Sedentary Behaviors and the Risk of Incident Hypertension

The SUN Cohort

Juan José Beunza, Miguel Ángel Martínez-González, Shah Ebrahim, Maira Bes-Rastrollo, Jorge Núñez, José Alfredo Martínez, and Álvaro Alonso

Background: Scientific evidence from different sources suggests a positive association between sedentary behaviors and the incidence of hypertension. However, no previous prospective study corroborated this potential relationship in an adult population. Our objective was to assess prospectively the association of different sedentary behaviors (interactive and noninteractive sedentary activity, television viewing, and sleeping) with the incidence of hypertension.

Methods: In this prospective, dynamic cohort study (the SUN Study), 11,837 Spanish university graduates, with a mean age of 36 years, were followed for an average of 40 months, from 1999 to 2006. Sedentary behavior was assessed with a questionnaire at baseline, and the incidence of hypertension was assessed with validated, biennial questionnaires.

Results: We identified 291 new cases of hypertension among 6742 participants who remained after excluding those with self-reported hypertension, cardiovascular disease, diabetes, and cancer at baseline. Self-reported total sedentary behavior was directly associated with a higher risk of hypertension (hazard ratio, 1.48; 95% confidence interval, 1.01 to 2.18, comparing those in the upper and lower quartiles; P for trend = .03). In subtype analyses, interactive sedentary behavior (driving and computer use), but not noninteractive sedentary behavior (television viewing and sleeping), was associated with a higher risk of hypertension.


Key Words: Hypertension, sedentary behavior, SUN, cohort, Spain.

Regular moderate to vigorous physical activity significantly lowers resting blood pressure in normotensive and hypertensive adults. In addition, the risk of developing hypertension (HTN) is higher among individuals who practice low levels of physical activity. This was confirmed by studies assessing physical activity through self-reported questionnaires and through direct measurement of cardiorespiratory fitness (maximal exercise testing).

Recent reports suggest an association between sedentary behaviors (measured generally as television [TV] viewing) and diabetes mellitus, obesity, and metabolic syndrome, and even blood pressure (BP) levels. Also, some studies point to a different relationship between chronically stressful and nonstressful situations and BP levels. No previous prospective study, however, assessed the overall effect of sedentary behavior and its different components on the risk of HTN in an adult population.

Our objective was to assess the association between sedentary behaviors (total and specific types) and the incidence of HTN in a prospective, dynamic cohort study among 6742 participants who remained after excluding those with self-reported hypertension, cardiovascular disease, diabetes, and cancer at baseline. Self-reported total sedentary behavior was directly associated with a higher risk of hypertension (hazard ratio, 1.48; 95% confidence interval, 1.01 to 2.18, comparing those in the upper and lower quartiles; P for trend = .03). In subtype analyses, interactive sedentary behavior (driving and computer use), but not noninteractive sedentary behavior (television viewing and sleeping), was associated with a higher risk of hypertension.


Key Words: Hypertension, sedentary behavior, SUN, cohort, Spain.
consisting of Spanish university graduates, ie, the Segui-
miento Universidad de Navarra (SUN; University of Na-
varra Follow-Up) Study.

**Methods**

The SUN Study is a dynamic cohort of university gradu-
ates. The objectives and methods of the SUN cohort were
reported in detail elsewhere. Briefly, beginning in De-

**Assessment of Sedentary Behavior**

At baseline, participants were asked to report their average
daily time spent in viewing TV, computer use, driving,
sleeping, “siesta” (short nap after midday meal), and sun-
bathing, differentiating between weekdays and weekends.
Information on sunbathing was assessed separately for
summer and winter exposure. The response included 13
categories (ranging from 0 to ≥9 hours per day). We
computed total sedentary behavior as the average time, in
hours per day, engaged in the previously mentioned be-
haviors. Interactive sedentary behavior was defined as

**Assessment of Incident Hypertension**

In the follow-up questionnaires, participants were asked
whether they had received a medical diagnosis of HTN in the
time after they completed the previous questionnaire.
We requested also the date (month and year) of diagnosis.
Incident cases of HTN were defined as those individuals
self-reporting a medical diagnosis of HTN in any of the
follow-up questionnaires. We observed an acceptable va-

**Assessment of Covariates**

The baseline questionnaire requested additional informa-
tion about a wide array of socio-demographic factors (sex,
age, university degree, and marital and employment status),
anthropometric measurements (weight and height),
health-related habits (smoking status, alcohol consump-
tion, and physical activity), and clinical variables (use of
medication, personal and family history of hypertension,
hypercholesterolemia, coronary heart disease, cancer, and
other diseases). We calculated body mass index (BMI)
using self-reported weight in kilograms divided by the
square of the height in meters, both in the basal question-
naire and in the first follow-up questionnaire (after 2 years
of follow-up). The amount of physical activity during
leisure time was quantified from an activity metabolic
equivalent (MET) index, computed by assigning a multi-
ple of resting metabolic rate (MET score) to each of 17
activities included in the baseline questionnaire. Time
spent in each activity was multiplied by the MET score
specific to each activity. Then, the value of overall weekly
activity was obtained from the sum of all activities.
The validity of self-reported weight and leisure-time
physical activity was demonstrated in the SUN cohort.

**Statistical Analysis**

We conducted a multivariable Cox regression analysis that
included 6742 SUN cohort participants (2576 men and
4166 women), to evaluate the association between seden-
tary behavior, categorized in quartiles, and incident hyper-
tension. Hazard ratios (HRs) of HTN and their 95%

Confidence intervals (95% CIs) were estimated by com-
puting the average total sedentary behavior was calculated as
daily hours of TV viewing and sleeping (both at night and “siesta”). Finally, we assessed separately sleeping time and nonsleeping sed-
entary behaviors. Computations of time spent in sedentary
behaviors took into account differences between weekdays
and weekends, and between summer and winter.
We examined separately the association of total sedentary behavior, interactive sedentary behavior, noninteractive sedentary behavior, and sleeping (night sleeping and “siesta”) with the risk of developing HTN. We performed initial analyses adjusting for age and gender, and to control for potential confounding, we ran additional analyses adjusting for the following variables: gender, age, baseline BMI, leisure-time physical activity, alcohol intake, family history of hypertension, sodium intake, hypercholesterolemia, smoking, olive-oil intake (quartiles), fruit and vegetable intake (four categories of servings/day), and low-fat dairy intake (quintiles). The model containing all these variables will be subsequently referred to as the multivariable Cox regression model. We assessed linear trends in the association of sedentary behavior with the risk of hypertension by entering into the models the median values of each category of sedentary behavior, and treating this variable as continuous.

We repeated the analyses after stratifying by gender, age, baseline BMI, and leisure-time physical activity measured by METs (hours/week), to assess effects within subgroups. We introduced product-terms in the multivariable Cox regression models to assess effect modification (interaction) by each of these variables. Additional analyses were conducted, including, in the multivariable model, change in BMI during the first 2 years of follow-up, and habitual use of aspirin or other nonsteroidal anti-inflammatory drugs.

Finally, to assess the joint effect of physical activity and total sedentary behavior on the risk of HTN, we created a new variable combining information from the two variables, using the median for each variable as the cutoff point. Thus, we had four exposure categories combining high or low physical activity with high or low total sedentary behavior. Individuals with high physical activity and low sedentary behavior were considered the reference category. All P values are two-tailed, and statements about statistical significance refer to the conventional .05 cutoff point.

**Results**

During the follow-up period (median, 40.1 months), we observed 291 incident cases of hypertension. The distribution of potential confounding variables across quartiles of total sedentary behavior is given in Table 1. Higher levels of sedentary behaviors were associated with being male, younger, not engaging in leisure-time physical activities, having a self-diagnosis of hypercholesterolemia and consuming fewer fruits and vegetables, and consuming more sodium and alcohol.

We found a direct association between quartiles of total sedentary behavior and the risk of incident HTN (Table 2). The multivariable, adjusted HR for those in the highest quartile compared with the lowest quartile was 1.48 (95% CI, 1.01 to 2.18; P for trend = .03). Because “sunbathing” in some cases is not necessarily a sedentary activity (eg, for some people it could include time spent in summer outdoor activities, such as hiking or water sports), we repeated the analysis after excluding this variable. The results were similar (data not shown).

Interactive sedentary behavior (computer use and driving) was also directly associated with the risk of HTN (HR, 1.49; 95% CI, 0.98 to 2.25, comparing the fourth to the first quartile; P for trend = .08; Table 2). No association was found for noninteractive sedentary behavior (TV viewing and sleeping), sleeping (total sleeping including “siesta”), TV viewing, and the risk of HTN (Table 2).

Because the patterns of both sleeping and TV viewing could affect the practice of interactive behavior, we in-

### Table 1. Distribution of potential confounding variables across quartiles of total sedentary behaviors in SUN Study, 1999 to 2006*

<table>
<thead>
<tr>
<th>Quartiles of total sedentary behavior</th>
<th>1 (lowest)</th>
<th>2</th>
<th>3</th>
<th>4 (highest)</th>
<th>P for trend</th>
</tr>
</thead>
<tbody>
<tr>
<td>Participants (n)</td>
<td>1685</td>
<td>1686</td>
<td>1686</td>
<td>1685</td>
<td></td>
</tr>
<tr>
<td>Gender (female) (%)</td>
<td>67.7</td>
<td>63.3</td>
<td>57.5</td>
<td>58.7</td>
<td>&lt;.01</td>
</tr>
<tr>
<td>Age (years) (mean)</td>
<td>39.1 (11.3)</td>
<td>36.4 (11.1)</td>
<td>35.2 (10.5)</td>
<td>33.3 (8.9)</td>
<td>&lt;.01</td>
</tr>
<tr>
<td>BMI (kg/m²) (mean)</td>
<td>23.0 (3.1)</td>
<td>22.9 (3.2)</td>
<td>23.0 (3.1)</td>
<td>23.1 (3.4)</td>
<td>.16</td>
</tr>
<tr>
<td>Physical activity (metabolic equivalent index-hours/week) (mean)</td>
<td>23.8 (20.8)</td>
<td>23.5 (20.6)</td>
<td>23.3 (19.3)</td>
<td>22.4 (20)</td>
<td>.04</td>
</tr>
<tr>
<td>Alcohol intake (g/day) (mean)</td>
<td>5.2 (8.1)</td>
<td>6 (9.3)</td>
<td>6.6 (9.2)</td>
<td>6.7 (9.3)</td>
<td>&lt;.01</td>
</tr>
<tr>
<td>Family history of hypertension (%)</td>
<td>35</td>
<td>37</td>
<td>36</td>
<td>33</td>
<td>.20</td>
</tr>
<tr>
<td>Sodium intake (g/day) (mean)</td>
<td>3.2 (2.1)</td>
<td>3.4 (2.5)</td>
<td>3.5 (2.1)</td>
<td>3.4 (2.1)</td>
<td>&lt;.01</td>
</tr>
<tr>
<td>Hypercholesterolemia, self-diagnosis (%)</td>
<td>13</td>
<td>12</td>
<td>13</td>
<td>10</td>
<td>.01</td>
</tr>
<tr>
<td>Smoker (%) C</td>
<td>49.5</td>
<td>51.5</td>
<td>49.3</td>
<td>52.9</td>
<td>.14</td>
</tr>
<tr>
<td>Fruit and vegetable intake (servings/day)</td>
<td>5.4</td>
<td>5.2</td>
<td>5.0</td>
<td>4.8</td>
<td>&lt;.01</td>
</tr>
<tr>
<td>Olive-oil intake (g/day)</td>
<td>19.7</td>
<td>20.6</td>
<td>20</td>
<td>20.1</td>
<td>.80</td>
</tr>
<tr>
<td>Low-fat dairy intake (g/day)</td>
<td>183</td>
<td>190</td>
<td>180</td>
<td>174</td>
<td>.11</td>
</tr>
</tbody>
</table>

BMI = body mass index; C = current and past smokers.
* Values are expressed as mean (standard deviation), unless otherwise stated.
Table 2. Hazard ratios (95% confidence intervals) of self-reported hypertension according to quartiles of sedentary behaviors, in SUN Study, 1999 to 2006

<table>
<thead>
<tr>
<th>Quartiles of total sedentary behavior</th>
<th>1 (lowest)</th>
<th>2</th>
<th>3</th>
<th>4 (highest)</th>
<th>P for trend</th>
</tr>
</thead>
<tbody>
<tr>
<td>Total sedentary behavior (h/day) (range)</td>
<td>&lt;14.2</td>
<td>14.2 to 17.2</td>
<td>17.2 to 21.0</td>
<td>&gt;21.0</td>
<td></td>
</tr>
<tr>
<td>Incident cases</td>
<td>65</td>
<td>75</td>
<td>82</td>
<td>69</td>
<td></td>
</tr>
<tr>
<td>N</td>
<td>1686</td>
<td>1686</td>
<td>1685</td>
<td>1685</td>
<td></td>
</tr>
<tr>
<td>Age- and sex-adjusted HR (95% CI)</td>
<td>1</td>
<td>1.30 (0.93 to 1.82)</td>
<td>1.49 (1.07 to 2.08)</td>
<td>1.54 (1.08 to 2.19)</td>
<td>.01</td>
</tr>
<tr>
<td>Multivariate HR (95% CI)*</td>
<td>1</td>
<td>1.15 (0.79 to 1.67)</td>
<td>1.28 (0.89 to 1.85)</td>
<td>1.48 (1.01 to 2.18)</td>
<td>.03</td>
</tr>
</tbody>
</table>

<table>
<thead>
<tr>
<th>Quartiles of interactive sedentary behavior</th>
<th>1 (lowest)</th>
<th>2</th>
<th>3</th>
<th>4 (highest)</th>
<th>P for trend</th>
</tr>
</thead>
<tbody>
<tr>
<td>Interactive sedentary behavior # (h/day) (range)</td>
<td>&lt;0.7</td>
<td>0.7 to 2.1</td>
<td>2.1 to 4.6</td>
<td>&gt;4.6</td>
<td></td>
</tr>
<tr>
<td>Incident cases</td>
<td>52</td>
<td>75</td>
<td>91</td>
<td>73</td>
<td></td>
</tr>
<tr>
<td>N</td>
<td>1656</td>
<td>1712</td>
<td>1691</td>
<td>1683</td>
<td></td>
</tr>
<tr>
<td>Age- and sex-adjusted HR (95% CI)</td>
<td>1</td>
<td>1.24 (0.87 to 1.77)</td>
<td>1.57 (1.11 to 2.23)</td>
<td>1.60 (1.10 to 2.32)</td>
<td>.01</td>
</tr>
<tr>
<td>Multivariate HR (95% CI)*</td>
<td>1</td>
<td>1.27 (0.85 to 0.88)</td>
<td>1.32 (0.88 to 1.96)</td>
<td>1.49 (0.98 to 2.25)</td>
<td>.08</td>
</tr>
</tbody>
</table>

<table>
<thead>
<tr>
<th>Quartiles of noninteractive sedentary behavior</th>
<th>1 (lowest)</th>
<th>2</th>
<th>3</th>
<th>4 (highest)</th>
<th>P for trend</th>
</tr>
</thead>
<tbody>
<tr>
<td>Noninteractive sedentary behavior C (h/day) (range)</td>
<td>&lt;7.9</td>
<td>7.9 to 8.9</td>
<td>8.9 to 10.0</td>
<td>&gt;10.0</td>
<td></td>
</tr>
<tr>
<td>Incident cases</td>
<td>76</td>
<td>81</td>
<td>76</td>
<td>58</td>
<td></td>
</tr>
<tr>
<td>N</td>
<td>1627</td>
<td>1750</td>
<td>1714</td>
<td>1651</td>
<td></td>
</tr>
<tr>
<td>Age- and sex-adjusted HR (95% CI)</td>
<td>1</td>
<td>1.21 (0.88 to 1.66)</td>
<td>1.20 (0.87 to 1.66)</td>
<td>1.04 (0.73 to 1.46)</td>
<td>.78</td>
</tr>
<tr>
<td>Multivariate HR (95% CI)*</td>
<td>1</td>
<td>1.15 (0.81 to 1.63)</td>
<td>1.13 (0.79 to 1.62)</td>
<td>0.93 (0.63 to 1.38)</td>
<td>.78</td>
</tr>
</tbody>
</table>

<table>
<thead>
<tr>
<th>Quartiles of sleeping (including siesta)</th>
<th>1 (lowest)</th>
<th>2</th>
<th>3</th>
<th>4 (highest)</th>
<th>P for trend</th>
</tr>
</thead>
<tbody>
<tr>
<td>Sleeping (h/day) (range)</td>
<td>&lt;6.8</td>
<td>6.8 to 7.3</td>
<td>7.3 to 8.0</td>
<td>&gt;8.0</td>
<td></td>
</tr>
<tr>
<td>Incident cases</td>
<td>85</td>
<td>66</td>
<td>83</td>
<td>57</td>
<td></td>
</tr>
<tr>
<td>N</td>
<td>1727</td>
<td>1627</td>
<td>2031</td>
<td>1357</td>
<td></td>
</tr>
<tr>
<td>Age- and sex-adjusted HR (95% CI)</td>
<td>1</td>
<td>1.04 (0.75 to 1.45)</td>
<td>1.05 (0.77 to 1.43)</td>
<td>0.95 (0.67 to 1.33)</td>
<td>.93</td>
</tr>
<tr>
<td>Multivariate HR (95% CI)*</td>
<td>1</td>
<td>1.08 (0.75 to 1.55)</td>
<td>1.19 (0.84 to 1.67)</td>
<td>0.95 (0.65 to 1.40)</td>
<td>.82</td>
</tr>
</tbody>
</table>
cluded in the analysis simultaneously noninteractive and interactive sedentary behavior, finding similar results (data not shown). We obtained similar results after removing baseline BMI from the model, as a potential intermediate mechanism in the association between sleeping and HTN (results not shown).

There was no effect modification by age, gender, baseline BMI, or leisure-time physical activity. Figure 1 depicts the risk of HTN according to joint categories of total sedentary behavior and physical activity. The association between sedentary behavior and risk of HTN was similar among those with high or low levels of physical activity (P for interaction = .75).

Similar results were found when we used quintiles instead of quartiles, and when we excluded individuals with incomplete responses to the sedentary behavior questionnaire. Additional analyses, adjusting for change in BMI during the first 2 years of follow-up or habitual use of aspirin or nonsteroidal anti-inflammatory drugs at baseline, did not materially change the results (data not shown).

### Discussion

In this analysis of the SUN Study, we observed that more interactive sedentary behavior appears to be a risk factor for incident HTN, independent of leisure-time physical activity and other factors. On the other hand, TV viewing and sleeping alone did not show a significant association with incident HTN.

Previous epidemiologic studies assessed the association between sedentary behaviors and BP, with inconsistent results. The McGill University Study on the Natural History of Nicotine Dependence in Teens, which followed 1267 Canadian adolescents for 5 years, pointed to a direct

<table>
<thead>
<tr>
<th>Quartiles of total sedentary behavior excluding sleep</th>
<th>1 (lowest)</th>
<th>2</th>
<th>3</th>
<th>4 (highest)</th>
<th>P for trend</th>
</tr>
</thead>
<tbody>
<tr>
<td>Total sedentary behavior, excluding sleep (h/day) (range)</td>
<td>&lt;6.6</td>
<td>6.6 to 9.6</td>
<td>9.6 to 13.4</td>
<td>&gt;13.4</td>
<td></td>
</tr>
<tr>
<td>Incident cases N</td>
<td>1685</td>
<td>1686</td>
<td>1686</td>
<td>1685</td>
<td></td>
</tr>
<tr>
<td>Age- and sex-adjusted HR (95% CI)</td>
<td>1.10 (0.78 to 1.55)</td>
<td>1.48 (1.07 to 2.06)</td>
<td>1.49 (1.05 to 2.11)</td>
<td>&lt;.01</td>
<td></td>
</tr>
<tr>
<td>Multivariate HR (95% CI)*</td>
<td>0.89 (0.61 to 1.30)</td>
<td>1.23 (0.85 to 1.77)</td>
<td>1.35 (0.93 to 1.96)</td>
<td>.04</td>
<td></td>
</tr>
</tbody>
</table>

<table>
<thead>
<tr>
<th>Quartiles of TV viewing</th>
<th>1 (lowest)</th>
<th>2</th>
<th>3</th>
<th>4 (highest)</th>
<th>P for trend</th>
</tr>
</thead>
<tbody>
<tr>
<td>TV viewing (h/day) (range)</td>
<td>&lt;.61</td>
<td>.61 to 1.1</td>
<td>1.1 to 2.2</td>
<td>&gt;2.2</td>
<td></td>
</tr>
<tr>
<td>Incident cases N</td>
<td>1670</td>
<td>1701</td>
<td>1646</td>
<td>1725</td>
<td></td>
</tr>
<tr>
<td>Age- and sex-adjusted HR (95% CI)</td>
<td>1.35 (0.97 to 1.87)</td>
<td>1.31 (0.94 to 1.83)</td>
<td>1.26 (0.90 to 1.79)</td>
<td>.35</td>
<td></td>
</tr>
<tr>
<td>Multivariate HR (95% CI)*</td>
<td>1.24 (0.86 to 1.80)</td>
<td>1.26 (0.87 to 1.83)</td>
<td>1.18 (0.803 to 1.73)</td>
<td>.56</td>
<td></td>
</tr>
</tbody>
</table>

HR = hazard ratio; CI = confidence interval; C = current and past smokers.
association between sedentary behaviors, measured by combining hours reported for television viewing, computer games, and Internet use, and high systolic BP, though this was not statistically significant. The relatively small sample size and short follow-up might account for the lack of statistical significance. In the CARDIA Study, TV viewing was not associated with the prevalence of HTN among 4280 young adults. Finally, another cross-sectional analysis of 15,515 participants in the EPIC-Norfolk cohort found a direct association between hours of TV viewing and levels of systolic and diastolic BP.

Several mechanisms could explain the observed association. First, sedentary behavior was linked to metabolic syndrome as a whole, and not only to the risk of HTN, suggesting a possible common mechanism, such as weight gain secondary to sedentary behaviors. Evidence from randomized, controlled intervention studies showed that a reduction in television, videotape, and video game use can count for the lack of statistical significance. In the EPIC-Norfolk cohort we observed a direct association between hours of TV viewing and levels of systolic and diastolic BP.

We observed an association between interactive sedentary behavior (driving and computer use) and the risk of HTN, but no association for noninteractive sedentary behavior. Physical activity, alcohol use, and other lifestyle variables could partially explain the observed inverse association. Although we cannot rule out the existence of unmeasured confounders, we adjusted our analyses for the most important known risk factors for hypertension, including physical activity, alcohol use, and other lifestyle variables such as smoking, which could act as markers of a generally healthier lifestyle. It is difficult to think of an unknown risk factor that could account for the observed increased risk among those with higher levels of interactive sedentary behavior. Although we validated most of the information in the questionnaires, sodium intake is not considered a reliable measure of BP at follow-up, though measurement of reactivity is not a useful clinical index of the course of future BP.

Changes in baroreceptor reflex sensitivity could account for the observed association. Tasks involving interaction (the detection of external stimuli) are associated with an increase in cardiac baroreceptor parameters, whereas cognitive elaboration (mental arithmetic, memory, and counting tasks) is associated with a reliable decrease in baroreceptor reflex sensitivity. Also, changes in respiratory pattern could modify baroreceptor reflex sensitivity. Abdominal breathing, produced mainly through diaphragm contraction, was suggested to reduce BP levels. Mental stress could lead to abdominal muscle contraction and to thoracic breathing, with shallow breathing and a faster rate. In the long term, this state might affect the sympathetic/parasympathetic balance and eventually raise BP levels. The mechanism involved could be related to adrenergic secretion by the adrenal gland or even renin secretion, also connected to the BP neurologic regulatory system.

Although a previous prospective study showed an association between TV viewing and incidence of obesity and type 2 diabetes, we did not find a similar association for incident HTN. Measurement error in our questionnaire, the use of a different outcome, and heterogeneity in the studied populations could explain the inconsistency.

There are some limitations in our study. First, our outcome is self-reported. However, abundant evidence indicates that self-reported information about HTN diagnosis is valid for epidemiologic studies, particularly among highly educated populations. Given the high educational level of our participants and access to universal healthcare in the Spanish population, we can assume the validity of self-reported HTN diagnoses. In fact, considering a medical diagnosis of HTN as the outcome, instead of using single BP measurements, decreases the chance of finding false positives. In a validation study conducted in a randomly selected subsample of our cohort, we observed acceptable positive and negative predictive values for self-reported medical diagnoses of hypertension, even when our gold standard, which was a repeated direct measurement, missed true cases of hypertension. Nevertheless, some degree of information bias most likely exists. This could be an important problem if those who engage more frequently in sedentary behavior receive closer medical attention, because it would be easier for them to be diagnosed as hypertensive compared with those who are less sedentary.

Secondly, residual or unmeasured confounding could explain the observed association. Those who devote fewer hours to sedentary behavior may have a healthier lifestyle. Although we cannot rule out the existence of unmeasured confounders, we adjusted our analyses for the most important known risk factors for hypertension, including physical activity, alcohol use, and other lifestyle variables such as smoking, which could act as markers of a generally healthier lifestyle. It is difficult to think of an unknown risk factor that could account for the observed increased risk among those with higher levels of interactive sedentary behavior. Although we validated most of the information in the questionnaires, sodium intake is not easily measured with food-frequency questionnaires, and could partially explain the observed inverse association. Certainly, adjustment for an imperfectly measured confounder could still lead to residual confounding. However, when we adjusted for the relevant set of confounders, the estimates for sedentary behavior went away from the null value. If residual confounding explained our results, then the expected change in estimates after adjustment would have been toward the null, and not away.
also play a role in the primary prevention of HTN, though further studies are needed, and the exact biological mechanism explaining the role of interactive sedentary behaviors in BP changes must be elucidated.

Acknowledgments

We thank the participants in the Seguimiento Universidad de Navarra (SUN) Study. We also thank Prof. Ricardo Uauy for his assistance, Prof. Esteban Santiago for his ideas and encouragement, and Dr. Gustavo Reyes del Paso for sharing his research with us.

References

AUTHOR QUERIES

AUTHOR PLEASE ANSWER ALL QUERIES

AQ8— Please explain meaning of asterisk in footnote (Table 2).
AQ9— Please spell out, or explain meaning of “#” in footnote (Table 2).
AQ10— “C” okay as spelled out (Table 2)?
AQ1— Are city names correct for grant sponsors?
AQ2— “effect modification” or “modification of effect”?
AQ3— Please spell out CARDIA.
AQ4— “generally healthier” or “generally less healthy”?
AQ5— “went away” or “diverged”?
AQ6— Please list all authors in Refs 5, 8, 12, 15, 16, 21, 27, and 31.
AQ7— Please add volume and page numbers. Year “2006” okay?