CHEST

Sleep Patterns and Hypertension Using Actigraphy in the Hispanic Community Health Study/Study of Latinos

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BACKGROUND: The aim of this study was to evaluate the association between actigraphy-based measures of sleep and prevalent hypertension in a sample of US Latinos.

METHODS: We analyzed data from 2,148 participants of the Sueño Sleep Ancillary Study of the Hispanic Community Health Study/Study of Latinos (HCHS/SOL), who underwent 1 week of wrist actigraphy to characterize sleep duration, sleep efficiency, sleep fragmentation index, and daytime naps. Insomnia was defined as an Insomnia Severity Index $\geq$ 15. Hypertension was defined based on self-reported physician diagnosis. Survey linear regression was used to evaluate the association of sleep measures with hypertension prevalence. Sensitivity analyses excluded participants with an apnea-hypopnea index (AHI) $\geq$ 15 events/h.

RESULTS: The mean age was 46.3 $\pm$ 11.6 years, and 65% of the sample consisted of women. The mean sleep duration was 6.7 $\pm$ 1.1 hours. Thirty-two percent of the sample had hypertension. After adjusting for age, sex, ethnic background, site, and AHI, each 10% reduction in sleep efficiency was associated with a 7.5% (95% CI, −12.9 to −2.2; $P = .0061$) greater hypertension prevalence, each 10% increase in sleep fragmentation index was associated with a 5.2% (95% CI, 1.4-8.9; $P = .0071$) greater hypertension prevalence, and frequent napping was associated with a 11.6% greater hypertension prevalence (95% CI, 5.5-17.7; $P = .0002$). In contrast, actigraphy-defined sleep duration ($P = .20$) and insomnia ($P = .17$) were not associated with hypertension. These findings persisted after excluding participants with an AHI $\geq$ 15 events/h.

CONCLUSIONS: Independent of sleep-disordered breathing, we observed associations between reduced sleep continuity and daytime napping, but not short sleep duration, and prevalent hypertension.

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KEY WORDS: Hispanic; hypertension; insomnia; sleep duration; sleep quality

ABBREVIATIONS: AHI = apnea-hypopnea index; HCHS/SOL = Hispanic Community Health Study/Study of Latinos; SDB = sleep-disordered breathing

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Hypertension affects approximately 26.4% of the adult population worldwide and is expected to affect 1.5 billion people by the year 2025.[1-4] Nearly 13.5% of all deaths associated with chronic disease and half of all strokes are attributed to hypertension.[3,4] Of importance, self-reports of short and long sleep durations are associated with increased risk of early mortality,[5,6] stroke, and hypertension.[6-10] Similarly, insomnia, a common sleep disorder seen in up to 15% of the US adult population, is associated with hypertension in some but not all studies.[11] However, most studies do not account for the confounding influence of sleep-disordered breathing (SDB), a known cause of hypertension.[12] In addition, self-reported sleep has been found to correlate only modestly with objectively measured sleep.[13-15] There is a paucity of studies evaluating sleep duration with actigraphy, which provides a better estimate of sleep duration and simultaneously allows evaluation of additional dimensions of sleep continuity (sleep efficiency and sleep fragmentation index), as well as daytime napping.[2,16]

This study evaluates the cross-sectional association between actigraphy-defined sleep measures and prevalent hypertension independent of SDB in a diverse and large sample of Latinos, a group with a greater than twofold risk of stroke and a large burden of vascular disease.[3,17-19] Latinos are one of the fastest-growing minorities in the United States, which has vast implications for US morbidity and health-care costs. Therefore, it is imperative to identify and address Latino-specific health needs.[6,17-19] Our primary hypothesis is that shorter sleep duration is associated with prevalent hypertension independent of SDB. Prior studies showed the strongest associations between self-reported short sleep and hypertension among women.[4,10] Therefore, we further evaluated sex as a moderator between short sleep and hypertension; we hypothesized that an association was stronger for women. Our secondary hypothesis was that measures of poor sleep quality (increased sleep fragmentation, decreased sleep efficiency, daytime napping, and insomnia) would also be associated with prevalent hypertension.

Methods

Population

Hispanic Community Health Study/Study of Latinos: The Hispanic Community Health Study/Study of Latinos (HCHS/SOL) is a multicenter community-based cohort study examining the prevalence of and risk factors for chronic disease among 16,145 Hispanic/Latino adults from four urban areas (Bronx NY, Miami FL, Chicago IL, San Diego CA). Demographics, socioeconomic status, lifestyle habits, and medical history were collected during baseline assessments from 2008 through 2011.[20] This examination included an assessment of SDB with an unattended sleep apnea study (ARES Unicorder 5.2; B-Alert) obtained at home for one night, from which the apnea-hypopnea index (AHI) was measured, as previously described.[21]

Analytic sample: Sueño Ancillary Study: This study analyzed data from the Sueño Ancillary Study, which was designed to obtain further in-depth information on sleep habits through questionnaires and actigraphy in a subsample of 2,252 HCHS/SOL participants aged 18 to 64 years without severe sleep disorders from the years 2010 to 2013.[22,23] There were 2,189 eligible participants in Sueño; 33 were excluded because they did not have at least 5 valid days of actigraphy, and eight were excluded for lack of hypertension data, leaving 2,148 for basic age- and sex-adjusted analyses. For multivariable analyses, there were 34 people with a missing covariate value who were removed from analyses, primarily due to lack of information from the sleep study monitor to calculate AHI. Both the baseline HCHS/SOL and the Sueño assessments were approved by the institutional review boards at each of the participating sites, and all participants provided written informed consent (e-Appendix 1).

Dependent Variable: Prevalent Hypertension

Hypertension was based on the self-report of a physician diagnosis of hypertension at the time of the Sueño examination. The Sueño definition was consistent ($P < .0001$) with the HCHS/SOL baseline definition of hypertension, which was based on a systolic BP $\geq$ 140 mm Hg or a diastolic BP $\geq$ 90 mm Hg or the use of antihypertensive medication. During baseline assessments, BP was measured on the participant's right arm while seated and rested for 5 minutes using an automated sphygmomanometer (Omron HEM-907 XL, Omron Healthcare, Inc.). The cuff size was matched to the participant using the measure of his/her upper arm circumference. Three sets of 1-min spaced BP measurements were taken from each participant (99% completion rate).[3]

Main Exposures: Sleep Duration, Sleep Continuity, and Daytime Napping

Seven days of wrist actigraphy with an Actiwatch Spectrum (Philips Respironics) was used to estimate sleep.[22,23] Participants wore the

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actigraph on the nondominant wrist. Activity and light data, along with a sleep diary for each day, were collected throughout this period in 30-s epochs. Rest-sleep periods were identified using a standardized protocol and validated scoring algorithm alongside polysomnography on an epoch by epoch basis.[22-24] Five or more days were considered valid actigraphy data. We then assessed sleep habits in the domains of sleep duration (sleep during the primary sleep period) and sleep continuity (sleep efficiency and sleep fragmentation index) as previously defined.[22,25] Frequent daytime napping was a dichotomous variable defined as two naps or more of 15-min duration over all valid data. Average sleep duration, sleep efficiency, and sleep fragmentation index were calculated by averaging across all nights of valid data.[24]

For analytic purposes, sleep duration was modeled continuously. We also evaluated for a nonlinear association by categorizing sleep duration (< 5 hours, 5-5.99 hours, 6-6.99 hours, 7-7.99 hours, 8-8.99 hours, ≥ 9 hours). Sleep efficiency and sleep fragmentation index were modeled continuously. Insomnia was assessed using the Insomnia Severity Index, which is a seven-item instrument designed to assess the impact of insomnia in community-based populations that has been validated in both English and Spanish.[26,27] Insomnia was defined as an Insomnia Severity Index score ≥ 15. This threshold has an 86.1% sensitivity and 87.7% specificity for detecting insomnia cases.[23]

Statistical Analysis

All analyses accounted for sampling weights, clustering, and the stratified sampling study design. Age- and sex-adjusted means of sleep measures by hypertension status were standardized to 2010 US census data. Multivariable modeling using survey linear regression was used to model hypertension status as a function of sleep measures adjusting for age, sex, ethnic background, site, and AHI. Effect modification of relationships by sex was assessed using a sex by sleep measure interaction term. A sensitivity analysis was conducted by repeating all analyses on a restricted subsample of 1,833 subjects without moderate to severe SDB (AHI < 15 events/h). All P values were based on two-tailed testing, with $P < .05$ considered significant. All analyses were completed using SAS, version 9.3 (SAS Institute).

Results

The mean age was 46.3 ± 11.6 years, with 65% being women. The majority of the sample had a Mexican background (26.7%), followed by Puerto Rican (21.0%), Cuban (18%), Central American (13.5%), Dominican (12.5%), and South American (8.2%). Thirty-two percent of the sample had prevalent hypertension (n = 678). e-Table 1 shows the characteristics of the initial Sueño sample.

In age- and sex-adjusted analyses, participants with hypertension had no difference in mean sleep duration (6.62 hours vs 6.72 hours) compared with participants without hypertension. Similarly, the distribution of sleep duration considered categorically did not vary by hypertension status ($P = .39$). However, participants with hypertension had an increased sleep fragmentation index, decreased sleep efficiency, increased frequency of naps, and increased moderate to severe SDB compared with participants without hypertension (Table 1). After additional adjustment for ethnic background, site, and AHI, participants with hypertension continued to have lower sleep efficiency, a higher sleep fragmentation index, and increased prevalence of daytime napping (Table 2). In contrast, the association between insomnia and hypertension disappeared after adjustment for AHI. This pattern of associations persisted after excluding participants with moderate to severe SDB, with a mostly unchanged effect size for sleep efficiency, sleep fragmentation index, and daytime napping (Table 3). The associations between sleep duration, sleep efficiency, sleep fragmentation index, and daytime napping and hypertension were similar in men and women ($P > .05$ for all interactions).

Discussion

We observed that actigraphy-defined sleep fragmentation, sleep efficiency, and naps were associated with prevalent hypertension in a diverse sample of Latinos in the United States. Conversely, there were no associations between actigraphy-defined sleep duration, reported insomnia severity, and hypertension. Our findings are in contrast to population-based studies

TABLE 1] Sleep Differences Across Categories of Hypertension Standardized by Age and Sex According to the 2010 US Census in the Sleep Ancillary to the Hispanic Community Health Study/Study of Latinos

Variable	Hypertension	No Hypertension	*P* Value
Sleep duration, h	6.62 (0.06)	6.72 (0.04)	.13
Sleep fragmentation index, No. (%)	23.0 (0.5)	21.4 (0.3)	.004
Sleep efficiency, No. (%)	87.4 (0.3)	88.4 (0.2)	.007
Insomnia, No. (%)	20.6 (2.4)	14.0 (1.1)	.01
Frequent napping, No. (%)	30.4 (3.1)	23.5 (1.4)	.03
Moderate-severe sleep apnea, No. (%)	15.4 (2.5)	4.8 (0.7)	< .0001

Values expressed as mean or prevalence (SEM). Insomnia defined as Insomnia Severity Index ≥ 15. Frequent napping defined as > two naps of 15 min or more. Moderate to severe sleep apnea defined as apnea-hypopnea index ≥ 15 events/h.

TABLE 2] Adjusted Prevalence Differences in Hypertension Associated With Sleep Measures in the Sleep Ancillary Study to the Hispanic Community Health Study/Study of Latinos

Variable	Beta (SE)	95% CI	*P* Value
Sleep duration (per h increase)	−1.6 (1.2)	−4.0 to 0.8	.1992
Sleep fragmentation index (per 10% increase)	5.2 (1.9)	1.4-8.9	.0071
Sleep efficiency (per 10% increase)	−7.5 (2.7)	−12.9 to −2.2	.0061
Insomnia (vs no insomnia)[a]	4.6 (3.4)	−2.0 to 11.2	.1677
Frequent napping (vs none-frequent napping)	11.6 (3.1)	5.5-17.7	.0002

Models adjusted for age, sex, ethnic background, site and apnea-hypopnea index (n = 2,144).
[a]n = 2,111 based on missing information for insomnia symptoms.

showing associations between self-reports of short sleep duration and hypertension, particularly in adults < 65 years of age. Of interest, the Coronary Artery Risk Development in young Adults (CARDIA) study found associations between actigraphy-defined short sleep duration and prevalent as well as incident hypertension. However, CARDIA did not control for SDB, whereas our findings with sleep continuity remained after accounting for it.[28] Similar to our study, a multiethnic cohort of middle-aged individuals showed associations between actigraphy-defined sleep continuity, but not sleep duration, and prevalent hypertension.[29]

In other population-based studies, self-reported short sleep duration had stronger effects on hypertension in female participants.[1,4,30,31] However, sex did not moderate associations between sleep duration and hypertension in our sample. Women have higher levels of non-rapid eye movement sleep, a sleep stage associated with the normal dipping of nighttime BP.[4] Hence short sleep, and consequently decreased amounts of non-rapid eye movement sleep, may lead to hypertension by disrupting the normal nighttime dipping of BP.[20] Although we did not observe sex differences in sleep duration and hypertension, our analysis provided the opportunity to evaluate multiple dimensions of sleep with objective measures of sleep duration, sleep continuity, and daytime napping. Differing from studies with self-reported data, our findings suggest independent effects on hypertension by sleep continuity not explained by sleep duration or the interaction between sleep duration and sex.

Of interest, various studies have shown that poor sleep quality is associated with lack of the dipping of BP, potentially due to increased sympathetic tone.[11,32,33] This mechanism may explain the associations between sleep continuity and hypertension in our sample. There is a paucity of studies with actigraphy-defined naps and hypertension. In our study, daytime napping was associated with prevalent hypertension. Our findings are consistent with a meta-analysis of nine cross-sectional studies (N = 112,267), in which self-reported daytime napping was associated with prevalent hypertension (OR, 1.19; 95% CI, 1.06-1.35).[34] Some studies suggest that > 60-min naps several times per week can increase cardiovascular disease, especially in older adults.[35] There is a paucity of studies evaluating actigraphy-defined naps, and prior studies are limited by self-reports, which did not adjust for SDB or sleep duration.[35] The mechanism by which daytime napping may be associated with hypertension is largely unknown.[34,35]

TABLE 3] Prevalence Differences in Hypertension Associated With Sleep Measures Among Participants Without Moderate to Severe Sleep Disordered Breathing

Variable	Beta (SE)	95% CI	*P* Value
Mean sleep duration (per h increase)	-1.5 (1.3)	−4.1 to 1.1	.2693
Mean sleep fragmentation index (per 10% increase)	5.2 (2.0)	1.2- 9.1	.0099
Mean sleep efficiency (per 10% increase)	−7.2 (2.9)	−12.8 to −1.5	.0128
Insomnia (vs no insomnia)[a]	3.6 (3.2)	−2.7 to 9.8	.2657
Frequent napping (vs none-frequent napping)	11.8 (3.2)	5.6-18.1	.0002

Models adjusted for age, sex, ethnic background, site, and apnea-hypopnea index (n = 1,930). Moderate to severe sleep-disordered breathing defined as apnea-hypopnea index < 15 events/h.
[a]n = 1,927 based on missing information for insomnia symptoms.

Short sleep and poor sleep quality can lead to daytime naps. Conversely, daytime naps can delay sleep onset, decreasing the homeostatic sleep drive.[34,36] Hence, daytime naps might be a surrogate or cause for insufficient sleep increasing hypertension through either short sleep or poor sleep quality. Alternatively, as with morning awakenings, rising from a prolonged daytime nap could transiently increase the sympathetic tone, resulting in BP surges.[37-39] Studies with actigraphy-defined sleep duration, daytime napping, and 24-hour BP monitoring can provide further information about the mechanisms and potential interventions in sleep and hypertension.

Of interest, the Insomnia Severity Index was not associated with prevalent hypertension in fully adjusted models. Chronic insomnia has been shown to increase the nighttime systolic BP and blunted dipping of BP in young adults.[11] However, results from population-based studies have been inconsistent and may be the result of different insomnia phenotypes.[40-42] Insomnia with objective short or fragmented sleep duration has been linked to worse cardiometabolic outcomes (eg, hypertension, diabetes, myocardial infarction) through its association with an overactive hypothalamic-pituitary-adrenal axis.[43] For example, in a recent meta-analysis, participants with insomnia symptoms and short sleep duration, disturbed sleep continuity, or early-morning awakenings had increased incident hypertension.[44] In contrast, insomnia complaints with normal sleep duration have been linked to psychological distress. Thus, our null findings could be partly explained by the use of the Insomnia Severity Index,[26] which queries insomnia symptoms irrespective of sleep duration. Finally, insomnia with short sleep duration may associate with hypertension by way of increased sympathetic tone, a pathophysiology shared with SDB, which may also explain the null findings observed in the Sueño sample.[11]

Our study has several strengths. The study is a large multicenter population-based study that included English- and Spanish-speaking participants of diverse Latino backgrounds. There are few studies with actigraphy-determined sleep, daytime napping, and hypertension. Actigraphy was administered for at least 5 days, using a validated algorithm to minimize variability of scores.[24] We also obtained systematic measurements of sleep and SDB with validated questionnaires.

Our study also has several limitations. First, the study is cross-sectional, which does not allow inferences about causality. Our sample was drawn from Latinos in urban areas; therefore, our results may not be applicable to other ethnic groups or Latinos living in rural areas.

Conclusions

We observed that sleep domains, such as sleep quality, fragmentation, and nap frequency, were associated with hypertension. These findings suggest that interventions to improve sleep quality could be an efficient public health tool to fight the clinical consequences of sleep disturbance.

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Additional information: The e-Appendix and e-Table can be found in the Supplemental Materials section of the online article.

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