BMC Geriatrics

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Mediating effect of social participation in the association between cognitive frailty and health-related quality of life among hospitalized older adults: a cross-sectional study in Xi'an, China

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Abstract

Background Cognitive frailty, the co-occurrence of physical frailty and cognitive impairment, has emerged as an essential factor affecting the health-related quality of life (HRQoL) among older adults; however, the role of social participation remains unknown. Our study aimed to explore the mediating role of social participation in the association between cognitive frailty and HRQoL among hospitalized older adults.

Methods A total of 467 older adults were recruited from three tertiary hospitals in Xi'an, China. Cognitive frailty was ascertained by the FRAIL scale and the Montreal Cognitive Assessment. Social participation was assessed by the questionnaire that was developed based on the China Health and Retirement Longitudinal Study. HRQoL was measured by the 36-item Short Form Health Survey. Bootstrap mediation effects were employed to estimate the mediating effect of social participation in the association between cognitive frailty and HRQoL.

Results The average age of the participants was 70.8 years and 51.8% were female. Individuals with cognitive frailty had significantly lower levels of social participation (5.9 ± 3.7 vs. 7.8 ± 4.1) and HRQoL (57.8 ± 15.5 vs. 68.1 ± 13.9) (physical component summary [PCS]: 52.4 ± 19.0 vs. 66.0 ± 16.7; mental component summary [MCS]: 63.2 ± 16.5 vs. 70.2 ± 15.4) compared to those without cognitive frailty. Social participation partially mediated the association between cognitive frailty and HRQoL (average causal mediation effect [ACME] = −1.22, 95% confidence interval [CI]: −2.20, −0.51) as well as on its dimensions of PCS (ACME = −1.12, 95% CI: −2.13, −0.55) and MCS (ACME = −1.29, 95% CI: −2.35, −0.49). Gender moderated the mediating effect of social participation in the association between cognitive frailty and HRQoL, which was more pronounced in women than that in men.

Conclusions The findings suggest that social participation mediates the association between cognitive frailty and HRQoL, particularly for women. This study expands the current literature on designing policy solutions to promote

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participation in social activities among older adults with cognitive frailty, with the goal of maintaining their HRQoL at a favorable level.

Keywords Health-related quality of life, Social participation, Cognitive frailty, Older adults, Mediation analysis

Background

Population aging poses a major challenge to most countries in the world [1]. In China, more than 296 million people were aged 60 years or older in 2023 [2]. This number is projected to increase to 402 million by 2040, representing approximately 28% of the total population, driven by increased life expectancy and declining fertility rates [3]. Aging is a complex, multi-system process accompanied by progressive deterioration of cellular and physiological functions, which reduces the body's homeostasis reserve and heightens susceptibility to disease [4, 5]. Older adults are three times more likely to require hospitalization compared to younger adults with similar conditions [6]. Given the profound impact of illness on various aspects of life, health status measures are often discordant with the assessment of global quality of life [7, 8]. Health-related quality of life (HRQoL) is a comprehensive and multidimensional construct that encompasses an individual's perceived functioning and well-being in the physical, mental, and social domains of health [9]. As the aging population grows, prioritizing the HRQoL of hospitalized older adults therefore is essential for improving their overall well-being [10].

Frailty, characterized by increased vulnerability of an organism to stressors, is highly prevalent among older adults [11, 12]. While frailty has historically been viewed from a physical perspective, contemporary frameworks emphasize its multidimensional nature. For instance, the model proposed by Gobbens et al. conceptualizes frailty as a dynamic interaction of physical, psychological, and social domains [13]. In 2013, an international consensus group proposed the concept of cognitive frailty, referring to the simultaneous presence of both physical frailty and cognitive impairment without concurrent Alzheimer's disease or other dementia [14]. This distinct subtype was operationalized to address the interplay between physical decline and cognitive dysfunction [15]. A systematic review revealed that cognitive frailty affects 9% of community-dwelling older adults [16]. Accumulating evidence indicates that cognitive frailty confers higher risks for adverse health outcomes in older adults, including worsening HRQoL [17–19]. A cohort study with a 1-year follow-up of Chinese community-dwelling older adults demonstrated that cognitive frailty was negatively associated with various dimensions of HRQoL [20]. Another cohort study conducted among Chinese Singaporeans aged 55 and above found that individuals with cognitive frailty had a 5-fold increase in the prevalence of low HRQoL [17]. This association has also been observed in older cancer survivors [21]. However, the potential causal mechanisms underlying the relationship between cognitive frailty and HRQoL remains unexplored.

Social participation involves conscious and active engagement in outdoor social activities leading to interaction and resource sharing with other people in the community, from which the older adult has personal satisfaction [22, 23]. According to the activity theory of aging, maintaining social activity among older adults can decelerate the aging process and promote their well-being [24, 25]. As a vital component of active aging, social participation has been significantly positively associated with the HRQoL of older people [26, 27]. For example, a study of older adults in rural China found that those who participated in social activities had higher HRQoL scores [27]. Similarly, Lestari et al. [28] found that greater social participation correlated with better HRQoL in the analysis of data from the Survey of Health, Ageing and Retirement in Europe across 17 countries. Although studies on Alzheimer's disease and physical frailty suggest that these conditions can limit social engagement [29, 30], the specific associations between cognitive frailty, social participation, and HRQoL remain scarce. Moreover, gender differences in social participation among older adults have been documented. Women are reported to have lower levels of engagement in volunteer activities compared to men, potentially due to their societal roles and caregiving responsibilities [31, 32]. These differences may influence the relationship between cognitive frailty, social participation, and HRQoL, yet they have not been thoroughly examined in the context of cognitive frailty.

Therefore, this study aimed to investigate whether and to what extent social participation mediates the relationship between cognitive frailty and HRQoL, with a particular focus on gender differences. It was hypothesized that cognitive frailty may hinder the maintenance of social participation, which, in turn, could negatively affect the HRQoL of older adults. By addressing these gaps, this study advances beyond prior research by providing a more comprehensive understanding of the mechanisms linking cognitive frailty, social participation, and HRQoL.

Methods

Participants

This cross-sectional study was conducted in three tertiary hospitals in Xi'an, China, between December 2021 and October 2022. These hospitals were selected as study sites due to their established research collaborations in aging-related studies. Individuals aged 60 years or older

were eligible to participate in this study. Recruitment was conducted in the inpatient wards of the participating hospitals by geriatricians and nurses with expertise in frailty, cognitive function assessment, and geriatric care. Data were collected by trained assessors through structured interviews with standardized questionnaires.

Participants were excluded if they had been diagnosed with any form of dementia ($n = 11$), suffered from serious psychiatric conditions ($n = 5$), were unable to fully participate in the assessment due to consciousness or speech impairment ($n = 2$), had undergone surgery within the past three months ($n = 6$), or had a life expectancy of less than six months ($n = 3$). After exclusion, 467 participants were included in the final data analyses (Fig. 1).

Ascertainment of cognitive frailty

Cognitive frailty was defined as the simultaneous presence of both physical frailty and cognitive impairment, which were assessed by the FRAIL scale [33] and the Montreal Cognitive Assessment (MoCA) [34], respectively. The FRAIL scale comprises five components: fatigue, resistance, ambulation, illnesses, and loss of weight [33]. Participants who met 3 or more criteria were considered as frail, 1–2 criteria as pre-frail, and 0 as robust. The MoCA consists of 30 items that assesses short-term memory, visuospatial abilities, executive functions, attention, concentration and working memory, language, and orientation to time and place [35]. The total MoCA score is calculated by summing up the scores of each item (range: 0–30), with higher scores indicating better cognitive function. The cut-off scores for cognitive impairment were set at 19 for individuals with no more than 6 years of education, 22 for individuals with 7 to 12 years of education, and 24 for individuals with more than 12 years of education [36]. Cognitive frailty was treated as a categorical variable. Participants were categorized as having cognitive frailty if they were both physically frail (FRAIL scale ≥ 3) and cognitively impaired (MoCA score below the respective educational cut-off) [14].

Evaluation of social participation

Social participation was assessed using a questionnaire developed based on the China Health and Retirement Longitudinal Study. Participants were asked how often they had engaged in the following 10 activities over the past month: (1) interacted with friends, (2) played mahjong, chess, cards or visited a community club, (3) provided help to family, friends, neighbors who do not live with them, (4) attended a sports, social, or other club, (5) participated in a community-related organization; (6) did voluntary or charity work, (7) cared for a sick or disabled adult who does not live with, (8) attended an educational or training course, (9) engaged in stock investment, and (10) used the Internet. To reflect a broader understanding of participation that extends beyond traditional social interactions, we included stock investment and Internet use in assessing social participation as previous evidence demonstrated that both activities could facilitate communication with social networks, allowing older adults to maintain social connections and access social support

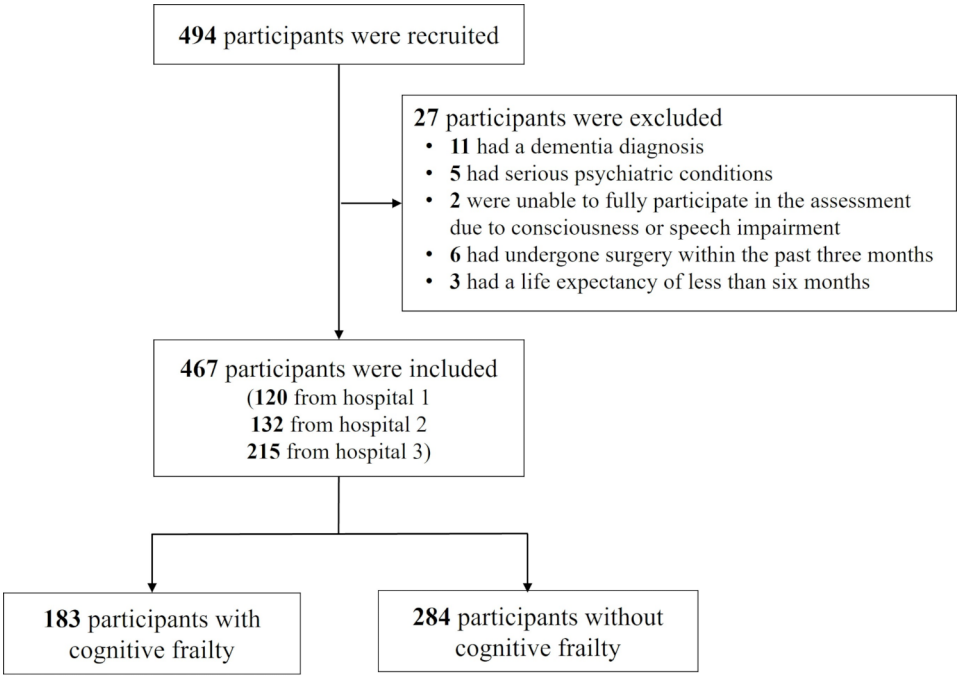

Fig. 1 The flowchart of study participants

[37, 38]. In this study, each activity was rated on a 4-point Likert scale ranging from 0 (never) to 3 (almost daily). The total score ranged from 0 to 30, with higher scores indicating more frequent engagement in social activities.

Determination of HRQoL

HRQoL was assessed using the 36-item Short Form Health Survey (SF-36), a self-administered questionnaire that generates assessment scores across eight domains of health: physical function (PF), role limitations due to physical problems (RP), bodily pain (BP), general health (GH), vitality (VT), social function (SF), role limitations due to emotional problems (RE), mental health (MH), as well as a single item on health transition [9]. The health concepts described by the SF-36 range in score from 0 to 100, with higher scores indicating higher levels of HRQoL. For all domains, each raw score was transformed using the following formula:

$$\text{Transformed scale} = \left[\frac{\text{Actual raw score} - \text{Lowest possible raw score}}{\text{Possible raw score range}}\right] \times 100$$

This transformation converts the lowest and highest possible scores to 0 and 100, respectively. Scores between these values represent the percentage of the total possible score. The scale scores can be aggregated into two summary scores: the Physical Component Summary (PCS) [PF, RP, BP, and GH domains] and the Mental Component Summary (MCS) [VT, SF, RE, and MH domains]. Both PCS and MCS scores range from 0 to 100, with higher scores indicating better HRQoL [39].

Assessment of covariates

Sociodemographic characteristics, lifestyle behaviors, and anthropometric measurements were collected as covariates. Sociodemographic characteristics included gender, age, educational attainment, marital status, and socioeconomic status, which was assessed by per capita monthly household income. Lifestyle behaviors included smoking and alcohol consumption. Anthropometric measurements included height and weight, which were taken by trained registered nurses following standard protocols. Body mass index (BMI) was calculated by dividing the participant's weight in kilograms by their height in meters squared (kg/m^2).

Statistical analysis

The normality of continuous data was assessed using the Kolmogorov-Smirnov test. Normally distributed variables were presented as mean and standard deviation (SD), while non-normally distributed variables were reported as median and interquartile range (IQR). Categorical variables were expressed as frequency and percentage. The Chi-square test and t-test were used to analyze differences in demographics, lifestyles, social participation, and HRQoL between participants with and without cognitive frailty. Point-biserial correlation coefficients were calculated to estimate the correlations of cognitive frailty with social participation and HRQoL, while Pearson correlation coefficients were applied to examine the correlations between social participation and HRQoL.

To explore the mediation mechanisms through which cognitive frailty affects HRQoL, the R package *mediation* was applied to conduct the regression-based mediation analysis. Social participation was specified as the mediator in the relationship between cognitive frailty and HRQoL, under the assumption of a causal link between cognitive frailty and levels of social participation. In the mediation model, the mean total effect, the mean direct effect of cognitive frailty, and the mean mediated effect of social participation were estimated. The 95% confidence intervals (CI) of these effects were derived using the quasi-Bayesian Monte Carlo method with 1000 bootstrap simulations [40]. The percentage mediated was calculated as the proportion of the total association between cognitive frailty and HRQoL explained by the mediator (i.e., social participation). To examine gender differences, a subgroup mediation analysis was performed. All mediation analyses were conducted by controlling for age (continuous), education attainment (primary school and below, junior high school, senior high school, and college and above), marital status (married and single/divorced/widowed), per capita monthly household income (< 1500, 1500–3499, 3500–5999, and ≥ 6000 China Yuan [CNY]), smoking status (never, past, and current), alcohol consumption (never, past, and current), and BMI (continuous).

All statistical analyses were conducted using R software (version 4.3.2). A two-tailed $P < 0.05$ was considered statistically significant.

Results

Socio-demographic characteristics of the participants

The sociodemographic characteristics of the participants are presented in Table 1. The average age was 70.8 years (SD = 7.7). Among the participants, 242 (51.8%) were female and 354 (75.8%) were married. The majority ($n = 288$, 61.7%) had achieved an education level of senior high school or above. Approximately one-third of the participants had a history of smoking ($n = 152$) or alcohol consumption ($n = 141$). Overweight and obese were prevalent in 35.5% and 8.4% of participants, respectively. In this study, 39.2% of the participants had cognitive frailty. The prevalence of cognitive frailty was significantly associated with age, marital status, educational attainment, and per capita monthly household income

Table 1 Characteristics of the participants

Variables	Total ($n=467$)	With cognitive frailty ($n=183$)	Without cognitive frailty ($n=284$)	*P*
Age (years, mean ± SD)	70.8 ± 7.7	72.9 ± 8.3	69.4 ± 7.0	**< 0.001**
Gender				0.054
Male	225 (48.2)	78 (42.6)	147 (51.8)	
Female	242 (51.8)	105 (57.4)	137 (48.2)	
Marital status				**0.005**
Married	354 (75.8)	126 (68.8)	228 (80.3)	
Single/divorced/widowed	113 (24.2)	57 (31.2)	56 (19.7)	
Educational attainment				**< 0.001**
Primary school and below	80 (17.1)	48 (26.2)	32 (11.3)	
Junior high school	99 (21.2)	48 (26.2)	51 (18.0)	
Senior high school	146 (31.3)	47 (25.7)	99 (34.8)	
College and above	142 (30.4)	40 (21.9)	102 (35.9)	
Per capita monthly household income (CNY)				**0.047**
< 1500	41 (8.8)	24 (13.1)	17 (6.0)	
1500–3499	97 (20.8)	39 (21.3)	58 (20.4)	
3500–5999	181 (38.8)	69 (37.7)	112 (39.4)	
≥ 6000	148 (31.7)	51 (27.9)	97 (34.2)	
Smoking status				0.085
Never	315 (67.5)	129 (70.5)	186 (65.5)	
Past	100 (21.4)	41 (22.4)	59 (20.8)	
Current	52 (11.1)	13 (7.1)	39 (13.7)	
Alcohol consumption				0.834
Never	326 (69.8)	129 (70.5)	197 (69.4)	
Past	69 (14.8)	28 (15.3)	41 (14.4)	
Current	72 (15.4)	26 (14.2)	46 (16.2)	
BMI (kg/m^2)				0.307
< 18.5	26 (5.6)	11 (6.0)	15 (5.3)	
18.5–23.9	235 (50.3)	101 (55.2)	134 (47.4)	
24.0–27.9	166 (35.5)	59 (32.2)	107 (37.8)	
≥ 28.0	39 (8.4)	12 (6.6)	27 (9.5)	
Social participation	7.1 ± 4.0	5.9 ± 3.7	7.8 ± 4.1	**< 0.001**
HRQoL	64.0 ± 15.4	57.8 ± 15.5	68.1 ± 13.9	**< 0.001**
PCS	60.6 ± 18.8	52.4 ± 19.0	66.0 ± 16.7	**< 0.001**
MCS	67.4 ± 16.2	63.2 ± 16.5	70.2 ± 15.4	**< 0.001**

Notes: SD = standard deviation, CNY = China Yuan, BMI = body mass index, HRQoL = health-related quality of life, PCS = physical component summary, MCS = mental component summary

(all *P* values < 0.05). Participants with cognitive frailty had significantly lower levels of social participation, HRQoL, PCS, and MCS scores compared to those without cognitive frailty (all *P* values < 0.001).

Bivariate correlations

As illustrated in Fig. 2, cognitive frailty was negatively correlated with HRQoL ($r=-0.33$, $P<0.001$), while social participation showed a positive correlation with HRQoL ($r=0.28$, $P<0.001$). Similar correlations were observed with both the PCS and MCS scores. Additionally, a significant negative correlation was identified between cognitive frailty and social participation ($r=-0.23$, $P<0.001$).

Mediation analyses

After adjusting for gender, age, marital status, educational attainment, monthly household income, smoking status, alcohol consumption, and BMI, the mediation analyses indicated that cognitive frailty was significantly associated with lower HRQoL (Table 2). Participants with cognitive frailty had an HRQoL score that was, on average, 8.21 points lower than those without cognitive frailty (95% CI: − 11.17, − 5.31). While a larger proportion of the total association was direct, a significant indirect effect through social participation was observed. Specifically, the indirect pathway from cognitive frailty to HRQoL via social participation accounted for 14.8% of the total effect (ACME = −1.22, 95% CI: − 2.20, − 0.51). Furthermore, social participation significantly mediated

Fig. 2 Correlations of cognitive frailty, social participation, and HRQoL. Notes: CF = cognitive frailty, SP = social participation, HRQoL = health-related quality of life, PCS = physical component summary, MCS = mental component summary

Table 2 Mediation of social participation in the association of cognitive frailty and HRQoL

Outcomes	Model pathways	Point estimate	95% CI		*P*	Relativistic effect
			Lower	Upper		
HRQoL	Total effect	−8.21	−11.17	−5.31	**< 0.001**	
	ADE	−6.99	−9.91	−4.41	**< 0.001**	
	ACME	−1.22	−2.20	−0.51	**< 0.001**	14.8%
PCS	Total effect	−10.78	−13.886	−7.87	**< 0.001**	
	ADE	−9.66	−12.76	−6.82	**< 0.001**	
	ACME	−1.12	−2.13	−0.55	**< 0.001**	10.4%
MCS	Total effect	−6.32	−10.07	−3.32	**< 0.001**	
	ADE	−5.03	−8.92	−2.09	**< 0.001**	
	ACME	−1.29	−2.35	−0.49	**< 0.001**	20.4%

Notes: HRQoL = health-related quality of life, PCS = physical component summary, MCS = mental component summary, ACME = average causal mediation effects, ADE = average direct effects

the effects of cognitive frailty on the individual dimensions of HRQoL. Specifically, social participation mediated 10.4% of the total effect of cognitive frailty on PCS (ACME = −1.12, 95% CI: − 2.13, − 0.55) and 20.4% for MCS (ACME = −1.29, 95% CI: − 2.35, − 0.49).

To examine whether the pathway from cognitive frailty to HRQoL, including PCS and MCS, through social participation differed by gender, a moderated mediation analysis was conducted (Fig. 3). For HRQoL, a significant mediating effect of social participation was observed in females (13.5%, ACME = −1.22, 95% CI: − 2.13, − 0.49), whereas the indirect pathway was not significant in males. For PCS, social participation mediated the effect of cognitive frailty in both males (ACME = −0.90, 95% CI: − 2.17, − 0.03) and females (ACME = −1.11, 95% CI: − 2.08, − 0.46), accounting for 7.4% and 10.2% of the total

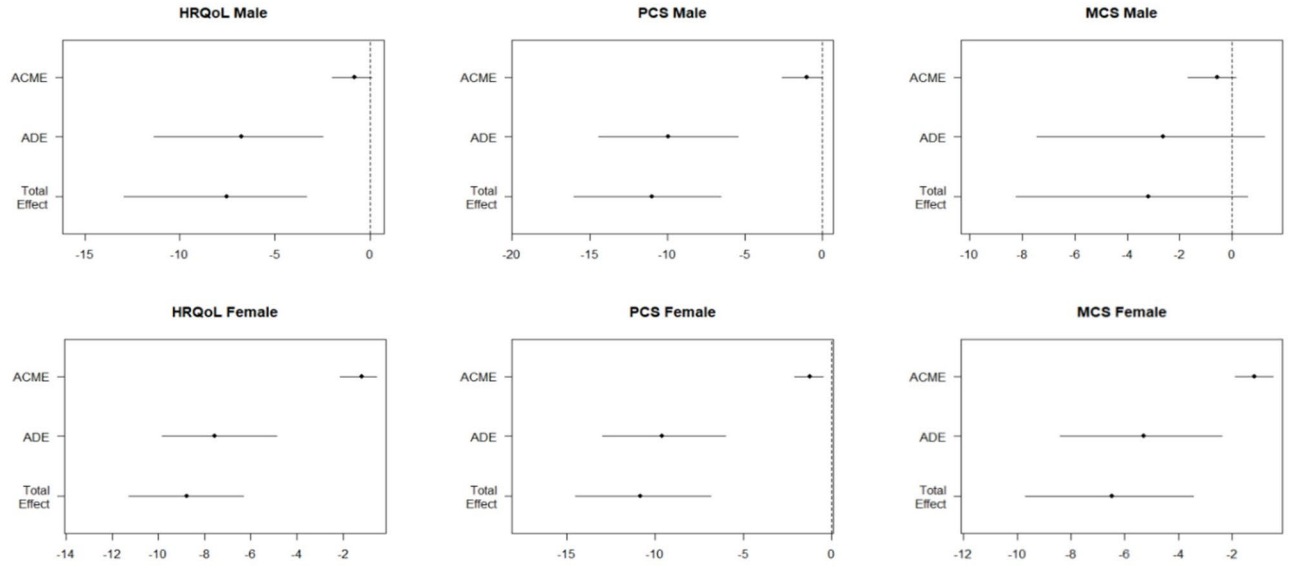

Fig. 3 Moderated mediation of social participation between cognitive frailty and HRQoL by gender. Notes: ACME = average causal mediation effects, ADE = average direct effects

effects, respectively. For MCS, cognitive frailty exerted its negative effects directly (21.4%, ADE=−4.78, 95% CI: −7.56, −2.62) and indirectly through social participation (18.6%, ACME = −1.17, 95% CI: −2.13, −0.52) in females, but no significant direct or indirect effects were observed in males.

Discussion

The results of our study indicate that older adults with cognitive frailty exhibit lower HRQoL, both in PCS and MCS, compared to their counterparts. Social participation emerges as a crucial mediator in the relationship between cognitive frailty and HRQoL, underscoring the importance of enhancing social participation for older adults with cognitive frailty. Our findings also contribute to the theoretical understanding of frailty and aging by integrating the multidimensional frailty framework with the activity theory of aging. Specifically, the study highlights how cognitive frailty disrupts the physical and mental domains of health, leading to diminished HRQoL. Regarding gender differences, the mediating effect of social participation between cognitive frailty and HRQoL was more pronounced in women than that in men, indicating that female participants with cognitive frailty may benefit more from social engagement.

Previous studies have examined the association between cognitive frailty and HRQoL. A cross-sectional study conducted among community-dwelling Chilean individuals aged 60 years and above, which differs from the samples of the current study, revealed that those with cognitive frailty had 4.25 and 4.01 times lower PCS and MCS scores, respectively [41]. Similarly, the study by Godin et al. [42] found that both frailty and cognitive impairment were associated with reduced HRQoL. Our findings further confirm that cognitive frailty negatively impacts HRQoL in older adults. One plausible explanation for the association between cognitive frailty and low HRQoL is the perception of poor health status. Sieber et al. [43] demonstrated that activities of daily living (ADL), instrumental ADL, and depressive symptoms mediate the relationship between multimorbidity and HRQoL in older European adults. The decline in HRQoL among cognitively frail older adults may be attributed to deficits in their ability to perform daily tasks independently [44], which can also lead to depressive symptoms [45]. Our findings highlight the need to focus healthcare efforts and resources on maintaining cognitive functioning or mitigating frailty symptoms in hospitalized older adults to preserve their HRQoL.

This study delves into the intricate relationship between cognitive frailty and HRQoL, highlighting the mediating role of social participation. The results are consistent with previous research on social participation among older adults, indicating that those who participate more frequently in social activities tend to have better HRQoL [28, 46]. A nationally representative cross-sectional study found that greater social participation was associated with better HRQoL among chronically ill older people in China [46]. In a longitudinal study using the Survey of Health, Ageing and Retirement in Europe data, Lestari et al. [28] revealed participation in at least one socially productive activity was positively associated with HRQoL after a two-year follow-up. However, the association between social participation and HRQoL was not observed among older Chinese adults with type 2 diabetes [47], which focused mainly on formal organizations.

On the one hand, engagement in social participation may boost the perceived social support of older adults, thereby promoting their social and psychological functioning [22]. As reported, social support plays a major role in predicting quality of life among hospitalized geriatric patients [48]. On the other hand, the health benefits associated with social participation may be linked to biological mechanisms, such as reduced inflammation [49, 50]. Chronic proinflammatory activation is a key pathophysiologic process contributing to cognitive frailty [51]; however, social engagement can suppress inflammatory responses [49, 50], potentially alleviating their deleterious effects on physical functioning. These results suggest that healthcare providers could design tailored interventions for older adults with cognitive frailty, such as group activities or social clubs, to encourage social engagement and improve their HRQoL. Moreover, the findings of this study have important implications for future research. Longitudinal studies should be conducted to investigate the causal relationships between cognitive frailty, social participation, and HRQoL over time.

Additionally, the stratified analyses showed that the mediating effect of social participation between cognitive frailty and HRQoL varied by gender. The gender differences in mediation patterns may be due to the divergent prevalence of cognitive frailty in women and men. A systematic review found that the prevalence of cognitive frailty was higher in older women [16]. The sample in our study also exhibited such a difference (women vs. men: 57.4% vs. 42.6%), although it was not statistically significant. Another possible explanation could be cultural factors and gender-differentiated social roles. Women traditionally assume family caregiving roles [32]. In a cross-sectional study from 17 European countries and Israel, Barbosa et al. found that spouse caregivers reported lower levels of social activities and life satisfaction than non-caregivers [52]. The caregiving role may limit their opportunities for social participation outside the home, which may, in turn, affect their HRQoL. This could amplify the mediating effect of social participation on HRQoL for women, as their social engagement may be more restricted and thus more impactful when it occurs. Additionally, Ma et al. [31] analyzed the China Health and Retirement Longitudinal Survey data and found that women were less likely to participate in volunteer activities than men. Li and Ferraro revealed a beneficial effect of formal volunteering on depression, but not for informal helping [53]. The nature of social participation may influence the pathway between cognitive frailty and HRQoL. These findings suggest that care programs of social participation for people living with cognitive frailty should consider gender differences, with a particular focus on the more pronounced needs among women [31, 32].

This study has several limitations that should be acknowledged when interpreting the findings. First, the cross-sectional design does not establish causality between exposures and health outcomes. Future research should employ longitudinal designs to determine the temporal sequence of cognitive frailty, social participation, and HRQoL. Second, although several potential confounders were collected and controlled for in the multivariate models, we could not rule out the possibility that unmeasured confounders, such as cultural factors, physical mobility, or mental health conditions, may have influenced the results. Third, the variables of interest in this study were collected by self-reports, which may introduce recall bias. Finally, the sample was recruited from three tertiary hospitals, which may limit the generalizability of the findings to community-dwelling older adults.

Conclusions

The findings of this study suggest that cognitive frailty was negatively associated with HRQoL, including the dimensions of PCS and MCS. Social participation appears to mediate the relationship between cognitive frailty and HRQoL, particularly for women. This study provides insights into future efforts to design policy solutions to promote participation in social activities among older adults with cognitive frailty, with the goal of maintaining their HRQoL at a favorable level.

Abbreviations

ACME	Average Causal Mediation Effects
ADE	Average Direct Effects
ADL	Activities of Daily Living
BMI	Body Mass Index
BP	Bodily Pain
CI	Confidence Intervals
GH	General Health
HRQoL	Health-Related Quality of Life
IQR	Interquartile Range
MCS	Mental Component Summary
MH	Mental Health
MoCA	Montreal Cognitive Assessment
PCS	Physical Component Summary
PF	Physical Function
RE	Role Limitations Due to Emotional Problems
RP	Role Limitations Due to Physical Problems
SD	Standard Deviation
SF-36	36-Item Short Form Health Survey
SF	Social Function
VT	Vitality

Acknowledgements

We would like to express our greatest appreciation to all the older adults for their participation.

Author contributions

All authors contributed to the study conception and design. Writing-original draft: ZH; Writing-review and editing: ZH, YZ, and XL; Investigation: QG, YL, FL, and XZ; Formal analysis: ZH; Supervision: XL. All authors read and approved the final manuscript.

Funding
This work was supported by the Fundamental Research Funds for the Central Universities (SK2023004), Shaanxi Social Science Foundation Project (2024F016), and the Key Research Base of Philosophy and Social Sciences in Shaanxi (23JZ015).

Data availability
The datasets used and/or analyzed during the current study are available from the corresponding author on reasonable request.

Declarations

Ethics approval and consent to participate
The study protocol was approved by the Ethics Committee of the First Affiliated Hospital of Xi'an Jiaotong University (KYLLSL-2021-425). All participants provided written informed consent. This study was conducted in accordance with the Declaration of Helsinki.

Consent for publication
Not applicable.

Competing interests
The authors declare no competing interests.

Clinical trial number
Not applicable.

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Received: 23 August 2024 / Accepted: 10 April 2025
Published online: 23 April 2025

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