Journal of Multidisciplinary Healthcare

Dovepress
Taylor & Francis Group

Open Access Full Text Article

ORIGINAL RESEARCH

ADL and Cognitive Function in Chinese Elderly: Mediating Role of Social Participation and Moderating Role of Intergenerational Support

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Purpose: This study aimed to explore the relationship between activities of daily living (ADL) and cognitive function in Chinese elderly, and to analyze in depth the mediating and moderating roles of social participation and children's intergenerational support in this relationship, in order to provide a reference basis for delaying cognitive decline in the elderly.

Patients and Methods: Based on data from the 2020 wave of China Health and Retirement Longitudinal Survey (CHARLS 2020), this study included 5612 subjects aged 60 years and older, and extracted main variables such as demographic information, ADL, social participation, cognitive function, and children's intergenerational support. Descriptive statistics and Pearson's correlation analysis in SPSS 27.0 were used to analyze the relationship between the main variables, and regression and Bootstrap analysis in SPSS 27.0 PROCESS macro (Model 4 and Model 14) were further used to analyze the mediating and moderating effects.

Results: Among Chinese elderly, ADL significantly positively correlated with social participation ($r = 0.086$, $P < 0.001$) and cognitive function ($r = 0.193$, $P < 0.001$), and social participation significantly positively correlated with cognitive function ($r = 0.144$, $P < 0.001$). Social participation partially mediated the relationship between ADL and cognitive function ($\beta = -0.202$, $P < 0.001$), accounting for 5.74% of the total effect. Moreover, children's intergenerational support negatively moderated the relationship between social participation and cognitive function ($\beta = -0.182$, $P < 0.001$). Thus, a moderated mediation model was developed.

Conclusion: ADL can affect cognitive function directly or indirectly through social participation in elderly. Furthermore, children's intergenerational support plays a negative moderating role in this mechanism. Therefore, governments, hospitals, communities, and families should provide personalized intervention strategies for elderly to delay cognitive decline and promote healthy aging through early prevention of ADL impairment, promotion of social participation, and optimization of family support.

Keywords: activities of daily living, cognitive function, elderly, social participation, intergenerational support

Introduction

Population ageing poses significant challenges to global healthcare systems.[1] According to the World Social Report 2023, the global population aged 65 and over was 761 million in 2021, which will increase to 1.6 billion by 2050.[2] China's aging process is developing rapidly. It is expected that by 2050, China's population aged 65 and over will exceed 400 million, accounting for more than one third of the total population.[3] Ageing is a multidimensional and dynamic process. During this process, older adults face serious and complex health problems, including declining physical function, social alienation, and impaired cognitive function.[4–6] These problems not only affect the quality of life of older adults, but may also occur in a range of adverse health outcomes, placing a heavy burden on families, society, and

Received: 16 February 2025
Accepted: 28 April 2025
Published: 6 May 2025

the healthcare system.[7,8] Accordingly, the World Health Organization (WHO) has introduced the concept of "healthy and active ageing" to address the problem of population ageing and, ultimately, to achieve successful ageing.

Cognitive decline and impairment usually manifest as one or more impairments in perception, attention, memory, and thinking.[9] Aging is usually accompanied by cognitive decline, which has become a health problem that cannot be ignored. If there is no timely and effective intervention, age-related cognitive decline may be a precursor to related cognitive impairment such as dementia.[10] According to the World Alzheimer Report 2023,[11] the number of patients with dementia worldwide is expected to increase from 55 million in 2019 to 139 million in 2050. In addition, the cost of dementia-related diagnosis and treatment is expected to reach 2.8 trillion dollars by 2030. According to the China Alzheimer Report 2024,[12] there are nearly 17 million existing dementia patients in China, accounting for approximately 29.7% of the global total; and there are nearly 500,000 deaths due to dementia, accounting for 25.2% of the global deaths. A cohort study showed that patients with all types of dementia and cognitive impairment had a higher mortality rate than patients with normal cognitive function (hazard risk: 2.61–5.20).[13] The above data suggest that older adults with impaired cognitive function may face a greater risk of adverse health-related events and a severe socioeconomic burden. However, to date, there is no effective treatment for dementia. Therefore, it is urgent and necessary to identify modifiable protective factors and risk factors for cognitive impairment in older adults at an early stage, and to explore their mechanisms of action. This will help to prevent and delay the decline of cognitive function in the elderly, and promote healthy aging.

Literature Review

Several studies have shown a close relationship between cognitive and physical functioning. A longitudinal study[14] analyzing 13 years of cross-lagged panel data suggested that there is an interrelationship between physical and cognitive function. In other words, physical function limitations may lead to cognitive decline, which in turn further exacerbates physical dysfunction and vice versa. Activities of daily living (ADL) is an important indicator for evaluating the functional status of the elderly and their ability to live independently, which is usually measured by Basic activities of daily living (BADL) and Instrumental activities of daily living (IADL). BADL are the most basic self-care abilities required for an individual to live independently (eg, dressing); IADL are more complex abilities required for an individual to live independently and participate in social activities (eg, shopping).[15] In recent years, a growing body of research has identified ADL limitations as an important risk factor for cognitive decline, and older adults are at higher risk for cognitive decline due to activity limitations and declining physical function.[16,17] In addition, previous research has demonstrated that declining ADL limits brain use, leading to atrophy of the hippocampus due to insufficient cognitive stimulation, which in turn affects cognitive functions such as memory and emotion regulation.[18] Therefore, ADL restriction may have an impact on cognitive function in older adults.

Social participation is a broad concept that refers to involvement in life situations, including participation in meaningful activities, community, family, work, society, and life.[19] Social participation prevents social isolation among older adults and is considered an important component of "active aging". Relevant studies have shown that ADL has a positive predictive effect on social participation.[20] As age continues to increase, the physical functioning of older adults gradually declines. Older adults with limited ADL may not be able to perform expected social activities, and their willingness and ability to participate in social activities may decline.[21] A review noted that social participation can reduce dementia risk by increasing cognitive reserve.[22] Specifically, active participation in social activities can have a compensatory effect on cognitive function by generating cognitive stimulation, increasing synaptic density and neural growth, and enhancing the effective utilization of brain network reserves. Thus, when older adults' social participation decreases, they receive less stimulation from external information, which can be detrimental to cognitive functioning, creating a vicious circle. In addition, participation in social activities promotes interpersonal relationships among older adults, enhances their sense of belonging, self-esteem, and promotes mental and emotional health, mitigating the neurogenic changes that lead to cognitive decline.[23] Thus, we hypothesized that social participation may play a crucial mediating role in the relationship between ADL and cognitive function.

Intergenerational support refers to the process by which parents and children provide each other with financial help, life care, and emotional communication, which can be categorized into upward intergenerational support, downward intergenerational support, and bidirectional intergenerational support according to different flows.[24,25] Intergenerational support in China differs from the Western "relay model" in that there is often a "feedback model" between generations, in which children are nurtured by

their parents when they are young, and then when their parents grow old, the children fulfill their obligation to support their parents and take on the family responsibility of caring for them.[26] Moreover, influenced by Confucianism and the traditional culture of filial piety, upward intergenerational support from children is the main source of the family support system for older adults in China, as older adults become increasingly dependent on family members as they age.[27] Upward intergenerational support effectively fulfills the expectations of Chinese parents to be supported by their children in old age, provides a sense of belonging and well-being in the lives of the elderly, and plays an important protective role in promoting their physical and mental health.[28] A systematic review suggests that intergenerational support can improve cognitive function by stimulating brain activity and releasing neurochemicals such as oxytocin and dopamine.[29] In addition, studies have shown that higher children's intergenerational support helps older adults stay connected to society and motivates them to participate in a variety of social activities, which is strongly associated with improved cognitive function.[30] Another view, however, is that older adults who receive too much intergenerational support from their children may undermine their self-esteem, leading to feelings of incompetence, frustration, and guilt, while at the same time potentially reinforcing their dependence on their children, which is not conducive to the psychological well-being of older adults and their participation in society.[31] Therefore, we hypothesized that children's intergenerational support would moderate the relationship between social participation and cognitive function.

In summary, existing studies have validated the relationship between ADLs, social participation, children's intergenerational support, and cognitive function in older adults, but the interaction between these four and the underlying mechanisms have not been reported. Therefore, utilizing data from the China Health and Retirement Longitudinal Study (CHARLS), the present study aimed to explore the relationships among ADL, social participation, children's intergenerational support, and cognitive function and their potential mechanisms of action in Chinese older adults. The results of the study will provide references for early prevention and delay of cognitive decline in the elderly, as well as for the formulation of measures and policies related to health promotion for the elderly. In light of the results of the above literature review, we proposed the following hypotheses: H1: ADL is positively correlated with cognitive function in older adults; H2: social participation mediates the relationship between ADL and cognitive function in older adults; and H3: children's intergenerational support moderates the relationship between social participation and cognitive function in older adults.

Materials and Methods

Participants

This study adopted a cross-sectional design, and the data came from the fifth national follow-up survey of the CHARLS 2020, which was publicly released on November 16, 2023 (the data collection period was from July to September 2020. CHARLS was a national survey project led by the National Institute of Development Studies of Peking University, which provided information on middle-aged and older adults aged 45 and above and their families. The program conducted follow-up surveys every 2–3 years, and five follow-up visits have already been conducted in 2011, 2013, 2015, 2018, and 2020. CHARLS adopted a stratified multi-stage probability proportionate to size sampling methodology, the core principle of which is that at each stage of sampling, larger sampling units are assigned a higher probability of being selected, proportional to the size of their populations, to ensure that the distributional characteristics of the final sample are highly consistent with the actual structure of the target population. The program sampled at four levels: county (district), village (community), household, and individual to ensure a representative and covered sample and to reduce potential bias. In the first stage, all counties and districts in the country except Tibet were ranked by urban-rural attributes and gross domestic product (GDP) per capita in each of the eight regions, and 150 counties or districts were selected with probability proportional to population size. In the second stage, three secondary sampling units (village committees or neighborhood committees) were randomly selected with probability proportional to population size within each sampled county unit, producing 450 villages/communities. Subsequently, in each village or community, CHARLS conducted on-site mapping and household information collection using specialized mapping software (CHARLS-GIS) designed and developed in-house to randomly select households from the map. Finally, individuals aged 45 and above were sampled from each household for the survey. After the above sampling process, the baseline sample of CHARLS was distributed in 150 counties and 450 communities (or villages) in 28 provinces (autonomous regions and municipalities) in China. In addition, after weighting with sampling weights, the demographic characteristics of the CHARLS baseline sample were very similar to those of the 2020 Census, demonstrating good representation of China's middle-aged and

elderly population. The project implemented strict quality control measures from survey design to data collection to ensure the accuracy and reliability of the data.[32]

The CHARLS questionnaire was based on the national standardized Chinese characters. In order to address regional dialect differences and minority language usage in China, the research team prioritized the recruitment of local university students as interviewers to ensure their fluency in local dialects and Mandarin. In areas where Uyghurs, Tibetans, and other ethnic minorities live, the team recruited only bilingual interviewers who were fluent in the local dialect/ethnic language and Mandarin to minimize language barriers at the implementation level. For the rare cases where interviewers and respondents do not speak the local dialect or need to use minority languages, local village staff or residents were invited to act as interpreters to ensure that the questionnaire content was accurately conveyed in semantic and cultural contexts, thus systematically solving the problem of implementing surveys in multilingual environments, and ensuring the accuracy and cultural appropriateness of data collection.[32]

The ethical approval number of the fieldwork protocol for the current round of the household questionnaire survey was IRB00001052-11015, and all study participants signed a written informed consent. In addition, the study was authorized by the Medical Ethics Committee of Shanxi Bethune Hospital (No. YXLL-2024-183).

This study selected older adults aged 60 and older from the 2020 CHARLS survey and excluded samples with missing data on ADL, social participation, children's intergenerational support, and cognitive function. In addition, samples with missing information on relevant covariates were also removed. The 2020 CHARLS survey included 19,395 respondents. Through screening, data from 5612 respondents were included in this analysis.

Instruments

Assessment of ADL

The ADL was assessed in both the BADL and the IADL. The assessment entries were based on Katz's Index of Independence in ADL[33] and Lawton's IADL scale.[34] Respondents were asked if they had any difficulty with any of the six BADL (dressing, eating, bathing, getting in or out of bed, toileting, controlling urination and defecation) or any of the six IADL (cooking, housework, shopping, making phone calls, taking medication, and managing money). Each entry was categorized into four levels: "No difficulty", "Some difficulty but still able to complete", "Difficult and need help to complete" and "Unable to complete", each of which is scored from 0 to 3, with a range of scores from 0 to 36. The higher the score, the worse the respondent's ADL. The Cronbach's a for this scale was 0.853.[35]

Assessment of Social Participation

The level of social participation was asked if the respondent had participated in the following activities in the past month: (1) visiting friends and relatives; (2) playing mahjong, chess, cards, or participating in community activities; (3) helping non-cohabiting relatives, friends, or neighbors; (4) dancing, exercising, or practicing qigong; (5) participating in clubs or organizing activities; (6) engaging in volunteer or charitable work; (7) caring for non-cohabiting sick people or disabled people; (8) going to school or attending a training course; and (9) other social activities. One point was awarded for each activity, no points for non-participation, and the total score ranged from 0 to 9 points. Higher scores indicate higher levels of social participation among respondents.[36]

Assessment of Children's Intergenerational Support

Children's intergenerational support refers primarily to the financial and emotional support that older adults receive from their children. The specific questions were (1) In the past year, have you or your spouse received financial support from your children?" (Specifically, this is necessary monetary and material support, including utilities, phone bills, rent, not additional monetary purchases). The answer to this question was coded separately, coded "0" if the parents had no financial support from their children and "1" otherwise. (2) Emotional support, including frequency of meeting with children and frequency of contact with children. The question for frequency of meeting with children was "How often do you meet your children?" Meeting more than once a month was considered be frequent (coded as "1"), otherwise it was considered that they would meet rarely (coded as "0"). The question for frequency of contact with your children was set as "When you and your children do not live together, how often do you contact your children by phone, text, letter, or e-mail?" Contact more than once

a month was considered be frequent (coded as "1"), otherwise, it was considered that contact would be rare (coded as "0"). The sum of all items represents the intergenerational support status from the respondent's children. The total score ranges from 0–3, with higher values indicating better children's intergenerational support.[30]

Assessment of Cognitive Function

The cognitive function was assessed by using the episodic memory and mental intactness components of the Modified Mental State Examination (MMSE), designed and developed by Folstein et al.[37] In episodic memory, respondents were asked to recall as many words as possible after the visitor read a list of 10 words (immediate recall). Approximately 10 minutes later, respondents were asked to repeat the original words again (delayed recall). One point was awarded for correctly recalling a word, and the final score for episodic memory was the average of immediate and delayed recall (0–10). In terms of mental intactness, using attention and numeracy (calculating 100 minus 7 five times in a row), time orientation (including answering the current year, season, month, date, and day of the week), and visuospatial ability (drawing overlapping pentagons). One point was awarded for each correct response, with total scores ranging from 0 to 11. The sum of the episodic memory and mental intactness scores represents the overall cognitive function of the respondent. The total score ranges from 0–21, with higher values indicating better cognitive function. The Cronbach's a for this scale was 0.85–0.96.[38]

Assessment of Covariates

Based on previous research,[18,36] several potential influences were selected as control variables for this study. Control variable information was obtained from the structured questionnaire. The main covariates included sociodemographic characteristics, lifestyle, and health status. Sociodemographic characteristics included age (years), gender (male or female), education level (elementary, middle school, high school, college or above), current marital status (married or unmarried), and place of residence (urban or rural). Lifestyle included whether or not the respondent drank alcohol, smoked cigarettes, or exercised. Health status included whether the respondent had a chronic disease (including hypertension, dyslipidemia, diabetes, cancer, chronic lung disease, heart disease, stroke, arthritis, or rheumatism) and the respondent's self-assessed health status.

Data Analysis

SPSS 27.0 and SPSS PROCESS Macro 4.1 were used for statistical analysis. First, variables were analyzed descriptively, with continuous variables expressed as mean and standard deviation, and categorical variables expressed as number of cases and percentage. Subsequently, Pearson correlation analysis was used to evaluate the correlation between the main variables. Finally, PROCESS model 4 was used to test the mediating role of social participation between ADL and cognitive function, and model 14 was used to test the moderating role of children's intergenerational support between social participation and cognitive function. In addition, to further substantiate the moderating role of children's intergenerational support, a simple slope test was used to assess the relationship between social participation and cognitive function at different levels of children's intergenerational support. The indirect effect of the mediating effect was estimated using a bootstrap method with 5000 samples, and the 95% confidence interval (*CI*) did not include zero, indicating a significant effect. All statistical analyses in this study were two-sided, and *P*-values less than 0.05 were considered statistically significant.

Results

Demographic Characteristics of Participants

Figure 1 displays the process of sample selection in this study. A total of 5612 participants were included in this study, of which 59.4% were between 60–69 years old, 34.3% were 70–79 years old, 6.2% were 80–89 years old, and only 0.2% were ≥90 years old. 43.2% of the participants were female and 56.8% were male. 83.1% of the participants were married and 16.9% were unmarried. About 39.5%, 25.9%, and 20.6% of the participants had primary, junior high, and senior high school education levels, respectively, and only 14% had university and higher education levels. 62.2% of the participants lived in rural areas and 37.8% in urban areas. 37.4% of the participants had a drinking habit, 28.8% had a smoking habit,

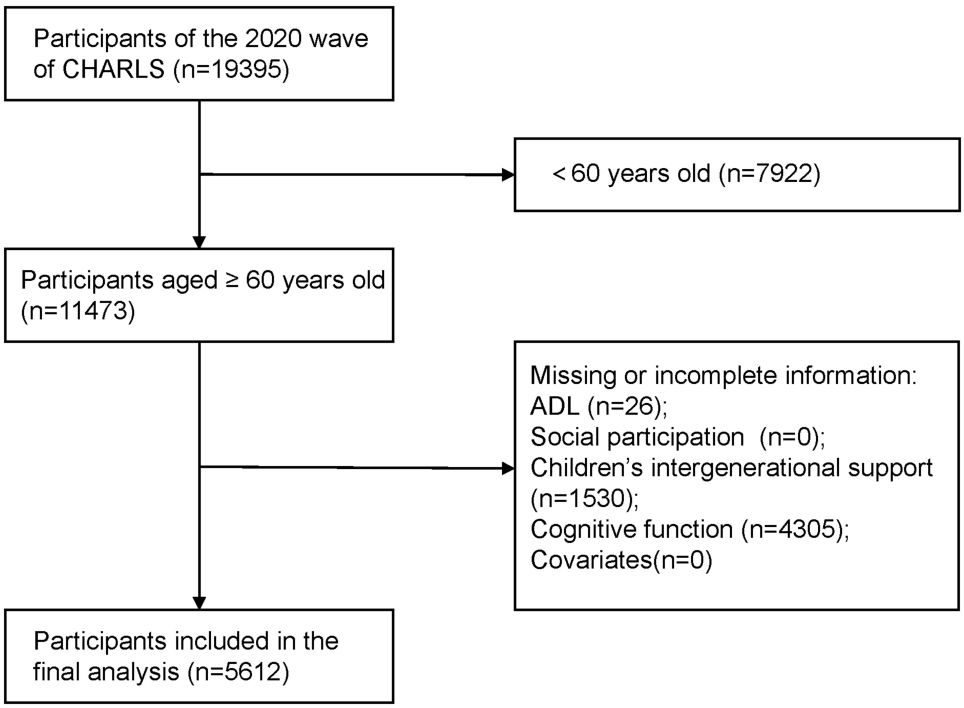

Figure 1 The flow chart of enrolled participants.

and 91.4% had an exercise habit. 86.5% of participants suffered from chronic diseases. More than half (52.7%) of the participants considered themselves to be in average health.

A one-way analysis using general demographic characteristics and cognitive function scores revealed that the differences in cognitive function scores between older adults of different ages, genders, marital statuses, education levels, places of residence, alcohol consumption, exercise, and self-assessed health statuses were all statistically significant ($P < 0.05$). In particular, the younger and more educated the older adults are, the higher their cognitive function is. Cognitive function was higher among male than female older adults, among married older adults than unmarried older adults, among older adults living in urban areas than in rural areas, and among older adults who had a drinking and exercise habit than those who did not. In addition, the better the self-assessed health, the higher the cognitive function scores (Table 1).

Table 1 Characteristics of the Participants

Variable	N	%	Cognitive Function (M ± SD)	t/F	P
Age				35.17	<0.001
60~69	3331	59.4	12.07 ± 3.32		
70~79	1922	34.3	11.73 ± 3.37		
80~89	346	6.2	10.23 ± 3.59		
≥90	13	0.2	9.08 ± 5.16		
Gender				10.63	<0.001
Female	2424	43.2	11.29 ± 3.58		
Male	3188	56.8	12.25 ± 3.17		
Marital status				9.14	<0.001
Unmarried	947	16.9	10.92 ± 3.56		
Married	4665	83.1	12.02 ± 3.32		

(*Continued*)

Table 1 (Continued).

Variable	N	%	Cognitive Function (M ± SD)	t/F	P
Educational level				440.46	<0.001
Primary	2215	39.5	10.17 ± 3.39		
Junior high school	1456	25.9	12.10 ± 2.98		
High school	1157	20.6	13.11 ± 2.73		
Bachelor's degree and above	784	14	14.15 ± 2.57		
Residence				−13.41	<0.001
Urban	2120	37.8	12.60 ± 3.21		
Rural	3492	62.2	11.37 ± 3.41		
Drinking				8.77	<0.001
No	3514	62.6	11.53 ± 3.45		
Yes	2098	37.4	12.34 ± 3.22		
Smoking				1.14	0.255
No	3994	71.2	11.80 ± 3.47		
Yes	1618	28.8	11.91 ± 3.19		
Physical exercise				6.90	<0.001
No	483	8.6	10.82 ± 3.45		
Yes	5129	91.4	11.93 ± 3.37		
Chronic disease				0.68	0.496
No	760	13.5	11.76 ± 3.53		
Yes	4852	86.5	11.85 ± 3.37		
Self-assessed health				13.17	<0.001
Very Poor	368	6.6	10.9 ± 3.39		
Poor	1133	20.2	11.59 ± 3.33		
Fair	2959	52.7	11.93 ± 3.33		
Good	582	10.4	12.40 ± 3.44		
Very Good	570	10.2	11.86 ± 3.59		

Abbreviations: M, Mean; SD, Standard Deviation.

Relationships Between ADL, Social Participation, Children's Intergenerational Support, and Cognitive Function in Older Adults

The results of Pearson's correlation analysis are shown in Table 2: ADL scores were negatively correlated with social participation ($r = -0.086$, $P < 0.001$), children's intergenerational support ($r = -0.020$, $P = 0.133$), and cognitive function ($r = -0.193$, $P < 0.001$) scores. However, in the present study, higher ADL scores were associated with poorer activities of daily living ability, so the actual significance of their two-by-two relationship should be positive. Furthermore, social participation was positively correlated with cognitive function ($r = 0.144$, $P < 0.001$). Children's intergenerational support was positively correlated with cognitive function ($r = 0.046$, $P < 0.001$) and social participation ($r = 0.025$, $P = 0.062$).

Table 2 Descriptive Statistics and Correlation Analysis (r)

Variables	M ± SD	1	2	3	4
1. ADL	13.36 ± 3.05	1			
2. Social participation	0.78 ± 0.98	−0.086***	1		
3. Children's intergenerational support	2.26 ± 0.74	−0.020	0.025	1	
4. Cognitive function	11.83 ± 3.39	−0.193***	0.144***	0.046***	1

Note: ***$P < 0.001$.
Abbreviations: M, Mean; SD, Standard Deviation; ADL, Activities of daily living.

https://doi.org/10.2147/JMDH.S523168

Mediating Effects of Social Participation

Model 4 in PROCESS was applied to test the mediating effect of social participation between ADL and cognitive function. The results showed that ADL scores had a significant negative effect on social participation ($\beta = -0.028$, $t = -6.461$) and cognitive function ($\beta = -0.214$, $t = -14.712$). With the addition of the mediating variable, social participation significantly positively predicted cognitive functions ($\beta = 0.445$, $t = 9.884$), and the direct predictive effect of ADL scores on cognitive functions remained significant ($\beta = -0.202$, $t = -13.934$) (Table 3). Bootstrap analyses indicated that social participation partially mediated the relationship between ADL and cognitive functions, with a mediating effect size of - 0.012, 95% *CI*= [−0.015, −0.008], with a mediating effect size of 5.74% (Table 4). Therefore, the H1 and H2 were supported.

Moderating Effects of Children's Intergenerational Support

Model 14 was used to test the moderating effect of children's intergenerational support. The results showed that ADL scores significantly negatively predicted cognitive function ($\beta = -0.201$, $t = -13.860$) and social participation ($\beta = -0.028$, $t = -6.461$) and that social participation ($\beta = 0.442$, $t = 9.834$) and children's intergenerational support ($\beta = 0.172$, $t = 2.891$) significantly positively predicted cognitive function. The interaction term of social participation and children's intergenerational support significantly negatively predicted cognitive function ($\beta = -0.182$, $t = -2.930$), indicating that the relationship between social participation and cognitive function was moderated by children's intergenerational support (Table 5). Thus, Hypothesis 3 was validated. The path coefficients of the moderated mediation model are shown in Figure 2.

Finally, in order to better interpret the model, a simple slope test was conducted by dividing children's intergenerational support into high (M+1SD) and low (M-1SD) subgroups, and the results are shown in Figure 3. Social participation had a significant positive effect on cognitive function in both the high and low children's intergenerational support groups. In the low children's intergenerational support group, the positive effect of social participation on cognitive functioning was stronger than in the high children's intergenerational support group (Table 6). It can therefore be argued that the positive predictive effect of social participation on cognitive functioning diminishes as children's intergenerational support increases. In addition, bias-corrected percentile bootstrap analyses confirmed that ADL indirectly affects cognitive function through social participation at different levels of children's intergenerational support, and the moderated mediated effect indicator value of 0.005 with a 95% confidence interval of [0.002, 0.009] did not contain a 0, suggesting that the moderated mediated effect test was significant (Table 7).

Table 3 Testing for the Mediation Effect

Predictors	Model 1 (Cognitive Function)		Model 2 (Social Participation)		Model 3 (Cognitive Function)	
	β	t	β	t	β	t
ADL	−0.214	−14.712***	−0.028	−6.461***	−0.202	−13.934***
Social participation	—	—	—	—	0.445	9.884***
R^2	0.037		0.007		0.054	
F	216.449***		41.745***		158.936***	

Note: ***P <0.001.
Abbreviation: ADL, Activities of daily living.

Table 4 The Total, Direct, and Indirect Effects of the Mediation Model

	β	SE	LLCI	ULCI	%
Total effects	−0.214	0.146	−0.243	−0.186	100
Direct effects	−0.202	0.015	−0.231	−0.174	94.26
Indirect effects	−0.012	0.002	−0.015	−0.008	5.74

Abbreviations: SE, Standard error; LLCI, lower level of confidence interval; ULCI, upper level of confidence interval.

Table 5 Coefficients for the Tested Moderated Mediation Model

Predictors	Model 1 (Cognitive Function)		Model 2 (Social Participation)	
	β	t	β	t
ADL	−0.201	−13.860***	−0.028	−6.461***
Social participation	0.442	9.834***		
Children's Intergenerational support	0.172	2.891**		
Social participation × Children's intergenerational support	−0.182	−2.930**		
R^2	0.057		0.007	
F	84.082***		41.745***	

Notes: × represents the interaction of social participation and children's intergenerational support **$P < 0.01$; ***$P < 0.001$.
Abbreviation: ADL, Activities of daily living.

Discussion

This study explored potential mechanisms underlying the link between ADL and cognitive function among elderly, and constructed a moderated mediation model. The results indicated that ADL positively predicted cognitive function and that social participation partially mediated the relationship. In addition, children's intergenerational support moderated the second half of the path of the mediated relationship. Moderating effects analyses revealed that social participation had a greater effect on cognitive function at low levels of children's intergenerational support. Our findings not only improve

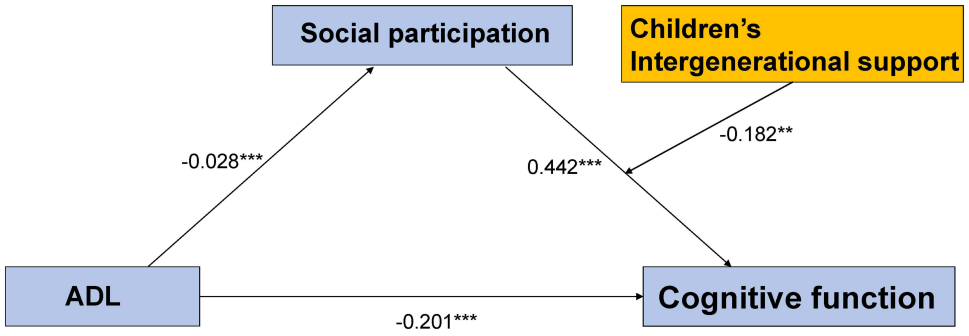

Figure 2 Path coefficient of the moderated mediation model.
Note: **$P < 0.01$, ***$P < 0.001$.

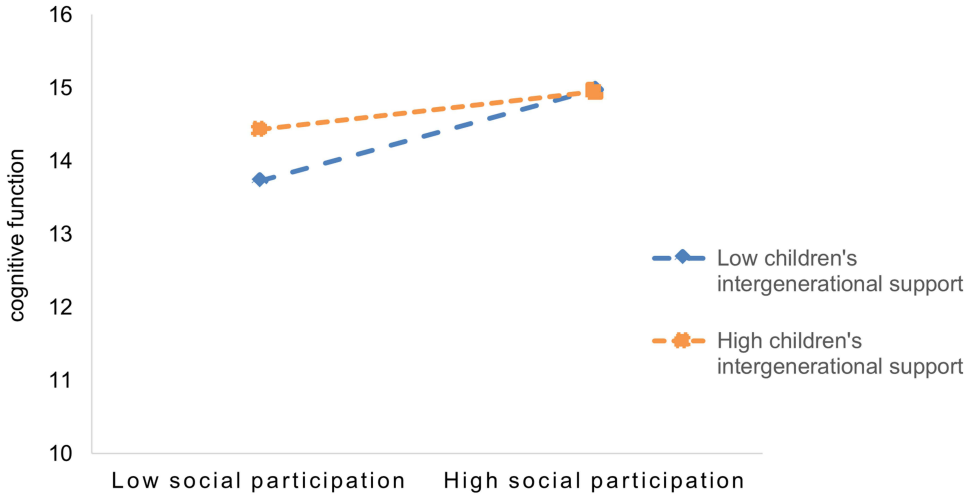

Figure 3 Moderating effect diagram of children's intergenerational support.

https://doi.org/10.2147/JMDH.S523168

Table 6 Conditional Direct Effects of Social Participation on Cognitive Function at Different Levels of Children's Intergenerational Support

Children's Intergenerational Support	β	SE	t	*P*	LLCI	ULCI
M-1SD	0.576	0.064	8.957	<0.001	0.4502	0.7025
M	0.442	0.045	9.834	<0.001	0.3537	0.5298
M+1SD	0.307	0.064	4.787	<0.001	0.1814	0.4329

Abbreviations: M, Mean; SD, Standard Deviation; SE, Standard error; LLCI, lower level of confidence interval; ULCI, upper level of confidence interval.

Table 7 Conditional Indirect Effects of ADL on Cognitive Function at Different Levels of Children's Intergenerational Support

Children's Intergenerational Support	Indirect Effect	Boot SE	LL 95% CI	UL 95% CI
M-1SD	−0.016	0.003	−0.021	−0.011
M	−0.012	0.002	−0.016	−0.009
M+1SD	−0.009	0.002	−0.013	−0.005
Index of moderated mediation	0.005	0.002	0.002	0.009

Abbreviations: M, Mean; SD, Standard Deviation; SE, Standard error; CI, confidence interval; LL, lower level; UL, upper level.

the understanding of the mechanisms underlying the interactions between ADL and cognitive function in older adults, but also provide valuable guidance for the development of targeted interventions aimed at preventing cognitive decline.

The present study found a positive association between ADL and cognitive function in older adults, which is consistent with previous research.[39] The result supported the "use it or lose it" theory that ADL restriction reduces the daily activities and social life of older adults, which reduces cognitive stimulation and accelerates disuse decline in cognitive function.[40] Relevant studies have shown that good ADL not only helps older adults remain independent, but also stimulates the brain by engaging in somatic activities and social interactions, which are essential for maintaining cognitive function.[41] When older adults are unable to perform activities of daily living independently due to declining ADL, they may experience health problems such as falls, fatigue, loneliness, and depression. These problems can further affect their cognitive functions such as attention, memory, reasoning, and thinking flexibility.[42] Based on this, healthcare professionals should routinely monitor and early recognize ADL impairment in older adults, focusing on those at risk for ADL impairment. For this group of older adults, early rehabilitation intervention is crucial. Healthcare professionals should carry out planned and step-by-step personalized rehabilitation training for them according to their impaired ADLs and characteristics, which can enhance their physical functions and improve their self-care ability.[43]

Consistent with existing research,[6] the present study found that ADL can indirectly affect cognitive function through social participation among older adults. A systematic review showed that physical activity can increase cerebral blood flow, and improve synaptic plasticity and neurotransmitter secretion levels, which in turn reduce the risk of cognitive impairment.[44] At the same time, mental activity stimulates the brain and promotes connections between neurons in the brain, helping to maintain cognitive functions, especially memory, attention, and coping skills.[45] In addition, organized social activities can promote information exchange and emotional support through interaction and cooperation with others, which can help reduce negative emotions such as anxiety and depression, which are essential for maintaining and enhancing cognitive functions.[46] For the elderly, with the growth of age, their physiological functions gradually deteriorate, the resistance to external adverse factors decreases, and they are more prone to various physical diseases, thus their ADL decreases as well.[47] When ADL declines, the autonomy and range of activities of the elderly will be further limited, which directly leads to weakened social skills and reduced social participation.[48] Older adults with low social participation have less contact with the outside world and receive less information and

stimulation, making it difficult for the brain to maintain an active state of activity, which ultimately leads to progressive deterioration of brain function and accelerates the risk of cognitive decline.[49] Another important reason is that older adults who lack social participation are more likely to feel lonely and develop depression and other maladies, which often leads to changes in their neurochemicals and neurological structure, thus affecting cognitive function.[50] Therefore, it is recommended that local governments and community committees improve appropriate activity facilities, increase the variety of community activities, and organize regular health activities, intellectually stimulating activities, volunteer services, cultural education, and other social welfare projects. In addition, older persons should be encouraged to venture out of their homes to participate in social activities such as community-based interest classes and universities for the elderly, which can stimulate brain vitality and reduce loneliness, thereby combating cognitive decline in older persons.[39]

Furthermore, the present study found that children's intergenerational support negatively moderated the relationship between social participation and cognitive function in older adults, which is similar to the findings of Hu.[31] The Social Convoy model holds that the size, quality, and function of one's social relationships change over the course of their life and have a significant impact on their health and well-being.[51] Hu argued that children's intergenerational support has a bidirectional effect and proposed a "boat-carrying" model, in which children's intergenerational support in high-quality intergenerational relationships facilitates the development of older adults' physical and mental health, whereas increased children's intergenerational support in low-quality intergenerational relationships may be detrimental to older adults' physical and mental health.[31] Cognitive reserve theory suggests that individuals build up a "cognitive reserve" through sustained intellectual activity, which helps to slow the development of cognitive impairment.[52] Thus, intergenerational support from children can stimulate the social environment and have a favorable effect on brain structure, thus resisting the deterioration of cognitive functions.[53] However, the negative moderating effect of intergenerational support observed in this study is deeply rooted in the cultural context of China. In China, family-based care remains the primary source of social support for the elderly, while in many Western societies, social welfare systems often play a more significant role. Culturally, Confucian values emphasize filial piety and intergenerational reciprocity, making upwardly mobile intergenerational support from children a central component of older adults' social support networks.[54] This may explain why high levels of intergenerational support weakened the impact of social participation in our sample: when children's intergenerational support is sufficient, the positive impact of family factors is enhanced, and older adults may then rely less on community-based social activities for cognitive stimulation. In addition, excessive contact between older adults and their children may lead to intergenerational conflict or ambivalence, which may exacerbate adverse emotions and further impair cognitive function.[55] Internationally, this finding emphasizes the need to place intergenerational support dynamics in a cultural context when studying cognitive health, as cultural norms of family support and social support can influence the role of social participation on cognitive function.

Implications

Theoretical Implication

The present study enriched the theoretical frameworks, including the "use it or lose it theory" and the "cognitive reserve theory", by demonstrating that ADL limitations affect cognitive functions in older adults by reducing social participation. Children's intergenerational support as a moderator enriches the "boat-carrying" model, revealing that excessive children's intergenerational support may weaken the protective effect of social participation on cognitive function in the Chinese cultural context. Overall, this study linked physical, social, and family factors to explain the mechanisms of cognitive decline, providing a theoretical perspective for future cross-cultural comparisons.

Practical Implication

The results of this study provided practical guidance for developing interventions to delay cognitive decline in older adults. First, healthcare professionals should develop individualized rehabilitation programs for older adults to maintain good activity and delay cognitive decline. Second, the government and community should integrate resources to provide tailored community activity facilities and social programs for older adults to ensure continued cognitive stimulation through social participation, thereby protecting cognitive function. In addition, the community should regularly assess and screen the cognitive functions of the elderly for early detection, intervention and treatment. Finally, children should

offer appropriate companionship and emotional support to the elderly to avoid excessive care that leads to a decline in their willingness to participate in society. They should strike a balance between family support and social interaction to achieve the dual protective effect on cognition.

Limitation and Future Research Recommendations

First, this was a cross-sectional study, which could not determine the causal relationship between the variables or the direction of the association between ADL decline and cognitive decline. In the future, more longitudinal studies should be conducted from a life course perspective to explore the dynamics of cognitive function in the elderly and its causal mechanisms with other variables. Second, this study used self-reported data and lacked the support of objective indicators, so reporting bias and recall bias are inevitable Future studies should incorporate objective evaluation indicators and qualitative research methods to improve the reliability and authenticity of the findings. Third, apart from the strong correlation observed between ADL and cognitive function, the correlations between the other key variables appear to be low. This suggests that certain key factors may not have been adequately considered, such as biological and pathologic factors. In future studies, more relevant factors could be collected to allow for a more comprehensive and in-depth analysis of the relationships between variables.

Conclusion

This study used data from CHARLS 2020 to explore the interactions and potential mechanisms between ADL, social participation, children's intergenerational support, and cognitive functions among the Chinese elderly. We found that cognitive function was closely related to ADL levels, with social participation playing a mediating role. In addition, children's intergenerational support negatively moderated the relationship between social participation and cognitive function, forming a moderated mediation model. With the rapid development of aging in China, these findings may have important health implications for the development of targeted preventive and intervention measures to delay cognitive decline. In the future, the government, communities, families, and older adults themselves should all take appropriate measures to work together to delay cognitive decline in older adults and ensure that they are able to lead healthy, active lives into old age.

Data Sharing Statement

Publicly available datasets were analyzed in this study. More information about the CHARLS can be obtained at http://www.Charls.pku.edu.cn.

Ethics Approval and Informed Consent

In accordance with the Declaration of Helsinki, the study was reviewed and approved by the ethics committee of the Peking University (IRB00001052–11015). The participants provided their written informed consent to participate in this study. In addition, the study was authorized by the Medical Ethics Committee of Shanxi Bethune Hospital (No. YXLL-2024-183).

Acknowledgments

We would like to express our gratitude to both the study participants and the CHARLS researchers.

Author Contributions

All authors made a significant contribution to the work reported, whether that is in the conception, study design, execution, acquisition of data, analysis and interpretation, or in all these areas; took part in drafting, revising or critically reviewing the article; gave final approval of the version to be published; have agreed on the journal to which the article has been submitted; and agree to be accountable for all aspects of the work.

Funding

This study was funded by the Shanxi Provincial Health Commission Scientific Research Project (2022139) and the Chinese Medical Association Journal Nursing Discipline Research Project (CMAPH-NRP2021002).

Disclosure

The authors report no conflicts of interest in this work.

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