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Original Article

Association between loneliness, sleep behavior and quality: a propensity-score-matched case–control study

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ABSTRACT

Objective: To explore the influence of loneliness on sleep behavior and sleep quality based on propensity score-matched samples in Southwest China.
Methods: Individual-level data were obtained from a Southwest China cohort study. Participants who felt lonely were matched with those who did not with propensity scores on the basis of age, gender, socioeconomic factors, physical exercise and social connection level. Sleep behavior (onset and offset timing), sleep quality (sleep latency, nocturnal awakenings and subjective sleep quality), and daytime function (daytime sleepiness and fatigue) were assessed with the Pittsburgh Sleep Index Scale (PSQI) and compared between the two groups. The data were collected between May 2019 and December 2019, and data analyses were completed in April 2021.
Results: A total of 11,696 participants were included, and 824 out of 839 participants who felt loneliness were statistically matched with 824 participants who did not. Analyses of the matched samples showed that sleep onset and offset timing were similar between those who felt lonely and those who did not ($p = 0.110$ and $p = 0.751$, respectively). Sleep latency was longer in those who felt lonely (26.84 [0.9] vs. 35.52 [1.2] min, $p < 0.001$) than in those who did not. Furthermore, participants who felt lonely tended to have poor subjective sleep, a higher frequency of nocturnal awakenings, daytime sleepiness and fatigue (all $p < 0.001$).
Conclusions: Loneliness was associated with extended sleep latency, increased nocturnal awakenings, and reduced subjective sleep quality and daytime function but was not associated with sleep behavior, including sleep onset and offset timings.

1. Introduction

Poor sleep has become a global health problem. Previous epidemiological surveys showed that the prevalence rates of sleeping problems were 23% in Japan, 31% in European countries, 53% in Ethiopia, and 56% in the USA [1,2], and varied from 3.9% to more than 40.0% in countries across Africa and Asia [3]. In China, sleep problems have been reported to vary from 8.3% to 49.7% [4,5]. Poor sleep significantly affects health and has been found to be associated with many chronic health problems, such as cardiovascular disorders, diabetes, stroke, and mental health disorders [6–9]. Previous studies also showed that longer sleep duration (≥7.95 h) and worse sleep behavior (sleep after 3:00 am) would increase the risk of cognitive decline [10].

Loneliness is an unpleasant feeling that occurs when one does not obtain the emotional or social intimacy he desires [11]. A few studies with small sample sizes have shown that loneliness was associated with sleep quality, but inconsistent results were found considering components of sleep [12–15]. For example, a previous study showed that loneliness was associated with shorter sleep duration [14], but other studies did not find this association [13,15]. The results regarding the association between loneliness and daytime function were also inconsistent [13,15]. In this study, we aimed to explore whether feeling loneliness was associated with alterations in sleep behavior (ie, timing of sleep onset and offset), and whether feeling loneliness was associated with longer sleep latency or worse daytime function by analyzing propensity score-matched samples from a large cohort study in Southwest China.

Abbreviations: IQR, interquartile range.

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2. Methods

2.1. Data sources

This study was approved by the ethical community of West China Hospital, Sichuan University, and individual-level data were obtained from a prospective population cohort study in Southwest China. Residents from Longquan (Chengdu suburb) who were older than 20 years were asked to participate in the project voluntarily. Standard structured questionnaires were used by trained field workers to collect basic information under strict quality control. The following information was retrieved: age, gender, occupation (employed or unemployed), marital status (married or unmarried), educational level (≤6 years, 6-9 years, 9-12 years, or ≥12 years), physical exercise during the previous half year (no, sometimes, or almost every day), and whether they lived alone. Participants were also asked the following question to assess their social connection: How often do you visit your friends, colleagues, relatives, the community neighborhood committee, or social volunteers, or how often do they visit you? The answer was almost every day, two to four times a week, nearly once a week, once a month, or less than once a month. The subjective feeling of loneliness was assessed with the following question: Do you often feel loneliness? The possible answers were yes and no. All responses that completed the baseline survey were considered. Baseline data collection was started in May 2019 and completed in December 2019, and data analyses were completed in April 2021.

2.2. Sleep behavior assessment

Sleep during the past month was assessed with reference to the Pittsburgh Sleep Index Scale (PSQI) [16]. The following components of sleep were assessed: sleep onset and offset timing, sleep latency, frequency of nocturnal awakenings, subjective sleep quality, daytime sleepiness and fatigue. Sleep onset and offset timing were recorded as hours:minutes, and sleep latency was measured in minutes. Subjective sleep quality was measured using scores varying from 0 to 3 (0 = very good, 1 = good, 2 = bad, 3 = very bad). Nocturnal awakening frequencies, daytime sleepiness or fatigue were ranked as 0 (no), 1 (less than once a week), 2 (once or twice a week) or 3 (more than 3 times a week).

2.3. Statistical analysis

Quantitative data are shown as the medians and interquartile ranges (IQRs) or means and standard errors (SEs), and were calculated with independent-sample t-tests. Qualitative data are shown as percentages and were calculated using the Mann–Whitney U test when ordered; otherwise, the chi-square test was used. We used propensity-score matching methods to reduce the effects of confounding factors. The individual propensities for loneliness were estimated using a binary logistic regression model that included age, gender, occupation, marital status, educational level, physical exercise, living alone or not, and social connection. Participants who felt lonely were matched with those who did not using 1:1 nearest neighbor matching with a caliper of 0.02 times the pooled estimate of the standard deviation of the propensity score. Additional sensitivity analyses were conducted using 1:2 and 1:3 nearest neighbor matching.

We further analyzed how loneliness differently influenced sleep latency in different genders (male and female) and different ages (≥60 years old and <60 years old) using one-way ANOVA and LSD for post hoc analyses between two groups. The statistical analyses were performed using SPSS 25 (IBM) and R 4.0 (R Project for Statistical Computing), and a two-sided p value less than 0.05 was considered statistically significant.

3. Results

3.1. Basic information of the included participants

Of the 11,812 participants enrolled in the cohort, 116 (1.0%) participants were excluded due to missing information. Ultimately, 11,696 (99.0%) participants were included in this study, and 839 (7.2%) of them felt lonely. Univariate analyses showed that people with loneliness were associated with a higher risk of being unmarried, living alone, having a lower frequency of visiting others or being visited, and having a low frequency of physical exercise

Table 1
Characteristics of participants with and without loneliness, before and after propensity-score matching.

Baseline	Unmatched			Propensity-score matched		
	No loneliness (n = 10,857)	Loneliness (n = 839)	p value	No loneliness (n = 824)	Loneliness (n = 824)	p value
Age (years, median and IQR)	55 (48–65)	53 (44–65)	<0.001	53 (45–65)	53 (44–65)	0.748
Gender (female, %)	7310 (67.3)	586 (69.8)	0.134	578 (70.1)	595 (72.2)	0.065
Occupation (employed, %)	3862 (35.6)	327 (39.0)	0.051	321 (39.0)	320 (38.8)	0.764
Married (yes, %)	9784 (90.1)	594 (70.8)	<0.001	595 (72.2)	594 (72.1)	0.627
Education (%)			0.255			0.690
≤6 years	4432 (40.8)	352 (42.0)		363 (44.1)	347 (42.1)	
6-9 years	3517 (32.4)	233 (27.8)		229 (27.8)	230 (27.9)	
9-12 years	1535 (14.1)	103 (12.3)		89 (10.8)	103 (12.5)	
≥12 years	1373 (12.6)	151 (18.0)		143 (17.4)	144 (17.5)	
Physical exercise (%)			<0.001			0.612
No	3470 (32.0)	306 (36.5)		279 (33.9)	299 (36.3)	
Sometimes	2596 (23.9)	262 (31.2)		275 (33.4)	254 (30.8)	
Almost every day	4791 (44.1)	271 (32.3)		270 (32.8)	271 (32.9)	
Live alone (yes,%)	504 (4.6)	160 (19.1)	<0.001	131 (15.9)	145 (17.6)	0.529
Visit or be visited (%)			<0.001			0.278
Almost every day	2553 (23.5)	155 (18.5)		154 (18.7)	154 (18.7)	
2-4 times a week	989 (9.1)	74 (8.8)		63 (7.6)	74 (9.0)	
Once a week	1517 (14.0)	95 (11.3)		94 (11.4)	95 (11.5)	
Once a month	2329 (21.5)	162 (19.3)		153 (18.6)	160 (19.4)	
Less than once a month	3469 (32.0)	353 (42.1)		360 (43.7)	341 (41.4)	

IQR: interquartile range.

(Table 1). Propensity score matching with a caliper of 0.02 generated 824 "cases" and 824 matched "controls".

3.2. Association between loneliness and sleep behavior

After matching, these confounding factors were comparable between the two groups (Fig. 1). The results using propensity score-matched samples showed that the sleep onset and offset timings were similar between the two groups ($p = 0.110$ and $p = 0.751$, respectively), while sleep latency was longer in those who felt lonely than in those who did not (26.84 [0.9] vs. 35.52 [1.2] min, $p < 0.001$) (Table 2). The results showed that 24.4% of prolonged sleep latency was accounted for by loneliness.

We further separately analyzed the negative effect of loneliness on sleep latency by gender. The results showed that loneliness was associated with longer sleep latency in both males (32.1 [2.2] vs. 20.6 [1.2], $p < 0.001$) and females (37.0 [1.5] vs. 29.2 [1.2], $p < 0.001$) (Fig. 2A). Moreover, loneliness was associated with prolonged sleep latency in both young (32.2 [1.3] vs. 24.4 [2.6], $p < 0.001$) and older adults (42.6 [1.0] vs. 31.9 [1.9], $p < 0.001$) (Fig. 2B).

3.3. Associations between loneliness, sleep quality and daytime function

Furthermore, the results showed that participants who felt lonely tended to have worse scores of subjective sleep ($p < 0.001$) and higher frequencies of nocturnal awakenings ($p < 0.001$). Participants who felt lonely also had higher rates of feeling sleepiness and fatigue when participating in daytime activities (both $p < 0.001$) (Table 2). A total of 16.1% of the increased frequency of

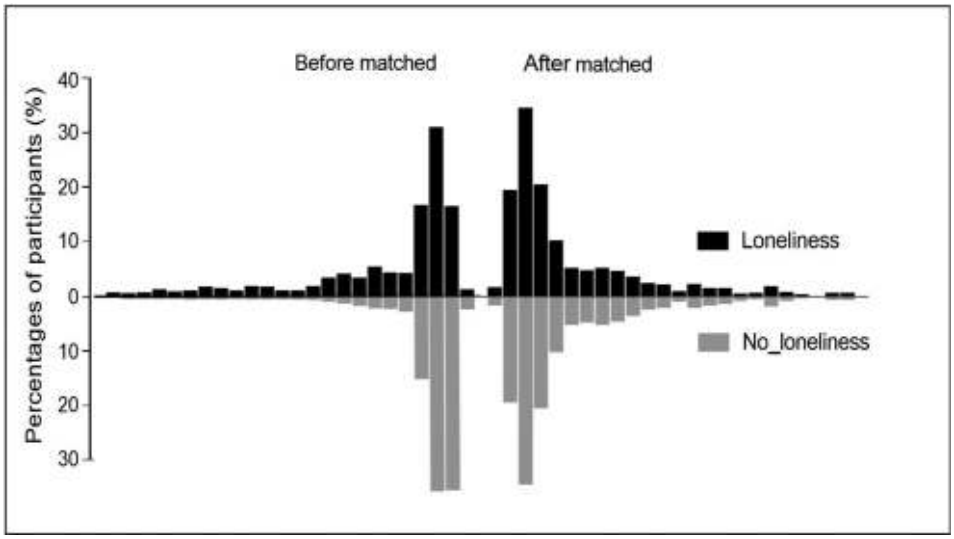

Fig. 1. Propensity scores of all samples before and after matching. The individual propensities for loneliness were estimated using a binary logistic regression model that included age, gender, occupation, marital status, educational level, physical exercise, living alone or not, and social connection. After matching, the propensity scores were comparable between the two groups.

Table 2
Comparison of sleep quality between participants with and without loneliness after Propensity-Score Matching.

Sleep quality	No loneliness (n = 824)	Loneliness (n = 824)	p value
Sleep onset (min, [SE])	22:28 [2.2]	22:33 [2.3]	0.110
Sleep offset (min, [SE])	6:44 [1.86]	6:43 [2.2]	0.751
Sleep latency (min, [SE])	26.8 [0.9]	35.5 [1.2]	<0.001
Easy to wake (%)			<0.001
No	378 (45.9)	246 (29.9)	
Less than once a week	80 (9.7)	85 (10.3)	
1-2 times a week	98 (11.9)	119 (14.4)	
More than 3 times a week	268 (32.5)	374 (45.4)	
Subjective sleep (%)			<0.001
Very good	204 (24.8)	110 (13.3)	
Fairly good	406 (49.3)	355 (43.1)	
Fairly bad	178 (21.6)	264 (32.0)	
Very bad	36 (4.4)	95 (11.5)	
Daytime sleepiness (%)			<0.001
No	632 (76.7)	495 (60.1)	
Less than once a week	82 (10.0)	114 (13.8)	
1-2 times a week	68 (8.3)	117 (14.2)	
More than 3 times a week	42 (5.1)	98 (11.9)	
Daytime fatigue (%)			<0.001
No	576 (69.9)	374 (45.4)	
Less than once a week	127 (15.4)	141 (17.1)	
1-2 times a week	74 (9.0)	182 (22.1)	
More than 3 times a week	47 (5.7)	127 (15.4)	

SE: standard error.

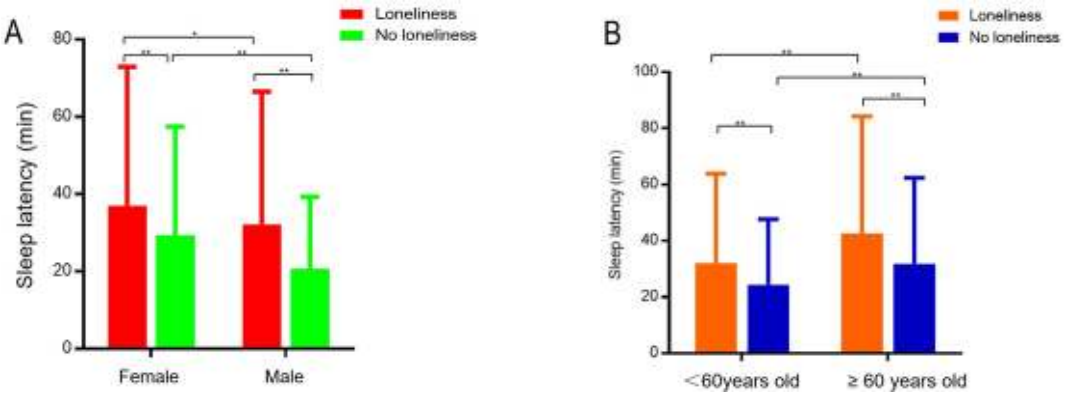

Fig. 2. Influence of loneliness on sleep latency by gender and age. Loneliness was associated with longer sleep latency in both males (32.1 [2.2] vs. 20.6 [1.2], $p < 0.001$) and females (37.0 [1.5] vs. 29.2 [1.2], $p < 0.001$) (A). Loneliness was associated with sleep latency in both young (32.2 [1.3] vs. 24.4 [2.6], $p < 0.001$) and older adults (42.6 [1.0] vs. 31.9 [1.9], $p < 0.001$) (B).

Table 3
Comparison of sleep quality between participants with and without loneliness after Propensity-Score Matching (1:2 and 1:3).

Sleep components	Loneliness (n = 824)	No loneliness			
		Matched (n = 1606)	P value	Matched (n = 2337)	p value
Age (years, median and IQR)	53 (44–65)	53 (44–64)	0.640	53 (45–64)	0.978
Gender (female, %)	595 (72.2)	1161 (72.3)	0.275	1684 (72.0)	0.302
Occupation (employed, %)	320 (38.8)	606 (37.7)	0.597	896 (38.3)	0.803
Married (yes, %)	594 (72.1)	1193 (74.3)	0.244	1770 (75.7)	0.040
Education (%)			0.740		0.589
≤6 years	347 (42.1)	709 (44.1)		1044 (44.7)	
6-9 years	230 (27.9)	447 (27.8)		642 (27.5)	
9-12 years	103 (12.5)	189 (11.8)		273 (11.6)	
≥12 years	144 (17.5)	261 (16.3)		378 (16.2)	
Physical exercise (%)			0.554		0.643
No	299 (36.3)	563 (35.1)		841 (36.0)	
Sometimes	254 (30.8)	530 (33.0)		759 (32.4)	
Almost every day	271 (32.9)	513 (31.9)		737 (31.5)	
Live alone (yes, %)	145 (17.6)	226 (14.1)	0.024	279 (11.9)	0.000
Visit or be visited (%)			0.566		0.608
Almost every day	154 (18.7)	324 (20.2)		471 (20.2)	
2-4 times a week	74 (9.0)	127 (7.9)		198 (8.4)	
Once a week	95 (11.5)	180 (11.2)		264 (11.3)	
Once a month	160 (19.4)	281 (17.5)		404 (17.3)	
Less than once a month	341 (41.4)	694 (43.2)		1000 (42.8)	
Sleep quality					
Sleep onset (min, [SE])	22:33 [2.3]	22:29 [1.6]	0.108	22:28 [1.3]	0.044
Sleep offset (min, [SE])	6:43 [2.2]	6:44 [1.4]	0.884	6:43 [1.1]	0.714
Sleep latency (min, [SE])	35.52 [1.238]	26.92 [0.663]	<0.001	27.60 [0.582]	<0.001
Easy to wake (%)			<0.001		<0.001
No	246 (29.9)	753 (46.9)		1031 (44.1)	
Less than once a week	85 (10.3)	176 (11.0)		264 (11.3)	
1-2 times a week	119 (14.4)	186 (11.6)		279 (11.9)	
More than 3 times a week	374 (45.4)	491 (30.6)		763 (32.6)	
Subjective sleep (%)			<0.001		<0.001
Very good	110 (13.3)	384 (23.9)		529 (22.6)	
Fairly good	355 (43.1)	816 (50.8)		1193 (51.0)	
Fairly bad	264 (32.0)	342 (21.3)		515 (22.0)	
Very bad	95 (11.5)	64 (4.0)		100 (4.3)	
Daytime sleepiness (%)			<0.001		<0.001
No	495 (60.1)	1197 (74.5)		1744 (74.6)	
Less than once a week	114 (13.8)	172 (10.7)		251 (10.7)	
1-2 times a week	117 (14.2)	154 (9.6)		214 (9.2)	
More than 3 times a week	98 (11.9)	83 (5.2)		128 (5.5)	
Daytime fatigue (%)			<0.001		<0.001
No	374 (45.4)	1102 (68.6)		1609 (68.8)	
Less than once a week	141 (17.1)	257 (16.0)		356 (15.2)	
1-2 times a week	182 (22.1)	161 (10.0)		237 (10.1)	
More than 3 times a week	127 (15.4)	86 (5.4)		135 (5.9)	

SE: standard error.

nocturnal awakenings, 15.0% of reduced subjective sleep, 20.3% of increased rate of daytime sleepiness, and 27.5% of increased rate of daytime fatigue was accounted for by loneliness. Sensitivity analyses with 1:2 and 1:3 nearest neighbor matching yielded similar results (Table 3).

4. Discussion

The results of this study showed that feeling loneliness was associated with extended sleep latency, increased frequency of nocturnal awakenings, reduced subjective sleep quality and daytime function. Since loneliness is a distressing feeling due to not experiencing adequate social intimacy, it can cause insecure feelings during sleep [14,17]. This feeling would make it more difficult for people to fall asleep and easier to wake at night, presenting as prolonged sleep latency and higher levels of sleep fragmentation [13,14]. Sleep behaviors such as sleep onset and offset timings are more self-determined and thus are less likely to be affected, which is consistent with previous findings that loneliness may not influence sleep duration [13,15].

Most previous studies included either older adults or young adults [12–14,17,18]. The large sample size and the distribution of ages in our sample allow us to evaluate the associations between loneliness and sleep quality in different genders and different ages. We found that in both males and females and young and old adults, loneliness was associated with prolonged sleep latency, indicating that loneliness may be a common mechanism underlying poor sleep among people of varied ages and of different genders.

Importantly, we used propensity score-matching methods to minimize the effects of common confounding factors such as age, gender, marital status, living arrangements and other factors that may be potentially associated with sleep quality [19–22]. The balance of these covariates between groups enables us to better understand the influence of loneliness on sleep quality. This method is verified to be useful for observational studies where randomized designs are not suitable [23,24]. We also performed multiple sensitivity analyses with 1:2 or 1:3 matches of “cases” and “controls” to verify the robustness of our findings.

The associations between social connection, feeling of loneliness, and sleep quality seems to be complex and interrelated. Consistent with previous findings [25,26], the results of our study showed that being unmarried, living alone and having a lower level of social connection would increase the feeling of loneliness. Loneliness was associated with increased frequencies of sleepiness and fatigue when participating in social activities, as shown in this study, and anenergia would cause social withdrawal and conversely aggravate the feeling of loneliness [27]. Together, this evidence suggests that breaking this vicious cycle may be vital for the improvement of sleep quality.

This study has several limitations. First, this is a single-center study, so the results of this study need to be further verified in other centers. Second, we could not infer the causality between loneliness and poor sleep because of the cross-sectional design. Third, sleep quality was self-reported in this study, and thus recall bias and reporting bias could exist. The results of this study should be further verified with more objective assessments of sleep using available wearable devices. Regardless of these limitations, this study provided key information for the study of the relationship between feeling of loneliness and sleep quality.

5. Conclusions

Feeling of loneliness was associated with extended sleep latency, increased frequency of waking up at night, and reduced subjective sleep quality and daytime function, but was not associated with sleep behavior, including sleep onset and offset timings.

Author contributions

Peng designed the study, conducted the study, carried out the statistical analysis and drafted the manuscript. Tang and He collected the data. Ji carried out the statistical analysis. Dong drafted the manuscript. Chen designed the study, and revised the manuscript.

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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.2021.08.008.

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