THE ANATOLIAN JOURNAL OF CARDIOLOGY

Official journal of the TURKISH SOCIETY OF CARDIOLOGY

A Study on the Association Between Social Activity and Depression and Cognitive Function in Patients with Heart Disease: The Mediating Role of Activities of Daily Living

ABSTRACT

Background: Patients with heart disease are frequently accompanied by heightened depressive symptoms and cognitive decline. Social activity (SA) and activities of daily living (ADL) may affect these associations. This study aims to investigate the associations between depression, cognitive function, and SA in patients with heart disease, and further assess the mediating role of ADL.

Methods: Multivariate linear and logistic regression models were adopted to assess the correlations between SA scores (SAs), depression, and cognitive function. Restricted cubic spline (RCS) regression was employed to detect potential non-linear relationships. Subgroup and interaction analyses were conducted to identify heterogeneous associations across population subgroups, while mediation analysis was performed to assess indirect pathways through ADL.

Results: Higher SAs were significantly correlated with lower odds of depression (OR = 0.90, 95% CI: 0.86-0.94, $P < .001$) and higher cognitive scores ($\beta = 0.15$, 95% CI: 0.09-0.22, $P < .001$) with evident dose-response trends. RCS results showed no significant non-linear associations between SAs and depression or cognitive function (P-non-linear > .05). Subgroup analysis showed that the association between SAs and cognitive function was modified by urban-rural disparities (P for interaction = .028). Exploratory mediation analysis showed that ADL could account for 28.5% and 20.3% of the total effect of SA on depression and cognitive function, respectively.

Conclusion: Higher SA engagement was associated with lower odds of depression and better cognitive function in patients with heart disease. Cardiac rehabilitation strategies should encourage active participation in SA while emphasizing recovery of daily functioning.

Keywords: Activities of daily living, cognitive function, depression, heart disease, social activity

INTRODUCTION

Cardiovascular diseases, especially heart disease, constitute a formidable challenge to global public health. According to the latest Global Burden of Disease, ischemic heart disease alone accounted for 193 million disability-adjusted life years and 8.95 million deaths in 2023, ranking as the leading cause of global mortality and disability[1,2] Beyond the substantial physical burden, patients with heart disease are confronted with prominent mental health risks. Epidemiological data unveil that over 19% of heart disease patients present with depressive symptoms meeting diagnostic criteria, and their risk of adverse outcomes is 2- to 3-fold higher than that of patients without depressive symptoms.[3,4] Furthermore, cognitive impairment is highly prevalent among heart disease patients: elevated cardiac burden induces reductions in hippocampal volume, cortical gray matter volume, and total brain volume, thereby accelerating cognitive decline.[5] Over 40% of patients with heart failure suffer from cognitive impairment,[6] posing a formidable challenge to patients' quality of life and long-term prognosis alongside depression.

ORIGINAL INVESTIGATION

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Received Date: February 3, 2026
Accepted Date: August 28, 2026
Available Online Date: September 21, 2026

Cite this article as: Xu J, Wang P, Chang D, Ye C, Shen J. A study on the association between social activity and depression and cognitive function in patients with heart disease: the mediating role of activities of daily living. *Anatol J Cardiol.* 2026;XX(X):1-14.

DOI: 10.14744/AnatolJCardiol.2026.6275

The effects of social engagement and social activity (SA) serving as social determinants of health have increasingly garnered attention. Patients with heart disease frequently encounter challenges of social circle contraction and diminished social engagement, attributable to disease burden, diminished exercise tolerance, and other comorbidities.[7] Beyond being tightly linked to elevated risk of depression onset and symptom persistence, social isolation, decreased SA, and subjective loneliness are also associated with accelerated cognitive decline and elevated dementia risk across diverse populations.[8,9] Accumulating evidence has demonstrated that maintaining SA with appropriate frequency and diversity is positively correlated with improved emotional well-being, preserved cognitive function, and reduced risk of cardiovascular mortality.[10,11] A previous study targeting community-dwelling older adults further indicated that frequent participation in social activities was linked to an approximately 26% reduction in the risk of cognitive decline.[12] Although relevant studies indicate that chronic heart diseases such as heart failure are frequently accompanied by reduced opportunities for social engagement, social isolation, and a substantial burden of depression, and that positive patient support is critical to maintaining quality of life among individuals with chronic illnesses.[13,14] It is noteworthy that most existing research still focuses primarily on older adults or general community populations. Studies specifically investigating the intrinsic associations between different types of SAs and depression as well as cognitive function among patients with heart disease remain scarce, with a lack of systematic analyses.

Activities of daily living (ADL) are also recognized as a core psychophysiological component affecting the overall health status of patients with heart disease, except for SA. The ADL is markedly associated with patients' mental health outcomes. Individuals with ADL limitations typically exhibit lower levels of cognitive function and more severe depressive symptoms.[15,16] Furthermore, a prominent association has been identified between SA and ADL. A longitudinal study unveils that abundant social engagement contributes to the maintenance and enhancement of ADL performance in patients with severe chronic illnesses.[17] Collectively, SA, depression, and cognitive function are interrelated with ADL. However, current research on the specific patterns of association among these 3 factors in patients with heart disease remains scarce. Further systematic investigations are warranted to elucidate their intrinsic connections.

Accordingly, this study adopted nationally representative data from the China Health and Retirement Longitudinal Study (CHARLS) to systematically explore the associations between SA and depressive symptoms as well as cognitive function among patients with heart diseases. The enrolled cardiac patients covered a broad spectrum of cardiac conditions, including heart attack, coronary heart disease, angina pectoris, congestive heart failure and other cardiac disorders. Despite heterogeneous clinical manifestations across these patients, they share prominent commonalities in confronting psychosocial challenges such as social withdrawal and limited daily functional capacity. By clarifying such correlation patterns and the mediating role of ADL, the present study aimed to provide empirical evidence for the formulation of targeted cardiac rehabilitation interventions.

HIGHLIGHTS

- Social activity scores (SAs) were associated with a lower likelihood of depression and higher cognitive scores in patients with heart disease.
- Exploratory pathway analysis identified activities of daily living as a potential indirect link between SAs, depression, and cognitive function.
- The positive association between SA and cognitive function is significantly stronger among urban residents compared to rural residents.
- Encouraging social engagement and supporting daily functional recovery should be integral components of cardiac rehabilitation strategies.

METHODS

Study Population

Data for this study were obtained from the CHARLS. CHARLS is a large-scale interdisciplinary survey project that launched its baseline survey in 2011, covering 150 county-level and 450 village-level units nationwide. It aims to collect high-quality representative data on middle-aged and older Chinese adults aged 45 years and above. The study was approved by the corresponding Medical Ethics Committee (IRB00001052-11015). All participants provided written informed consent prior to the survey; therefore, no additional ethical certification is required.

Leveraging the 2015 CHARLS data as the baseline, 21095 participants were initially investigated. Patients with heart disease at baseline were enrolled (n=2958). Participants confirming the following criteria were subsequently excluded: age <45 years (n=90), missing data on social engagement (n=169), missing data on depressive symptoms (n=235), missing data on cognitive function (n=456), and missing values for other covariates (n=423). Ultimately, 1585 participants were enrolled in the analysis (Figure 1).

In this study, heart disease was defined based on participants' self-reported physician-diagnosed outcomes in the CHARLS questionnaire. All respondents were asked whether they had ever been diagnosed with heart diseases by clinicians, including heart attack, coronary heart disease, angina pectoris, congestive heart failure and other cardiac ailments. Given that the CHARLS survey only adopted binary yes-or-no response options for such disease-related items, a dichotomous variable was established to identify individuals with cardiac conditions in the current analysis. Restricted by the original survey design of the database, this study failed to conduct separate classification and subgroup analyses for specific clinical subtypes such as coronary heart disease, heart failure and arrhythmia. Nevertheless, this diagnostic classification criterion for cardiac disorders has been widely applied in numerous high-quality studies using CHARLS datasets, which possess satisfactory population representativeness and sound scientific credibility.[18-21]

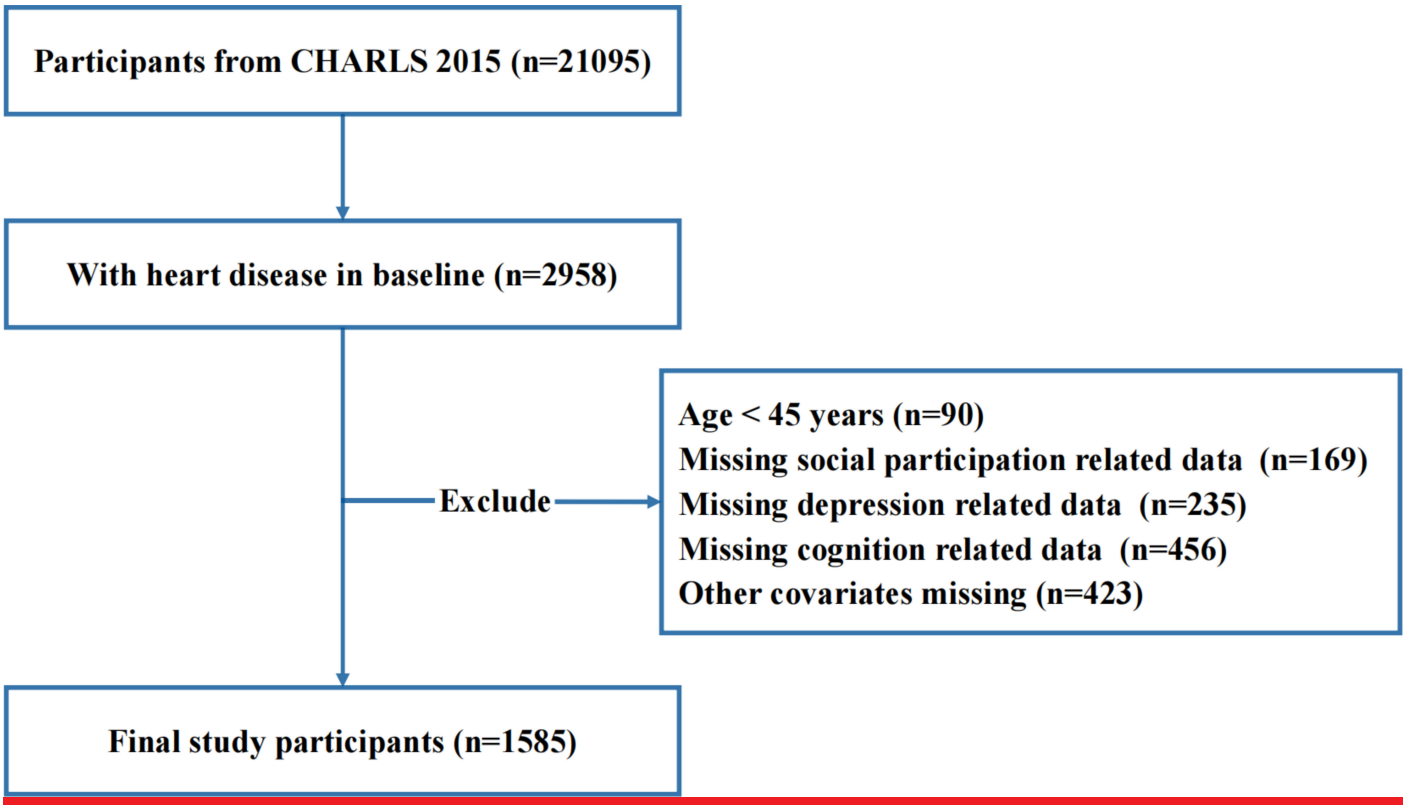

Figure 1. Inclusion and exclusion criteria.

Social Activity

Social engagement situations were evaluated via a questionnaire developed based on CHARLS. Participants were queried regarding the frequency of their engagement in the following 10 activities over the preceding month: (1) interacting with friends; (2) playing mahjong, chess, card games, or visiting community clubs; (3) providing assistance to family members, friends, or neighbors not residing in the same household; (4) participating in sports, social, or other types of clubs; (5) engaging with community-related organizations; (6) undertaking volunteer or charitable work; (7) caring for ill or disabled adults who do not cohabit with others; (8) attending educational or training courses; (9) participating in stock investments; and (10) using the Internet. Collectively, each activity was rated on a scale ranging from 0 (never) to 3 (almost daily). The total score spanned from 0 to 30, with higher scores indicating a greater frequency of SA engagement.[22]

The SA scores of heart disease patients in this study exhibited a markedly right-skewed distribution (Figure S1), with most participants scoring between 0 and 2 points. To balance sample sizes across groups and ensure stable statistical analyses, this study categorized SA scores into 3 groups in accordance with grouping strategies adopted by previous CHARLS-based relevant investigations:[11,23] ① No SAs (0 points, n=594); ② Low-level SAs (1-2 points, n=353); ③ High-level SAs (>2 points, n=638). Given the extremely low proportion of participants with relatively high scores such as SA ≥ 7, further subdivision of samples scoring > 2 points would lead to severely insufficient sample size in high-score subgroups and weaken statistical power and analytical robustness. Accordingly, participants with scores > 2 points were integrated into the moderate-to-high SA group. This grouping approach not only achieves relatively balanced sample distribution among the 3 strata, but also facilitates horizontal comparative analysis with other empirical studies utilizing the same database.

Psychological State

Depression

The questionnaire encompassed the 10-item Center for Epidemiological Studies Depression Scale-10, where each item was rated on a scale ranging from 0 to 3. Items 5 and 8 were reverse scored, with a total score of ≥10 defined as depression.[24]

Cognitive Performance

Episodic memory was evaluated via the word memory tests, with executive function examined via the mental state tests at each follow-up visit. Word memory assessment consisted of 2 components: immediate word recall and delayed word recall. For the immediate recall task, participants were instructed to retrieve as many of the 10 experimenter-presented words as possible in any order. For the delayed recall task, participants were required to retrieve these words again. Each correctly recalled word was awarded 1 point; the word memory score was derived as the mean of the immediate and delayed recall test scores, with a range of 0-10.

Mental cognitive status was assessed via the 10-item Telephone Interview of Cognitive Status (TICS-10) and a

figure copying task. The TICS-10 encompassed date orientation (day, week, month, season, and year) and serial subtraction of 7 from 100 (up to 5 trials). The total TICS-10 score was the count of correct responses, ranging from 0 to 10. For the figure copying task, participants were required to replicate a given figure with maximum fidelity. A score of 1 was assigned for successful completion of the task, and 0 for unsuccessful completion. The overall cognitive score was computed as the sum of the word memory score and the cognitive status score, with a range of 0 to 21.[25,26]

Mediating Variables

The CHARLS questionnaire incorporated 6 basic ADL items (dressing, bathing, eating, transfer, toileting, and bowel/bladder control), and 5 instrumental ADL items: housework, cooking, shopping, money management, and medication adherence. For each item, a score of 1 was assigned if the participant reported difficulty completing the activity.

Covariates

Age, sex (female/male), educational attainment (illiterate/primary school or below/secondary school or above), marital status (partnered/single), residential location (rural/urban), smoking status (yes/no), alcohol consumption (yes/no), and body mass index (BMI) (normal: <24 kg/m^2; overweight: 24 kg/m^2 ≤ BMI <28 kg/m^2; obese: ≥28 kg/m^2).

Hypertension was defined as meeting either of the following criteria: (1) systolic blood pressure/diastolic blood pressure ≥140/90 mmHg; (2) self-reported physician diagnosis. Diabetes mellitus was defined as satisfying any one of the following: (1) fasting blood glucose ≥126 mg/dL; (2) HbA1c level ≥6.5%; (3) self-reported physician diagnosis. Dyslipidemia was defined as meeting either of the following: (1) triglycerides ≥150 mg/dL, total cholesterol ≥240 mg/dL, high-density lipoprotein cholesterol <40 mg/dL, or low-density lipoprotein cholesterol ≥160 mg/dL; (2) self-reported physician diagnosis.

Statistical Analysis

The baseline tables were stratified by participants' SA engagement levels. Categorical variables are presented as sample sizes [N (%)], while continuous variables were summarized as mean±standard deviation. Analysis of variance for continuous variables and chi-square test for categorical variables were employed to implement group comparisons. The baseline table was generated with the "tableone" package. Leveraging the frequency scores, SA was categorized into 3 groups: No SAs, Low SAs, and High SAs. Multivariable linear regression and logistic regression models were employed to evaluate the associations of individual SA and SA groups with depression and cognitive performance, respectively. Linear regression and logistic regression analyses were performed using the "stats" package. When analyzing SA participation as a categorical variable, the No SAs group was set as the reference group.

In subgroup analyses, the SA score was included in the models as a continuous variable. The OR and β values within each subgroup represented the odds ratio for depression and the change in cognitive score associated with each one-point increment in the SA score, rather than comparisons across distinct SA subgroups. To test for effect modification, product interaction terms between SA score and each potential modifier (age group, sex, educational attainment, marital status, residential location, smoking status, alcohol consumption, BMI, hypertension, diabetes mellitus, and dyslipidemia) were separately incorporated into the fully adjusted models. A single *P* value for interaction was reported for each effect modifier.

For the binary depression outcome, Wald χ^2 tests with 1 degree of freedom were applied to assess interactions involving binary effect modifiers. For multi-categorical modifiers such as educational attainment and BMI category, likelihood ratio χ^2 tests via nested logistic regression models were used to jointly test all complete interaction terms. For the continuous cognitive outcome, joint Wald χ^2 tests were conducted for the full set of interaction terms of each effect modifier. The reference levels of categorical effect modifiers in the interaction models were as follows: age < 60 years, female, illiterate, single, rural residence, non-smoker, non-drinker, BMI < 24 kg/m^2, no hypertension, no diabetes mellitus, and no dyslipidemia. Subgroup analyses and interaction effect testing were implemented using the "jstable" package.

The non-linear relationships between SAs and depression, as well as cognitive performance, were dissected via restricted cubic spline (RCS); RCS curves were visualized with the "rms" package. The mediating role of ADL was evaluated via the Bootstrap method 500 times. Mediation analysis was implemented with the "mediation" package, with 3 model specifications: Model 1 (unadjusted), Model 2 (adjusted for age and sex), and Model 3 (adjusted for age, sex, educational attainment, marital status, residential location, smoking status, alcohol consumption, BMI, hypertension, diabetes mellitus, and dyslipidemia). Given the cross-sectional nature of the dataset, the present analytical approach was designated as exploratory associational pathway analysis.

All statistical analyses were conducted via *R* software (version 4.4.2). $P < .05$ was considered statistically significant.

RESULTS

Baseline Characteristics

A total of 1,585 participants were enrolled, with a mean age of 63.0 ± 9.0 years. Statistically significant differences across SA participation groups were observed with respect to age, educational attainment, residential location, alcohol consumption, BMI, dyslipidemia, depressive status, and cognitive scores (all $P<0.05$) (Table 1). The depression and cognitive function of the population regarding the 10 SA items are presented in Table S1.

Association Analysis of Social Activity with Depression and Cognitive Function

The association analyses between SAs and depression as well as cognitive function among patients with heart disease revealed that when SAs were treated as a continuous variable, it was negatively associated with the prevalence of depression (OR = 0.90, 95% CI: 0.86-0.94, $P < .001$) and positively correlated with cognitive function levels (β = 0.15, 95%

Table 1. Baseline Characteristics of Patients with Heart Disease

	Overall	No SAs	Low SAs	High SAs	*P*
n	1585	594	353	638	
Age (years)	63.0 (9.0)	64.0 (9.0)	61.9 (8.9)	62.9 (9.0)	.002
Gender (%)					.966
Female	946 (59.7)	357 (60.1)	210 (59.5)	379 (59.4)	
Male	639 (40.3)	237 (39.9)	143 (40.5)	259 (40.6)	
Education level (%)					<.001
Illiterate	303 (19.1)	142 (23.9)	65 (18.4)	96 (15.0)	
Elementary and below	665 (42.0)	272 (45.8)	148 (41.9)	245 (38.4)	
Middle and above	617 (38.9)	180 (30.3)	140 (39.7)	297 (46.6)	
Marital status (%)					.331
Single	233 (14.7)	80 (13.5)	49 (13.9)	104 (16.3)	
Coupled	1352 (85.3)	514 (86.5)	304 (86.1)	534 (83.7)	
Address (%)					<.001
Rural	813 (51.3)	338 (56.9)	197 (55.8)	278 (43.6)	
Urban	772 (48.7)	256 (43.1)	156 (44.2)	360 (56.4)	
Smoke (%)					.500
No	915 (57.7)	353 (59.4)	204 (57.8)	358 (56.1)	
Yes	670 (42.3)	241 (40.6)	149 (42.2)	280 (43.9)	
Alcohol (%)					.025
No	1124 (70.9)	445 (74.9)	243 (68.8)	436 (68.3)	
Yes	461 (29.1)	149 (25.1)	110 (31.2)	202 (31.7)	
BMI (kg/m^2)	25.0 (4.1)	24.7 (4.1)	25.0 (4.0)	25.3 (4.1)	.018
Hypertension (%)					.159
No	593 (37.4)	239 (40.2)	131 (37.1)	223 (35.0)	
Yes	992 (62.6)	355 (59.8)	222 (62.9)	415 (65.0)	
Diabetes (%)					.849
No	1172 (73.9)	436 (73.4)	265 (75.1)	471 (73.8)	
Yes	413 (26.1)	158 (26.6)	88 (24.9)	167 (26.2)	
Dyslipidemia (%)					<.001
No	659 (41.6)	278 (46.8)	156 (44.2)	225 (35.3)	
Yes	926 (58.4)	316 (53.2)	197 (55.8)	413 (64.7)	
Depression (%)					<.001
No	951 (60.0)	320 (53.9)	191 (54.1)	440 (69.0)	
Yes	634 (40.0)	274 (46.1)	162 (45.9)	198 (31.0)	
Cognition score	11.4 (3.8)	10.7 (3.9)	11.5 (3.7)	12.1 (3.6)	<.001

Categorical variables are presented as n (%) and continuous variables as mean ± standard deviation (SD).

CI: 0.09-0.22, $P < .001$). After converting SAs into categorical variables and constructing fully adjusted models, participants in the high SAs group presented a remarkably lower likelihood of depression (OR = 0.56, 95% CI: 0.44-0.71, $P < .001$) and distinctly higher cognitive function scores ($\beta = 0.75$, 95% CI: 0.39-1.11, $P < .001$) in comparison with individuals without SA participation (Table 2). The associations between participation in individual SA and depression, as well as cognitive function, are presented in Table S2.

RCS results elucidated that the overall associations of SAs with depression (Figure 2A) and cognitive function (Figure 2B) were prominent (P-overall < .001), while no non-linear relationships were observed (P-non-linear > .05).

Subgroup Analysis

In subgroup analyses, the SA score was entered into the models as a continuous variable, and the effect estimates within each stratum represented the corresponding OR or β per one-unit increase in the SA score. The associations of the SA score with lower odds of depression and higher cognitive scores were consistent in direction across most subgroups. Tests for interaction revealed that only the interaction between SA score and residential location attained statistical significance in the cognitive function analysis (P for interaction = .028). This P value was derived from the test of the product term between continuous SA score and residential location in the fully adjusted model. Stratified analyses demonstrated a positive correlation between SA score

Table 2. The Association Between Social Activity Scores and Depression and Cognitive Function in Patients with Heart Disease

	Model 1	*P*	Model 2	*P*	Model 3	*P*
Depression	**OR (95% CI)**		**OR (95% CI)**		**OR (95% CI)**	
(Continuous)	0.88 (0.85~0.92)	<.001	0.88 (0.84~0.92)	<.001	0.90 (0.86~0.94)	<.001
No SAs	Ref		Ref		Ref	
Low SAs	0.99 (0.76~1.29)	.944	0.96 (0.73~1.25)	.758	1.00 (0.76~1.32)	.989
High SAs	0.53 (0.42~0.66)	<.001	0.51 (0.40~0.64)	<.001	0.56 (0.44~0.71)	<.001
Cognition	β (95% CI)		β (95% CI)		β (95% CI)	
(Continuous)	0.31 (0.23~0.38)	<.001	0.29 (0.22~0.36)	<.001	0.15 (0.09~0.22)	<.001
No SAs	Ref		Ref		Ref	
Low SAs	0.80 (0.31~1.29)	.001	0.60 (0.12~1.07)	.014	0.36 (−0.06~0.77)	.094
High SAs	1.48 (1.07~1.90)	<.001	1.37 (0.97~1.78)	<.001	0.75 (0.39~1.11)	<.001

Model 1: Unadjusted model; Model 2: Adjusted for age and gender; Model 3: Adjusted for age, gender, educational level, marital status, residential location, smoking status, alcohol consumption, body mass index (BMI), hypertension, diabetes mellitus, and dyslipidemia.

and cognitive score among urban residents (β = 0.21, 95% CI: 0.14-0.29, $P < .001$), whereas the association was not statistically significant in rural residents (β = 0.06, 95% CI: −0.05-0.16, $P = .300$) (Table S3).

Mediation Analysis

Mediation analysis was further performed to explore the potential mediating role of ADL in the associations of SA with depressive status and cognitive function. The results demonstrated that ADL exerted significant indirect effects on the linkages between SA and depression (β = −0.006, $P < .001$, Figure 3A) as well as cognitive function (β = 0.029, $P < .001$, Figure 3B), with the corresponding mediating proportions being 28.5% and 20.3% respectively. In view of the cross-sectional study design, such mediating effects merely reflect the indirect associational pathways among relevant variables.

DISCUSSION

The results indicated that higher SA scores were associated with lower odds of depression and better cognitive function. Moreover, the association between SA score and cognitive function differed between urban and rural residents. Exploratory path analysis suggested that ADL may partially mediate the associations of SA with depression and cognitive function. The results of this study align with conclusions from multiple prior investigations. A cross-sectional study elucidated that social support exhibited a marked negative correlation with depressive symptoms in patients with coronary heart disease and served as an essential negative predictor of depressive symptoms.[27] For cognitive function, a cohort study targeting community-based senior populations confirmed that higher SA frequency was markedly associated with a lower risk of cognitive decline.[28] Concurrently, active social engagement in middle age forecasts better episodic memory and mental integrity in later life.[29] As a chronic disease population characterized by high incidence, high disability rates, and heavy psychological burden, the emotional state and cognitive function of patients with heart disease directly impact disease prognosis, treatment adherence, and quality of life.[30] Against this backdrop, concentrating

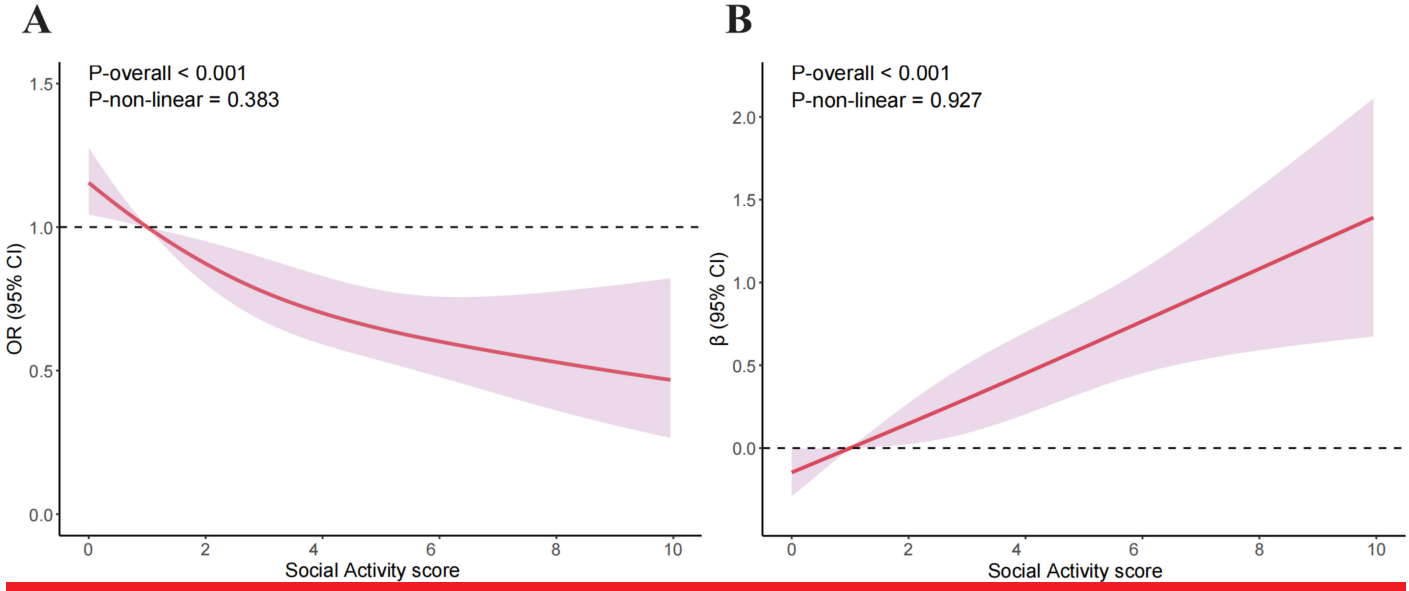

Figure 2. Dose-response Association of SAs with Depression and Cognitive Function (A) dose-response association between SAs and depression; (B), dose-response association between SAs and cognitive function.

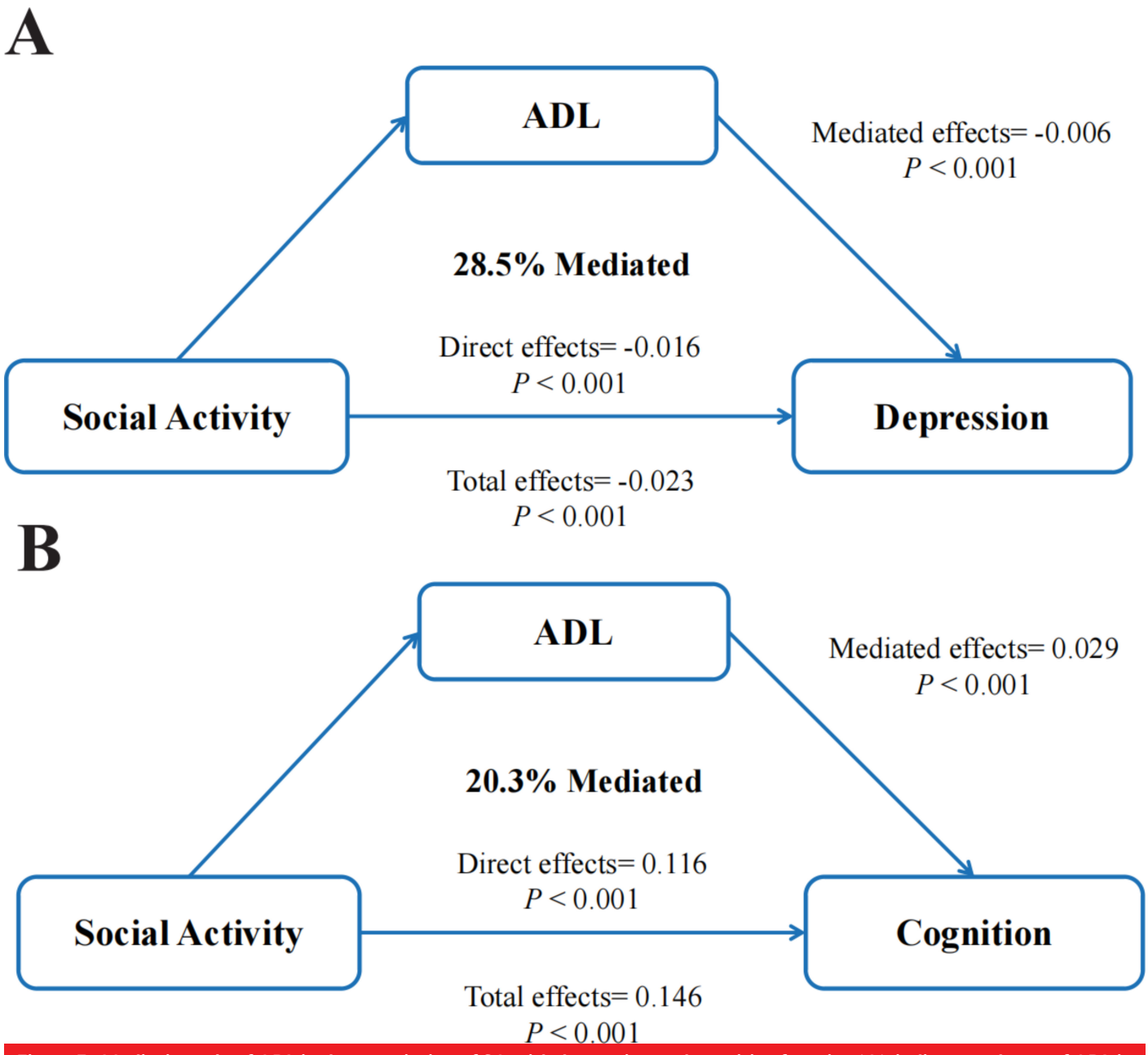

Figure 3. Mediating role of ADL in the association of SA with depression and cognitive function (A), indirect pathway of ADL in the association between SA and depression; (B), indirect pathway of ADL in the association between SA and cognitive function.

on the physically and psychologically vulnerable cohort of patients with heart disease, a combined analysis of the relationships among SA, depressive symptoms, cognitive function, and ADL capacity was implemented. In addition, significant indirect pathways of ADL were observed in the associations of SA with depression and cognitive function. Collectively, beyond offering novel empirical evidence for elucidating the reciprocal influences of psychological, cognitive, and functional states in patients with heart disease, this investigation also implies that clinical management is supposed to prioritize the pharmacological interventions and traditional risk factor control, as well as the promotion of social participation and maintenance of ADL capacity. The target is to achieve the integrated goals of boosting quality of life, improving moods, and preserving cognitive function.

The associations identified in the present study are representative of the overall population with heart diseases. Nevertheless, accumulating clinical evidence has confirmed obvious heterogeneity in depressive mood, social engagement status, and severity of cognitive impairment across patients with distinct cardiac conditions. Specifically, patients with coronary heart disease and angina pectoris tend to exhibit a higher tendency toward social withdrawal and a greater prevalence of depressive symptoms due to concerns over chest pain and disease uncertainty.[31] Owing to

markedly reduced exercise tolerance and persistent physical fatigue, individuals with heart failure generally show lower levels of social participation, alongside a greater tendency toward cognitive decline and impaired executive function.[32,33] Although patients with arrhythmia tend to have relatively milder cognitive deficits, feelings of loneliness and social avoidance are also commonly observed in this population.[34] Despite such discrepancies across clinical subtypes, previous studies focusing on single cardiac subtypes have consistently verified that insufficient social engagement is closely linked to depressive manifestations and cognitive deterioration, which is in line with the associative trends observed in the overall cardiac population in this research. Restricted by the binary survey design of the CHARLS database, this study failed to stratify participants into the above clinical subtypes for further intergroup comparative analysis and only reported the overall associative patterns among all patients with heart disease.

SA may exert comprehensive favorable associative correlations with depressive manifestations and cognitive status in patients with heart disease by modulating neuroendocrine and inflammatory processes closely implicated in cardiovascular disorders. Patients presenting with depressive symptoms and cognitive decline frequently exhibited hyperactivation of the hypothalamic-pituitary-adrenal (HPA) axis. This persistent state of stress led to abnormally elevated cortisol levels, which impaired hippocampal neurogenesis and prefrontal-limbic connectivity, thereby disrupting neural circuits associated with emotion regulation, learning, and memory.[35,36] Regular SA effectively modulated this pathological cascade. Active engagement in SA markedly modulated HPA axis function status; compared to elderly adults with lower SA rates, those with a higher weekly SA proportion displayed a more pronounced diurnal decline in cortisol levels,[37] facilitating the restoration of hippocampal neurogenesis rates and potentiated prefrontal structural plasticity. Furthermore, social isolation correlated with both chronic psychological stress and elevated inflammatory markers,[38,39] emerging as an essential risk factor for depression and cognitive decline in patients with heart disease.[40,41] In contrast, active social engagement was consistently correlated with decreased levels of inflammatory cytokines.[42] This attenuation of inflammatory load might defend the structural and functional integrity of brain regions linked to emotion and memory, including the limbic system, via mitigating the disruption of blood-brain barrier permeability by inflammatory mediators, thereby contributing to the maintenance of brain function and improvement of emotional states to a certain extent.[43]

The association between SA and cognitive function exhibited residential location differences. Urban environments typically offered denser, more diverse social networks and cultural engagement opportunities,[44] with social interactions frequently entailing intricate information processing and cognitive demands. Concurrently, urban residents exhibited greater accessibility to education, transportation, healthcare, and cultural facilities,[45] which might facilitate the translation of SA into sustained stimuli conferring positive effects on cognitive function. In contrast, rural social patterns tended to rely heavily on traditional strong ties encompassing kinship and neighborhood bonds, etc., with activity formats and cognitive challenges being relatively limited.

Mediation analysis results indicated that ADL served as a critical bridging mechanism linking SA to depression and cognitive function. Clinically, patients with heart disease frequently underwent decreased activity and functional decline due to impaired cardiac function and fatigue, etc. Such ADL impairment often elevated dependence on family members or caregivers and induced diminished self-efficacy and helplessness, thereby exacerbating depressive symptoms and driving social withdrawal.[46,47] Conversely, higher levels of SA tended to be accompanied by elevated physical activity, contributing to the maintenance or improvement of patients' ability to independently perform basic self-care tasks that included dressing, bathing, toileting, eating, etc.[48,49] This independence potentiated perceived control and self-esteem, thereby mitigating depressive experiences on account of disability. Regarding cognition, ADL limitations were frequently accompanied by decreased activity and environmental stimulation, contributing to cognitive deterioration.[15] In contrast, superior ADL required patients to consistently engage in planning, sequencing, multi-step operations, and problem-solving in daily life.[50] The process constituted repeated training for cognitive function, including attention, executive function, and memory, *etc.*, contributing to cognitive decline delay.

Although statistically significant associations between SAs and depressive symptoms as well as cognitive function were detected in this study, the overall effect sizes remained moderate. Emotional status and cognitive performance tend to change gradually among middle-aged and elderly community-dwelling patients with cardiac diseases, and single behavioral factors are unlikely to trigger drastic alterations within a short period. Such modest effect magnitudes are largely consistent with the physiological and health variation characteristics of this population. From clinical and public health perspectives, even with limited individual-level effect sizes, social engagement, as an easy-to-implement, low-cost, and widely accessible lifestyle-related factor, still holds substantial practical implications. When popularized across the large group of middle-aged and elderly cardiac patients in communities, these mild associative tendencies may collectively contribute to improved population-level psychological well-being and cognitive health, thereby providing references for cardiac rehabilitation and community elderly health management.

Several limitations of the present study need to be acknowledged. Firstly, due to the cross-sectional research design, this study can only clarify correlational relationships rather than confirm definitive temporal causal sequences, and the possibility of reverse causality cannot be ruled out. Specifically, patients with aggravated depressive conditions or declining cognitive competence may exhibit reduced willingness to participate in social interactions and impaired abilities

to perform daily self-care activities. Notably, all exposure, mediator, and outcome variables were collected simultaneously in the mediation analysis, which fails to satisfy the temporal prerequisite for causal mediation inference. Accordingly, relevant findings should only be interpreted as exploratory evidence of associational pathways. Secondly, constrained by the questionnaire framework of the CHARLS database, heart disease was defined as a composite binary variable in this analysis, without detailed information regarding specific clinical subtypes including coronary heart disease, heart failure and arrhythmia, as well as disease severity and illness duration. This restricts further subtype-stratified analyses and in-depth exploration of relevant heterogeneity. Additionally, although multiple covariates were adjusted in the statistical models, residual confounding factors may still exist. More refined indicators such as cardiac function classification, prior stroke history, clinical medication regimens, occupational status, and medical insurance conditions were not incorporated due to data availability constraints. Furthermore, SA assessments relied predominantly on self-reported information, which is susceptible to recall bias and social desirability bias, and the representativeness of the study sample may hinder the generalizability of conclusions to other populations. Future longitudinal investigations combining objective activity monitoring tools and comprehensive clinical datasets are warranted to further validate the present findings.

CONCLUSION

The study demonstrated that higher levels of SAs were correlated with a lower likelihood of depression and superior cognitive status among patients with heart diseases, and ADL exerted partial mediating effects in such associative relationships. This cross-sectional analysis was conducted among the general cardiac patient population. Restricted by the CHARLS dataset, this study did not further classify clinical subtypes such as coronary heart disease and heart failure; hence, the present findings are only applicable to the overall cardiac population. Given that the conclusions are derived from cross-sectional correlational analyses without definitive temporal causal evidence, clinical cardiac rehabilitation practice may prioritize monitoring patients' social participation status and daily living functional competence. Further longitudinal studies are required to clarify temporal sequences among relevant variables. Additionally, cohort studies with complete clinical subtype classification are needed to explore the heterogeneity of associations between social activities and psychological as well as cognitive indicators across distinct cardiac disease subtypes, so as to provide evidence for the development of more individualized cardiac rehabilitation strategies.

Ethics Committee Approval: This study utilized publicly available data from the China Health and Elderly Tracking Survey (China Health and Retirement Longitudinal Study, CHARLS). The CHARLS project was jointly implemented by Peking University and Wuhan University, and received ethical approval from the Biomedical Ethics Committee of Peking University (IRB number: IRB00001052-11015). Detailed information regarding the project is accessible via the official website.

Informed Consent: All participants provided written informed consent prior to the survey.

Peer-review: Externally peer-reviewed.

Author Contributions: Concept – J.X., J.S.; Design – P. W., D. C.; Supervision – J. X., P. W., D.C.; Resources – C.Y., J.S.; Materials – J.X., J.S.; Data Collection and/or Processing – P.W., D.C.; Analysis and/or Interpretation – J.X., P.W., D.C.; Literature Search – C.Y., J.S.; Writing – C.Y., J.S., P.W., D.C., J.X.; Critical Review – C.Y., J.S., J.X., P.W., D.C.

Declaration of Interests: The authors have no conflict of interest to declare.

Funding: The authors declared that this study has received no financial support.

REFERENCES

1. GBD 2023 Disease and Injury and Risk Factor Collaborators. Burden of 375 diseases and injuries, risk-attributable burden of 88 risk factors, and healthy life expectancy in 204 countries and territories, including 660 subnational locations, 1990-2023: a systematic analysis for the Global Burden of Disease Study 2023. *Lancet*. 2025;406(10513):1873-1922. [CrossRef]
2. GBD 2023 Causes of Death Collaborators. Global burden of 292 causes of death in 204 countries and territories and 660 subnational locations, 1990-2023: a systematic analysis for the Global Burden of Disease Study 2023. *Lancet*. 2025;406(10513):1811-1872. [CrossRef]
3. Zeng J, Qiu Y, Yang C, et al. Cardiovascular diseases and depression: a meta-analysis and Mendelian randomization analysis. *Mol Psychiatry*. 2025;30(9):4234-4246. [CrossRef]
4. Pan Y, Chen Y, Wu S, et al. Prevalence and management of depressive symptoms in coronary heart disease patients and relationship with cardiovascular prognosis: a prospective cohort study. *BMC Psychiatry*. 2024;24(1):644. [CrossRef]
5. Song R, Xu H, Dintica CS, et al. Associations between cardiovascular risk, structural brain changes, and cognitive decline. *J Am Coll Cardiol*. 2020;75(20):2525-2534. [CrossRef]
6. Yap NLX, Kor Q, Teo YN, et al. Prevalence and incidence of cognitive impairment and dementia in heart failure - A systematic review, meta-analysis and meta-regression. *Hellenic J Cardiol*. 2022;67:48-58. [CrossRef]
7. Akasaki Y, Tabira T, Maruta M, et al. Social frailty and meaningful activities among community-dwelling older adults with heart disease. *Int J Environ Res Public Health*. 2022;19(22):15167. [CrossRef]
8. Luo M. Social isolation, loneliness, and depressive symptoms: a twelve-year population study of temporal dynamics. *J Gerontol B Psychol Sci Soc Sci*. 2023;78(2):280-290. [CrossRef]
9. Guarnera J, Yuen E, Macpherson H. The impact of loneliness and social isolation on cognitive aging: a narrative review. *J Alzheimers Dis Rep*. 2023;7(1):699-714. [CrossRef]
10. Yang Q, Lin S, Zhang Z, et al. Relationship between social activities and cognitive impairment in Chinese older adults: the mediating effect of depressive symptoms. *Front Public Health*. 2024;12:1506484. [CrossRef]
11. Wu Y, Cheng Q, Song H, et al. The impact of social activity on cardiovascular disease risk among middle-aged and older adults in China: a nationwide cohort study based on the CHARLS database. *Front Public Health*. 2025;13:1554130. [CrossRef]
12. Hikichi H, Kondo K, Takeda T, et al. Social interaction and cognitive decline: results of a 7-year community intervention. *Alzheimers Dement (N Y)*. 2017;3(1):23-32. [CrossRef]

13. Skouri HN, Çavuşoğlu Y, Bennis A, et al. Expert recommendations to bridge gaps in heart failure patient support in the Middle East and Africa region. *Anatol J Cardiol*. 2024;28(1):2-18. [CrossRef]
14. Li X, Zhang P, Cai J, et al. Effects of cardiac rehabilitation exercise plus sacubitril valsartan sodium on cardiac function, lung function, and quality of life in patients with chronic heart failure. *Anatol J Cardiol*. 2025;29(12):723-730. [CrossRef]
15. Huang S, Zhong W, Cheng Q, et al. Instrumental Activities of Daily Living function and cognitive status among Chinese older adults: a serial multiple mediation model. *Front Public Health*. 2024;12:1378979. [CrossRef]
16. Zhang F, Yang W. Interaction between activities of daily living and cognitive function on risk of depression. *Front Public Health*. 2024;12:1309401. [CrossRef]
17. Ojijieme NG, Chui CM. Social participation enhances activities of daily living capacity of older adults with multimorbidity more than in healthy non-participants. *Geriatr Nurs*. 2025;64:103441. [CrossRef]
18. Liu Y, Yuan C, Chen T, et al. Associations between physical activity and heart disease among middle-aged and older Chinese adults. *Front Cardiovasc Med*. 2025;12:1383888. [CrossRef]
19. Jin Z, Wang H, Wen HB. Sleep duration and cardiovascular disease risk in type 2 diabetes: a prospective cohort study. *PLOS One*. 2025;20(11):e0337232. [CrossRef]
20. Lin L, Xue Y, Huang D, et al. Dynapenic abdominal obesity and the risks of heart disease and all-cause mortality: a 7-year longitudinal study among middle-aged and older Chinese adults. *BMC Public Health*. 2025;25(1):2470. [CrossRef]
21. Zhang J, Lu N. The association between childhood conditions and heart disease among middle-aged and older population in China: a life course perspective. *BMC Geriatr*. 2021;21(1):184. [CrossRef]
22. Hui Z, Zhao Y, Gong Q, et al. 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. *BMC Geriatr*. 2025;25(1):264. [CrossRef]
23. Zhang X, Zheng X, Zheng T, et al. Associations between leisure activities with trajectories of intrinsic capacity among Chinese older adults: the China health and retirement longitudinal study. *Arch Public Health*. 2025;83(1):162. [CrossRef]
24. Zhou S, Liang Z, Li Q, et al. Association of cumulative average sensory impairments with cognitive function and depressive symptoms: two prospective cohort studies. *J Affect Disord*. 2025;369:16-24. [CrossRef]
25. Liu K, Wang J, Wang J, et al. Association between thermal inversion and cognitive trajectories among middle-aged and older adults in CHARLS: a latent class trajectory analysis. *PLOS One*. 2025;20(11):e0335902. [CrossRef]
26. Xiong J, Jiang Y, Wu JL, et al. Bidirectional relationship between anemia and cognitive function in middle-aged and older Chinese adults: a longitudinal study. *Sci Rep*. 2025;15(1):26080. [CrossRef]
27. Su SF, Chang MY, He CP. Social support, unstable angina, and stroke as predictors of depression in patients with coronary heart disease. *J Cardiovasc Nurs*. 2018;33(2):179-186. [CrossRef]
28. Fu C, Li Z, Mao Z. Association between social activities and cognitive function among the elderly in China: a cross-sectional study. *Int J Environ Res Public Health*. 2018;15(2):231. [CrossRef]
29. Yu C, Barr AB. Social activities and cognitive functioning across mid- and late life: evidence from China. *Gerontologist*. 2025;65(4):gnaf014. [CrossRef]
30. Bano S, Salahuddin Z, Choudhry SA, et al. Cognitive decline and psychological distress in chronic cardiovascular patients: the interplay of mental health, cognition, and disease severity. *Cureus*. 2025;17(1):e77412. [CrossRef]
31. Bueno H, Deaton C, Farrero M, et al. 2025 ESC Clinical Consensus Statement on mental health and cardiovascular disease: developed under the auspices of the ESC Clinical Practice Guidelines Committee. *Eur Heart J*. 2025;46(41):4156-4225. [CrossRef]
32. Boureau AS, Annweiler C, Belmin J, et al. Practical management of frailty in older patients with heart failure: statement from a panel of multidisciplinary experts on behalf the Heart Failure Working Group of the French Society of Cardiology and on behalf French Society of Geriatrics and Gerontology. *ESC Heart Fail*. 2022;9(6):4053-4063. [CrossRef]
33. Nagano T, Tanaka H, Fujimoto W, et al. Association of tricuspid regurgitation severity with activities of daily living and dementia in patients with heart failure: insight from the KUNIUMI registry chronic cohort. *J Card Fail*. 2026:S1071-9164(26)00146-6. [CrossRef]
34. Pal T, Preg Z, Baba DF, et al. Neurocognitive and psychosocial interactions in atrial fibrillation: toward a holistic model of care. *Healthcare (Basel)*. 2025;13(15):1863. [CrossRef]
35. Feng LS, Wang YM, Liu H, et al. Hyperactivity in the hypothalamic-pituitary-adrenal axis: an invisible killer for anxiety and/or depression in coronary Artherosclerotic heart disease. *J Integr Neurosci*. 2024;23(12):222. [CrossRef]
36. Rusch JA, Layden BT, Dugas LR. Signalling cognition: the gut microbiota and hypothalamic-pituitary-adrenal axis. *Front Endocrinol (Lausanne)*. 2023;14:1130689. [CrossRef]
37. Zilioli S, Fritz H, Tarraf W, et al. Socioeconomic status, ecologically assessed social activities, and daily cortisol among older urban African Americans. *J Aging Health*. 2020;32(7-8):830-840. [CrossRef]
38. Matthews T, Rasmussen LJH, Ambler A, et al. Social isolation, loneliness, and inflammation: a multi-cohort investigation in early and mid-adulthood. *Brain Behav Immun*. 2024;115:727-736. [CrossRef]
39. Wirtz PH, von Känel R. Psychological stress, inflammation, and coronary heart disease. *Curr Cardiol Rep*. 2017;19(11):111. [CrossRef]
40. Halaris A. Inflammation, heart disease, and depression. *Curr Psychiatry Rep*. 2013;15(10):400. [CrossRef]
41. Traub J, Frey A, Störk S. Chronic neuroinflammation and cognitive decline in patients with cardiac disease: evidence, relevance, and therapeutic implications. *Life (Basel)*. 2023;13(2):329. [CrossRef]
42. Walker E, Ploubidis G, Fancourt D. Social engagement and loneliness are differentially associated with neuro-immune markers in older age: time-varying associations from the English Longitudinal Study of Ageing. *Brain Behav Immun*. 2019;82:224-229. [CrossRef]
43. Medina-Rodriguez EM, Beurel E. Blood brain barrier and inflammation in depression. *Neurobiol Dis*. 2022;175:105926. [CrossRef]
44. Shen J, Lu T, Luo X. Urban enclosure, neighbourhood commons, and community participation willingness: Evidence from Shanghai, China. Geoforum. 2023;141:103719. DOI: 10.1016/j.geoforum.2023.103719.
45. Xu R, Yue W, Wei F, et al. Inequality of public facilities between urban and rural areas and its driving factors in ten cities of China. *Sci Rep*. 2022;12(1):13244. [CrossRef]
46. Niklasson A, Maher J, Patil R, et al. Living with heart failure: patient experiences and implications for physical activity and daily living. *ESC Heart Fail*. 2022;9(2):1206-1215. [CrossRef]
47. Yan W, Wang L, Li C, et al. Bidirectional association between ADL disability and depressive symptoms among older adults:

longitudinal evidence from CHARLS. *Sci Rep*. 2025;15(1):7125. [CrossRef]
48. Abe T, Seino S, Tomine Y, et al. Identifying the specific associations between participation in social activities and healthy lifestyle behaviours in older adults. *Maturitas*. 2022;155:24-31. [CrossRef]
49. Feng M, Li J, Xie F, et al. The relationship between social support, cognitive function and activities of daily living in older people: a cross-sectional study. *Front Public Health*. 2025;13:1602466. [CrossRef]
50. Edemekong PF, Bomgaars DL, Sukumaran S, et al. Activities of daily living. *StatPearls*. StatPearls Publishing LLC.; 2025.

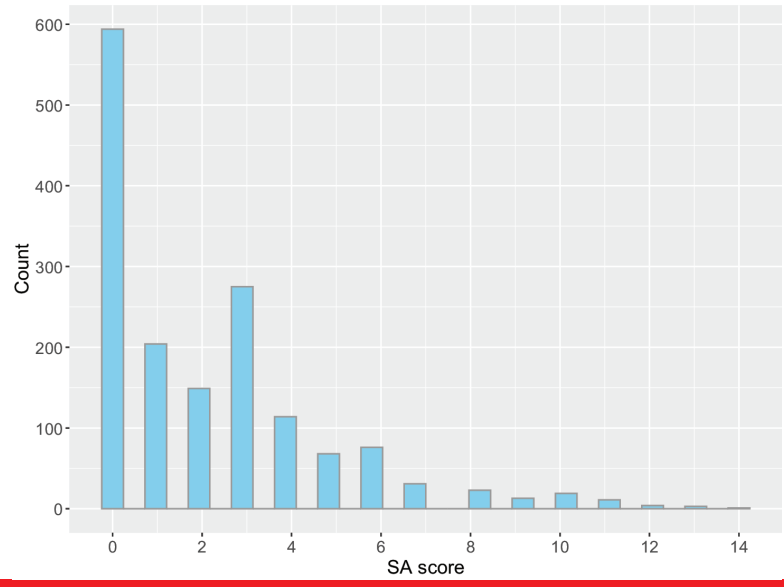

Figure S1. Distribution of SA scores among patients with heart disease. This histogram illustrates the frequency distribution of SA scores for 1,585 participants. The distribution is markedly right-skewed, with scores primarily clustered between 0 and 2. Thresholds are indicated: ① No SAs (0); ② Low SAs (1–2); and ③ High SAs (>2). This categorization was adopted to balance group sample sizes and ensure statistical power, as the proportion of participants with high scores (SA ≥ 7) is extremely low.

Table S1. Depression and Cognitive Function Profiles Across Individual SA Among Patients With Heart Disease

Social Activities	Overall	Non-Depression	Depression	Cognition score (SD)
	1585	951	634	11.4 (3.8)
Interacted with friends (SA1)				
No	912	538	374	11.1 (3.8)
Yes	673	413	260	11.8 (3.8)
Played Ma-jong, played chess, played cards, or went to community club (SA2)				
No	1205	691	514	11.2 (3.9)
Yes	380	260	120	12.2 (3.3)
Provided help to family, friends, or neighbors (SA3)				
No	1332	790	542	11.3 (3.8)
Yes	253	161	92	11.9 (3.9)
Went to a sport, social, or other kind of club (SA4)				
No	1409	821	588	11.3 (3.8)
Yes	176	130	46	12.7 (3.2)
Took part in a community-related organization (SA5)				
No	1521	903	618	11.4 (3.8)
Yes	64	48	16	13.1 (2.9)
Done voluntary or charity work (SA6)				
No	1537	922	615	11.4 (3.8)
Yes	48	29	19	12.5 (3.4)
Cared for a sick or disabled adult (SA7)				
No	1520	916	604	11.4 (3.8)
Yes	65	35	30	12.0 (3.5)
Attended an educational or training course (SA8)				
No	1573	940	633	11.4 (3.8)
Yes	12	11	1	14.2 (3.1)
Stock investment (SA9)				
No	1562	932	630	11.4 (3.8)
Yes	23	19	4	15.2 (1.9)
Used the Internet (SA10)				
No	1484	865	619	11.2 (3.8)
Yes	101	86	15	14.7 (2.2)

Table S2. Analysis of Association Between Engagement in Individual SA and Depression and Cognitive Function

	Model 1	P(value)	Model 2	*P*	Model 3	*P*
Depression	OR (95% CI)		OR (95% CI)		OR (95%CI)	
SA1	0.91(0.74~1.11)	0.340	0.87(0.71~1.07)	0.202	0.91(0.73~1.12)	0.362
SA2	0.62(0.48~0.79)	<0.001	0.65(0.50~0.83)	<0.001	0.70(0.54~0.91)	0.007
SA3	0.83(0.63~1.10)	0.198	0.83(0.63~1.10)	0.204	0.88(0.66~1.18)	0.400
SA4	0.49(0.34~0.70)	<0.001	0.45(0.31~0.64)	<0.001	0.57(0.39~0.82)	0.003
SA5	0.49(0.27~0.85)	0.014	0.48(0.26~0.84)	0.013	0.69(0.37~1.23)	0.225
SA6	0.98(0.54~1.75)	0.952	0.97(0.53~1.74)	0.917	1.16(0.62~2.12)	0.641
SA7	1.30(0.79~2.14)	0.302	1.26(0.76~2.09)	0.369	1.30(0.77~2.18)	0.330
SA8	0.13(0.01~0.70)	0.055	0.13(0.01~0.68)	0.052	0.16(0.01~0.83)	0.078
SA9	0.31(0.09~0.83)	0.035	0.32(0.09~0.86)	0.041	0.55(0.16~1.52)	0.291
SA10	0.24(0.13~0.41)	<0.001	0.23(0.12~0.38)	<0.001	0.33(0.18~0.58)	<0.001
Cognition	β (95%CI)		β (95%CI)		β (95%CI)	
SA1	0.69(0.32~1.07)	<0.001	0.59(0.23~0.95)	0.001	0.41(0.09~0.72)	0.012
SA2	1.02(0.58~1.45)	<0.001	0.95(0.53~1.37)	<0.001	0.43(0.06~0.80)	0.021
SA3	0.57(0.07~1.08)	0.027	0.38(-0.11~0.88)	0.128	0.16(-0.27~0.58)	0.463
SA4	1.46(0.87~2.04)	<0.001	1.59(1.02~2.16)	<0.001	0.56(0.05~1.06)	0.031
SA5	1.71(0.77~2.65)	<0.001	1.77(0.86~2.68)	<0.001	0.39(-0.40~1.19)	0.332
SA6	1.07(-0.01~2.16)	0.053	0.93(-0.12~1.98)	0.084	0.24(-0.66~1.15)	0.598
SA7	0.63(-0.31~1.56)	0.192	0.27(-0.64~1.18)	0.561	0.10(-0.68~0.89)	0.801
SA8	2.83(0.69~4.98)	0.010	1.94(-0.14~4.02)	0.068	1.09(-0.71~2.88)	0.235
SA9	3.83(2.29~5.38)	<0.001	3.60(2.10~5.10)	<0.001	1.73(0.42~3.04)	0.010
SA10	3.45(2.71~4.19)	<0.001	3.07(2.35~3.80)	<0.001	1.52(0.86~2.19)	<0.001

Model 1: Unadjusted model; Model 2: Adjusted for age and gender; Model 3: Adjusted for age, gender, educational level, marital status, residential location, smoking status, alcohol consumption, body mass index (BMI), hypertension, diabetes mellitus, and dyslipidemia

Table S3. Subgroup Analysis of the Association of Social Activity Score With Depression and Cognitive Function

	Depression			Cognition		
	OR (95% CI)	*P*	P for interaction	β (95% CI)	*P*	P for interaction
Age (years)			0.296			0.251
< 60	0.92(0.86~1.00)	0.037		0.09(-0.01~0.19)	0.064	
≥ 60	0.88(0.83~0.94)	<0.001		0.18(0.10~0.26)	<0.001	
Gender			0.781			0.434
Female	0.90(0.85~0.96)	<0.001		0.16(0.08~0.25)	<0.001	
Male	0.89(0.82~0.96)	0.003		0.14(0.05~0.24)	0.004	
Education level			0.168			0.167
Illiterate	0.87(0.77~0.99)	0.028		0.03(-0.18~0.24)	0.788	
Elementary and below	0.95(0.88~1.03)	0.192		0.10(-0.01~0.22)	0.073	
Middle and above	0.87(0.81~0.93)	<0.001		0.21(0.13~0.28)	<0.001	
Marital status			0.504			0.443
Single	0.93(0.82~1.06)	0.293		0.01(-0.18~0.21)	0.892	
Coupled	0.89(0.85~0.94)	<0.001		0.17(0.10~0.23)	<0.001	
Address			0.785			0.028
Rural	0.91(0.85~0.98)	0.009		0.06(-0.05~0.16)	0.300	
Urban	0.9(0.84~0.95)	<0.001		0.21(0.14~0.29)	<0.001	
Smoke			0.581			0.491
No	0.89(0.84~0.95)	<0.001		0.17(0.08~0.25)	<0.001	
Yes	0.91(0.84~0.98)	0.009		0.14(0.04~0.23)	0.004	
Alcohol			0.345			0.949
No	0.88(0.84~0.94)	<0.001		0.16(0.08~0.24)	<0.001	
Yes	0.93(0.86~1.01)	0.083		0.13(0.03~0.24)	0.011	
BMI (kg/m^2)			0.649			0.360
<24	0.93(0.87~1.01)	0.078		0.12 (0.00−0.23)	0.043	
24 to <28	0.89(0.82~0.96)	0.003		0.21(0.11~0.30)	<0.001	
≥28	0.88(0.80~0.97)	0.012		0.12(0.00~0.24)	0.059	
Hypertension (%)			0.972			0.976
No	0.90(0.84~0.98)	0.010		0.14(0.04~0.24)	0.005	
Yes	0.90(0.85~0.96)	<0.001		0.15(0.07~0.23)	<0.001	
Diabetes (%)			0.062			0.977
No	0.92(0.87~0.97)	0.002		0.16(0.08~0.23)	<0.001	
Yes	0.84(0.75~0.93)	0.001		0.15(0.02~0.28)	0.028	
Dyslipidemia (%)			0.817			0.801
No	0.90(0.84~0.98)	0.010		0.15(0.04~0.25)	0.007	
Yes	0.90(0.85~0.95)	<0.001		0.16(0.08~0.23)	<0.001	

Values are ORs or β coefficients with 95% CIs for each 1-point increase in the continuous social activity (SA) score within each stratum; they do not represent contrasts between SA subgroups. The P for interaction was derived from the product term(s) between the continuous SA score and each effect modifier in the fully adjusted model, with one P for interaction reported for each modifier. For depression, 1-df Wald chi-square tests were used for binary modifiers, whereas likelihood-ratio chi-square tests of the complete interaction block were used for multilevel modifiers. For cognition, joint Wald chi-square tests of the complete interaction block were used for all modifiers. The reference levels for categorical modifiers in the interaction models were age <60 years, female sex, illiteracy, single marital status, rural residence, non-smoking, non-drinking, BMI <24 kg/m^2, absence of hypertension, absence of diabetes, and absence of dyslipidemia. All models were adjusted for the prespecified covariates, as appropriate.