,524, retention rate = 90.5%). Finally, 12,691 participants were included in our statistical analyses (Figure 1).

Figure 1

Flowchart of participants. The SUN Project (Seguimiento Universidad de Navarra cohort), Navarra, Spain, 1999-2015.



The Institutional Review Board of the University of Navarra provided ethical approval. Participants were informed about the study in writing, and voluntary completion of the first self-administered questionnaire was considered as an informed consent.

Incident cases of depression was the outcome variable of this study, which were defined as participants who were free of this disease at baseline (those who did not report a previous diagnosed depression at baseline, or were not using any antidepressant) and positively responded any of the follow-up questionnaires to the question: "Have you ever been diagnosed with depression by a physician?".

The self-reported diagnosis of depression has been previously validated in a subsample of our cohort using the *Structured Clinical Interview for DSM-IV* (conducted by a senior psychiatrist or clinical psychologist) as gold standard, yielding a 96% specificity – the percentages of confirmed depression and confirmed non-depression were 74.2% (95%CI: 63.3-85.1) and 81.1% (95%CI: 69.1-92.9), respectively [16].

The exposures variables of this study were the times spent (hours/day) on four different sedentary behaviors: overall sitting time, TV-viewing, computer use, and driving. They were measured using the following questions: (1) "How much time on average have you spent doing the activity (overall sitting time, TV-viewing, computer use, or driving) in the last year on business days (hours/day)?" and (2) "How much time on average did you spend doing the activity (overall sitting time, TV-viewing, computer use, or driving) last year on weekend days (hours/day)?". The sum of the answers to these two questions was considered the total time doing the activity (hours/day).

Overall sitting time, TV-viewing, computer use, and driving were divided into roughly quartiles, being the lowest quartile considered as the reference category in all data analyses and the highest quartile the category with larger time of sedentary behavior.

The baseline questionnaire also gathered a wide array of participants' information which were used as covariates in this study: sociodemographic characteristics (e.g., gender, age, marital status, years of university education, working hours, living alone), lifestyle and health-related behavior (e.g., smoking status, alcohol consumption, physical activity, hanging out with friends), dietary habits (e.g., total energy intake, Mediterranean diet adherence score), personality traits (e.g., self-perceived level of competitiveness, psychological tension, and dependency), anthropometric data (e.g., weight, height), and health conditions (use of tranquilizers or anxiolytics, and sleeping hours).

Dietary habits were assessed using a 136-item semi-quantitative food frequency questionnaire (SFFQ), previously validated in Spain [17,18]. Based on the responses in this SFFQ, participants were classified according to their nine points score of Mediterranean diet adherence [19].

Leisure-time physical activity was collected by a validated questionnaire that included information about 17 activities, such as walking, running, cycling, swimming, judo, soccer, skiing or sailing. This questionnaire was previously validated by our group using a triaxial accelerometer as a gold standard. In the validation study, physical activity during leisure time (estimated as METs-hours/week) derived from the questionnaire moderately correlated with Kcal/day measured with the accelerometer [20].

Personality traits were determined using the following Likert-type questions previously used in this cohort and associated with depression [21]: (1) "Do you consider yourself a competitive, nonconformist, fighter person, who demands everything of yourself at work and sometimes even more of what you can afford?", (2) "Do you consider yourself a tense, aggressive, usually feeling overloaded, highly strung person, or you think of yourself as a relaxed and calm person?", and (3) "Do you think you have enough resources, preparation, and autonomy to solve any problems at work, or do you exclusively depend on others to do it?". For each question, the participant could choose 11 possible answers ranging from 0 (more conformist, relaxed, or autonomous) to 10 (more competitive, tense, or dependent).

Body mass index (BMI), defined as weight (in kilograms) divided by height^2 (in meters), was ascertained at the baseline questionnaire. The validity of self-reported weight was assessed in a subsample of the cohort. The mean relative error in self-reported weight was 1.5%. The correlation coefficient (r) between measured and self-reported weight was 0.99 (95%CI: 0.98-0.99) [22].

Baseline characteristics of participants were described according to extreme quartiles of the overall sitting time and computer use, estimating relative frequencies, means, and standard deviations. Significative statistical differences were evaluated with Pearson's chi-square or Student t-tests.

Person-years of follow-up were calculated for each participant as the following: from the date of returning the baseline questionnaire to the date of returning the questionnaire in which depression was reported; the date of death; and the date of returning the last follow-up questionnaire whichever occurred first.

Cox regression models were fitted to assess the risk of depression during follow-up according to quartiles of each sedentary behavior (overall sitting time, TV-viewing, computer use, and driving) [23]. We calculated hazard ratios (HR) and their 95%CI defining the reference category to participants with the lowest time doing each sedentary behavior (1st quartile). Multivariable models were adjusted for gender, marital status, years of university education, working hours, living status, hanging out with friends, smoking, physical activity, total energy intake, Mediterranean diet score, baseline self-perception of competitiveness, anxiety, and dependence levels, baseline BMI, use of tranquilizers or anxiolytics, insomnia, and sleeping hour. Moreover, analyses were stratified by age groups (10-year periods) and calendar year of recruitment (1999-2001, 2002-2004, 2005-2007, 2008-2010, 2011-2013, and from 2014 onwards). Robust standard errors (SEs) were used. Also, the proportional hazards assumption was evaluated using Schoenfeld residuals. Multiplicative interactions between quartiles of each sedentary behavior and different sociodemographic and lifestyle-related variables regarding depression risk were assessed. Possible effect modification of each sedentary behavior by gender, age (< 40/≥ 40 years), and physical activity (below/above the median – 16.1 METs-hours/week) was tested using likelihood ratio tests comparing the fully adjusted model and the same model also including an interaction product term. Finally, tests of linear trend across increasing quartiles of exposures were conducted by assigning the medians to each quartile and treating them as continuous variables.

Moreover, sensitivity analyses were used to assess the robustness of our results under different scenarios. All analyses were repeated: (1) including participants with prevalent diabetes, cardiovascular disease (CVD) or cancer at baseline; (2) excluding pregnant women at baseline; (3) excluding participants who used anxiolytics at baseline; (4) excluding participants with obesity at baseline; (5) considering new cases of medically diagnosed depression only from two years until eight years of follow-up; (6) additionally, adjusting for incident events of cardiovascular disease occurred during the follow-up period.

All p-values showed are two-tailed; p-value < 0.05 was considered statistically significant. Analyses were performed using Stata/SE version 13.0 (https://www.stata.com).

Results

Our study included 12,691 participants (5,035 men and 7,656 women). After a median of 10.9 years of follow-up (137,947 person-years), we recorded 560 incident cases of depression.

Participants who reported higher overall sitting time (4th quartile) were more likely to be younger, male, single, smoker, less physically active and adherent to Mediterranean diet, spent more time in sedentary activities, and had higher BMI. Moreover, they had more years of university education, worked more hours/week, were more competitive and tense, used less anxiolytics or tranquilizers, had higher prevalence of insomnia, and slept less hours/day than those who reported lower overall sitting time (1st quartile). Overall, similar characteristics were observed in participants who reported higher computer use (4th quartile) when compared with those who reported lower computer use (1st quartile) (Table 1).

We did not find any significant association between overall sitting time, TV-viewing or driving and depression risk. On the other hand, computer use was directly associated with the risk of developing depression during the follow-up (p-value for trend = 0.020), with the 4th quartile having a significantly increased risk (HR = 1.33; 95%CI: 1.05-1.70) as compared to the 1st quartile after adjusting for a wide array of potential confounders (Table 2). The p-value of proportional-hazards assumption test = 0.733 (data not shown).

The sensitivity analyses confirmed the robustness of our findings, as the association between computer use and incident depression did not substantially change in any of the different alternative scenarios (Table 3). All p-values of proportional-hazards assumption tests ≥ 0.05 (data not shown).

Table 1

Baseline characteristics of participants according to quartiles of overall sitting time and computer use (4th quartile versus 1st quartile). The SUN project (Seguimiento Universidad de Navarra cohort), Navarra, Spain, 1999-2015.

Characteristics	Overall sitting time (hours/day)		Computer use (hours/day)	
	1st quartile (0.00 to 3.71)	4th quartile (7.21 to 10.00)	1st quartile (0.00 to 0.25)	4th quartile (3.64 to 10.00)
n	3,253	3,101	3,027	2,982
Age (years) [mean (SD)] *,**	38.2 (11.4)	34.3 (10.8)	36.3 (12.1)	34.2 (9.5)
Female [%] *,**	67.2	53.9	74.5	54.5
Marital status [%] *,**				
Single	38.2	56.7	45.7	53.3
Married	58.2	41.5	51.0	44.7
Other ***	3.5	1.8	3.3	1.9
University education (years) [mean (SD)] *,**	4.9 (1.3)	5.2 (1.6)	4.7 (1.2)	5.3 (1.6)
Living alone [%]	2.0	2.1	2.0	2.2
Sitting time (hours/day) [mean (SD)] *,**	2.4 (1.0)	8.6 (0.8)	4.4 (2.5)	7.3 (1.9)
TV viewing (hours/day) [mean (SD)] *,**	1.4 (1.3)	1.7 (1.2)	1.6 (1.3)	1.7 (1.5)
Computer use (hours/day) [mean (SD)] *,**	1.0 (1.5)	3.7 (2.5)	0.1 (0.1)	5.5 (1.4)
Driving (hours/day) [mean (SD)] *,**	0.9 (1.4)	0.8 (1.0)	0.8 (1.2)	1.1 (1.5)
Working hours (hours/week) [mean (SD)] *,**	36.5 (16.7)	38.8 (18.4)	31.8 (19.4)	42.2 (13.9)
Hanging out with friends (hours/week) [mean (SD)] **	1.4 (1.3)	1.4 (1.1)	1.4 (1.2)	1.6 (1.4)
Current smokers [%]	20.5	23.8	23.7	23.1
Leisure-time physical activity (METs-hours/week) [mean (SD)] *	23.4 (24.2)	21.0 (19.4)	21 (20.9)	22.0 (21.4)
Total energy intake (Kcal/day) [mean (SD)]	2,356 (611)	2,361 (609)	2,341 (594)	2,356 (623)
Mediterranean diet score (0 to 9 points) [mean (SD)] *,**	4.2 (1.7)	3.9 (1.7)	4.0 (1.7)	3.9 (1.6)
Psychological traits (0 to 10 points) [mean (SD)] #				
Competitiveness *,**	6.9 (1.7)	7.1 (1.7)	6.7 (1.8)	7.2 (1.7)
Anxiety/Tension *,**	5.8 (2.2)	6.0 (2.2)	5.8 (2.2)	5.9 (2.2)
Dependency	3.6 (2.9)	3.5 (2.8)	3.6 (2.8)	3.5 (2.9)
BMI (kg/m^2) [mean (SD)] *,**	23.3 (3.4)	23.6 (3.5)	23.0 (3.4)	23.4 (3.8)
Insomnia [%] *	9.0	7.5	7.4	7.2
Use of anxiolytics or tranquilizers [%] **	1.2	0.9	1.4	0.8
Sleeping hours (hours per day) [mean (SD)] *,**	7.2 (1.2)	7.5 (0.8)	7.4 (1.1)	7.3 (0.9)

BMI: body mass index; Kcal: kilocalories; METs: metabolic equivalent of task; SD: standard deviation.
Note: adjusted by inverse probability weighting.
* p-value from Person's chi-square or t-Student tests for comparison between 1st quartile versus 4th quartile of overall sitting time < 0.05;
** p-value from Person's chi-square or t-Student tests for comparison between 1st quartile versus 4th quartile of computer use < 0.05;
*** Widowed, divorced, cohabiting;
# Self-perception at baseline of competitiveness, anxiety, and emotional dependence.

Moreover, the likelihood ratio tests determined that no statistical interaction was apparent between computer use and the variables a priori selected to be potential effect-modifiers: gender (p-value for interaction = 0.124), age (p-value for interaction = 0.748) or physical activity (p-value for interaction = 0.833) (data not shown).

Table 2

Hazard ratios (HR) and 95% confidence intervals (95%CI) of incident depression according to quartiles of sedentary behaviors. The SUN Project (Seguimiento Universidad de Navarra cohort), Navarra, Spain, 1999-2015.

Overall sitting time (hours/day) [n = 12,691]	**1st quartile (0.00 to 3.71)**	**2nd quartile (3.74 to 5.42)**	**3rd quartile (5.43 to 7.14)**	**4th quartile (7.21 to 10.00)**	**p-value for trend**
Cases	144	151	124	141	
Persons-year	34,323	36,747	32,877	33,997	
Model 2: gender-adjusted [HR (95%CI)]	1.00 (Reference)	0.98 (0.78-1.24)	0.93 (0.73-1.18)	1.05 (0.82-1.33)	0.801
Model 3: multivariable adjusted * [HR (95%CI)]	1.00 (Reference)	1.02 (0.81-1.28)	0.94 (0.74-1.20)	1.04 (0.81-1.32)	0.894
TV viewing (hours/day) [n = 12,314]	**1st quartile (0.00 to 0.75)**	**2nd quartile (0.78 to 1.28)**	**3rd quartile (1.32 to 2.28)**	**4th quartile (2.36 to 10.00)**	**p-value for trend**
Cases	160	118	135	127	
Persons-year	39,638	31,506	36,927	25,747	
Model 2: gender-adjusted [HR (95%CI)]	1.00 (Reference)	0.95 (0.75-1.21)	0.92 (0.73-1.16)	1.18 (0.94-1.49)	0.239
Model 3: multivariable adjusted * [HR (95%CI)]	1.00 (Reference)	0.94 (0.74-1.19)	0.89 (0.71-1.12)	1.11 (0.88-1.41)	0.510
Computer use (hours/day) [n = 11,978]	**1st quartile (0.00 to 0.25)**	**2nd quartile (0.28 to 1.42)**	**3rd quartile (1.5 to 3.57)**	**4th quartile (3.64 to 10.00)**	**p-value for trend**
Cases	143	131	98	147	
Persons-year	35,08	32,426	30,795	31,628	
Model 2: gender-adjusted [HR (95%CI)]	1.00 (Reference)	1.11 (0.88-1.42)	0.91 (0.70-1.18)	1.33 (1.05-1.69)	0.031
Model 3: multivariable adjusted * [HR (95%CI)]	1.00 (Reference)	1.13 (0.89-1.44)	0.92 (0.71-1.20)	1.33 (1.05-1.70)	0.020
Driving (hours/day) [n = 11,898]	**1st quartile (0.00 to 0.25)**	**2nd quartile (0.28 to 0.61)**	**3rd quartile (0.71 to 1)**	**4th quartile (1.04 to 10.00)**	**p-value for trend**
Cases	172	113	105	126	
Persons-year	41,078	25,384	31,220	31,461	
Model 2: gender-adjusted [HR (95%CI)]	1.00 (Reference)	1.17 (0.92-1.48)	0.91 (0.71-1.17)	1.09 (0.86-1.38)	0.687
Model 3: multivariable adjusted * [HR (95%CI)]	1.00 (Reference)	1.15 (0.90-1.47)	0.91 (0.71-1.17)	1.05 (0.83-1.34)	0.905

BMI: body mass index; Kcal: kilocalories; METs: metabolic equivalent of task.

Note: analyzes stratified by age groups (10 year periods) and year of entrance to the cohort (1999-2001, 2002-2004, 2005-2007, 2008-2010, 2011-2013, and from 2014 onwards).

* Additionally adjusted for gender, marital status, years of university education, working hours (hours/week), living status, hanging out with friends (hours/week), smoking, physical activity (METs-hours/week), total energy intake (Kcal/day), Mediterranean diet score (0 to 9), baseline self-perception of competitiveness, anxiety, and dependence levels (continuous, scale 0 to10), baseline BMI (kg/m^2), use of tranquilizers or anxiolytics, insomnia, sleeping hours (hours/day).

Discussion

In this analysis of the SUN Project, higher hours per day of computer use was independently associated with a 33% relatively increased risk for depression. Higher incidence of depression was also observed among participants who spent more time in other sedentary behaviors (sitting time, TV-viewing, and driving), but these associations were not statistically significant at the conventional threshold (p-value ≥ 0.05).

Elevated risk of depression associated to computer use is in accordance with results of a meta-analysis which showed a pooled RR of 1.22 (95%CI: 1.1-1.34) for the association between computer use and depression (heterogeneity: $I^2 = 0$; p-value = 0.53) [8]. Most studies included in this analysis had a cross-sectional design or were conducted with adolescents. The unique prospective study previously conducted with adult population showed that time spent e-mailing and chatting online predicted an

Table 3

Sensitivity analyses: hazard ratios (HR) and 95% confidence intervals (95%CI) of incident depression according to quartiles of computer use. The SUN Project (Seguimiento Universidad de Navarra cohort), Navarra, Spain, 1999-2015.

	Computer use (hours/day) [HR (95%CI)]				p-value for trend
	1st quartile (0.00 to 0.25)	2nd quartile (0.28 to 1.42)	3rd quartile (1.50 to 3.57)	4th quartile (3.64 to 10.00)	
Overall (n = 11,978)	1.00 (Reference)	1.13 (0.89-1.44)	0.92 (0.71-1.20)	1.33 (1.05-1.70)	0.020
Including participants with prevalent diabetes, CVD or cancer (n = 13,462)	1.00 (Reference)	1.09 (0.86-1.38)	0.88 (0.68-1.14)	1.30 (1.02-1.64)	0.043
Excluding pregnant women (n = 11,065)	1.00 (Reference)	1.19 (0.92-1.53)	0.88 (0.66-1.18)	1.42 (1.10-1.83)	0.018
Excluding participants who use anxiolytics at baseline (n = 11,862)	1.00 (Reference)	1.08 (0.85-1.38)	0.90 (0.69-1.18)	1.32 (1.04-1.69)	0.029
Excluding participants with prevalent obesity (n = 11,456)	1.00 (Reference)	1.12 (0.87-1.43)	0.91 (0.70-1.20)	1.32 (1.03-1.69)	0.042
Considering medical diagnosis of depression only from 2 until 8 years of follow-up (n = 11,978)	1.00 (Reference)	1.43 (0.98-2.09)	1.17 (0.78-1.77)	1.63 (1.12-2.39)	0.039
Additionally, adjusted for incident CVD during follow-up (n = 11,978)	1.00 (Reference)	1.12 (0.88-1.42)	0.92 (0.70-1.19)	1.33 (1.04-1.69)	0.034

BMI: body mass index; CVD: cardiovascular disease; Kcal: kilocalories; METs: metabolic equivalent of task.
Note: adjusted for gender, marital status, years of university education, working hours (hours/week), living alone, hanging out with friends (hours/week), smoking, alcohol consumption (grams/day), physical activity (METs-hours/week), total energy intake (Kcal/day), Mediterranean diet score, baseline self-perception of competitiveness, anxiety, and dependence levels (continuous, scale 0 to 10), baseline BMI (kg/m^2), use of tranquilizers or anxiolytics, insomnia, sleeping hours (hours/day), and stratified by age groups (10 year periods) and year of entrance to the cohort (1999-2001, 2002-2004, 2005-2007, 2008-2010, 2011-2013, and from 2014 onwards).

increased risk of depression at the 1-year follow-up in women (but not in men). However, no relationship was found in that short-term study between overall computer or internet use and risk of depression [24].

Contradictory findings were reported by a prospective study developed with older adults (≥ 60 years old) participating in the Seniors-ENRICA cohort. Women, but not men, who spent more time in sedentary behaviors, including reading, using the computer and commuting, and excluding TV-viewing, showed a lower number of depressive symptoms [25]. These results should be interpreted with caution since the study was conducted only with older adults and all sedentary activities were considered together. Thus, exposure to computer use was not assessed in isolation, but was included in an unspecific manner in a variable that included a set of a variety of sedentary behaviors. Moreover, the outcome analyzed was not a medical diagnosis of depression, but a scale that assessed depressive symptoms.

Thus, the debate over the association between computer use and depression might involve differences in exposure characteristics of specific sedentary behaviors. Spending time using computer in activities that require cognitive engagement and are mentally stimulating, such as working tasks, could counterbalance their passive nature regarding their impact on brain and mental health [25]. On the other hand, the prolonged use of computer in passive activities, such as reading e-mail and chatting online have been suggested as risk factors for depression [24]. These statements are reinforced in the conclusions of a recent review which highlighted important differences between passive and mentally active sedentary behaviors, where passive behaviors appeared to increase the risk of depression while mentally active sedentary behaviors might protect against depression [13]. Unfortunately, our baseline questionnaire did not allow us to further differentiate subtypes of computer use. Thus, if we were able to exclude the effect of computer use at work (active activity), probably the association between computer use and depression might be higher than the one we found.

In recent years, more people have been using the computer rather than TV to watch movies and other video contents (passive activities). Thereby, computers using could contribute to explain two findings: (1) the higher mean time of computer use in comparison to TV-viewing; and (2) the lack of association of TV-viewing with depression in our study, since the harmful effect of this sedentary behavior on mental health seems to appear in people exposed six or more hours per day [8,13,26]. In our study, the mean of TV-viewing in the last quartile of this variable was 3.6 hours/day.

The absence of statistically significant relationships between other sedentary behaviors evaluated in our study and depression have been also reported in previous publications [8,13,26]. A potential explanation for these findings might be based on differentiating mental engagement for the performance of activities and mixing activities of different types in the same variable. For instance, overall sitting time includes TV-viewing, computer use, reading, driving, etc. Moreover, we were not able to examine the use of smartphone as the cohort was initiated in 1999. However, studies demonstrated that the overuse of this device may lead to depression [27]. We cannot exclude the possibility of the presence of a non-differential misclassification bias in our study when assessing overall sitting time without considering the use of smartphone. Thus, the presence of this bias would lead the association of overall sitting time with depression to the null. Therefore, the real effects should be even higher than those we have found.

The potential mechanisms which might help to explain associations of sedentary behaviors with depression involve health habits, social interactions, and biological aspects. People with higher adherence to sedentary activities could displace time spent in physical activity [13], which reduces the risk of depression [3,4,5,6], although this explanation is not very likely as we adjusted all estimated associations for physical activity. Moreover, people engaged in prolonged sedentary activities could isolate themselves socially, decreasing supportive or mood-enhancing social interactions, and, thus, decreasing the risk of depression [13]. Uninterrupted sedentary behaviors generate deleterious changes in insulin sensitivity, glucose tolerance, and plasma triglyceride levels [28]. Glycemic variability may influence brain health and cognition [29], alter dopamine system dysregulation [30], and increase the risk of depression [31]. Additionally, people with higher time spent in sedentary behaviors are more likely to be obese and to have other cardiometabolic risk markers [28], conditions related to subclinical chronic inflammation and to oxidative stress, which contribute to neurodegeneration presents in depression [32]. Finally, sedentary activities might contribute to hypovitaminosis D since these activities are mostly done indoor with scarce exposure to sun light. Low levels of vitamin D seem to affect mood symptoms [13].

Our study has limitations. First, the SUN Project is not representative of the general Spanish population. However, generalization of results in epidemiology should be based on biological mechanisms rather than on statistical representativeness [33]. Second, variables used for estimating sedentary behaviors were self-reported and their validity and reproducibility has not been validated in our cohort. Studies recommended the use of objective assessments to evaluated sedentary behaviors, such as accelerometers and inclinometers [13], although the use of these instruments is not efficient in epidemiological studies. Nevertheless, the presence of a non-differential misclassification bias would lead the associations toward the null, expecting a higher significant effect for computer use in depression. Third, we were not able to evaluate different forms to use computer (passive versus active activities) which has been demonstrated to influence the association between the exposure to this sedentary behavior and depression [13,24,25]. Fourth, sedentary behaviors were collected at baseline, assuming that these habits remained stable throughout the study. Unfortunately, we did not have enough information in the follow-up questionnaires regarding sedentary behaviors to assess changes over time. However, when the analysis was censored until six years of follow-up, our results were consistent. Finally, despite the results were adjusted for several major potential confounders, we cannot eliminate the presence of residual confounding.

Despite these limitations, our study has many strengths, including its prospective design, the high retention rate, the ability to control for a variety of major potential confounders, the existence of published validation studies of our assessments, and the restriction to highly educated participants, who may be able to provide more reliable information. In addition, we performed multiple sensitivity analyses that confirm the robustness of our results. Moreover, the exclusion of incident depression cases during the first two years of follow-up decreases the possibility of reverse causality.

In conclusion, a higher time spent using computer was associated with an increased risk of developing depression among young middle-aged adult university graduates from a Spanish cohort. Further studies are needed to confirm our findings, and to go deeper into the understanding of this relationship, focusing on different forms to computer use (active versus passive activities) and including the use of other devices.

Contributors

A. M. Pimenta and A. Sánchez-Villegas managed the literature searches, undertook the statistical analysis, and wrote the manuscript. R. D. Mendonça and C. I. Fernandez-Lazaro undertook the statistical analysis and revised the manuscript with substantial contribution. F. Lahortiga-Ramos revised the manuscript with substantial contribution. M. A. Martínez-González designed the study and revised the manuscript with substantial contribution. All authors approved the final version of the manuscript.

Additional informations

ORCID: Adriano Marçal Pimenta (0000-0001-7049-7575); Raquel de Deus Mendonça (0000-0001-7599-8715); Francisca Lahortiga-Ramos (0000-0001-7624-6902); Cesar I. Fernandez-Lazaro (0000-0003-2366-2528); Miguel Angel Martínez-González (0000-0002-3917-9808); Almudena Sánchez-Villegas (0000-0001-7733-9238).

Acknowledgments

We thank all participants in the SUN cohort for their long-standing and enthusiastic collaboration, and our advisors from Harvard TH Chan School of Public Health, United States (Walter Willett, Alberto Ascherio and Frank B. Hu), who helped us to design the SUN Project. A. M. P. received a postdoctoral fellowship from the Carolina Foundation/Tordesillas Group for internship development at University of Las Palmas de Gran Canaria, Spain. A. M. P. also is research productivity fellows of the Brazilian National Research Council (CNPq). We thank the Carlos III Health Institute (Spain), European Regional Development Fund, Navarra Regional Government, and Navarra University (Spain).

References

1. World Health Organization. Depression and other common mental disorders: global health estimates. Geneva: World Health Organization; 2017.
2. Lotfaliany M, Bowe SJ, Kowal P, Orellana L, Berk M, Mohebbi M. Depression and chronic diseases: co-occurrence and communality of risk factors. J Affect Disord 2018; 241:461-8.
3. Mammen G, Faulkner G. Physical activity and the prevention of depression: a systematic review of prospective studies. Am J Prev Med 2013; 45:649-57.
4. Schuch F, Vancampfort D, Firth J, Rosenbaum S, Ward P, Reichert T, et al. Physical activity and sedentary behavior in people with major depressive disorder: a systematic review and meta-analysis. J Affect Disord 2017; 210:139-50.
5. Schuch FB, Vancampfort D, Richards J, Rosenbaum S, Ward PB, Stubbs B. Exercise as a treatment for depression: a meta-analysis adjusting for publication bias. J Psychiatr Res 2016; 77:42-51.
6. Schuch FB, Vancampfort D, Rosenbaum S, Richards J, Ward PB, Stubbs B. Exercise improves physical and psychological quality of life in people with depression: a meta-analysis including the evaluation of control group response. Psychiatry Res 2016; 241:47-54.
7. Sedentary Behaviour Research Network. Letter to the editor: standardized use of the terms "sedentary" and "sedentary behaviours". Appl Physiol Nutr Metab 2012; 37:540-2.
8. Zhai L, Zhang Y, Zhang D. Sedentary behaviour and the risk of depression: a meta-analysis. Br J Sports Med 2015; 49:705-9.
9. Lucas M, Mekary R, Pan A, Mirzaei F, O'Reilly EJ, Willett WC, et al. Relation between clinical depression risk and physical activity and time spent watching television in older women: a 10-year prospective follow-up study. Am J Epidemiol 2011; 174:1017-27.

10. Primack BA, Silk JS, DeLozier CR, Shadel WG, Carpentier FRD, Dahl RE, et al. Using ecological momentary assessment to determine media use by individuals with and without major depressive disorder. Arch Pediatr Adolesc Med 2011; 165:360-5.
11. Yancey AK, Wold CM, McCarthy WJ, Weber MD, Lee B, Simon PA, et al. Physical inactivity and overweight among Los Angeles County adults. Am J Prev Med 2004; 27:146-52.
12. Huang Y, Gan Y, Wang C, Cao S, Lu X. Sedentary behavior and risk of depression: a meta-analysis of prospective studies. Transl Psychiatry 2020; 10:26.
13. Hallgren M, Dunstan D, Owen FN. Passive versus mentally active sedentary behaviors and depression. Exerc Sport Sci Rev 2020; 48:20-7.
14. Carlos S, De La Fuente-Arrillaga C, Bes-Rastrollo M, Razquin C, Rico-Campà A, Martínez-González MA, et al. Mediterranean diet and health outcomes in the SUN cohort. Nutrients 2018; 10:439.
15. Willett W, Stampfer MJ. Total energy intake: implications for epidemiologic analyses. Am J Epidemiol 1986; 124:17-27.
16. Sánchez-Villegas A, Schlatter J, Ortuno F, Lahortiga F, Pla J, Benito S, et al. Validity of a self-reported diagnosis of depression among participants in a cohort study using the Structured Clinical Interview for DSM-IV (SCID-I). BMC Psychiatry 2008; 8:43.
17. Martín-Moreno JM, Boyle P, Gorgojo L, Maisonneuve P, Fernandez-Rodriguez JC, Salvini S, et al. Development and validation of a food frequency questionnaire in Spain. Int J Epidemiol 1993; 22:512-9.
18. De La Fuente-Arrillaga C, Ruiz ZV, Bes-Rastrollo M, Sampson L, Martínez-González MA. Reproducibility of an FFQ validated in Spain. Public Health Nutr 2010; 13:1364-72.
19. Trichopoulou A, Costacou T, Bamia C, Trichopoulou D. Adherence to a Mediterranean diet and survival in a Greek population. N Engl J Med 2003; 348:2599-608.
20. Martinez-Gonzalez MA, López-Fontana C, Varo JJ, Sanchez-Villegas A, Martinez JA. Validation of the Spanish version of the physical activity questionnaire used in the Nurses' Health Study and Health Professionals' Follow-up Study. Public Health Nutr 2005; 8:920-7.
21. Lahortiga-Ramos F, Unzueta CR, Zazpe I, Santiago S, Molero P, Sánchez-Villegas A, et al. Self-perceived level of competitiveness, tension and dependency and depression risk in the SUN cohort. BMC Psychiatry 2018; 18:241.
22. Bes-Rastrollo M, Pérez JR, Sánchez-Villegas A, Alonso A, Martinez-Gonzalez MA. Validation of the weight and body mass index self-declared by participants in a cohort of university graduates. Rev Esp Obes 2005; 3:352-8.
23. Lalanne C, Mesbah M. Survival data analysis. In: Lalanne C, Mesbah M, editors. Biostatistics and computer-based analysis of health data using Stata. New York: Elsevier; 2016. p. 101-15.
24. Thomee S, Harenstam A, Hagberg M. Computer use and stress, sleep disturbances, and symptoms of depression among young adults: a prospective cohort study. BMC Psychiatry 2012; 12:176.
25. Andrade-Gómez E, Martínez-Gómez D, Rodríguez-Artalejo F, García-Esquinas E. Sedentary behaviors, physical activity, and changes in depression and psychological distress symptoms in older adults. Depress Anxiety 2018; 35:884-97.
26. Teychenne M, Ball K, Salmon J. Sedentary behavior and depression among adults: a review. Int J Behav Med 2010; 17:246-54.
27. Demirci K, Akgönül M, Akpinar A. Relationship of smartphone use severity with sleep quality, depression, and anxiety in university students. J Behav Addict 2015; 4:85-92.
28. Saunders TJ, Larouche R, Colley RC, Tremblay MS. Acute sedentary behaviour and markers of cardiometabolic risk: a systematic review of intervention studies. J Nutr Metab 2012; 2012:712435.
29. Wheeler MJ, Dempsey PC, Grace MS, Ellis KA, Gardiner PA, Green DJ, et al. Sedentary behavior as a risk factor for cognitive decline? A focus on the influence of glycemic control in brain health. Alzheimers Dement 2017; 3:291-300.
30. Kleinridders A, Cai W, Cappellucci L, Ghazarian A, Collins WR, Vienberg SG, et al. Insulin resistance in brain alters dopamine turnover and causes behavioral disorders. Proc Natl Acad Sci U S A 2015; 112:3463-8.
31. Belujon P, Grace AA. Dopamine system dysregulation in major depressive disorders. Int J Neuropsychopharmacol 2017; 20:1036-104.
32. Leonard BE. Inflammation and depression: a causal or coincidental link to the pathophysiology? Acta Neuropsychiatr 2018; 30:1-16.
33. Rothman KJ, Gallacher JE, Hatch EE. Why representativeness should be avoided. Int J Epidemiol 2013; 42:1012-4.

Resumen

El objetivo del estudio fue examinar prospectivamente la asociación entre diferentes comportamientos sedentarios y el riesgo de depresión. Incluimos a 12.691 graduados universitarios españoles (media de edad: 36,7 años; SD: 11,5), participantes en la cohorte de Seguimiento Universidad de Navarra (Proyecto SUN), que no sufrieran depresión inicialmente y a quienes se les realizó un seguimiento durante una mediana de 10.9 años. Basados en los ítems presentados en nuestro cuestionario de línea de base, se evaluó el tiempo transcurrido con cuatro comportamientos sedentarios (horas/día): tiempo sentado en general, tiempo viendo TV, usando el ordenador, y conduciendo. Los participantes se clasificaron como casos incidentes de depresión, si informaban de un diagnóstico médico de depresión, emitido por un doctor en al menos una de las evaluaciones de seguimiento llevadas a cabo tras los dos primeros años de seguimiento. Los modelos de regresión Cox se usaron para evaluar la relación entre comportamientos sedentarios y depresión. Se identificaron un total de 560 casos incidentes de depresión durante el seguimiento. No encontramos ninguna asociación significativa entre el tiempo sentado en general, tiempo viendo TV, o conduciendo y el riesgo de depresión. Por otro lado, el uso del ordenador estuvo directamente asociado con el riesgo de desarrollar depresión durante el seguimiento (valor de p para tendencia = 0,020), con los participantes en el cuartil más alto de uso del ordenador (3,64 a 10 horas/semana) teniendo un riesgo más alto de desarrollar depresión (HR = 1,33; IC95%: 1,05-1,70), respecto a quienes estaban en el cuartil más bajo (0 a 0,25 horas/semana) tras realizar un ajuste para potenciales factores de confusión. El uso prolongado del ordenador estuvo independientemente asociado con el mayor riesgo de desarrollar depresión entre adultos jóvenes de mediana edad, graduados universitarios, procedentes de una cohorte española.

Depresión; Conducta Sedentaria; Computadores; Adulto; Estudios de Cohortes

Resumo

O estudo buscou examinar prospectivamente a associação entre diversos comportamentos sedentários e risco de depressão. Incluímos 12.691 indivíduos espanhóis com nível universitário (média de idade: 36,7 anos; DP: 11,5), participantes da coorte Seguimiento Universidad de Navarra (Projeto SUN), inicialmente sem depressão, que foram seguidos por uma mediana de 10,9 anos. Com base nos itens apresentados no questionário da linha de base, foram avaliados os tempos gastos em quatro comportamentos sedentários (horas/dia): total de tempo sentado e tempo assistindo televisão, usando computador e dirigindo. Os participantes eram classificados como casos incidentes de depressão quando relatavam um diagnóstico de depressão feito por médico em pelo menos uma das avaliações de seguimento após os primeiros dois anos de seguimento. Foram usados modelos de regressão Cox para avaliar a relação entre comportamentos sedentários e depressão. Foram identificados 560 casos incidentes de depressão durante o seguimento. Não encontramos associação entre total de tempo sentado, tempo assistindo TV ou dirigindo e risco de depressão. Por outro lado, o uso de computador mostrou associação direta com o risco de desenvolver depressão durante o seguimento (valor de p para tendência = 0,020), no qual os participantes no quartil mais alto de uso de computador (entre 3,64 e 10 horas/semana) tiveram o risco maior de desenvolver depressão (HR = 1,33; IC95%: 1,05-1,70) comparados com aqueles no quartil mais baixo (0 a 0,25 horas/semana), depois de ajustar para potenciais fatores de confusão. O uso prolongado do computador esteve associado de maneira independente com risco aumentado de desenvolver depressão em adultos de meia idade com nível universitário em uma coorte espanhola.

Depressão; Comportamento Sedentário; Computadores; Adulto; Estudos de Coortes

Submitted on 22/Mar/2021
Final version resubmitted on 04/Aug/2021
Approved on 20/Aug/2021