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The relationship between sleep quality and depressive symptoms in older adults: the mediated role of muscle strength (dynapenia)

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Abstract

Background The association between sleep quality and depressive symptoms was established, which could be varied by some mediators. Muscle strength might be a potential mediator for this association. The purpose of this study was to explore the mediating role of muscle strength in the relationship between sleep quality and depressive symptoms among the older individuals with or without dynapenia.

Methods Three hundreds and nine older adults were allocated into two groups: dynapenia and non-dynapenia groups. The handgrip strength was assessed by the hand-held dynamometer. The quality of sleep and depressive symptoms were evaluated using Pittsburgh Sleep Quality Index and the 15-item Geriatric Depression Scale, respectively. The ProcessV3.3 was used to estimate the simple mediation model, with controlled covariates and centralized variables.

Results In both dynapenia ($n=142$) and non-dynapenia ($n=167$) groups, the quality of sleep was positively correlated to depressive symptoms, while negatively related to muscle strength ($p<0.05$). Meanwhile, depressive symptoms were negatively correlated to muscle strength (dynapenia: $p=0.001$; non-dynapenia: $p<0.001$). Muscle strength only acted as a mediator accounting for 10.04% of the total effect of sleep quality on depressive symptoms in the older individuals with dynapenia. No mediating role was found in the effect of depressive symptoms on sleep quality in both dynapenia and non-dynapenia group.

Conclusion Muscle strength was a mediator in the one direction of the relationship between sleep quality and depressive symptoms (the effect of PSQI on GDS-15) in older individuals with dynapenia.

Keywords Depressive symptoms, Sleep quality, Dynapenia, Mediating effect, Old population

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Background

Depressive symptoms are common in older adults [1], leading to many adverse consequences, such as a decrease in the quality of life of the individual [2], an increase in healthcare costs [3], morbidity [4], and risk of suicide [5]. The risk factors for depressive symptoms, including physical frailty, cognitive impairment, and unhealthy behaviors, have been identified in community-dwelling elderly individuals [6]. Among the related behavioral factors, sleep quality has attracted much attention from researchers in recent years. Several studies have reported that sleep quality was significantly associated with depressive symptoms in older adults [7, 8]. A bidirectional relationship between sleep quality and depressive symptoms was also established. The presence of mental disorders could deteriorate sleep quality [9], meanwhile poor sleep quality might increase the likelihood of depressive symptoms in older adults [10].

The association between sleep quality and depressive symptoms may vary according to the mediator. Only two studies have investigated the potential mediators of the relationships between sleep quality and depressive symptoms in young adults. Cheng et al. noted that functional connectivity in the brain was a mediator of the effects of depressive symptoms on sleep quality [11]. Mao et al. reported that life skills can mediate the effects of sleep quality on depressive symptoms in adolescents with childhood household dysfunction [12]. As the number of studies is limited, the potential mediators of the relationship between sleep quality and depressive symptoms in the older population are still unknown.

Muscle strength, which is easy to assess and intervene, might be a mediator in elderly individuals. Both sleep quality and depressive symptoms are correlated with muscle strength in the elderly population. Two large-scale cross-sectional studies reported that muscle strength was negatively correlated with the incidence of depression in older individuals [13, 14]. Meanwhile, age-related loss of muscle strength (dynapenia) was found to be associated with an increase in the probability of incident (OR = 1.44; 95% CI: 1.08–1.92) and persistent (OR = 1.61; 95% CI: 1.01–2.58) depressive symptoms [15]. Poor sleep quality was associated with weak muscle strength in middle-aged and older adults [16]. A recent finding indicated that sleep duration (both prolonged and insufficient sleep duration) was negatively related to muscle strength in individuals with dynapenia [17]. Moreover, the causal association of muscle strength with depressive symptoms and sleep quality in older adults was confirmed. A systematic review with meta-analysis of randomized controlled trials, reported that increasing muscle strength through physical training significantly improved depressive symptoms in older adults ($p = 0.003$) [18]. Although no systematic review or meta-analysis has investigated the causal association of muscle strength with sleep quality in older individuals, existing randomized controlled trials have confirmed that gain of muscle strength can improve sleep quality in individuals with low muscle strength [19].

Based on published studies, muscle strength might be a potential mediator in the relationship between sleep quality and depressive symptoms in older individuals, which needs be examined first. Moreover, we are curious about one question: whether muscle strength plays a similar role in individuals with or without dynapenia? Therefore, in this study, we investigated whether muscle strength mediates the bidirectional relationship between sleep quality and depressive symptoms in older people with or without dynapenia.

Table 1 Characteristics of the participants ($n = 309$)

	Dynapenia ($n = 142$)	Non-dynapenia ($n = 167$)	*p* value
Age (year) (M ± SD)	78.14 ± 5.82	75.36 ± 5.59	<0.001
BMI (kg/m^2) (M ± SD)	22.41 ± 3.04	24.82 ± 3.85	<0.001
PSQI score (M ± SD)	8.49 ± 4.10	7.96 ± 4.33	0.268
GDS-15 score (M ± SD)	5.12 ± 2.38	4.68 ± 2.88	0.529
Living Situations, %			0.616
Alone	11.97	10.18	
Not alone	88.03	89.82	
Smoking status, %			0.837
Never	67.61	65.87	
Former	19.01	28.14	
Current	13.38	5.99	
Drinking status, %			0.998
Never	83.80	84.43	
Former	8.45	4.19	
Current	7.75	11.38	
Fall history, %			0.836
Never	79.58	80.84	
1 ~ 2 times	17.60	14.97	
≥ 3 times	2.82	4.19	
Exercise situation, %			0.674
Never	31.69	33.53	
1 ~ 2 times/week	11.97	12.57	
≥ 3 times/week	56.34	53.90	
Comorbidity, %			0.187
0	2.82	5.39	
1	11.97	14.97	
≥ 2	85.21	79.64	

M ± SD: Mean ± Standard deviation; BMI: Body mass index; GDS-15: 15-item Geriatric Depression Scale

Methods

Participants

A cross-sectional design with a convenience non-probability sample was conducted in the Central Hospital of Wuhan between October 2020 and August 2021. The inclusion criteria of participants were as follows: (1)

Table 2 The relationships between sleep quality, depressive symptoms and muscle strength

	Dynapenia group (*N* = 142)			Non-dynapenia group (*N* = 167)		
	PSQI	**GDS-15**	**MS**	**PSQI**	**GDS-15**	**MS**
PSQI	-			-		
GDS-15	0.432***	-		0.453***	-	
MS	-0.177*	-0.272**	-	-0.258**	-0.296***	-

PSQI: Pittsburgh Sleep Quality Index; GDS-15: 15-item Geriatric Depression Scale; MS: Muscle strength; *** $p<0.001$; ** $p<0.01$; *$p<0.05$

individual aged 70 years and older above; (2) those who were willing to participate to this study and signed the informed consent; and (3) those who could communicate and cooperate normally. The exclusion criteria were as follows: (1) The individuals with mental illness or severe cognitive impairment unable to communicate normally; (2) those with severe visual and hearing impairment; (3) those who were unable to complete for the handgrip strength test. The procedures were reviewed and approved by the Human Ethics Review Board of the College of Medicine and Health Science of Wuhan Polytechnic University prior to commencement of the study (Approval number: BME-2020-1-04).

Sleep quality

The quality of sleep was evaluated using Pittsburgh Sleep Quality Index (PSQI) [20]. Seven components were assessed, including sleep quality, sleep latency and duration, habitual sleep efficiency, sleep disturbance, use of sleep medications, and daytime dysfunction using various questions. The scores ranged from 0 to 21, with a higher score implying a poor quality of sleep, while low score points to good quality of sleep.

Depressive symptoms

The 15-item Geriatric Depression Scale (GDS-15) was used to evaluate the level of depressive symptoms. It is a reliable and valid tool for evaluating depressive symptoms in the old population [21], including 15 yes/no questions. The range of the total scores is 0 to 15. Greater depressive symptoms are indicated by higher scores [22].

Dynapenia and non-dynapenia

Dynapenia was screened using handgrip strength (HG) in this study, which is a representation of the overall muscle strength [23, 24]. The diagnostic criteria of HG for dynapenia in men and women were <28 kg and <18 kg, respectively [25]. The participants were allocated into two groups: dynapenia group and non-dynapenia group. The HG was assessed with the dominant hand twice using the hand-held dynamometer (kg; CAMRY Model EH101). During the test, the participants were instructed to stand straight, with arms close to the body and the elbow flexed at 90°, as well as squeezing the dynamometer as hard as possible. The highest value of the two trials, accurate up to 0.1 kg, was analyzed.

Covariates

Participant demographics and individual medical conditions, including data on sex, age, body mass index (BMI), living situations, exercise situations, smoking status, drinking status, fall history, and the number of comorbidities were examined. A standardized protocol was used for recording anthropometric parameters (height and body weight). The living situations were categorized as alone or not alone. Fall history was the number

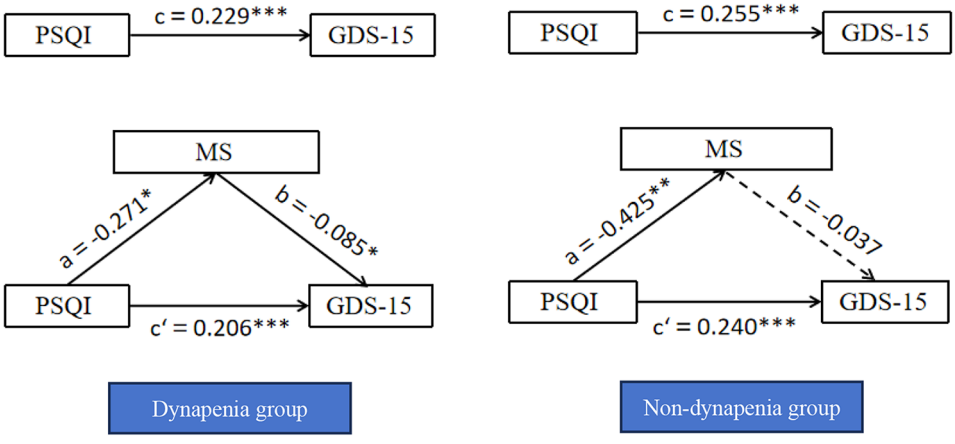

Fig. 1 A simple mediation model of muscle strength between sleep quality and depressive symptoms (the effect of PSQI on GDS-15) in the dynapenia and non-dynapenia groups. PSQI: Pittsburgh Sleep Quality Index; GDS-15: 15-item Geriatric Depression Scale; MS: Muscle strength; *** $p<0.001$; ** $p<0.01$; *$p<0.05$

of falls in the past year. Exercise situation was defined as how many times weekly more than 30 min of moderate-intensity physical activity was performed and was classified as 0 times/week, 1–2 times/week or ≥3 times/week. Smoking and drinking status were classified as "never," "former," or "current".

Statistical analysis

The data were presented as percentages or means and standard deviations. The muscle strength groups were compared using student t-tests, Mann-Whitney U tests, and $\chi 2$ tests for quantitative, ordinal, and qualitative variables, respectively. The relationships between sleep quality, dynapenia, and depressive symptoms were determined using Spearman's correlation in both dynapenia and non-dynapenia groups. Statistical analysis was performed using SPSS 26.0 (SPSS Inc., Chicago, Illinois, USA) with a significance level of 0.05. The ProcessV3.3 in SPSS designed by Hayes was used to estimate the simple mediation model, with controlled covariates and centralized variables. As an alternative resource to overcome the limitations of the classical proposal of Baron and Kenny, this resource enabled regression models to be computed with information on indirect effects. Bootstrapping (5000 bootstraps) enabled the estimation of 95% confidence intervals (CIs), and the effect of the mediator variable was determined. The path was considered statistically significant when the 95% CI did not contain 0. Finally, if the 95% CI of the indirect effect (path a×path b) did not include 0, it indicated that the mediating effects were statistically significant.

Results

Demographics and characteristics of participants

The sample comprised 309 older adults with an average of 76.64 years (SD=5.85, ranging from 70 to 95 years). The mean scores of PSQI and GDS-15 were 8.20±4.23 and 4.88±2.66, respectively. The demographics and characteristics of the dynapenia and non-dynapenia groups were presented in Table 1.

The relationships between PSQI, GDS-15, and muscle strength in the participants with dynapenia and non-dynapenia

In both dynapenia and non-dynapenia groups, PSQI was positively correlated to GDS-15 ($p<0.001$), while negatively related to muscle strength (dynapenia: $p=0.036$; non-dynapenia: $p=0.001$). Meanwhile, GDS-15 was negatively correlated to muscle strength (dynapenia: $p=0.001$; non-dynapenia: $p<0.001$). The details were demonstrated in Table 2.

Mediation model of muscle strength in the relationship between sleep quality and depressive symptoms (the effect of PSQI on GDS-15)

The effects of PSQI's indirect path coefficients (path a and path b) on GDS-15 through muscle strength in dynapenia group were −0.271 ($p=0.012$) and −0.085 ($p=0.02$), respectively. While in the non-dynapenia group, the effect of PSQI on GDS-15 through muscle strength was only significant in path a (p=0.002), not for path b (p=0.164). The total (path c) and direct (path c') effects of PSQI on GDS-15 were significant in both the dynapnia and non-dynapenia groups. The results suggested muscle strength was a mediator of the effect of PSQI on GDS-15 in the dynapenia groups, but not in the non-dynapenia group. Muscle strength accounted for 10.04% of the total effect of PSQI on GDS-15 in the dynapenia group. The final mediation model was presented in Table 3; Fig. 1.

Mediation model of muscle strength in the relationship between sleep quality and depressive symptoms (the effect of GDS-15 on PSQI

The effects of GDS-15's indirect path coefficients (path a and path b) on PSQI through muscle strength in dynapenia group were only significant in path a ($p=0.006$),

Table 3 Mediation analyses of muscle strength between sleep quality and depressive symptoms (the effect of PSQI on GDS-15) in the dynapenia and non-dynapenia groups

	Dynapenia group (*N* = 142)						Non-dynapenia group (*N* = 167)					
	R^2	F	β	SE	t	95% CI	R^2	F	β	SE	t	95% CI
GDS-15	0.238	8.504***					0.301	13.862***				
PSQI			0.229[c]	0.046	5.015***	0.139, 0.319			0.255[c]	0.046	5.591***	0.165, 0.346
MS	0.076	2.285*					0.115	4.198**				
PSQI			-0.271[a]	0.106	-2.555*	-0.481, -0.061			-0.425[a]	0.136	-3.134**	-0.093, -0.157
GDS-15	0.268	8.248***					0.309	11.946***				
PSQI			0.206[c']	0.046	4.476***	0.115, 0.297			0.240[c']	0.047	5.108***	0.147, 0.332
MS			-0.085[b]	0.036	-2.355*	-0.157, -0.014			-0.037[b]	0.026	-1.400	-0.089, 0.015
Indirect effect												
a × *b*			0.023	0.013		0.002, 0.053			0.006	0.004		-0.002, 0.015

PSQI: Pittsburgh Sleep Quality Index; GDS-15: 15-item Geriatric Depression Scale; MS: Muscle strength; *** $p<0.001$; ** $p<0.01$; * $p<0.05$. a: path a, the path coefficients between PSQI and MS. b: path b, the path coefficients between MS and GDS-15. c: path c, the path coefficients between PSQI and GDS-15. c': path c', the path coefficients of PSQI affects GDS-15 through MS

Table 4 Mediation analyses of muscle strength between sleep quality and depressive symptoms (the effect of GDS-15 on PSQI) in the dynapenia and non-dynapenia groups

	Dynapenia group (*N* = 142)						Non-dynapenia group (*N* = 167)					
	R^2	F	β	SE	t	95% CI	R^2	F	β	SE	t	95% CI
PSQI	0.232	6.797***					0.253	9.041***				
GDS-15			0.678[c]	0.138	4.918***	0.405, 0.950			0.642[c]	0.112	5.727***	0.421, 0.863
MS	0.463	19.431*					0.758	83.280**				
GDS-15			-0.395[a]	0.141	-2.795**	-0.674, -0.115			-0.360[a]	0.112	-3.212**	-0.582, -0.139
PSQI	0.237	5.953***					0.254	7.716***				
GDS-15			0.646[c']	0.142	4.557***	0.366, 0.927			0.634[c']	0.116	5.465***	0.405, 0.863
MS			-0.080[b]	0.084	-0.955	-0.246, -0.086			-0.022[b]	0.079	-0.282	-0.179, 0.134
Indirect effect												
a × *b*			0.032	0.035		-0.027, 0.110			0.008	0.028		-0.058, 0.055

PSQI: Pittsburgh Sleep Quality Index; GDS-15: 15-item Geriatric Depression Scale; MS: Muscle strength; *** $p<0.001$; ** $p<0.01$; * $p<0.05$. a: path a, the path coefficients between GDS-15 and MS. b: path b, the path coefficients between MS and PSQI. c: path c, the path coefficients between GDS-15 and PSQI. c': path c', the path coefficients of GDS-15 affects PSQI through MS

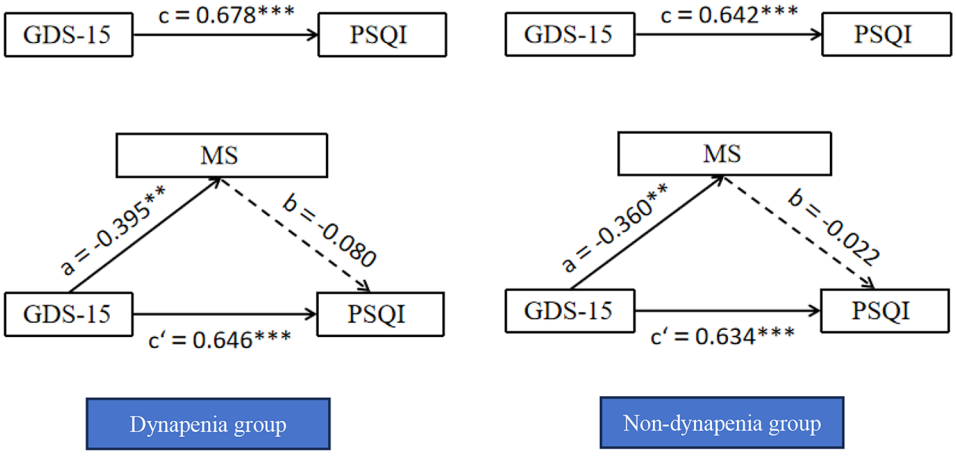

Fig. 2 A simple mediation model of muscle strength between sleep quality and depressive symptoms (the effect of GDS-15 on PSQI) in the dynapenia and non-dynapenia groups. PSQI: Pittsburgh Sleep Quality Index; GDS-15: 15-item Geriatric Depression Scale; MS: Muscle strength; *** $p<0.001$; ** $p<0.01$; * $p<0.05$

not in path b ($p=0.341$). Similar findings were found in the non-dynapenia group (path a: $p=0.002$; path b: $p=0.778$). The total (path c) and direct (path c') effects of GDS-15 on PSQI were significant in both the dynapnia and non-dynapenia groups ($p<0.001$). The results suggested muscle strength was not a mediator of the effect of PSQI on GDS-15 neither in the dynapenia groups nor in the non-dynapenia group. The final mediation model was presented in Table 4; Fig. 2.

Discussion

To the best of our knowledge, this was the first study to examine the role of muscle strength in mediating the bidirectional relationship between sleep quality and depressive symptoms in older people with or without dynapenia. The results suggested that muscle strength only mediated the effect of sleep quality on depressive symptoms in individuals with dynapenia.

In this study, we found that the higher level of sleep quality was independently associated with the lower level of depressive symptoms in the dynapenia and non-dynapenia groups. Moreover, muscle strength was significantly correlated with sleep quality and depressive symptoms in the dynapenia and non-dynapenia groups. Our findings are consistent with the findings of previous studies. A bunch of studies confirmed the negative relationship between sleep quality and depressive symptoms in the old population [6, 7, 10]. Meanwhile, several previous studies also found muscle strength was inversely associated with depressive symptoms [22, 26] but positively associated with sleep quality [16].

The results of this study indicated that muscle strength only mediated the relationship between sleep quality and depressive symptoms in the effect of sleep quality on depressive symptoms in individuals with dynapenia. Some previous studies found dynapenia (low muscle strength) was associated with a higher incidence of depressive symptoms [15, 27, 28]. Individuals with dynapenia are more likely to have a physical disability status than those without dynapenia, which indicates that they

are more likely to develop depressive symptoms since they have less communication with the outside world and do not receive adequate emotional support [29]. Moreover, older individuals with dynapenia are more likely to have a low-grade state of inflammation [30], which might be one of the causes of depressive symptoms in this specific population. Considering that muscle strength accounts for only 10.04% of the total effects of sleep quality on depressive symptoms, other factors, such as proinflammatory cytokines, might also mediate this relationship in older individuals. In contrast, muscle strength did not mediate the relationship between sleep quality and depressive symptoms in the effect of depressive symptoms on sleep quality. A previous study reported that functional connectivity in the brain was a mediator of the relationship between sleep quality and depressive symptoms in the effect of depressive symptoms on sleep quality [11]. The existing work in this area is far from conclusive. Further studies are needed to provide a comprehensive understanding of the mediators of the relationship between sleep quality and depressive symptoms in both directions.

There are some limitations in this study. First, this was a cross-sectional study, and causal relationships between variables cannot be inferred from the results. Second, the diagnostic criteria for dynapenia have not been agreed upon across different countries. We screened the participants according to the criteria of Asian Working Group for Sarcopenia [25]. Thus, the findings of this study may be generalized only to Asian countries. It is necessary to reach an agreement on the diagnosis of dynapenia in the future. Third, owing to the challenges of measuring the sleep parameters of clinical patients, in this study, we used the PSQI scale, a subjective method, to estimate sleep quality. However, the reliability and validity of the PSQI scale have been verified, and it has been widely used in epidemiological studies. Fourth, owing to practical considerations, only the mediating role of muscle strength was examined in this study. Other mediators and confounding factors may influence this bidirectional relationship between sleep quality and depressive symptoms in older individuals; further studies are needed to investigate them in detail.

Conclusions

The findings of this study suggested that muscle strength is a mediator of the relationship between sleep quality and depressive symptoms (the effect of sleep quality on depressive symptoms) in older individuals with dynapenia. Further studies are needed to figure out other potential mediators and their mechanisms of the relationship between sleep quality and depressive symptoms in both directions.

Abbreviations

PSQI	Pittsburgh Sleep Quality Index
BMI	Body mass index
HG	Handgrip strength
GDS-15	15-item Geriatric Depression Scale
CIs	Confidence intervals

Supplementary Information

The online version contains supplementary material available at https://doi.org/10.1186/s12889-024-21178-1.

Supplementary Material 1

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Author contributions

NW and LC drafted the manuscript. XW, ML and LC contributed to data collection and analysis. NW conceptualized and designed the study, and critically reviewed and revised the manuscript.

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Data availability

All data generated or analyzed during this study are included in this published article and its supplementary information files.

Declarations

Ethics approval and consent to participate

This study was performed in accordance with the Declaration of Helsinki. All methods were carried out with STROBE guideline. The Human Ethics Review Board of the College of Medicine and Health Science reviewed and approved the procedures before the study commencement (Approval number: BME-2020-1-04). All informed consents had been obtained from the eligible participants before initiating data collection.

Consent for publication

Not applicable.

Competing interests

The authors declare no competing interests.

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