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The association between sleep disorder, sleep duration and chronic back pain: results from National Health and Nutrition Examination Surveys, 2009–2010

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Abstract

Background Back pain is a typical condition, and the association among sleep disorders, sleep duration and back pain is currently being investigated. The purpose of this research is to explore the connection between sleep disorders, sleep duration and chronic back pain as well as confounding factors.

Methods Our data were obtained from the National Health and Nutrition Examination Survey (NHANES) data set of the USA and 1,131 participants were included in the study. Multivariable logistic regression was employed to investigate the relationship between sleep disorders, sleep duration and chronic back pain. And subgroup analysis conducted by gender, age, race, education, marital status, PIR, BMI, awakening events, hypertension condition and diabetes condition was also performed.

Results Our study includes 1131 participants, 513 are men (45.4%) and 618 are women (54.6%), 151 participants with sleep disorders (13.4%) and 980 participants without (86.6%). The fully adjusted model with adjustment variables including age, gender, race, BMI, PIR, drink, smoke, education, marital status, awakening conditions, hypertension, diabetes and part of back pain constructed through multiple logistic regression shows that chronic back pain is associated with sleep disorders [OR = 3.71, 95% CI: (1.25, 10.99), $p < 0.05$]. Using normal sleep duration as a reference, there is no statistical difference between short sleep duration [OR=-0.35, 95% CI: (-0.95, 0.24), $p = 0.241$], long sleep duration [OR = 0.81, 95% CI: (-1.61, 3.24), $p = 0.513$] and chronic back pain. It can be found through subgroup analysis that age between 40 and 60 years, age larger than 60 years, different race, marital status and BMI >30 kg/m2 are associated with chronic back pain and sleep disorders. We also find a nonlinear relation which is likely to be rotated S-shape among chronic back pain and sleep duration by fitting smooth curves.

Conclusion Our results suggest a substantial positive relationship between chronic back pain and sleep disorders and there is no statistical association between sleep duration and chronic back pain. The findings drawn from our study provide a basis for future exploration of the causal association between chronic back pain and sleep disorders, and provide references for timely elimination of interfering factors.

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Introduction

Back pain is a typical chronic non-specific condition [1]. Chronic low back pain with a nearly 23% prevalence rate is more common in the classification of back pain and is more likely to appear in the elderly group [2, 3]. It can be seen from the research in recent years that chronic back pain is a global phenomenon which is likely to cause disability, loss of work, and significant impact on life and work [4–8].

Chronic back pain has a variety of causes. It can be induced on by conditions such as osteoarthritis, disc degeneration, and nerve compression [9]. And in recent studies, the pathogenesis of chronic back pain is considered to be abnormal spinal forces due to disease, trauma, posture, etc., which leads to disc degeneration, causing long-term chronic pain [10]. Long-term pain will worsen the patient's nervous system degeneration, which will reduce gray matter in the brain and cause neuronal apoptosis. These effects will then have an impact on the patient's cognitive performance [11–14]. Sleep disorders refer to a group of disorders that cause changes in normal sleep patterns which create changes in the duration, quality, and quantity of sleep [15]. There are many types of sleep disorders, including sleep-disordered breathing, insomnia, central disorders of hypersomnolenceand, circadian rhythm sleep-wake disorders, sleep-related movement disorders and parasomnias [16]. Current evidence indicates correlations exist between sleep disorders and chronic back pain, the fundamental mechanisms between sleep disorders and chronic back pain is still being explored [17]. There may be a bidirectional link between sleep duration and pain in older adults, and correlations exist between sleep duration and chronic back pain also need to be explored [18]. Our study's main goal was to investigate the connection between sleep disorders, sleep duration and chronic back pain according to the data from the National Health and Nutrition Examination Survey data set of the USA (NHANES) as well as exploring the impact of various factors.

Methods

Research methodology and population

This study is cross-sectional and uses data from the NHANES database which is implemented by the National Center for Health Statistics (NCHS) includes physical measurements, dietary-related surveys, tests such as hearing examinations, laboratory testing and questionnaire on various aspects of patients in order to evaluate the health and nutritional status of people living in the United States [19]. All NHANES study protocols were accepted by the NCHS Research Ethics Review Board, and each study participant provided informed consent. All research data used in this investigation came from NHANES database that includes all detailed NHANES investigation layout. This cross-sectional study adheres to the STROBE (Strengthening the Reporting of Observational Studies in Epidemiology) reporting requirements and uses data from the NHANES database [20].

Our study selected study participants recruited in 2009–2010 from the NHANES database and initially comprised 10,537 patients in all. After the exclusion of participants with missing or incomplete back pain ($n=9390$), participants with uncertain upper back pain, low back pain and sleep disorder ($n=9$) and participants with missing or incomplete sleep duration($n=7$), a total of 1131 eligible participants used for inclusion in this final study analysis (Fig. 1).

Variable definition

Sleep disorder was found in questionnaire interview data throughout the NHANES questionnaire in 2009–2010. Participants were questioned ever received a diagnosis of a sleep disorder from a physician or other health care provider. Sleep disorders were determined by study participants answering yes or no to the question. On the basis of their answers, we separated the study participants into two groups and considering sleep disorders as an outcome variable. The National Sleep Foundation's recommendation for adults entailed that sleep duration could be classified as short (less than 7 h), normal (7–9 h), or long (more than 9 h), with 7–9 h each night serving as the reference group [21]. In this study, back pain that last longer than three months was classified as chronic back pain [22–24]. Information on chronic back pain was taken from the Arthritis Questionnaire Section. Study participants were asked whether there was ever a period of time when they experienced stiffness, soreness, or hurting in their low back, mid back, or upper back virtually every day for three months or longer. Chronic back pain was determined by study participants answering yes or no to the question. Based on their responses, we also split the study participants into two groups, and we took chronic back pain into account as an exposure variable.

Assessment of covariates

We acquired the information of demographic and lifestyle data of the individuals gathered from the questionnaires which included gender, age, race, education level, BMI[Body Mass Index, (kg/m**2)], ratio of family income to poverty(PIR), drink condition(frequency of drinking alcohol in the past 12 months), smoke condition(number of cigarettes smoked per day), marital status, awakening
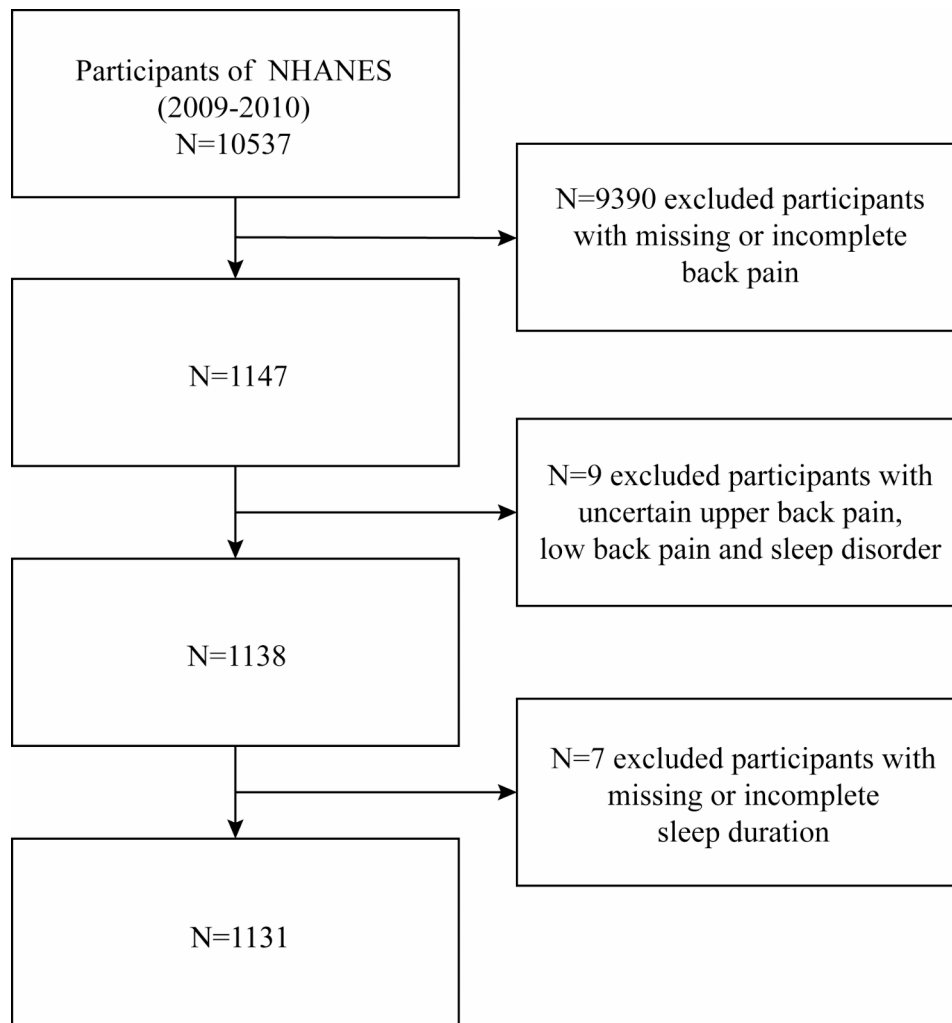
Fig. 1 Flow chart

conditions (pain wakes individuals from sleep), hypertension, diabetes and part of back pain(no pain, only one part, two parts and three parts). Information and acquisition method of all variables is publicly accessible to NHANES Official Website.

Statistical analysis

The entire statistical analysis was conducted by R software (Version 4.2.2) and EmpowerStats by CDC guidelines. For the purpose of understanding the relevance of different covariates to the study, we developed three different multivariate logistic regression models on chronic back pain and sleep disorders includes the following types that Crude model, no covariates were adjusted; Model 1: Age, gender, and race were adjusted; Model 2: Gender, age, race, education level, BMI, PIR, drink condition, smoke condition, marital status, awakening conditions, hypertension, diabetes and part of back pain were adjusted. Multiple logistic regression was also performed

using the same method above between chronic back pain and sleep duration.

Results

Baseline characteristics

This study comprises 1131 participants in total, 151 with sleep disorders (13.4%) and 980 without sleep disorders (86.6%). Chronic back pain is present in 115 participants (76.16%) of those with sleep disorders and 666 participants (67.96%) of those without sleep disorders. The baseline information of the research population between sleep disorders group and non-sleep disorders group can be obtained from Table 1. We find statistically significant differences by age, BMI, marital status, PIR, awakening conditions, hypertension conditions and diabetes conditions between the sleep disordered and non-sleep disordered groups. People with sleep disorders may have a higher age, higher BMI, higher single rate and more nighttime awakenings, and are more likely to have a powerful prevalence of back pain, hypertension and diabetes.

Table 1 Basic characteristics of participants in sleep disorders group and non-sleep disorders group, NHANES 2009–2010

Characteristics	Sleep disorders	Non-sleep disorders	*P* value
	N = 151	*N* = 980	
Age(years of age)	47.71 ± 12.68	44.48 ± 13.86	**0.007**
Gender			0.659
Male	71 (47.02%)	442 (45.10%)	
Female	80 (52.98%)	538 (54.90%)	
Race			0.126
Mexican American adults	20 (13.24%)	196 (20.00%)	
Other Hispanic adults	16 (10.60%)	95 (9.69%)	
Non-Hispanic White adults	81 (53.64%)	504 (51.43%)	
Non-Hispanic Black adults	31 (20.53%)	147 (15.00%)	
Adults of other Races including Multi-Racial	3 (1.99%)	38 (3.88%)	
Education level			0.790
Beneath the ninth grade	13 (8.61%)	116 (11.84%)	
Grades 9 through 11 (including 12th grade without a diploma)	28 (18.54%)	159 (16.22%)	
Graduate of high school / GED or a similar program	40 (26.49%)	253 (25.82%)	
A college degree or an AA	47 (31.13%)	310 (31.63%)	
A college graduate or higher	23 (15.23%)	142 (14.49%)	
Marital Status			**0.002**
Married	62 (41.06%)	474 (48.42%)	
Widowed	13 (8.61%)	31 (3.17%)	
Divorced	27 (17.88%)	151 (15.42%)	
Separated	12 (7.95%)	35 (3.58%)	
Never married	24 (15.89%)	172 (17.57%)	
Living with partner	13 (8.61%)	116 (11.84%)	
Awakening conditions (pain wakes individuals from sleep)			**< 0.001**
Yes	101 (67.33%)	511 (52.46%)	
No	49 (32.67%)	463 (47.54%)	
Part of back pain			0.086
No pain	36 (23.84%)	314 (32.04%)	
Pain in one area	74 (49.01%)	475 (48.47%)	
Pain in two areas	20 (13.25%)	93 (9.49%)	
Pain in three areas	21 (13.90%)	98 (10.00%)	
Hypertension			**< 0.001**
Yes	82 (54.30%)	341 (34.80%)	
No	69 (45.70%)	639 (65.20%)	
Diabetes			**0.001**
Yes	32 (21.19%)	107 (10.93%)	
No	115 (76.16%)	852 (87.03%)	
Borderline	4 (2.65%)	20 (2.04%)	
Back pain			**0.042**
Yes	115 (76.16%)	666 (67.96%)	
No	36 (23.84%)	314 (32.04%)	
BMI (kg/m2)	33.85 ± 9.46	29.94 ± 7.12	**< 0.001**
PIR	1.93 ± 1.48	2.25 ± 1.63	**0.030**
How often drink alcohol over past 12 months	7.18 ± 29.08	5.06 ± 21.34	0.334
How many cigarettes did you smoke per day	14.35 ± 9.85	14.08 ± 10.92	0.864

Baseline information between groups of different sleep duration can be obtained from Table 2. There are a total of 580 participants with sleep duration less than 7 h. The mean age is 45.43 ± 13.46 years and 53.45% participants are female. Participants who sleep less than 7 h have a higher likelihood of back pain and are more likely to have more pain areas, lower PIR and more nighttime awakenings.

Associations between chronic back pain and sleep disorder

Table 3 demonstrates the association between chronic back pain and sleep disorders. Our study created three

Table 2 Basic characteristics of participants in groups of different sleep duration, NHANES2009-2010

Characteristics	Sleep duration <7 h	Sleep duration ≥ 7 h,<9 h	Sleep duration ≥ 9 h	*P* value
	N = 580	*N* = 468	*N* = 83	
Age(years of age)	45.43 ± 13.46	44.14 ± 13.74	45.66 ± 15.58	0.279
Gender				0.672
Male	270 (46.55%)	205 (43.80%)	38 (45.78%)	
Female	310 (53.45%)	263 (56.20%)	45 (54.22%)	
Race				**0.003**
Mexican American adults	100 (17.24%)	104 (22.22%)	12 (14.46%)	
Other Hispanic adults	64 (11.03%)	38 (8.12%)	9 (10.84%)	
Non-Hispanic White adults	278 (47.93%)	256 (54.70%)	51 (61.45%)	
Non-Hispanic Black adults	113 (19.49%)	56 (11.97%)	9 (10.84%)	
Adults of other Races including Multi-Racial	25 (4.31%)	14 (2.99%)	2 (2.41%)	
Education level				0.083
Beneath the ninth grade	61 (10.52%)	59 (12.61%)	9 (10.84%)	
Grades 9 through 11 (including 12th grade without a diploma)	12 (14.46%)	68 (14.53%)	107 (18.45%)	
Graduate of high school / GED or a similar program	162 (27.92%)	108 (23.08%)	23 (27.71%)	
A college degree or an AA	183 (31.55%)	148 (31.62%)	26 (31.34%)	
A college graduate or higher	67 (11.55%)	85 (18.16%)	13 (15.66%)	
Marital Status				0.092
Married	252 (43.45%)	243 (52.03%)	41 (49.40%)	
Widowed	26 (4.48%)	17 (3.64%)	1 (1.20%)	
Divorced	100 (17.24%)	66 (14.13%)	12 (14.46%)	
Separated	28 (4.83%)	16 (3.43%)	3 (3.61%)	
Never married	96 (16.55%)	80 (17.13%)	20 (24.10%)	
Living with partner	78 (13.45%)	45 (9.64%)	6 (7.23%)	
Awakening conditions (pain wakes individuals from sleep)				**< 0.001**
Yes	369 (64.06%)	207 (44.42%)	36 (43.90%)	
No	207 (35.94%)	259 (55.58%)	46 (56.10%)	
Part of back pain				**< 0.001**
No pain	155 (26.72%)	177 (37.82%)	18 (21.69%)	
Pain in one area	286 (49.31%)	209 (44.66%)	54 (65.06%)	
Pain in two areas	68 (11.73%)	40 (8.55%)	5 (6.02%)	
Pain in three areas	71 (12.24%)	42 (8.97%)	6 (7.23%)	
Hypertension				0.176
Yes	232 (40.00%)	163 (34.83%)	28 (33.73%)	
No	348 (60.00%)	305 (65.17%)	55 (66.27%)	
Diabetes				0.448
Yes	77 (13.30%)	52 (11.11%)	10 (12.05%)	
No	486 (83.94%)	409 (87.39%)	72 (86.75%)	
Borderline	16 (2.76%)	7 (1.50%)	1 (1.20%)	
Back pain				**< 0.001**
Yes	425 (73.28%)	291 (62.18%)	65 (78.31%)	
No	155 (26.72%)	177 (37.82%)	18 (21.69%)	
BMI (kg/m2)	30.30 ± 7.76	30.49 ± 7.12	31.58 ± 9.13	0.368
PIR	2.08 ± 1.57	2.33 ± 1.65	2.38 ± 1.70	**0.039**
How often drink alcohol over past 12 months	4.52 ± 17.23	5.82 ± 24.66	8.16 ± 36.90	0.395
How many cigarettes did you smoke per day	14.46 ± 10.79	13.57 ± 11.28	13.90 ± 8.11	0.755

different models to explore the relationship between chronic back pain and sleep disorders in different situations. Using the population without sleep disorders as a point of reference, crude model [OR=1.51, 95% CI: (1.01, 2.24), p < 0.05] and model 2 [OR=3.71, 95% CI: (1.25, 10.99), p < 0.05] demonstrated that back pain had a significant correlation with the higher incidence of sleep disorders. After full adjustment, individuals with chronic pain had more than two-fold odds of having sleep disorders

Table 3 Associations between chronic back pain and sleep disorder, NHANES2009-2010

	Non sleep disorder	Sleep disorder OR (95% CI)	*P* value
Crude model	ref	1.51 (1.01, 2.24)	0.0435
Model 1	ref	1.36 (0.90, 2.03)	0.1404
Model 2	ref	3.71 (1.25, 10.99)	0.0179

Model 1: Age, gender, and race were adjusted

Model 2: Age, gender, race, BMI, PIR, how often drink alcohol over past 12 months, how many cigarettes did you smoke per day, education level, marital status, awakening conditions (pain wakes individuals from sleep), hypertension, diabetes and part of back pain were adjusted

as compared to those who reported not having chronic pain.

Associations between chronic back pain and sleep duration

Table 4 demonstrates the association between chronic back pain and sleep duration. Using the population with sleep between 7 h and 9 h as a point of reference, we created three different models to explore the relationship between chronic back pain and sleep duration in different situations. The outcome reveals a significant negative correlation between chronic back pain and sleep duration less than 7 h in both the crude model [OR=-0.40, 95% CI: (-0.58, -0.22), $p<0.001$] and model 1 [OR=-0.36, 95% CI: (-0.55, -0.18), $p<0.001$]. And our study also shows a positive relationship between chronic back pain and sleep duration lager than 9 h in both the crude model [OR=0.24, 95% CI: (0.05,0.43), $p<0.05$] and model 1 [OR=0.22, 95% CI: (0.03, 0.41), $p<0.05$]. However, the connection disappears in the fully adjusted model of both short sleep group [OR=-0.35, 95% CI: (-0.95, 0.24), $p=0.241$] and long sleep group [OR=0.81, 95% CI: (-1.61, 3.24), $p=0.513$].

Subgroup analyses

We conducted subgroup analyses by gender, age, race, education, marital status, PIR, BMI, awakening events, hypertension condition and diabetes condition, in order to explore potential differences in chronic back pain and sleep disorders in different populations. We detect statistical significance in the group of age between 40 years

and 60 years[OR=2.47, 95% CI: (1.32, 4.64), $p=0.005$], age larger than 60 years[OR=2.53, 95% CI: (1.27, 5.05), $p=0.008$], other Hispanic adults[OR=3.82, 95% CI: (1.18, 12.43), $p=0.026$], non-Hispanic white adults[OR=3.30, 95% CI: (1.17, 9.35), $p=0.025$], non-Hispanic black adults[OR=5.03, 95% CI: (1.69, 15.02), $p=0.004$], married population[OR=2.30, 95% CI: (1.16, 4.53), $p=0.016$], windowed population[OR=5.95, 95% CI: (2.28, 15.50), $p=0.0003$], divorced population[OR=2.80, 95% CI: (1.31, 6.01), $p=0.008$], separated population[OR=4.16, 95% CI: (1.47, 11.78), $p=0.007$] and in the group with BMI >30 kg/m2[OR=2.93, 95% CI: (1.29, 6.61), $p=0.010$]. Our outcomes indicate a dependence of the relationship between different age, race, marital status and higher BMI with chronic back pain and sleep disorders. (Table 5).

Fitting smooth curves between back pain and sleep duration

Additionally, we attempted to model the nonlinear relationship among prevalence of back pain and the sleep duration with a smoothed curve, and the results indicated that there is a nonlinear relation which is likely to be rotated S-shape among the two variables. (Fig. 2) And with the pain range decreased, the sleep time also gradually increased from Fig. 3.

Discussion

Our study is a cross-sectional investigation of the relationship between sleep disorders, sleep duration and chronic back pain based on the NHANES database (2009–2010) for a U.S. population. The results of this study demonstrate that the presence of chronic back pain is positively associated with sleep disorders. In the fully adjusted model, individuals with chronic pain have more than two-fold odds of having sleep disorders as compared to those who reported not having chronic pain. [OR=3.71, 95% CI: (1.25, 10.99), $p<0.05$]. The results of this study significantly suggest that there is a correlation between chronic back pain and sleep disorders, and point out the influencing factors between the two, which provide a basis and reference value for researching the specific influences between chronic back pain and sleep

Table 4 Associations between chronic back pain and sleep duration, NHANES2009-2010

	Sleep duration <7 h	*P* value	Sleep duration ≥7 h,<9 h	Sleep duration ≥9 h OR (95% CI)	*P* value
Crude model	-0.40(-0.58, -0.22)	<0.001	ref	0.24(0.05,0.43)	0.014
Model 1	-0.36(-0.55, -0.18)	<0.001	ref	0.22(0.03, 0.41)	0.026
Model 2	-0.35(-0.95, 0.24)	0.241	ref	0.81(-1.61, 3.24)	0.513

Model 1: Age, gender, and race were adjusted

Model 2: Age, gender, race, BMI, PIR, how often drink alcohol over past 12 months, how many cigarettes did you smoke per day, education level, marital status, awakening conditions (pain wakes individuals from sleep), hypertension, diabetes and part of back pain were adjusted

Table 5 Subgroup analysis between chronic back pain and sleep disorders, NHANES 2009–2010

	No back pain	Back pain OR (95% CI)	P value	P for interaction
Gender				0.623
Male	ref	1.68 (0.93, 3.03)	0.086	
Female	ref	1.47 (0.82, 2.64)	0.193	
Age				0.201
<40	ref	1.31 (0.65, 2.64)	0.446	
≥40,<60	ref	2.47 (1.32, 4.64)	0.005	
≥60	ref	2.53 (1.27, 5.05)	0.008	
Race				0.281
Mexican American adults	ref	2.70 (0.87, 8.38)	0.085	
Other Hispanic adults	ref	3.82 (1.18, 12.43)	0.026	
Non-Hispanic White adults	ref	3.30 (1.17, 9.35)	0.025	
Non-Hispanic Black adults	ref	5.03 (1.69, 15.02)	0.004	
Adults of other Races including Multi-Racial	ref	0.76 (0.08, 7.10)	0.810	
Education level				0.385
Beneath the ninth grade	ref	6.32 (0.79, 50.33)	0.082	
Grades 9 through 11 (including 12th grade without a diploma)	ref	7.72 (1.01, 59.14)	0.129	
Graduate of high school / GED or a similar program	ref	6.67 (0.88, 50.47)	0.066	
A college degree or an AA	ref	7.07 (0.94, 52.98)	0.057	
A college graduate or higher	ref	6.45 (0.82, 50.51)	0.076	
Marital Status				0.525
Married	ref	2.30 (1.16, 4.53)	0.016	
Widowed	ref	5.95 (2.28, 15.50)	0.0003	
Divorced	ref	2.80(1.31, 6.01)	0.008	
Separated	ref	4.16 (1.47, 11.78)	0.007	
Never married	ref	2.11(0.95, 4.67)	0.066	
Living with partner	ref	1.56 (0.60, 4.05)	0.357	
PIR				0.734
<4	ref	1.42 (0.91, 2.20)	0.121	
≥4	ref	0.70 (0.35, 1.38)	0.299	
BMI				0.468
<25 kg/m2	ref	1.06 (0.41, 2.70)	0.906	
≥25 kg/m2,<30 kg/m2	ref	1.41 (0.59, 3.37)	0.437	
≥30 kg/m2	ref	2.93 (1.29, 6.61)	0.010	
Awakening conditions (pain wakes individuals from sleep)				0.521
Yes	ref	1.14 (0.66, 1.97)	0.629	
No	ref	0.70 (0.38, 1.29)	0.250	
Hypertension				0.697
Yes	ref	1.29 (0.73, 2.30)	0.397	
No	ref	0.62 (0.35, 1.11)	0.108	
Diabetes				0.614
Yes	ref	1.69 (0.63, 4.51)	0.296	
No	ref	0.74 (0.30, 1.84)	0.523	
Borderline	ref	1.18 (0.29, 4.76)	0.820	

disorders. However, this study finds no link between the period of sleep and chronic back pain. By fitting smooth curves, we detect a nonlinear relationship between the duration of sleep and chronic back pain that is probably rotated S-shape. These findings also establish a foundation and point of reference for studies examining the precise relationships between chronic back pain and sleep duration.

Sleep and pain are traditionally thought to be interrelated [25]. A sleep problem is considered as a potential risk factor for the beginning or exacerbation of pain [26]. Edwards and other researchers find nighttime sleep duration can be predicted by pain frequency [27]. Sleep disorders interact with pain and pain-related disorders. In an experiment by Mock et al. it was concluded that middle-aged women with frequent sleep issues were
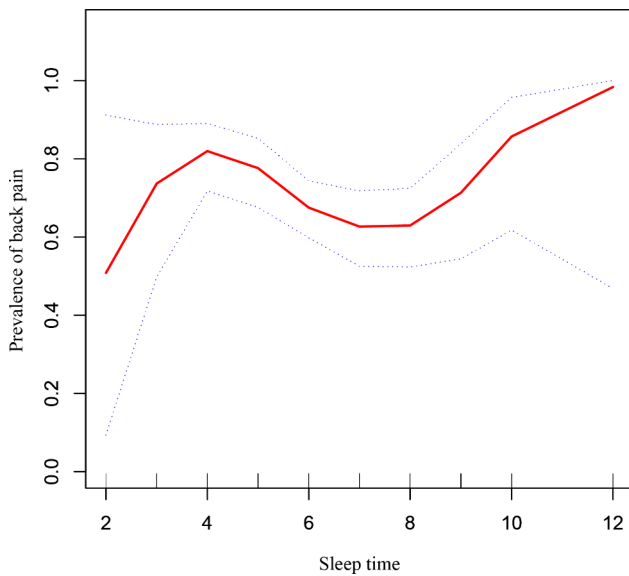
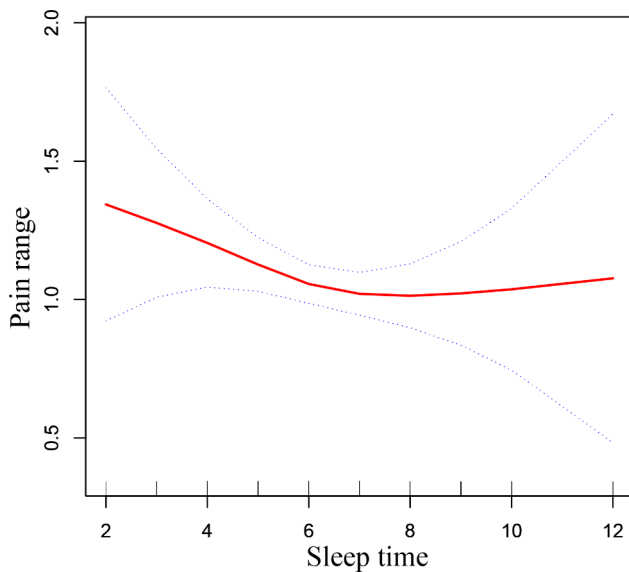**Fig. 2** The association between sleep time and prevalence of back pain

Fig. 3 The association between sleep time and prevalence of pain range

having a greater probability to develop fibromyalgia [28]. Research on the classification of sleep disorders associated with chronic low back pain (part of back pain) has been progressing in recent years. Some studies claim that there is a relationship between insomnia and chronic low back pain [29], and that insomnia may be a risk factor for chronic low back pain [30–32], even increasing incidence of chronic low back pain [33], reducing the likelihood of recovery from low back pain [34] and causing lower back pain the next day [35]. It's also been shown that women with poor sleep quality are having a greater probability to experience persistent low back pain [36] and poor sleep quality can also lead to a greater likelihood of residual chronic back pain [37]. Increasing age also correlates

with chronic low back pain and living standards [38] that insomnia in the elderly often coexists with chronic low back pain [39]. A recent study suggests that increased sleep difficulties in the adolescent population also contribute to an elevated prevalence of chronic back pain [40]. Decreased quality and quantity of sleep is associated with a two- to three-fold increased risk of developing pain and consistent good sleep facilitates better pain relief and promotes good health [41]. Studies have shown that for elderly patients, pain is related to poor sleep quality and short sleep duration [42]. Most of the current articles explore the relationship between the classification of sleep disorders and chronic low back pain (part of chronic back pain) and the factors associated with them. And they use the classification of sleep disorders as the expose variables and chronic low back pain as the strain variable to explore the correlation between both of them. In this study, we attempted to construct a model using chronic back pain as the expose variable as well as sleep disorder and sleep duration as the strain variable to investigate the connection between the two and the related influencing factors.

Sleep-related problems can lead to increased secretion of inflammatory factors leading to promotion or exacerbation of pain, and activation of the prostaglandin system can also cause spontaneous pain [43, 44]. The mechanism of interaction between chronic back pain and sleep disorders has also not yet been explored. Some studies have shown a correlation between elevated C-reactive protein and the presence of insomnia and low back pain [45]. In a recent study by Edwin et al. had shown that the relationship between insomnia, one of the classifications of sleep disorders, and chronic low back pain is possible to be mediated by the pace of biological aging [46]. However, extra investigation is required to discover more specific mechanisms. Some studies have suggested that chronic low back pain is connected to patients' ethnicity and standard of living and it encouraged the point that increasing medical assistance for minorities [47]. Our study yielded the opposite result, but given the year of the data from the two studies, it is speculated that there may be a bias due to sociologic confounding factors.

There are a number of strengths to our study. Unlike previous studies, our study is a cross-sectional study that utilize sleep disorders and sleep duration as the response variable and chronic back pain as the exposure variable. In addition, we take into account different confounding factors such as age, race, and education by creating different models to simulate different scenarios to make the results more reliable and to inform future studies.

There are further limitations to our research. Due to its cross-sectional design, this study is unable to establish causality between chronic back pain and sleep disorders. And the information we get on sleep disorders is not

categorized in detail by disease type. The data we used comes from the NHANES database. The results obtained by analyzing the data are limited to the characteristics of the population in the NHANES database, and cannot reflect the characteristics of all Americans or even people in other regions around the world. Our study provides a reference for related studies that focus on other groups in different parts of the world. Meanwhile, the data we used were collected more than 10 years ago, and given the presence of psychosocial factors interfering with pain, we cannot exclude the influence on the results of the study due to changes in the social environment in recent years [48]. In the future we need further prospective studies to discover the potential connection between sleep disorders and persistent back pain.

Conclusion

In conclusion, our research demonstrates a strong connection between chronic back pain and sleep disorders, and indicates no statistical correlation between chronic back pain and sleep duration. And our also study provides reference value and basis for exploring the causal relationship and influencing factors of chronic back pain and sleep disorders. In the future, additional clinical research will be required to confirm our findings.

Abbreviations
BMI   Body mass index
NCHS   National Center for Health Statistics
NHANES   National Health and Nutrition Examination Survey --
PIR   Income-to-Poverty Ratio

Author contributions
MZ established the research, gathered and analyzed data, and drafted the manuscript. ZW revised the manuscript. Every writer accepted the submitted version of the article and participated to its writing. Contact Address: Shandong University, Jinan, People's Republic of China Department of Anesthesiology, Qilu Hospital of Shandong University, Jinan, People's Republic of China.

Data availability
Researchers and data users from all over the world can assess the survey data on the internet (www.cdc.gov/nchs/nhanes/).

Declarations

Ethics approval and consent to participate
The NCHS Ethics Review Board authorized the total components about this research that involved material or information pertaining to human subjects were completed in accordance with the Helsinki Declaration. Written informed consent was given by the patients/participants to participate into this investigation.

Consent for publication
Not applicable.

Competing interests
The authors declare no competing interests.

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