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Sleep disorders and the association with frailty among community-dwelling older adults in Northwest China: a cross-sectional study

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ABSTRACT

Objectives To investigate the status of sleep disorders and their association with comprehensive frailty in the community-dwelling older adults.

Design A cross-sectional study.

Setting Six community healthcare centres in Xi'an City, Northwest China.

Participants A total of 2647 community-dwelling older adults completed the study.

Primary and secondary outcome measures The primary outcomes included frailty and sleep disorders, measured with the Comprehensive Frailty Assessment Instrument and Pittsburgh Sleep Quality Index (PSQI), respectively. The secondary outcomes were potential factors associated with frailty.

Results The participants averaged 5.23±2.94 in the total score of the PSQI, with a poor sleep quality prevalence of 19.9%. Individuals with poor sleep quality are more likely to have mild and high frailty, with an OR of 1.64 and 2.81, respectively. Both shortened (<5 hours) and prolonged (>8 hours) sleep duration are associated with higher level of frailty. Poor overall sleep, poor subjective sleep quality, extended sleep latency, sleep disturbances, use of sleeping medication and daytime dysfunction were associated with higher level of frailty (with a correlational coefficient of 0.237, 0.201, 0.223, 0.197, 0.087 and 0.378, respectively).

Conclusion Sleep disorders are common problems among community-dwelling older adults, the severity of which rises with the increase in frailty level. Poor overall sleep quality, poor subjective sleep quality, extended sleep latency, sleep disturbances, daytime dysfunction and abnormal sleep duration are associated with frailty.

STRENGTHS AND LIMITATIONS OF THIS STUDY

⇒ A large-scale multicentred survey was conducted, which enhanced the sample representativeness and the accuracy of estimates.
⇒ Multiple statistical analysis strategies were employed to examine the association between frailty and sleep disorders, the consistent results of which improved the reliability of the association.
⇒ Due to the nature of a cross-sectional design, a causal relationship between frailty and sleep disorders could not be established.

INTRODUCTION

Frailty is a common geriatric syndrome physically characterised by declines in function and reserves across multiple physiological systems, accompanied by increased vulnerability to stressors.[1 2] Despite the ongoing debates on the operative definition of frailty, the conceptual framework of physical phenotype and accumulation of age-related deficits are currently dominating the field.[2 3] Instruments developed based on these two concepts, such as the Frailty Phenotype, FRAIL (Fatigue, Resistance, Ambulation, Illnesses and Loss of weight) scale and Frailty Index, measure frailty with the presentation of definable clinical manifestations.[1 4] However, the chronic nature of the condition highlights the necessity of a comprehensive frailty concept comprising multidimensional constructs.

With the accumulation of research evidence, Gobbens and colleagues proposed an integral conceptual model of frailty and developed the Tilburg Frailty Indicator, an instrument that measures frailty from physical/physiological, psychological and social perspectives.[5 6] Individuals with frailty spend the majority of their time in the community, thus their surrounding environment could play an important role in the development and progression of frailty. Under this background, the Comprehensive Frailty Assessment Instrument (CFAI) was developed to measure frailty with environmental indicators in addition to physical, psychological and social domains.[7] A comprehensive assessment of frailty regards an individual as a social integrity and facilitates targeted management.

As frailty is an ageing-related condition, the rapidly accelerating population ageing has

made frailty a worldwide health concern. The reported prevalence of frailty in different studies was highly heterogeneous due to the difference in study setting and assessment instrument. The pooled prevalence of frailty was estimated to exceed 10% among community-dwelling older adults, and this figure tripled when confined to comprehensive frailty.[8 9] The burden of frailty is also highlighted by its significant association with a spectrum of adverse health outcomes, such as increased risk of falls, fractures, cognitive declines, emotional disorders, social isolation, hospitalisation and compromised health-related quality of life.[1 10] The research evidence suggests that frailty could increase the mortality rate of older adults by up to 50%.[11]

Sleep plays fundamental biological functions for human bodies, allowing for the maintenance, repair and building of the body. High-quality sleep promotes growth and development and improves cognitive performance and psychological well-being.[12] Unfortunately, a large proportion of older adults are suffering from sleep disorders, and thus become vulnerable to the subsequent consequences, ranging from microstructural abnormality to increased mortality, through multiple functional declines.[13–17]

Among the various associated factors of frailty, sleep disorders have been frequently identified as the key contributors to the condition. Research evidence has consistently shown an association between sleep quality and frailty.[18 19] Both shortened and prolonged sleep duration could increase the risk of frailty.[20 21] In a large-scale prospective cohort study, individuals maintaining a comprehensive healthy sleep pattern, defined as a sleep duration of 7–8 hours/day without insomnia or snoring, were reported to be less likely to demonstrate worsening frailty status and more likely to demonstrate improving frailty during a median follow-up period of 8 years.[22] Based on the analysis of 1022 participants who have been followed for up to 16 years in the Rush Memory and Ageing Project, Cai *et al* found that several patterns of circadian rest-activity disturbances, such as decreased rhythm strength, reduced stability and increased variation of cycle length, are associated with an increased risk of incident frailty and accelerated progress of frailty over time.[23] The potential association between other patterns of sleep disorders, such as insomnia symptoms, excessive daytime sleepiness, prolonged sleep latency, low sleep efficiency, disturbed sleep-wake pattern and sleep disordered breathing, and increased level of frailty has also been reported in the literature.[20 24] However, such associations are inconclusive until further sound evidence is available.[18]

Despite the flourishing evidence regarding the status of sleep disorders and their association with frailty among older adults, the remaining research gaps make further investigations guaranteed. On the one hand, relevant studies are still lacking, especially studies based on the analysis of large-scale cross-sectional data, rather than retrospective data, as well as studies focused on other patterns of sleep disorders as abovementioned. On the other hand, in the majority of existing studies, frailty was measured with exclusively physical-origin instruments, making the investigation on the association between sleep disorders and comprehensive frailty unfeasible.[18 20 24] Thus, this large-scale cross-sectional study was conducted with the objectives to investigate the status of sleep disorders and their association with comprehensive frailty, as measured with the CFAI, in the community-dwelling older adults.

METHODS

The reporting of this study adhered to the Strengthening the Reporting of Observational Studies in Epidemiology statement.[25]

Study design, setting and participants

This is a multicentre cross-sectional study conducted in six community healthcare centres in Xi'an City, a metropolis in Northwestern China, from March to August 2021. The community healthcare centres in China are public institutions established to provide primary healthcare services to the citizens in defined regions. The duties include building health records, providing basic medical treatments, implementing health prevention strategies, organising health education, regular health check-ups and home visits, etc.

The target population was community-dwelling older adults. The inclusion criteria for eligibility were (1) aged≥60 years; (2) had a health record in the community healthcare centres; (3) had sufficient communication ability and (4) consented to participation. Individuals were excluded in the following conditions: (1) received hospitalised treatments in the preceding month; (2) during the recovery period of a surgery or an accident that limits mobility (eg, fracture) and (3) with a clinical diagnosis of mental disorders, malnutrition or malignant cancer.

The research participants were sampled from the six research sites using simple random sampling method. The sample size calculation formula for correlational studies was used to determine the sample size: $N = ((Z_{1-\alpha/2}+Z_{1-\beta/2})/C)^2 + 3$.[26] In the formula, $C=0.5 \times \ln((1+r)/(1-r))$. A minimum of weak correlation (r=0.2–0.4) between sleep quality and frailty was expected in this study.[27] Take $\alpha=0.05$ and $\beta=0.2$, a minimum number of 200 participants was required in this study. This study is based on a secondary analysis of the data from a prevalence study that scheduled 3000 participants, which accounts for 1.6‰ of the population aged≥60 years (1.88 million) in Xi'an City.[28 29] All available data were included in the current analysis to improve the precision of statistical estimates.

Measures

Socio-demographic and health-related information

A self-designed socio-demographic and health-related information sheet was used to collect data from the

research participants. The socio-demographic information included age, gender, marital status, educational level and living status. Health-related information included body mass index (BMI), types of medication taken, comorbid chronic diseases (with a clinical diagnosis) and number of hospitalisations in the preceding 12 months.

Frailty

The CFAI was employed to measure frailty.[7 30] The 23-item CFAI is a comprehensive frailty assessment instrument developed based on the integral conceptual model, measuring the condition from the physiological, psychological, social and environmental domains. For the physiological domain, the participants are asked to indicate how long they have been hampered by their health status in performing the following activities: 'Less demanding activities like carrying shopping bags', 'Walking up a hill or stairs', 'Bending or lifting' and 'Going for a walk'. The answers and scoring options are 0='not at all', 1='3 months or less' and 2='more than 3 months', resulting in a sum ranging from 0 to 8.

The psychological domain consists of two measurements. The first measurement is mood disorders which are assessed with the following five propositions: 'Feeling unhappy', 'Losing self-confidence', 'Unable to cope with problems', 'Feeling pressure' and 'Feeling worth nothing anymore'. The answer and scoring options are 0='not at all', 1='not more than usual', 2='more than usual' and 3='considerably more than usual'. Adding these scores could result in a sum score of 0–15. The other measurement is emotional loneliness assessed with the following three propositions: 'I experience a general sense of emptiness', 'I miss having people around me' and 'I often feel rejected'. The answer and scoring options are: 0='I completely disagree', 1='I disagree', 2='I neither agree nor disagree', 3='I agree' and 4='I completely agree'. Adding the item scores results in a sum score of 0–12.

The social domain consists of social loneliness and social support network. Social loneliness is measured through three propositions: 'There are plenty of people I can lean on when I have problems', 'There are many people I can trust completely' and 'There are enough people I feel close to'. As these propositions are positively stated, the scoring options are reversed as 4='I completely disagree', 3='I disagree', 2='I neither agree nor disagree', 1='I agree' and 0='I completely agree', with a sum score ranging from 0 to 12. Furthermore, the participants are asked which of the following persons they could rely on for help if necessary: partner, son, daughter-in-law, daughter, son-in-law, grandchildren, brother or sister (-in-law), family, neighbours and friends. For each source of social support, the respondent can rely on a score of 0 if assigned; otherwise, the score is 1. Therefore, the sum score of the social support network is between 0 and 10.

For the environmental domain, five propositions are used to assess the respondent's actual housing and environmental conditions: 'My house is in a bad condition', 'My house is not comfortable', 'It is difficult to heat my house', 'There is insufficient comfort in my house' and 'I do not like the neighbourhood'. The answer and scoring options are: 0='I completely disagree', 1='I disagree', 2='I neither agree nor disagree', 3='I agree' and 4='I completely agree' and the sum score ranges from 0 to 20.

Based on a standard scoring algorithm (table 1), equal weight was given to each domain, with the maximum domain scores of 25 and total score of 100. Higher scores indicate a higher level of frailty. A total score of 0–21.9, 22.0–38.8 and 38.9–100.0 is classified as no-low, mild and high frailty, respectively.[30] The original version of the CFAI showed good internal consistency reliability (Cronbach's α=0.812) and construct validity.[7] The Chinese version of the instrument exhibited acceptable psychometric properties among community-dwelling older adults. [31]

Sleep disorders

The Pittsburgh Sleep Quality Index (PSQI) was employed to identify sleep disorders.[29] The 19-item PSQI assesses the informants' overall sleep quality and disturbance during the past month. Following a standard scoring algorithm, the 19 items can generate seven component scores and a global score. The possible range of the PSQI total score is 0–21, with higher scores indicating poorer sleep quality. A total score of >7 is regarded as poor sleep quality for the Chinese population. Both the original and Chinese versions of the PSQI are of sufficient reliability and validity.[32 33]

Procedures and ethical considerations

On the completion of sampling, the research assistants from the community healthcare centres contacted the eligible individuals via phone calls, introduced the study objectives and procedures, and invited them to join.

Table 1 Scoring algorithm for calculating the domain and total scores of the CFAI

CFAI domains	Scoring algorithm
Physiological domain	(sum of physical domain items)×25/8
Psychological domain	(sum of mood disorder items)×12.5/15 + (sum of emotional loneliness items)×12.5/12
Social domain	(sum of social loneliness items)×12.5/12 + (sum of social support network items)×12.5/10
Environmental domain	(sum of psychological domain)×25/20
Total score	Sum of the domain scores

CFAI, Comprehensive Frailty Assessment Instrument.

Home visits were arranged with interested participants, during which they were provided with an information sheet that outlined the key study details. Written informed consent was obtained from the participants before the commencement of data collection. Subsequently, objective variables were measured by independent physical examiners from the research sites while subjective data were collected by trained investigators via individual face-to-face interviews. The investigators simultaneously entered the participants' data into an online electronic questionnaire. Input of responses to key questions/items was set as compulsory and limited to rational ranges, so that valid questionnaires could be maximised. Training and competency assessments were arranged before the study to minimise information bias and maximise inter-rater consistency.

The study obtained permissions from the participating community healthcare centres. An information sheet detailing the study was provided to the participants. Written informed consent forms were obtained before data collection. The participants' rights and safety were protected by adhering to the Declaration of Helsinki, local laws and institutional policies.

Statistical analysis plan

The IBM SPSS V.24.0 was used for data analysis. Continuous data were described as mean±SD when normally distributed, while categorical data as n (%). One-way analysis of variance and χ^2 test were used, where appropriate, to compare the difference in socio-demographic and health-related variables and sleep disorders across different levels of frailty. Multinomial logistic regression with the adjustment of potential confounding variables was employed to examine the independent association between sleep quality and frailty. Existing evidence suggested that both shortened and prolonged sleep duration are associated with frailty;[20 33] therefore, sleep duration in this study was categorised as normal (5–8 hours), shortened (<5 hours) or prolonged (>8 hours) based on the absolute night sleep time, and examined for the independent association with frailty using adjusted multinomial logistic regression. The Pearson correlation analysis was employed to investigate the correlation between scores in the PSQI (total score and domain scores except the sleep duration domain) and the total score in the CFAI. The statistical significance level for all inferential statistics was set to α=0.05, two-sided.

Patient and public involvement

Patients and/or the public were not involved in the design, or conduct, or reporting, or dissemination plans of this research.

RESULTS

Participants' recruitment

A total of 3923 potentially eligible individuals were approached to recruit the scheduled 3000 participants, representing a response rate of 76.5%. The main reasons for refusing to participate were no interest, schedule conflict and lack of time. After screening, 2647 (88.2%) valid questionnaires remained and were included in the statistical analyses.

Socio-demographic and health-related characteristics and frailty status of the samples

The average age of the research participants was 68.59±6.13 years. Women accounted for 58.9% of the samples. More than half of the participants were with abnormal body weight based on the classification of BMI. Around 90% of the participants had chronic diseases, of which hypertension was the most commonly reported condition. Approximately one-quarter of the participants were hospitalised in the preceding 12 months.

The participants averaged 27.77±10.13 in the total score of the CFAI. According to the classification criteria, 1478 (55.8%) and 390 (14.8%) of the participants were with mild and high comprehensive frailty, respectively. The detailed socio-demographic and health-related characteristics and frailty status of the samples are presented in table 2.

Sleep disorders among community-dwelling older adults

The participants scored 5.23±2.94 in the total score of the PSQI, with a poor sleep quality prevalence of 19.9%. Of the total sample, 3.2% and 12.5% had shortened and prolonged sleep duration, respectively (table 3).

There are significant differences in the PSQI total score, the PSQI domain scores and the prevalence of poor sleep quality and abnormal sleep duration across different levels of frailty, suggesting a gradually rising tendency in the severity of sleep disorders with the increase of frailty level (table 3).

The association of sleep disorders with frailty among community-dwelling older adults

The results of multinomial logistic regression showed that older adults with poor sleep quality are more likely to have mild and high frailty after the adjustment of potential confounding variables, with an OR of 1.61 and 2.64, respectively (table 4). Similarly, older adults with shortened sleep duration are at a higher risk of having mild frailty (OR: 2.62), while those with prolonged sleep duration are at a higher risk of having mild and high frailty compared with their counterparts with normal sleep duration, with an OR of 1.39 and 1.64, respectively (table 5).

The result of Pearson correlation analysis demonstrated a positive correlation between the total score of the PSQI and CFAI (r=0.237, p<0.001), indicating a significant association of poor sleep quality with a higher level of frailty. Poor subjective sleep quality, extended sleep latency, sleep disturbances, use of sleeping medication and daytime dysfunction were also found to be associated with a higher level of frailty (table 6).

Table 2 Socio-demographic and health-related characteristics of the total samples and the comparison between different levels of frailty (n=2647)

Variables	Total samples (n=2647) Mean±SD/n (%)	Intergroup comparison			
		No-low frailty group (n=779) Mean±SD/n (%)	Mild frailty group (n=1478) Mean±SD/n (%)	High frailty group (n=390) Mean±SD/n (%)	P value
Age (years)	68.59±6.13	67.03±5.61	68.97±6.14	70.29±6.41	<0.001*
Gender					
Female	1560 (58.9)	417 (53.5)	904 (61.2)	239 (61.3)	0.001†
Male	1087 (41.1)	362 (46.5)	574 (38.8)	151 (38.7)	
Marriage status					
Married	2293 (86.6)	686 (88.1)	1289 (87.2)	318 (81.5)	0.005†
Unmarried/divorced/widowed	354 (13.4)	93 (11.9)	189 (12.8)	72 (18.5)	
Educational level					
Primary school or below	628 (23.7)	156 (20.0)	349 (23.6)	123 (31.5)	<0.001†
Middle school	955 (36.1)	283 (36.3)	547 (37.0)	125 (32.1)	
High school	821 (31.0)	255 (32.7)	447 (30.2)	119 (30.5)	
College or above	243 (9.2)	85 (11.0)	135 (9.1)	23 (5.9)	
Living status					
Empty nesters	596 (22.5)	165 (21.2)	327 (22.1)	104 (26.7)	0.092†
Non-empty nesters	2051 (77.5)	614 (78.8)	1151 (77.9)	286 (73.3)	
BMI (kg/m^2)	23.91±3.13	23.95±3.10	23.99±3.11	23.55±3.27	0.047*
BMI<18.5, underweight	94 (3.6)	19 (2.4)	50 (3.4)	25 (6.4)	0.013†
18.5≤BMI<24, normal body weight	1281 (48.4)	396 (50.8)	700 (47.4)	185 (47.4)	
24≤BMI<28, overweight	1034 (39.1)	292 (37.5)	589 (39.9%)	153 (39.2)	
BMI≥28, obese	238 (8.9)	72 (9.3)	139 (9.3)	27 (7.0)	
Comorbid chronic diseases					
Yes	2371 (89.6)	699 (89.7)	1329 (89.9)	343 (87.9)	0.519†
No	276 (10.4)	80 (10.3)	149 (10.1)	47 (12.1)	
Hypertension					
Yes	1209 (45.7)	331 (42.5)	680 (46.0)	198 (50.8)	0.026†
No	1438 (54.3)	448 (57.5)	798 (54.0)	192 (49.2)	
Diabetes					
Yes	479 (18.1)	133 (17.1)	276 (18.7)	70 (17.9)	0.641†
No	2168 (81.9)	646 (82.9)	1202 (81.3)	320 (82.1)	
Number of hospitalisations in the preceding 12 months					
0	2021 (76.4)	637 (81.8)	1112 (75.2)	272 (69.7)	<0.001†
1	480 (18.1)	118 (15.1)	278 (18.8)	84 (21.5)	
2	100 (3.8)	17 (2.2)	62 (4.2)	21 (5.4)	
≥3	46 (1.7)	7 (0.9)	26 (1.8)	13 (3.3)	
Frailty (CFAI)					
CFAI_TOTAL	27.77±10.13	16.34±4.17	29.31±4.49	44.78±5.10	0.000*
CFAI_PHYS (physiological domain)	8.27±5.66	3.52±3.98	9.29±4.64	13.85±4.91	<0.001*
CFAI_PSYCH (psychological domain)	5.36±3.91	2.35±2.39	5.87±3.37	9.39±3.74	<0.001*
CFAI_SOC (social domain)	9.94±3.68	8.94±3.40	10.13±3.82	11.21±3.17	<0.001*
CFAI_ENV (environmental domain)	4.21±4.97	1.53±2.79	4.01±4.09	10.32±6.05	<0.001*

*One-way analysis of variance.
†X^2.
BMI, body mass index; CFAI, Comprehensive Frailty Assessment Instrument.

Table 3 Sleep disorders of the total samples and the comparison between different levels of frailty (n=2647)

Variable	Total sample Mean±SD/n (%)	Intergroup comparison			
		No-low frailty group Mean±SD/n (%)	Mild frailty group Mean±SD/n (%)	High frailty group Mean±SD/n (%)	P value
PSQI total score	5.23±2.94	4.48±2.64	5.29±2.90	6.49±3.16	<0.001*
Normal sleep quality (≤7)	2112 (80.1)	676 (87.0)	1168 (79.4)	268 (68.7)	<0.001†
Poor sleep quality (>7)	526 (19.9)	101 (13.0)	303 (20.6)	122 (31.3)	
Subjective sleep quality	1.13±0.67	0.96±0.62	1.15±0.67	1.36±0.68	<0.001*
Sleep latency	1.04±0.83	0.80±0.78	1.09±0.82	1.31±0.87	<0.001*
Sleep duration	0.92±0.92	0.96±0.90	0.90±0.93	0.93±0.91	0.315*
Normal (5–8 hours)	2231 (84.3)	690 (88.6)	1226 (82.9)	315 (80.8)	<0.001†
Shortened (<5 hours)	86 (3.2)	14 (1.8)	60 (4.1)	12 (3.1)	
Prolonged (>8 hours)	330 (12.5)	75 (9.6)	192 (13.0)	63 (16.1)	
Habitual sleep efficiency	0.55±0.94	0.53±0.95	0.55±0.95	0.54±0.90	0.838*
Sleep disturbances	0.94±0.43	0.85±0.46	0.95±0.39	1.08±0.47	<0.001*
Use of sleeping medication	0.11±0.47	0.07±0.37	0.11±0.47	0.20±0.64	<0.001*
Daytime dysfunction	0.54±0.71	0.30±0.54	0.53±0.68	1.06±0.86	<0.001*

*One-way analysis of variance.
†X^2 Test.
PSQI, Pittsburgh Sleep Quality Index.

DISCUSSION

This large-scale cross-sectional study showed a high prevalence of sleep disorders among community-dwelling older adults. The results also supported the hypothesised association between sleep disorders and comprehensive frailty. Specifically, poor overall sleep quality, poor subjective sleep quality, extended sleep latency, sleep disturbances, use of sleeping medication, daytime dysfunction and shortened and prolonged sleep duration are found to be associated with higher levels of comprehensive frailty.

Sleep disorders are common among community-dwelling older adults

Sleep disorders are detrimental to individuals at all age groups due to the association with a wide range of adverse health outcomes.[34] The result of this study indicated that community-dwelling older adults are suffering from various patterns of sleep disorders. In a recent large-scale cross-sectional study conducted in China, community-dwelling older adults averaged 5.33 in the total score of the PSQI, indicating poor sleep quality. The result is highly agreed with that of the current study.[35] Such findings were also reported in studies originating from other countries.[36 37] Similarly, the reported prevalence of poor sleep quality among community-dwelling older adults in existing studies is comparable to the figure in the current study, which confirms the challenging situation of the condition.[35 38] Various factors could contribute to the high prevalence of poor sleep quality among older adults, such as chronic disease, medication taking, emotional problems and social isolation.[39]

Both insufficient and excessive amounts of sleep are associated with adverse health outcomes, such as cardiovascular diseases, depressive symptoms and increased all-cause mortality.[17 40] In the current study, the average night sleep time of the participants was 7.10 hours, which meets the international recommendations of 7–8 hours every day for older adults.[41] However, among the old adults involved in the current study, 3.2% had a sleep duration of less than 5 hours with another 12.5% slept more than 8 hours every night. The reported prevalence of shortened and prolonged sleep duration in different studies was highly heterogeneous, possibly due to the difference in geographic region, ethnicity, specific age group and measurement of sleep duration.[42–44] Nevertheless, it is apparent that undesirable sleep duration is common among older adults.

Various patterns of sleep disorders are associated with higher levels of frailty among community-dwelling older adults

Sleep disorders could have both direct and indirect effects on frailty.[18 45] On the one hand, sleep disorders could lead to symptoms such as fatigue, unsteady gait and physical inactivity, which are the featured manifestations of frailty. On the other hand, sleep disorders could result in altered metabolic and inflammatory pathways, such as decreased levels of insulin-like growth factor-1 and increased level of interlukin-6 and C-reactive protein, which are the major mechanisms of frailty.[1 46] Besides, multiple patterns of sleep disorders could cause psychological and social problems, such as depression and loneliness, which are known contributors of frailty.

Poor sleep quality was found to be significantly associated with increased level of frailty in the current study. To be specific, it was indicated that community-dwelling older adults with poor sleep quality are more likely to have mild

Table 4 The adjusted multinomial logistic regression on the association between sleep quality and frailty (n=2647)

Level of frailty	Independent variables		OR	95% CI	P value
Mild frailty*					
	Sleep quality	**Poor (PSQI>7)**	**1.61**	**1.25 to 2.06**	**<0.001**
		Normal (PSQI≤7)	**Reference**	**–**	**–**
	Age		1.06	1.04 to 1.07	<0.001
	Gender	Female	1.36	1.14 to 1.64	<0.001
		Male	Reference	–	–
	Marriage status	Unmarried/divorced/widowed	0.85	0.64 to 1.12	0.240
		Married	Reference	–	–
	Educational level	Primary school or below	1.21	0.86 to 1.70	0.284
		Middle school	1.19	0.87 to 1.63	0.285
		High school	1.17	0.84 to 1.61	0.354
		College or above	Reference	–	–
	BMI	BMI<18.5, underweight	1.46	0.84 to 2.53	0.178
		24≤BMI<28, overweight	1.13	0.94 to 1.37	0.205
		BMI≥28, obese	1.05	0.77 to 1.45	0.753
		18.5≤BMI<24, normal body weight	Reference	–	–
	Hypertension	Yes	1.06	0.88 to 1.26	0.562
		No	Reference	–	–
	Number of hospitalisations in the preceding 12 months	1	1.21	0.95 to 1.54	0.129
		2	1.87	1.07 to 3.25	0.027
		≥3	2.03	0.87 to 4.77	0.103
		0	Reference	–	–
High frailty*					
	Sleep quality	**Poor (PSQI>7)**	**2.64**	**1.94 to 3.60**	**<0.001**
		Normal (PSQI≤7)	**Reference**	**–**	**–**
	Age		1.08	1.06 to 1.11	<0.001
	Gender	Female	1.23	0.95 to 1.60	0.119
		Male	Reference	–	–
	Marriage status	Unmarried/divorced/widowed	1.20	0.84 to 1.71	0.322
		Married	Reference	–	–
	Educational level	Primary school or below	2.37	1.38 to 4.08	0.002
		Middle school	1.61	0.95 to 2.71	0.075
		High school	1.93	1.14 to 3.27	0.015
		College or above	Reference	–	–
	BMI	BMI<18.5, underweight	2.65	1.39 to 5.05	0.003
		24≤BMI<28, overweight	1.09	0.83 to 1.42	0.554
		BMI≥28, obese	0.71	0.43 to 1.16	0.171
		18.5≤BMI<24, normal body weight	Reference	–	–
	Hypertension	Yes	1.24	0.96 to 1.60	0.104
		No	Reference	–	–
	Number of hospitalisations in the preceding 12 months	1	1.39	1.00 to 1.93	0.047
		2	2.38	1.21 to 4.68	0.012
		≥3	3.77	1.44 to 9.87	0.007
		0	Reference	–	–

*The reference is no-low frailty.
BMI, body mass index; PSQI, Pittsburgh Sleep Quality Index.

Table 5 The adjusted multinomial logistic regression on the association between sleep duration and frailty (n=2647)

Level of frailty	Independent variables		OR	95% CI	P value
Mild frailty*					
	Sleep duration	**Shortened (<5 hours)**	**2.62**	**1.44 to 4.78**	**0.002**
		Prolonged (>8 hours)	**1.39**	**1.05 to 1.86**	**0.024**
		Normal (5–8 hours)	**Reference**	**–**	**–**
	Age		1.06	1.04 to 1.07	<0.001
	Gender	Female	1.39	1.16 to 1.67	<0.001
		Male	Reference	–	–
	Marriage status	Unmarried/divorced/widowed	0.81	0.62 to 1.07	0.146
		Married	Reference	–	–
	Educational level	Primary school or below	1.23	0.87 to 1.74	0.235
		Middle school	1.20	0.87 to 1.64	0.265
		High school	1.18	0.86 to 1.63	0.304
		College or above	Reference	–	–
	BMI	BMI<18.5, underweight	1.45	0.83 to 2.51	0.190
		24≤BMI<28, overweight	1.12	0.92 to 1.35	0.265
		BMI≥28, obese	1.06	0.77 to 1.45	0.731
		18.5≤BMI<24, normal body weight	Reference	–	–
	Hypertension	Yes	1.05	0.88 to 1.26	0.583
		No	Reference	–	–
	Number of hospitalisations in the preceding 12 months	1	1.24	0.98 to 1.59	0.077
		2	1.96	1.13 to 3.40	0.017
		≥3	2.19	0.94 to 5.12	0.071
		0	Reference	–	–
High frailty*					
	Sleep duration	**Shortened (<5 hours)**	**1.89**	**0.84 to 4.24**	**0.122**
		Prolonged (>8 hours)	**1.64**	**1.13 to 2.38**	**0.009**
		Normal (5–8 hours)	**Reference**	**–**	**–**
	Age		1.08	1.06 to 1.11	<0.001
	Gender	Female	1.28	0.99 to 1.67	0.061
		Male	Reference	–	–
	Marriage status	Unmarried/divorced/widowed	1.16	0.81 to 1.67	0.408
		Married	Reference	–	–
	Educational level	Primary school or below	2.53	1.48 to 4.34	<0.001
		Middle school	1.68	1.00 to 2.82	0.051
		High school	2.01	1.19 to 3.39	0.009
		College or above	Reference	–	–
	BMI	BMI<18.5, underweight	2.65	1.40 to 5.05	0.003
		24≤BMI<28, overweight	1.07	0.82 to 1.40	0.635
		BMI≥28, obese	0.73	0.45 to 1.19	0.207
		18.5≤BMI<24, normal body weight	Reference	–	–
	Hypertension	Yes	1.25	0.97 to 1.61	0.085
		No	Reference	–	–
	Number of hospitalisations in the preceding 12 months	1	1.44	1.04 to 1.99	0.028
		2	2.48	1.27 to 4.85	0.008
		≥3	4.42	1.70 to 11.48	0.002
		0	Reference	–	–

*The reference is no-low frailty.
BMI, body mass index.

Table 6 The Pearson correlation analysis on the correlation between sleep disorders and frailty (n=2638)

Frailty (CFAI) Sleep quality (PSQI)	R	95% CI	P value
Total score	0.237	0.201 to 0.273	<0.001
Subjective sleep quality	0.201	0.164 to 0.237	<0.001
Sleep latency	0.223	0.187 to 0.259	<0.001
Habitual sleep efficiency	0.005	−0.033 to 0.043	0.789
Sleep disturbances	0.197	0.160 to 0.233	<0.001
Use of sleeping medication	0.087	0.049 to 0.125	<0.001
Daytime dysfunction	0.378	0.345 to 0.410	<0.001

CFAI, Comprehensive Frailty Assessment Instrument; PSQI, Pittsburgh Sleep Quality Index.

and high frailty, with an OR of 1.61 and 2.64, respectively. Existing evidence tends to be consistently concurred with the current study.[18–20 24 47] A recent systematic review with meta-analysis demonstrated that older adults with poor sleep quality have 1.49-fold higher odds of being frail compared with their counterparts.[20] A similar conclusion was also drawn in several earlier relevant systematic reviews.[18 24] The OR tended to be greater when investigating the association with comprehensive frailty,[20] which might be due to the accumulative effects of sleep quality on the multiple domains of comprehensive frailty.[46]

This study also showed that community-dwelling older adults with both shortened and prolonged sleep duration are at a higher risk of being frail. Even though the results of different studies are slightly heterogeneous, the syntheses of available evidence tend to present a U-sharp association between sleep duration and frailty.[20 21 24] This might be because older adults with perceived sleep problems are prone to report more symptoms of extreme sleep duration. Nevertheless, it is worthy noticing that the operational definition of normal, shortened and prolonged sleep duration varies greatly across studies. Thus, to establish a more precise pattern of association between sleep duration and frailty, further studies with identical definition of sleep duration categories are worthwhile.

Both extended sleep latency and daytime dysfunction were demonstrated to be associated with frailty in the current study, which is consistent with the findings of recent evidence syntheses.[20 24] This study also showed that poor subjective sleep quality and sleep disturbances are associated with higher level of frailty. Such associations have also been reported in relevant studies.[47 48] The associations between these patterns of sleep disorders and frailty could be explained by two reasons. First, individuals with the disorders are subjected to depressive symptoms, which are known contributors of frailty.[49] Additionally, drowsiness, which is among the manifestations of frailty, is usually a concomitant syndrome of these sleep disturbances. Acknowledged that existing evidence tends to support the associations between these patterns of sleep disorders and frailty, cautions should be taken when making the conclusion due to the limited quantity of original studies.

A statistically significant but very weak association was found between the use of sleeping medication and higher level of frailty in the current study. Evidence on the association between these two variables is quite rare. In recent studies, the investigators reported that older adults who have poor sleep quality in the domain of sleeping medication use are significantly more vulnerable to frailty.[50 51] This could be explained by the findings of many studies that the risk of frailty rises with the number of medications taken.[28] Differently, the small correlational coefficient in the current study might be due to the employment of a comprehensive frailty assessment. No association was detected between habitual sleep efficiency and frailty in the current study. Similar studies exhibited inconclusive findings, which could be due to the difference in ethnicity, specific age group of research participants and the operational definition of frailty.[47 51 52] In view of the scarcity of existing evidence and the inconsistent results across studies, further investigations on the association of sleeping medication use and habitual sleep efficiency with frailty are worthwhile.

Strengths and limitations

This study has several notable strengths. For one thing, it is among the few studies that investigated the correlation between sleep quality and comprehensive frailty, the findings of which generated new knowledge in the field. For another, this study is featured with its large sample size and the inclusion of multiple research sites, which could improve the precision of estimates.

Despite these strengths, the findings of this study should be interpreted with the caution of its limitations. First, causal inference cannot be made due to the nature of a cross-sectional study design. Second, all participants were from one single city in Northwest China, which would downgrade the generalisability of the findings. Third, the primary variables, for example sleep disorders, were measured in a subjective manner, which could introduce detection bias to the study.

Implications

Acknowledged that existing evidence tended to support the association of sleep disorders with frailty among older adults, further large-scale multicentred studies with longitudinal designs are desirable before a causal relationship could be substantially established. To enhance the internal validity of future studies, researchers are encouraged to take advantage of technology-enabled instruments to measure study variables more accurately, for example, using actigraphy or wearable devices to measure sleep disorders.

Although some physiological changes in sleep are a normal part of the ageing process, sleep disorders should not be regarded as an inherent part of the process. Instead, healthcare professionals should pay attention to improve the sleep quality of older adults. As a modifiable factor, the improvement of sleep quality possesses the potential to prevent or even revert frailty.

CONCLUSIONS

Sleep disorders are common problems among community-dwelling older adults, the severity of which rises with the increase in frailty level. Poor overall sleep quality, poor subjective sleep quality, extended sleep latency, sleep disturbances and daytime dysfunction are associated with frailty. Both shortened and prolonged sleep duration are associated with frailty.

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