



Original Article

The association of sleep duration and feeling rested with health in U.S. Hispanic women

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ABSTRACT

This study aims to understand the health correlates of sleep deficiencies in non-elderly U.S. Hispanic¹ women. Data from a sample of U.S. Hispanic women ($n = 1531$; ages 18–65 [$M = 39.98$; $SD = 12.85$]) who completed the 2017 National Health Interview Survey were analyzed to understand (1) sleep duration and quality; (2) the association of sleep patterns with key health indicators; and (3) whether these relationships are mediated by health behaviors (ie, healthy eating and physical activity). Shorter sleep duration was associated with a higher likelihood of often feeling anxious and having hypertension. Worse sleep quality was associated with a higher likelihood of being overweight, having fair or poor health status, often feeling depressed, often feeling anxious, having high cholesterol, and having asthma. Doctor's recommendation to engage in physical activity and to decrease calorie intake served as mediators in some of these relationships. Results indicate that among Hispanic women: (1) sleep is an important determinant of a variety of health outcomes and (2) the association of sleep and many health outcomes are mediated by healthy eating and physical activity. Further research on the association of sleep and risk of chronic disease among Hispanic women is needed.

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Sleep is critical to physical and mental health [1–3]. In the general population, poor sleep quantity and quality contribute to the burden of chronic conditions such as high blood pressure, obesity, diabetes, cardiovascular disease, depression, and anxiety [1,3]. These health issues are to a great extent preventable and disproportionately prevalent among Hispanic women [4,5]. By 2050, Hispanic women will be 25% of the U.S. female population; accordingly, understanding sleep patterns for Hispanic women and how sleep may be associated to physical and mental health outcomes in this population is crucial to unpacking health disparities [6,7].

For Hispanics as a whole (not disaggregated by gender), both sleep quantity and quality are important determinants of health behaviors and consequently health [4,8]. Sleep disturbances have been linked to limited engagement in health promoting behaviors

such as healthy eating and physical activity [8–12]. Sleep disturbances in Hispanics are also associated with obesity [10,13–17], hypertension [13,14,18–20], and diabetes [14,19,21–25]. These risk factors, in turn, are known to predict cardiovascular disease and cancer [25,26].

In Hispanics, health behaviors such as healthy eating and engagement in physical activity are linked to physical and mental health outcomes such as depression, heart disease, stroke, diabetes, and cancer [27–29]. Given that sleep predicts engagement in health promoting behaviors and health promoting behaviors are linked to health outcomes, it is likely that health behaviors such as physical activity and healthy eating may act as mediators between sleep disturbances and the health disparities experienced by Hispanic women.

Hispanic women may experience different barriers to healthy sleep than men due to a combination of biological, social, and cultural differences, which can be lost in gender-aggregated data [30,31]. As an example, literature on the general population (ie, not exclusive to Hispanics) shows that distinct hormonal changes before menstruation, during pregnancy, and after menopause can lead to gender-specific sleep disorders in women [30]. In addition, psychosocial issues, such as the disproportionate burden of

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¹ The term “Hispanic” refers to people who speak Spanish and/or are descended from Spanish-speaking populations. The term Hispanic was used in this manuscript as it best aligns with the demographic question used in the main study from which this study is derived (ie, 2017 National Health Interview Survey).

caregiving on women, tend to impact women's health more significantly than men's health [32–34]. Yet, most studies investigating the association of sleep disturbances with health in Hispanics are not disaggregated by gender [2,17]. The identification of important within-group differences among Hispanics in their sleep patterns and health may be obscured when data is reported as an aggregate [25].

Hispanic women report significantly greater number of and higher severity scores of sleep-related symptoms than non-Hispanic White (NHW) women [9,36]. It is estimated that 25% of Hispanic women have some sleep-disordered breathing problems [19]. Moreover, research on the Multi-Ethnic Study of Atherosclerosis national dataset shows that Hispanic women tend to have shorter sleep duration than NHW women [37]. Habitual snoring (31.1%) and sleep-disordered breathing are also high among Hispanic women [19,37]. Additionally, Makarem et al. [38] showed that, in Hispanic women, poor sleep quality, insomnia, snoring, and risk for obstructive sleep apnea are associated with poorer cardiovascular health scores. These studies, and others, call for further research to corroborate these findings [4].

This project seeks to address this call by understanding: (1) sleep patterns in U.S. Hispanic women; (2) whether sleep patterns in Hispanic women are associated to health outcomes; and (3) whether these relationships are mediated by engagement in physical activity [PA] and by being told by a doctor or health professional to engage in health promoting behaviors (ie, being told to increase PA and decrease calorie intake).

1. Methods

1.1. Participants

The National Health Interview Survey (NHIS) is an annual, cross-sectional, nationally representative source of data on a broad range of health topics in U.S. community-dwelling adults, which is conducted by U.S. National Center for Health Statistics [39]. The 2017 release of the NHIS was used in this study. This study was exempt from human subjects review.

A total of 26,742 adults were surveyed in the 2017 NHIS. There were 1531 Hispanic women participants aging from 18 to 65 years ($M = 39.38$, $SD = 12.85$) included in this study. Most participants (59.3%) were Mexican or Mexican–American (see Table 1 for details). Participants reported being of the following races: White (87.1%), Black/African American (4.8%), American Indian/Alaska Native (2.7%), Asian (2.4%), Multiple Race (2.8%), Other/did not respond (0.2%). Of the participants, 52.7% were either married or currently living with a partner; 26% were never married; 12% were divorced; 5.9% were separated; and 3.4% were widowed. About a quarter (25.1%) of participants reported less than high school education. The majority of participants had held a job the week (64.5%) and year (70.9%) prior to the survey. In terms of annual family income, a bit over half (55.9%) of participants were from a low to middle-income background (under \$49,999/year).

1.2. Measures

All measures used in this study were self-report. Measures come from the Sample Adult, Person, and Functioning and Disability files of the 2017 NHIS dataset. NHIS interviews were conducted in English or Spanish, based on participants' preference.

1.2.1. Predictor variables: sleep patterns

Sleep duration and sleep quality were two indicators of sleep patterns used in the present investigation. To assess sleep duration,

Table 1

Demographic characteristics of the adult Latina sample ($n = 1531$).

Characteristic	<i>n</i>	%
Hispanic origin or ancestry		
Multiple Hispanic	30	2.0
Puerto Rico	180	11.8
Mexican	521	34.0
Mexican American	387	25.3
Cuban/Cuban American	65	4.2
Dominican (Republic)	52	3.4
Central or South American	248	16.2
Other Latin American	5	0.3
Other Spanish	43	2.8
Race		
White only	1333	87.1
Black/African American	74	4.8
American Indian/Alaska Native	41	2.7
Asian	37	2.4
Multiple race	43	2.8
Other/did not respond	3	0.2
Marital status		
Married	676	44.2
Widowed	52	3.4
Divorced	184	12.0
Separated	90	5.9
Never married	398	26.0
Living with partner	130	8.5
Annual family income		
\$0–34,999	667	43.6
\$35,000–49,999	188	12.3
\$50,000–74,999	238	15.5
\$75,000–99,999	118	7.7
\$100,000 and over	188	12.3
Other/did not respond	132	8.6
Employment status in the prior week and prior year		
Had job last week	987	64.5
No job last week, had job past 12 months	98	6.4
No job last week, no job past 12 months	250	16.3
Never worked	196	12.8
Highest level of school completed		
Elementary school (up to fifth grade)	57	3.6
Junior high/middle school (sixth–eighth grade)	117	7.7
High school, no degree	212	13.8
High school	356	23.3
Some college, no degree	318	20.8
2-year college (associate degree)	180	11.8
4-year college/university	197	12.9
Professional/graduate school	89	5.8
Other/did not respond	5	0.3

participants were asked: “On average, how many hours of sleep do you get in a 24-h period?” To assess sleep quality, participants were asked, “In the past week, on how many days did you wake up feeling well-rested?” More well-rested days was interpreted as better sleep quality.

1.2.2. Outcome variables: health status

Participants were asked to rate their health status (“How would you rate your health?”) on a 5-point Likert scale that ranged from 1 (Excellent) to 5 (poor). This measure of health status is frequently used and a valid predictor of mortality [40,41]. In line with previous research (eg, Refs. 40,42,43), we transformed it into a dichotomous indicator by combining the ‘excellent,’ ‘very good,’ and ‘good’ categories (coded 0) and the ‘fair’ and ‘poor’ categories (coded 1). This practice also avoided any category with a very small size (eg, only 2.9% reported ‘poor’).

1.2.3. Body mass index (BMI)

BMI was reported by participants. Based on recommendations by the CDC [1], we categorized BMI into underweight (below

18.5 kg/m²), normal or healthy weight (18.5–24.95 kg/m²), and overweight or obese (255 kg/m² and above).

1.2.4. Health conditions

Participants also answered the following four dichotomous questions: “Have you ever been told you have [hypertension/asthma/high cholesterol/diabetes] by a doctor or other health professional?” (with possible answers yes = 1 and no = 0). Additionally, two mental health questions were asked: “How often do you feel depressed?” and “How often do you feel worried, nervous, or anxious?” Each question was rated on a 5-point scale: 1 (Daily), 2 (Weekly), 3 (Monthly), 4 (A few times a year), and 5 (Never). Responses were then recoded into “often depressed” if participants reported daily or weekly feelings of depression [44], or “not often depressed” if participants reported feeling depressed monthly/a few times a year/never. The “often anxious” variable was created following the same rule.

1.2.5. Mediators: health behaviors

Participants were asked to report whether they had been told by a doctor or health professional to increase PA and to reduce fat/calories in their diet, in the past 12 months (with possible answers yes = 1 and no = 0). Additionally, we included as a mediator whether participants met light/moderate and vigorous leisure-time PA guidelines [29], that is, whether participants performed light- or moderate-intensity PA for at least 150 min per week, or 75 min per week of vigorous-intensity activity (yes = 1 and no = 0).

1.3. Overview of statistical analyses

Path models were conducted using *Mplus* software v7.4 to examine the associations between sleep and health, as well as the mediation effects of health behaviors [45]. Notably, while portions of missing values were very small or negligible in most studied variables, there were 52.9% missing data in the depression and 52.6% missing data in the anxiety indicators. As described by NHIS [46], about half of the adult samples were randomly selected to answer questions in the Functioning and Disability section. In other words, these were planned random missing [47]. To accommodate this issue and the categorical feature of outcome variables, a robust maximum likelihood estimator (MLR) with Monte-Carlo integration was applied [45]. MLR incorporates the Yuan–Bentler correction [48] and uses a sandwich estimator [49], which can avoid listwise deletion and generate robust standard errors in the analyses. The estimates of direct and indirect effect are typically used for investigating mediation effects [50], but indirect effect estimates are not available for analyses using a numerical integration algorithm in *Mplus*. Alternatively, mediation effects were analyzed through stepwise models [51,52] and indirect effect calculated by the Sobel test [53,54]. Of note is that the current study is a secondary analysis of existing data rather than a pre-designed study, so the large analytic sample could produce too much statistical power in detecting significances of certain relations.

2. Results

Descriptive statistics for sleep, health, and health behavior variables are presented in Table 2. The average reported sleep duration was 7.01 h/night (*SD* = 1.34). Participants reported feeling rested 3.99 days on average in the past week (*SD* = 2.76). Under a third (30.6%) of participants in this study had a healthy BMI; 1.1% were underweight; and 64.1% were overweight/obese. Given that the very small group size of underweight participants could lead to biased estimates, we removed those participants from the analysis related to BMI. Consequently, BMI resulted in a dichotomous

Table 2

Descriptive statistics for sleep, health, and health behavior.

Continuous variables	<i>M</i>	<i>SD</i>
Average hours of sleep in a 24-h period (sleep duration)	7.01	1.34
Number of feeling rested days in the past week (sleep quality)	3.99	2.76
Categorical variables: frequencies		
	<i>n</i>	%
BMI		
underweight	17	1.1
Normal (code 0)	469	30.6
overweight/obese (code 1)	982	64.1
Health status		
Excellent/very good/good (code 0)	1303	85.1
Fair/poor (code 1)	228	14.9
Ever been told that you have hypertension		
Yes (code 1)	282	18.4
No (code 0)	1246	81.4
Ever been told that you have high cholesterol		
Yes (code 1)	289	18.9
No (code 0)	1236	80.7
Ever been told that you have asthma		
Yes (code 1)	198	12.9
No (code 0)	1333	87.1
Ever been told that you have diabetes		
Yes (code 1)	126	8.2
No (code 0)	1405	91.8
Often feel depressed		
Yes (code 1)	72	4.7
No (code 0)	649	42.4
Missing	810	52.9
Often feel worried, nervous, or anxious		
Yes (code 1)	147	9.6
No (code 0)	578	37.8
Missing	806	52.6
Met physical activity guidelines		
Yes (code 1)	678	44.3
No (code 0)	830	54.2
Told to increase physical activity in the past 12 months		
Yes (code 1)	552	36.1
No (code 0)	978	63.9
Told to reduce fat/calories in diet in the past 12 months		
Yes (code 1)	478	31.2
No (code 0)	1052	68.7

indicator (overweight/obese = 1; healthy weight = 0). Most participants (85.1%) reported having excellent/very good/good health, while 14.9% reported having fair or poor health. Of the participants, the following percentages reported having been told they had the following conditions: 18.4% hypertension; 18.9% high cholesterol; 12.9% asthma; 8.2% diabetes. With regard to mental health, 4.7% of participants often reported often feeling depressed, and 9.6% often reported often feeling worried, nervous, or anxious.

Slightly below half of the participants (44.3%) met the PA guidelines (ie, performed light- or moderate-intensity PA for at least 150 min per week, or 75 min per week of vigorous-intensity activity). About one-third of participants (36.1%) had been told to increase PA in the past 12 months, and 31.2% had been told to reduce fat/calories in their diet in the past 12 months.

2.1. Associations of sleep with health

Sleep duration and sleep quality were significantly correlated ($r = 0.35$, $p < 0.001$), and therefore these two variables were set to be correlated in the path models (see Fig. 1). Given that the underweight cases were removed in the BMI model, BMI results were estimated separately from other outcome variables in order to maximize the utilization of available data.

All coefficient estimates of paths and logistic regression odds ratio (OR) resulting from the baseline models are displayed in Table 3 (model 1 and 2). Greater sleep duration was associated with

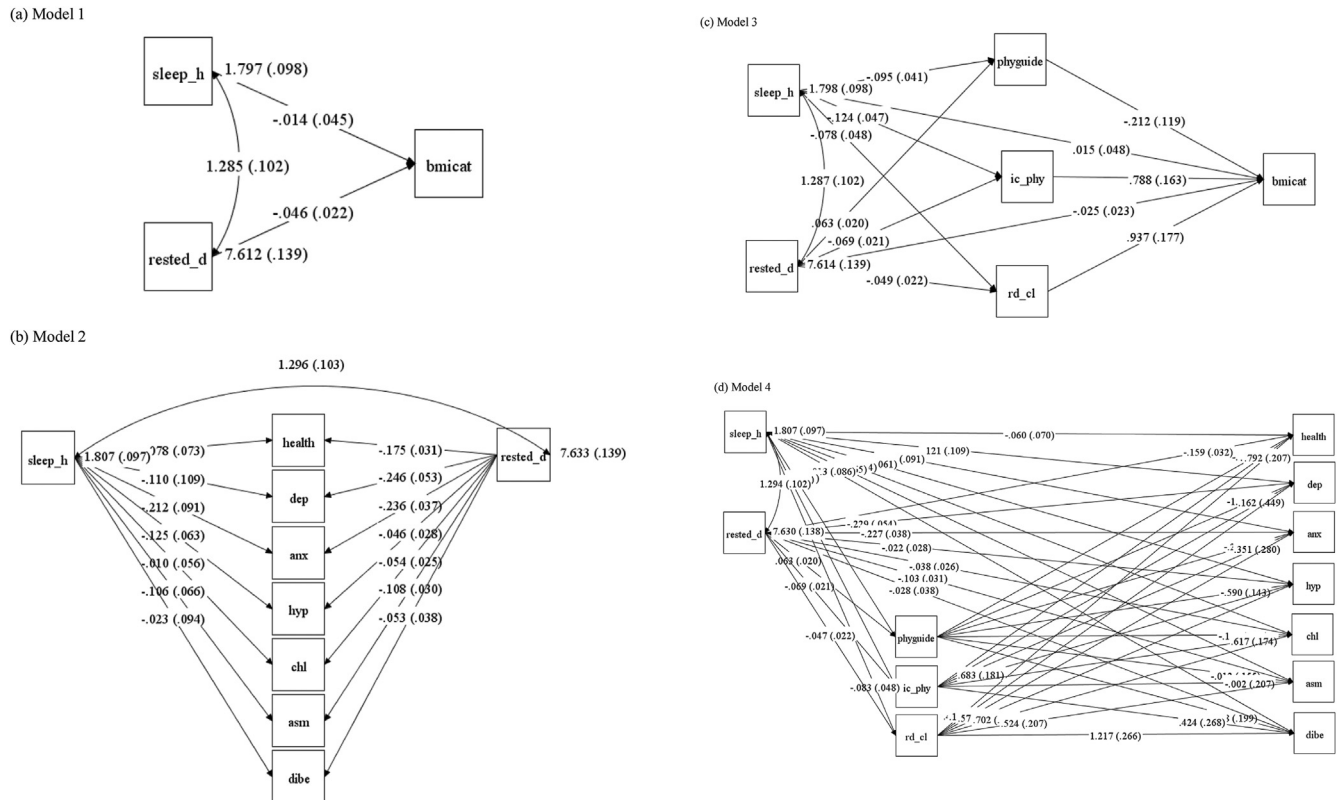


Fig. 1. Configuration of Path Models for Examining Mediation Effects. *Notes:* Specific path coefficients in each model were also presented in Tables 3 and 4. sleep_h = sleep hours; rested_d = well-rested days; phyguide = PA guidelines; ic_phy = being told to increase activities; rd_cl = being told to reduce fat/calories; health = health status; dep = depression; anx = anxious; hyp = hypertension; chl = high cholesterol; asm = asthma; dibe = diabetes.

a lower likelihood of often feeling anxious ($B = -0.21$, $p = 0.02$, $OR = 0.81$) and having hypertension ($B = -0.13$, $p = 0.046$, $OR = 0.88$). Moreover, higher sleep quality was associated with a lower likelihood of being overweight ($B = -0.05$, $p = 0.035$, $OR = 0.96$), having fair or poor health status ($B = -0.18$, $p < 0.001$, $OR = 0.84$), often feeling depressed ($B = -0.25$, $p < 0.001$, $OR = 0.78$), often feeling anxious ($B = -0.24$, $p < 0.001$, $OR = 0.79$), having high cholesterol ($B = -0.05$, $p = 0.033$, $OR = 0.95$), and having asthma ($B = -0.11$, $p < 0.001$, $OR = 0.90$). Neither sleep duration nor quality was significantly related to diabetes.

2.2. Mediation effects of health behaviors

Three health behaviors (ie, meeting physical activity [PA] guidelines, having been told to increase PA, and having been told to reduce fat/calories) were tested as mediators of the association between sleep and health. Table 4 presents the coefficient estimates and odds ratio results of mediation models. Data codes for each category of studied variables are listed in Table 2 as references for interpreting odds ratios. In the previous section, we built the baseline models (Fig. 1a and b) by testing the relations between independent and outcome variables without mediators. To examine mediation effects, we re-estimated those relations with mediators included (Fig. 1c and d). Full mediation was identified when two conditions were met: first, the indirect effect of an independent variable on an outcome variable via a mediator was significant; second, a direct path from independent variable to

Table 3

Coefficient estimates of direct paths and odds ratio results in the baseline models.

Paths	B	S.E.	p	Odds ratio
Model 1: BMI as an outcome variable (no mediator)				
BMI predicted by				
Sleep hours	−0.01	0.05	0.751	0.96
Rested days	−0.05	0.02	0.035	
Model 2: Health status, depression, anxious, hypertension, high cholesterol, asthma and diabetes as outcome variables (no mediator)				
Health status predicted by				
Sleep hours	−0.08	0.07	0.284	0.84
Rested days	−0.18	0.03	<0.001	
Depression predicted by				
Sleep hours	−0.11	0.11	0.312	0.78
Rested days	−0.25	0.05	<0.001	
Anxiety predicted by				
Sleep hours	−0.21	0.09	0.020	0.81
Rested days	−0.24	0.04	<0.001	0.79
Hypertension predicted by				
Sleep hours	−0.13	0.06	0.046	0.88
Rested days	−0.05	0.03	0.096	
High cholesterol predicted by				
Sleep hours	−0.01	0.06	0.865	0.95
Rested days	−0.05	0.03	0.033	
Asthma predicted by				
Sleep hours	−0.11	0.07	0.110	0.90
Rested days	−0.11	0.03	<0.001	
Diabetes predicted by				
Sleep hours	−0.02	0.09	0.810	
Rested days	−0.05	0.04	0.160	

Notes. Odds ratio results are only presented for significant associations.

Table 4
Coefficient estimates of direct paths and odds ratio results in the mediation models.

Paths	B	S.E.	p	Odds ratio
Model 3: BMI as an outcome variable with three mediators (Meet PA guidelines, Being told to increase PA and Being told to reduce fat/cal)				
BMI predicted by				
Sleep hours	0.02	0.05	0.751	
Rested days	−0.03	0.02	0.277	
Meet PA guidelines	−0.21	0.12	0.075	
Told to increase PA	0.79	0.16	<0.001	2.20
Told to reduce fat/cal	0.94	0.18	<0.001	2.55
Meeting PA guidelines predicted by				
Sleep hours	−0.10	0.04	0.021	0.91
Rested days	0.06	0.02	0.002	1.07
Being told to increase PA predicted by				
Sleep hours	−0.12	0.05	0.009	0.88
Rested days	−0.07	0.02	0.001	0.93
Being told to reduce fat/cal predicted by				
Sleep hours	−0.08	0.05	0.105	
Rested days	−0.05	0.02	0.025	0.95
Model 4: Health status, depression, anxious, hypertension, high cholesterol, asthma and diabetes as outcome variables with three mediators (PA guidelines, Being told to increase PA and Being told to reduce fat/cal)				
Health status predicted by				
Sleep hours	−0.06	0.07	0.391	
Rested days	−0.16	0.03	<0.001	0.85
Meet PA guidelines	−0.85	0.16	<0.001	0.43
Told to increase PA	0.36	0.21	0.083	
Told to reduce fat/cal	0.79	0.21	<0.001	2.21
Depression predicted by				
Sleep hours	−0.12	0.11	0.267	
Rested days	−0.23	0.05	<0.001	0.80
Meet PA guidelines	−1.32	0.32	<0.001	0.27
Told to increase PA	0.16	0.45	0.718	
Told to reduce fat/cal	0.49	0.45	0.273	
Anxious predicted by				
Sleep hours	−0.20	0.09	0.026	0.82
Rested days	−0.23	0.04	<0.001	0.80
Meet PA guidelines	−0.29	0.20	0.154	
Told to increase PA	0.35	0.28	0.210	
Told to reduce fat/cal	0.15	0.29	0.595	
Hypertension predicted by				
Sleep hours	−0.10	0.06	0.104	
Rested days	−0.02	0.03	0.435	
Meet PA guidelines	−0.59	0.14	<0.001	0.55
Told to increase PA	0.68	0.18	<0.001	1.98
Told to reduce fat/cal	0.58	0.18	<0.001	1.78
High cholesterol predicted by				
Sleep hours	0.02	0.05	0.655	
Rested days	−0.04	0.03	0.150	
Meet PA guidelines	−0.14	0.14	0.307	
Told to increase PA	0.62	0.17	<0.001	1.85
Told to reduce fat/cal	0.70	0.17	<0.001	2.02
Asthma predicted by				
Sleep hours	−0.09	0.07	0.155	
Rested days	−0.10	0.03	0.001	0.90
Meet PA guidelines	−0.01	0.16	0.938	
Told to increase PA	0.00	0.21	0.994	
Told to reduce fat/cal	0.52	0.21	0.011	1.69
Diabetes predicted by				
Sleep hours	0.01	0.09	0.876	
Rested days	−0.03	0.04	0.467	
Meet PA guidelines	−0.44	0.20	0.028	0.65
Told to increase PA	0.42	0.27	0.114	
Told to reduce fat/cal	1.22	0.27	<0.001	3.38
Meet PA guidelines predicted by				
Sleep hours	−0.09	0.04	0.022	0.91
Rested days	0.06	0.02	0.002	1.07
Increase activities predicted by				

Table 4 (continued)

Paths	B	S.E.	p	Odds ratio
Sleep hours	−0.12	0.05	0.008	0.88
Rested days	−0.07	0.02	0.001	0.93
Reduce fat/cal predicted by				
Sleep hours	−0.08	0.05	0.082	
Rested days	−0.05	0.02	0.031	0.95

Notes. * $p < 0.05$, ** $p < 0.01$, *** $p < 0.001$. Odds ratio results are only presented for significant associations.

outcome variable in the baseline model turned to be insignificant in the mediation model. If the first condition was met but the direct path remained significant in both baseline and mediation models, partial mediation effect was found. Table 5 summarizes the mediation effects of health behaviors.

2.2.1. Sleep quality and BMI

Worse sleep quality was associated with meeting PA guidelines ($B = 0.06$, $p < 0.05$, $OR = 1.07$), and with a higher likelihood of having been told to increase PA ($B = -0.07$, $p = 0.001$, $OR = 0.93$) and reduce fat/calories ($B = -0.05$, $p = 0.025$, $OR = 0.95$). As can be seen in model 3, while meeting PA guidelines did not predict BMI, the participants who had been told to increase PA ($B = 0.79$, $p < 0.001$, $OR = 2.2$) or told to reduce fat/calories ($B = 0.94$, $p < 0.001$, $OR = 2.55$) had a higher BMI. The association between sleep quality and BMI category turned to be non-significant in the mediation model, and meanwhile the indirect effects of sleep quality on BMI via both mediators were significant (increase PA: $z = -2.72$, $p = 0.007$; reduce fat/cal: $z = -2.05$, $p = 0.040$); thus, being told to increase PA and reduce fat/calories were full mediators in this relationship.

2.2.2. Sleep duration/quality and health status/health conditions

2.2.2.1. Health status. Meeting PA guidelines was associated with a lower likelihood of reporting fair or poor health status ($B = -0.85$, $p < 0.001$, $OR = 0.43$), and being told to reduce fat/calories was associated with a higher likelihood of reporting fair or poor health status ($B = 0.79$, $p < 0.001$, $OR = 0.221$). Being told to increase PA was not significantly associated with health status. Compared to the baseline model estimates, the association between sleep quality and health status only slightly decreased ($\Delta B = 0.02$) and remained significant when mediators were included. Moreover, only the indirect effect of sleep quality on health status via meeting PA guidelines was statistically significant ($z = -2.69$, $p = 0.007$), so meeting PA guidelines had a partial mediation effect on this association.

2.2.2.2. Hypertension. Sleep duration was negatively associated with meeting PA guidelines ($B = -0.09$, $p = 0.022$, $OR = 0.91$) and being told to increase PA ($B = -0.12$, $p = 0.008$, $OR = 0.88$), but not with being told to reduce fat/calories. Meeting PA guidelines and being told to increase PA were negatively associated with hypertension ($B = -0.59$, $p < 0.001$, $OR = 0.55$, and $B = 0.68$, $p < 0.001$, $OR = 1.98$, respectively). The direct path from sleep duration to hypertension in the baseline model ($p = 0.046$) turned to be insignificant in the mediation model ($p = 0.104$), and both indirect effects were statistically significant (PA guidelines: $z = 2.00$, $p = 0.045$; increase PA: $z = -2.16$, $p = 0.031$). Thus, the association

Table 5
Summary of mediation effects of health behaviors.

IV	Mediator	Outcome	Tests of indirect effects			Meeting condition two	Types of mediation
			<i>z</i>	<i>se</i>	<i>p</i>		
Sleep quality	Being told to increase PA	BMI	−2.72	0.02	0.007	yes	Full
Sleep quality	Being told to reduce fat/calories	BMI	−2.05	0.02	0.040	yes	Full
Sleep quality	Meeting PA guidelines	Health status	−2.69	0.02	0.007	no	Partial
Sleep quality	Being told to reduce fat/calories	Health status	−1.87	0.02	0.062	no	Insignificant
Sleep duration	Meeting PA guidelines	Hypertension	2.00	0.03	0.045	yes	Full
Sleep duration	Being told to increase PA	Hypertension	−2.16	0.04	0.031	yes	Full
Sleep quality	Being told to reduce fat/calories	Asthma	−1.63	0.02	0.103	no	Insignificant
Sleep quality	Being told to increase PA	High cholesterol	−2.41	0.02	0.016	yes	Full
Sleep quality	Being told to reduce fat/calories	High cholesterol	−1.89	0.02	0.058	yes	Insignificant
Sleep quality	Meeting PA guidelines	Depression	−2.52	0.03	0.012	no	Partial

Notes. Condition two: a direct path from independent variable to outcome variable in the baseline model (model 1 or 2) turned to be insignificant in the mediation model (model 3 or 4). * $p < 0.05$, ** $p < 0.01$.

between sleep duration and hypertension was fully mediated by these two health behaviors. In addition, being told to reduce fat/calories was merely considered a predictor of hypertension ($B = 0.58$, $p < 0.001$, $OR = 1.78$), and not a mediator of the relationship between sleep duration and hypertension.

2.2.2.3. Asthma. Of the three health behaviors, only being told to reduce fat/calories predicted higher reports of asthma ($B = 0.52$, $p < 0.05$, $OR = 1.69$). Yet, the indirect mediation effect of sleep quality on asthma via being told to reduce fat/calories was not significant (see Table 5).

2.2.2.4. High cholesterol. Being told to increase PA ($B = 0.62$, $p < 0.001$, $OR = 1.85$) and to reduce fat/calories ($B = 0.70$, $p < 0.001$, $OR = 2.02$) were both predictors of high cholesterol. The direct path of sleep quality to high cholesterol in the baseline model ($p = 0.033$) turned to be not significant in the mediation model ($p = 0.15$), and the indirect effect via being told to increase PA was significant, $z = -2.41$, $p = 0.016$. The relation of sleep quality to high cholesterol was fully mediated by being told to increase PA, but the mediation effect via being told to reduce fat/calories was not statistically significant (indirect path: $z = -1.89$, $p = 0.058$).

2.2.2.5. Diabetes. Neither sleep duration nor quality was significantly related to diabetes. Accordingly, we did not continue with the mediation analysis (see Table 4).

2.2.2.6. Mental health (depression/anxiety). The direct effect of sleep quality on depression were significant in both baseline ($p < 0.001$) and mediation ($p < 0.001$) models, and the indirect effect of the relation via meeting PA guidelines was statistically significant, $z = -2.52$, $p = 0.012$. Thus, meeting physical activity guidelines partially mediated the relation of sleep quality to depression ($\Delta B = 0.02$). Being told to increase PA and reduce fat/calories were not predictors of depression. Anxiety was not related to any studied health behaviors, and therefore there was no mediation effect on its association with sleep duration and quality.

3. Discussion

Sleep is important for individuals to meet their full health and well-being potential. Hispanics have persistent, severe, and underdiagnosed sleep disturbances, with serious health consequences such as cardiovascular disease [4,8,25] and cancer [8,26]. Yet, sleep in Hispanics remains understudied, with the mechanisms that link sleep disturbances to health disparities in Hispanics being poorly understood. This study is novel in that it explored (1) sleep patterns among U.S. Hispanic women, (2) whether poor sleep

patterns contribute to the poor health outcomes experienced by Hispanic women, and (3) whether engagement in health promoting behaviors (ie, being told to engage in physical activity and to decrease caloric intake) serves as a pathway between sleep and health outcomes.

Generally, the health status and health conditions of this study's sample are consistent with existing national data. A slightly higher percentage of participants in this study were in the healthy weight range compared to the general Hispanic population [55]. Rates of hypertension, cholesterol, asthma, and diabetes were also lower in this sample when compared to the total Hispanic sample participating in the 2017 NHIS. These differences may be attributed to the vast majority of participants self-identifying as White. It is likely that race may intersect with ethnicity in a way that influences initial health outcomes and health trajectories over time [35] – Hispanics who do not identify as White may be more vulnerable to health disparities because they experience unique racial and ethnic discrimination [56–58]. For this reason, existing literature promotes moving beyond studying Hispanics as a panethnic group and including other variables such as race, country of origin, and acculturation [35].

The percentage of participants who met leisure-time PA guidelines (44.3%) was low, though similar to the national percentage of Hispanic adults who meet federal guidelines for aerobic PA through leisure time activity [46,59,60]. Nearly a third of participants had been told by a doctor or health professional to increase PA and reduce fat/calories in the 12 months prior to the survey – a common recommendation given to Hispanics in the U.S. As demonstrated in prior research, engagement in health promoting behaviors is linked to sleep quality and sleep duration [11]. In this study, sleep quality (ie, having more well-rested days) positively predicted meeting PA guidelines and was inversely associated with being told to increase PA and being told to reduce fat or calories. Sleep duration was negatively associated with meeting PA and being told to increase PA. Given that physical inactivity and unhealthy eating, and consequently overweight/obesity, are major risk factors for cardiovascular disease and other chronic diseases that are highly prevalent in Hispanics, these results warrant attention.

In this study, poor sleep quality was associated with a higher likelihood of being overweight. These results align with existing research showing that sleep variables beyond sleep duration, like wake after sleep onset or intranight instability index, are significant predictors of obesity in Hispanics [13,16]. Being told to engage in health promoting behaviors (PA and healthy eating) were full mediators between sleep quality and BMI; these results are novel contributors to the understanding of sleep and BMI among Hispanic women in the U.S. Surprisingly, this study also showed that

meeting PA guidelines did not mediate the relationship between sleep quality and BMI (as meeting PA did not predict BMI). While, per existing research, objectively derived data on engagement in PA is linked to cardiometabolic markers in Hispanics [61], data used in this study was self-report. Prior research has documented that women with overweight/obesity tend to overestimate their engagement in PA [62–65], which could impact the associations evaluated in this study.

Meanwhile, sleep duration was not associated with BMI in this study. Prior literature shows that the relationship of sleep duration and obesity is differentially distributed among major subgroups of Hispanics. For instance, Knutson and Grandner [14,15] showed that self-reported short sleep duration is linked to a larger body size only in Mexican–Americans (and not ‘Other Hispanics’). This could, in part, explain the results of our study because nearly 40% of this study’s sample was not Mexican or Mexican–American.

Worse sleep quality (and not sleep duration) also appeared to be associated with poorer health status. Results of the Behavioral Risk Factor Surveillance System showed that, in a nationally representative sample, restless sleep was positively associated with poor self-rated health [66]. No studies were found, to date, that look at the association of sleep quality/duration with general, self-reported health status in U.S. Hispanics.

This study showed that neither sleep quality nor sleep duration were significant predictors of diabetes. In general, research on the association of sleep disturbances with diabetes is scarce and contradictory, with some studies showing no association and others showing a significant association [14,22,25]. These results indicate that more research is needed in this area.

In this study, short sleep duration was a predictor of hypertension, as has been evidenced in existing research on Hispanics when not disaggregated by gender [13,14,18]. Yet, results of this study run counter to prior research with Hispanic women, which showed that poorer sleep quality is associated with poorer cardiovascular health [38]. Existing research [38] used the well-established Pittsburgh Sleep Quality Index (PSQI) [67], which, to assess sleep quality, asks, “During the past month, how would you rate your sleep quality overall?” Instead, this study asked about days waking up feeling rested. More research is needed to understand if it is this difference in measurement that is driving inconsistencies in studies’ results.

Results from this study showed that both short sleep duration and feeling rested were predictors of anxiety. Only feeling rested was a predictor of depression. Studies on the link between sleep and mental health are limited. The existing literature associates insomnia and short sleep duration with depression in Hispanic adults [68,69]. Thus far, no existing research appears available that investigates the association of sleep disturbances with anxiety in Hispanics.

3.1. Strengths & limitations

This study has two notable strengths. First, it includes a large, nationally representative sample of Hispanic women, who experience high prevalence of poor sleep duration and quality and yet are understudied in health research. Second, it unveils behavioral mechanisms that may connect sleep with poor health outcomes, responding to a national call to explore health disparity causal pathways in research approaches and study designs [70]. Finally, this study analyzed a large number of sleep and health-related variables to understand their association and, in this way, could be helpful to orient future research.

Although this study has a number of strengths, it also has limitations that warrant discussion. First, this study used NHIS data, which is based on self-report of symptoms and medical conditions. It also included a single-item, self-report of sleep duration and

quality that is not validated with actigraphy or polysomnography may be subject to recall and other response biases [70]. Moreover, single item scores can be less reliable than scales that have shown reliability and validity. While direct physical examination of participants may yield a more accurate estimate of subclinical cases, self-report data can be helpful to estimate disease among individuals with symptoms [40]. In addition, self-report measures of sleep are commonly used because they are low-cost, can be easily administered to national samples, and have been shown to accurately predict morbidity and mortality [71–73]. However, future research might be better served from a combination of both subjective and objective measures of health and sleep.

Second, there are limitations to measuring someone’s overweight/obesity using BMI. Individuals with a similar BMI can have very different body compositions because BMI does not distinguish between excess fat, muscle, or bone mass [41,74,75]. Further, BMI categories are somewhat arbitrary and have changed over time [74]. While BMI should not be used as a diagnostic tool, BMI remains an easy-to-use measure that allows for widespread collection, analysis, and interpretation of overweight/obesity data in population health research [1,41]. Generally, use of BMI is best when in combination with other measures such as self-rated health status (ie, a subjective measure), as it was done in this study [41].

Third, while this study involved a nationally representative sample, the sample was skewed in that 87% of participants self-identified as White and 70% had been employed in the within the past year. Of Hispanics, 53% identify as White [76], and, in June 2017 (around the time this study’s data was collected), the employment-population ratio in Latinas over 20 years old was 55.4% [77]. These factors may limit generalizability in that: (a) as stated above, Hispanic women who do and do not identify as White may have different experiences of racial and ethnic discrimination leading to a unique health presentation; and (b) higher SES is often associated with better health. Future research should aim to include a broader, more representative sample of Hispanic women.

Finally, this study did not control for acculturation, which, based on prior research, may impact sleep patterns in Hispanics [2] and could possibly impact the association of sleep and health in Hispanic women. Existing studies have shown that acculturation may be linked to increased likelihood of short sleep and poor sleep [36,78]. Other covariates that have been shown to impact Latinx sleep and could be included in future research are country of origin, age, and socioeconomic status [19,37,79–81].

4. Conclusion

This study provides strong preliminary data for the continued exploration of sleep patterns, and their association with health, in Hispanic women. This study also provides support for more rigorously designed studies using objective and subjective measures of sleep and health, both short-term and long-term. A more profound understanding of this relationship, and engagement in health promoting behaviors as a potential pathway, will likely open spaces for health promotion interventions that reduce morbidity and mortality in this population. Therefore, more research is necessary to understand the fundamental ways in which sleep and health may be connected in this population.

Credit author statement

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Public significance statement

This secondary data analysis is the first to demonstrate the association of sleep duration and quality (ie, waking up rested) with physical and mental health outcomes in U.S. Hispanic women. This study also shows that health promoting behaviors (ie, healthy eating and physical activity) are at times pathways that connect these variables. Findings from this study respond to a national call to disaggregate Hispanic sleep data by gender and can be used by researchers and clinicians to orient health promotion interventions among U.S. Hispanic women.

Conflict of interest

None.

The ICMJE Uniform Disclosure Form for Potential Conflicts of Interest associated with this article can be viewed by clicking on the following link: <https://doi.org/10.1016/j.sleep.2021.03.044>.

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