Research Square

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A Study on the Association Between the Course of Heart Failure and Cognitive Function in Older Adults: Based on Data from the 2011–2014 National Health and Nutrition Examination Survey

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Research Article

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Abstract

Background

Heart failure (HF), a highly prevalent chronic and progressive cardiovascular disease worldwide, is characterized by high incidence, high mortality, and high readmission rates, placing a heavy burden on patients' families and the healthcare system.Clinically, the treatment and management of HF often focus on improving cardiac function and preventing adverse cardiovascular outcomes; however, cognitive impairment (CI)—a common complication of HF—is frequently overlooked in clinical practice.Although existing evidence confirms an association between HF and CI, there remain significant gaps in current research regarding the dose-response relationship between duration of HF (HFD) and cognitive performance, population-specific differences (such as age at onset), and potential underlying mechanisms; relevant analyses have not yet been sufficiently in-depth or systematic.

Methods

This study analyzed data from the 2011–2012 and 2013–2014 waves of the National Health and Nutrition Examination Survey (NHANES). After two rounds of rigorous screening (excluding participants with incomplete cognitive function questionnaires, missing core variables, or insufficient data quality), a total of 2,885 eligible participants (aged > 60 years) were ultimately included.Three validated tools were used to comprehensively assess cognitive function:the Digit Symbol Substitution Test (DSST), the Animal Fluency Test (AFT), and the Consortium to Establish a Registry for Alzheimer's Disease (CERAD) scale. Cognitive impairment was defined as a DSST score < 32, an AFT score < 12, or a CERAD score ≤ 20.Logistic regression models and point-biserial correlation analysis were used to assess the association between the duration of HF (binary classification: >1 year vs. other durations) and the risk of CI, while adjusting for potential confounding factors such as demographic characteristics (age, sex, education level), lifestyle factors (smoking history, alcohol consumption), and clinical indicators (diagnoses of chronic diseases, medication history).

Results

The 2,885 participants had a mean age of 69.5 years. Logistic regression analysis was performed on 172 cases with valid data, revealing a marginally significant association between the duration of heart failure and the risk of cognitive impairment as assessed by the DSST (OR = 1.043, 95% CI: 0.999–1.090, *P* = 0.054) and was significantly associated with the risk of memory impairment as assessed by CERAD (OR = 1.040, 95% CI: 1.002–1.080, *P* = 0.044), and was not significantly associated with the risk of language fluency impairment as assessed by the AFT (OR = 1.023, 95% CI: 0.978–1.068, *P* = 0.314).; The absence of diabetes reduces the risk of cognitive impairment as assessed by the DSST.Duration-response analysis showed that the duration of heart failure was significantly positively correlated with cognitive impairment as assessed by all three scales (r = 0.182, 0.156, 0.215; *P* < 0.05).Subgroup analysis

showed that, among patients aged 60–71 years, the duration of heart failure was positively correlated only with the DSST score (r = 0.319, $P < 0.05$), whereas among patients aged ≥ 72 years, it was positively correlated with both the CERAD and AFT scores (r = 0.219, 0.277, $P < 0.05$).

Conclusion

A longer duration of heart failure is positively correlated with a decline in cognitive function. This finding suggests that clinical management targeting the progression of HF may have potential value in protecting cognitive function; however, longitudinal studies are needed to further verify the causal relationship.

Introduction

Heart failure (HF) is a chronic, progressive cardiovascular disease characterized by impaired cardiac systolic or diastolic function and inadequate systemic blood perfusion. Its global prevalence exceeds 26 million adults, and it consistently ranks as the leading cause of hospitalization among the elderly, imposing a heavy burden on individuals, families, and the healthcare system [1,2] .Clinically, the harm caused by HF extends far beyond the cardiovascular system itself; a series of complications it triggers—such as arrhythmias, pulmonary infections, and renal impairment—significantly exacerbate the burden on patients, reduce their quality of life, and may even shorten survival.However, it is worth noting that among the many complications of HF, neurocognitive impairment induced by the condition—referred to as post-heart failure cognitive impairment—has long been overlooked in clinical practice. It has not received sufficient attention and has become a neglected “silent killer.”

Cognitive function is a complex psychological process through which an individual receives, processes, stores, and applies information from internal and external environments to carry out thinking, judgment, decision-making, and social interaction. It encompasses multiple core dimensions, including memory, attention, executive function, language expression, and spatial orientation, and serves as a vital foundation for maintaining normal daily life, social interaction, and self-health management [3–5] .The onset of post-heart failure cognitive impairment is primarily associated with multiple pathological mechanisms, including chronic cerebral hypoperfusion caused by HF, abnormal neurohormonal activation, systemic inflammatory responses, and disturbances in calcium ion channels in the hippocampus [4]; its typical clinical manifestations include memory loss, inattention, slowed reaction times, impaired decision-making, and impaired verbal fluency.Statistics show that over 40% of heart failure patients experience cognitive impairment to varying degrees, and within 7 years of diagnosis, their cognitive decline is equivalent to 10 years of aging in healthy individuals [7]. These symptoms not only directly impair patients’ ability to care for themselves—preventing them from independently performing basic daily activities such as dressing, eating, and taking medication—but also severely affect their social functioning, causing them to gradually withdraw from society and experience negative emotions such as anxiety and depression. This further exacerbates their physical and psychological distress and

significantly reduces their quality of life and confidence in recovery [6,8] .More critically, cognitive impairment leads to reduced understanding of and adherence to treatment regimens, preventing patients from strictly following medical instructions regarding medication and monitoring their condition. This creates a vicious cycle of “HF progression → cognitive decline → reduced treatment adherence → worsening HF,” ultimately leading to a substantial increase in readmission and mortality rates [9] .

In recent years, as clinical research has deepened, the association between heart failure and cognitive impairment has gradually garnered attention in the academic community. Multiple studies have confirmed that HF is an independent risk factor for mild cognitive impairment (MCI) and dementia [10], but overall, current research on the correlation between the two remains significantly insufficient, and a systematic, clear body of knowledge has yet to be established.On the one hand, at the clinical level, there is a lack of awareness regarding the screening and assessment of cognitive impairment following heart failure. Most healthcare professionals and patients’ families continue to focus primarily on controlling the symptoms of HF itself, failing to remain sufficiently vigilant about changes in cognitive function. This leads to a large number of patients with post-heart failure cognitive impairment being underdiagnosed or misdiagnosed, resulting in missed opportunities for early intervention [11]; on the other hand, at the research level, existing studies have largely focused on preliminarily confirming the association between HF and cognitive impairment. Discussions regarding the specific mechanisms and influencing factors (such as the duration of HF and disease severity) remain relatively scattered, and the conclusions of some studies are controversial. The specific relationship between the duration of heart failure (Duration of HF) and the degree of cognitive impairment has not yet been clearly established [12]. Furthermore, research on differences in cognitive impairment across different types of HF (reduced ejection fraction and preserved ejection fraction) has not been sufficiently in-depth. These research gaps severely limit the precise prevention, control, and effective intervention for cognitive impairment following heart failure.

Given the current situation—where HF poses serious health risks and post-HF cognitive impairment is highly insidious and underrecognized, while cognitive impairment significantly affects patients’ quality of life and disease prognosis—and considering that current academic research on the correlation between the two remains markedly insufficient, the exploration of underlying mechanisms is not in-depth, and clinical prevention and control lack evidence-based guidance, this study utilizes sample data from the National Health and Nutrition Examination Survey (NHANES)to systematically investigate the association between the duration of heart failure and cognitive outcomes, and to identify the characteristics influencing post-heart failure cognitive impairment. The study aims to fill existing research gaps,clarify the underlying patterns of their association, raise clinical awareness of post-heart failure cognitive impairment, and provide scientific, evidence-based support for the early screening, precise intervention, and comprehensive health management of cognitive impairment in heart failure patients. Ultimately, this study seeks to break the vicious cycle between heart failure and cognitive impairment and improve patients’ long-term quality of life and disease prognosis.

Methods

Research Objective and Design

The National Health and Nutrition Examination Survey (NHANES), conducted jointly by the Centers for Disease Control and Prevention (CDC) and the National Center for Health Statistics (NCHS), is designed to assess the health and nutritional status of the U.S. population. The survey includes comprehensive questionnaires on demographic characteristics, socioeconomic status, dietary patterns, and health-related issues, supplemented by laboratory tests.This study utilized data from the 2011–2012 and 2013–2014 cycles for individual-level analysis, strictly adhering to ethical standards. All participants were required to sign an informed consent form after approval by the NCHS Research Ethics Review Committee .

Study Population

From the 19,931 participants in the 2011–2014 National Health and Nutrition Examination Survey (NHANES), 2,885 individuals aged 60 years or older with complete cognitive and heart failure (HF) data were included. Heart failure was defined based on participants' responses to the survey question, "How old were you when you were first diagnosed with congestive heart failure?"Duration of heart failure was calculated as the number of years since the initial diagnosis.

Study Subject Screening Process

Data for this study were drawn from the 2011–2012 and 2013–2014 waves of the National Health and Nutrition Examination Survey (NHANES). A total of 19,931 participants were initially included, comprising 9,756 from the 2011–2012 wave and 10,175 from the 2013–2014 wave;The study identified eligible participants through two rounds of screening. In the first round, 17,008 participants were excluded because they did not complete the Cognitive Function Questionnaire, lacked data on core study variables, or failed to meet analysis requirements due to technical issues or insufficient data quality, leaving 2,885 participants(Fig. 1.)

Definition of Heart Failure

Participants' responses to the survey question "How old were you when you were first diagnosed with congestive heart failure?" and their age at the time of the survey were used to calculate the number of years since the diagnosis of heart failure.

Heart Failure Duration

In this study, the duration of heart failure was assessed as the time interval between the age at which the participant was informed of having heart failure and the age at the time of the survey screening.

Data Sources and Bias Considerations

Information on the duration of heart failure was derived from patient self-reports or retrospective medical record reviews and may be subject to recall bias. The data for this study were sourced from the NHANES database; the data collection methods and quality control for heart failure duration strictly adhered to the NHANES database's standardized survey protocol and quality control standards.

Cognitive Assessment

A series of tests was used to assess participants' cognitive function, including the Alzheimer's Disease Registry Alliance (CERAD) Word Learning and Recall Module, the Animal Fluency Test (AFT), and the Digit-Symbol Substitution Test (DSST); all of these tests are components of the National Health and Nutrition Examination Survey (NHANES).The CERAD test assesses the ability to immediately learn and recall new verbal information; the AFT measures categorical verbal fluency; and the DSST measures information processing speed and attention. Since there are no standardized clinical cutoffs for the DSST, CERAD, and AFT, this study used the 25th percentile of each test score as the cutoff for cognitive impairment.This method has been widely used in previous NHANES-related studies; however, it should be noted that its cutoff values are not directly comparable to those of commonly used clinical tools such as the MoCA and MMSE. Across all tests, higher scores indicate better cognitive function [13].

Covariates

In addition, our analysis incorporated various covariates, including demographic data, physical examination data, laboratory data, and various questionnaire data. Specific variables included age, sex (male and female), systolic blood pressure, diastolic blood pressure, body mass index (BMI), smoking status, alcohol consumption, history of diabetes, and lipid profile indicators.

Statistical Analysis

All statistical analyses in this study were performed using R version 4.1.3 and SPSSAU software.Continuous variables are expressed as mean ± standard error (SE), and categorical variables are presented as frequencies and percentages. After grouping, continuous variables were analyzed using Student's t-test, and categorical variables were analyzed using the chi-square test. Four multivariate logistic regression models were constructed to investigate the association between the course of heart failure (HF) and cognitive function, and odds ratios (OR) and 95% confidence intervals (CI) were calculated.Model 1 was the unadjusted model; Model 2 was adjusted for diabetes status; Model 3 was Model 2 further adjusted for body mass index (BMI); and Model 4 was the fully adjusted model, which

included adjustments for age, sex, educational level, poverty-income ratio (PIR), BMI, smoking status, alcohol consumption, diabetes, and hypertension. In addition, point-biserial correlation analysis was used to assess the association between the duration of heart failure and cognitive function, and subgroup analyses were conducted to investigate heterogeneity in the association between heart failure duration and cognitive function across different subgroups.

Results

Participant Characteristics

In this study, a total of 17,008 participants were enrolled based on NHANES data. The characteristics of the participants, stratified by heart failure status, are summarized in Table 1. A total of 2,885 participants were included, of whom 2,691 had no heart failure and 194 had heart failure.Compared with the group without heart failure, the heart failure group was older, had a higher BMI, lower diastolic blood pressure, a lower poverty income ratio (PIR), and lower levels of total cholesterol, HDL-C, and LDL-C, as well as higher prevalence rates of diabetes, hypertension, and obesity.In terms of cognitive function, the heart failure group scored lower on all tests, including the CERAD immediate recall subscales (CERAD1–CERAD3, CERADLATE), the Animal Fluency Test, and the DSST scores; all differences were statistically significant (all $P < 0.001$).There were no significant differences between the two groups in terms of gender distribution, alcohol consumption, or smoking status; however, there were some intergroup differences in educational level, marital status, poverty status, and racial distribution. Overall, patients with heart failure exhibited poorer cardiovascular and metabolic profiles and lower performance on cognitive tests.(Table 1.)

Table 1
Baseline characteristics of the study subjects

Variable	ALL (N = 2885)	No HF (N = 2691)	HF (N = 194)	*P* value
Age, mean (SD)	69.25 (6.73)	69.25 (6.73)	71.93 (6.74)	< 0.001
BMI, mean (SD)	28.86 (6.17)	28.86 (6.17)	31.81 (8.15)	< 0.001
SBP, mean (SD)	133.20 (19.14)	133.20 (19.14)	132.24 (22.13)	0.515
DBP, mean (SD)	68.16 (14.18)	68.16 (14.18)	63.32 (14.03)	< 0.001
PIR, mean (SD)	2.64 (1.60)	2.64 (1.60)	2.07 (1.42)	< 0.001
TC_mmol, mean (SD)	4.99 (1.11)	4.99 (1.11)	4.45 (1.14)	< 0.001
TG_mmol, mean (SD)	1.73 (1.16)	1.73 (1.16)	1.82 (1.08)	0.271
HDL_mmol, mean (SD)	1.42 (0.42)	1.42 (0.42)	1.26 (0.40)	< 0.001
LDL_mmol, mean (SD)	2.87 (0.93)	2.87 (0.93)	2.64 (1.04)	0.018
CERAD1, mean (SD)	4.73 (1.70)	4.73 (1.70)	4.20 (1.65)	< 0.001
CERAD2, mean (SD)	6.73 (1.81)	6.73 (1.81)	6.23 (1.92)	< 0.001
CERAD3, mean (SD)	7.57 (1.79)	7.57 (1.79)	7.00 (2.01)	< 0.001
CERADLATE, mean (SD)	5.99 (2.31)	5.99 (2.31)	5.03 (2.29)	< 0.001
AnimalFluency, mean (SD)	16.72 (5.50)	16.72 (5.50)	15.18 (4.85)	< 0.001
DSST, mean (SD)	46.41 (17.31)	46.41 (17.31)	38.31 (14.03)	< 0.001
Gender, n (%)				**0.639**
Male	1403 (48.6)	1305 (48.5)	98 (50.5)	
Female	1482 (51.4)	1386 (51.5)	96 (49.5)	
Education, n (%)				**0.057**
Below high school	734 (25.4)	673 (25.0)	61 (31.4)	
High School or above	2151 (74.6)	2018 (75.0)	133 (68.6)	
Marital status, n (%)				**0.053**
No	1119 (41.6)	1119 (41.6)	95 (49.0)	
Yes	1572 (58.4)	1572 (58.4)	99 (51.0)	
Drink, n (%)				**0.573**
No	835 (31.6)	835 (31.6)	64 (33.9)	
Yes	1807 (68.4)	1807 (68.4)	125 (66.1)	

Variable	ALL (N = 2885)	No HF (N = 2691)	HF (N = 194)	*P* value
Smoke, n (%)				**1.000**
No	2348 (87.3)	2348 (87.3)	169 (87.1)	
Yes	343 (12.7)	343 (12.7)	25 (12.9)	
DM, n (%)				**< 0.001**
No	1931 (66.9)	1836 (68.2)	95 (49.0)	
Yes	885 (30.7)	787 (29.2)	98 (50.5)	
Missing	69 (2.4)	68 (2.5)	1 (0.5)	
Hypertension, n (%)				**< 0.001**
No	844 (29.3)	817 (30.4)	27 (13.9)	
Yes	2041 (70.7)	1874 (69.6)	167 (86.1)	
PIR, n (%)				**0.006**
Not poor	2438 (84.5)	2288 (85.0)	150 (77.3)	
Poor	447 (15.5)	403 (15.0)	44 (22.7)	
Obesity, n (%)				**< 0.001**
No	1701 (63.2)	1701 (63.2)	90 (46.4)	
Yes	990 (36.8)	990 (36.8)	104 (53.6)	
Race, n (%)				**0.002**
Mexican American	242 (9.0)	242 (9.0)	15 (7.7)	
Non-Hispanic Black	643 (23.9)	643 (23.9)	43 (22.2)	
Non-Hispanic White	1257 (46.7)	1257 (46.7)	115 (59.3)	
Other	549 (20.4)	549 (20.4)	21 (10.8)	

Abbreviations: BMI, body mass index; SBP, systolic blood pressure; DBP, diastolic blood pressure; PIR, poverty income ratio; TC, total cholesterol; TG, triglycerides; HDL, high-density lipoprotein; LDL, low-density lipoprotein; CERAD, Consortium to Establish a Registry for Alzheimer's Disease; AFT, Animal Fluency Test; DSST, Digit Symbol Substitution Test; DM, diabetes mellitus; HF, heart failure.

Values are presented as mean (SD) for continuous variables and n (%) for categorical variables. P values were calculated from chi-square tests (categorical variables) or Student's t-tests (continuous variables).

Results of Multivariate Logistic Regression Analysis

Information Processing Speed (DSST)

A marginally significant positive association was observed between prolonged duration of heart failure and increased risk of cognitive impairment (OR = 1.043, 95% CI: 0.999–1.090, *P* = 0.054), while advancing age showed statistical significance (OR = 1.087, 95% CI: 1.019–1.166, *P* = 0.015). An educational level of high school or higher was associated with a significant protective effect (OR = 0.135, 95% CI: 0.054–0.318, *P* < 0.001). Other factors, including female gender, income-poverty ratio, BMI, smoking, alcohol consumption, diabetes, and hypertension, did not show statistically significant associations (all *P* > 0.05).(Fig. 2.)

Memory Function (CERAD)

Advancing age (OR = 1.103, 95% CI: 1.042–1.173, *P* = 0.002) and duration of heart failure (OR = 1.040, 95% CI: 1.002–1.080, *P* = 0.044) were both significantly positively associated with the risk of cognitive impairment. A protective trend was observed for those with a high school education or higher, but it did not reach statistical significance (OR = 0.514, 95% CI: 0.232–1.126, *P* = 0.098). None of the remaining variables were statistically significant (all *P* > 0.05).(Fig. 3.)

Verbal Fluency (AFT)

An educational level of high school or higher was associated with a significant protective effect (OR = 0.251, 95% CI: 0.096–0.624, *P* = 0.004). Factors such as duration of heart failure, age, sex, income-to-poverty ratio, BMI, smoking, alcohol consumption, diabetes, and hypertension did not reach statistical significance (all *P* > 0.05). Among these, the point estimate for hypertension suggested an increased risk (OR = 2.794, 95% CI: 0.785–13.619, *P* = 0.153); however, its confidence interval was extremely wide, indicating limited precision in the estimate.(Fig. 4.)

Duration-Response Analysis of Heart Failure and Cognitive Function

Subsequently, the point-biserial correlation was used to explore the duration-response relationship between heart failure and cognitive function. Correlation analysis was conducted to examine the relationships between cognitive impairment measures (CERAD, AFT, DSST) and the duration of heart failure. The analysis revealed that all measures showed significant correlation coefficients: CERAD (0.182),AFT (0.156), and DSST (0.215). Since all correlation coefficients were greater than 0, this indicates a positive relationship between heart failure and cognitive function in the duration-response analysis. This suggests that among individuals with a heart failure duration exceeding one year, the longer the duration of heart failure, the greater the likelihood of cognitive impairment. [14–18](Fig. 5.)

Subgroup Analysis

The results from the main analysis indicate that the impact of heart failure on cognitive performance differs between middle-aged and older adults. The heart failure event suggests that cognitive decline

occurs more rapidly in middle-aged adults. Therefore, we further examined the association between heart failure duration and cognitive function in middle-aged and older adults.We conducted a subgroup analysis by age using point-biserial correlation. In this study, we used the median age of participants (71 years) as the cutoff point to divide heart failure patients into two groups—those aged 60–71 years and those aged ≥ 72 years—for subgroup analysis. The groups were categorized as 60–71 years and 72 years and older.

We found that when using correlation analysis to examine the relationships between CERAD, AFT, and DSST and the duration of HF in patients aged 71 or younger, Pearson correlation coefficients were used to indicate the strength of these relationships.No significant correlations were observed between CERAD, AFT, and Duration of HF; the correlation coefficients were 0.197 and 0.125, respectively, and all p-values were greater than 0.05, indicating that there was no correlation between CERAD and Duration of HF or between AFT and Duration of HF.In contrast, a significant correlation was observed between DSST and Duration of HF, with a correlation coefficient of 0.319. Since this value is greater than 0, it indicates a positive correlation between DSST and Duration of HF; that is, among patients aged 60–71 with a heart failure duration exceeding one year, the longer the duration of heart failure, the greater the likelihood that the DSST score will be less than 32.

Correlation analysis was used to examine the relationships between CERAD, AFT, and DSST, respectively, and the duration of HF in patients over 71 years of age, with Pearson's correlation coefficient used to indicate the strength of these relationships. All relationships between CERAD and the duration of HF, as well as between AFT and the duration of HF, were statistically significant,with correlation coefficients of 0.219 and 0.277, respectively. Since both values are greater than 0, this indicates a positive correlation between CERAD and Duration of HF, as well as between AFT and Duration of HF. In other words, among patients aged 71 and older with a history of heart failure lasting more than one year, the longer the duration of heart failure, the greater the likelihood of a CERAD score ≤ 20 and an AFT score < 12.In contrast, no significant correlation was observed between DSST and Duration of HF; the correlation coefficient was 0.143, which is close to 0, and all p-values were greater than 0.05, indicating that there is no correlation between DSST and Duration of HF.(Fig. 6.)(Fig. 7.)

Discussion

Based on data from the 2011–2014 NHANES, this study evaluated the association between the duration of heart failure and cognitive function in 2,885 participants aged 60 years and older. Key findings include: (1) Duration of heart failure was marginally significantly positively associated with the risk of cognitive impairment as defined by the DSST (OR = 1.043, 95% CI: 0.999–1.090, *P* = 0.054) and significantly associated with the risk of memory impairment as defined by the CERAD (OR = 1.040, 95% CI: 1.002–1.080, *P* = 0.044). (2) A duration-response analysis showed that the duration of heart failure was positively correlated with scores on all three cognitive tests (r = 0.156–0.215, *P* < 0.05);(3) Subgroup analysis suggested that this association varied across age groups: in patients aged 60–71 years, disease duration was associated only with the DSST, whereas in patients aged 72 years and older, it was

associated with both the CERAD and AFT. This reveals that the neurotoxic effects of HF vary depending on age-related vulnerabilities in the brain.In the younger group (60–71 years), HF may primarily act as a vascular-metabolic stressor, preferentially impairing the prefrontal-subcortical network. This network has high metabolic demands and is extremely sensitive to chronic cerebral hypoperfusion induced by HF; functional impairment in this network often manifests as slowed processing speed, which is an early feature of vascular cognitive impairment [22] .This supports the view that reduced cardiac output is associated with impaired prefrontal function [23]. In the older group (≥ 72 years), HF is more likely to produce synergistic effects with age-related neurodegeneration, selectively targeting the already vulnerable hippocampal memory system.The hippocampus is highly sensitive to ischemia [24], and HF may interact with Alzheimer's disease pathology by impairing lymphatic clearance and exacerbating β-amyloid deposition [25] .Low cardiac output has been shown to be directly associated with hippocampal atrophy and an increased risk of dementia [26]. The combination of this "vascular blow" and the "degenerative background" leads to the significant decline in memory and language function typical of elderly patients.

The study findings strongly suggest that patients with heart failure, particularly those with a longer disease duration, are at high risk for cognitive impairment. This necessitates that clinicians, in addition to monitoring traditional cardiovascular parameters, incorporate cognitive function assessments into routine follow-up protocols when managing patients with heart failure.For patients with a longer disease duration, clinicians should exercise heightened vigilance and consider using simple, effective cognitive screening tools (such as the MoCA, MMSE, etc.) for periodic assessment [19, 20, 21] to detect signs of cognitive decline at an early stage. Recognizing that the duration of heart failure is a key risk factor for cognitive decline prompts us to shift toward a more comprehensive "heart-brain" integrated management model. This means that the goals of heart failure management should not only focus on optimizing cardiac function and reducing readmission rates but should also proactively incorporate strategies to protect and promote cognitive health.This may require close collaboration among a multidisciplinary team—including cardiologists, neurologists, geriatricians, psychiatrists, nurses, physical therapists, and social workers—to jointly develop individualized management plans.

This study uses "disease duration" as a quantifiable risk stratification indicator.Clinicians can use this information to more accurately assess the level of cognitive risk in different heart failure patients. For patients with a longer disease duration, interventions that may delay cognitive decline should be more actively explored and implemented. These may include optimizing heart failure treatment to improve cerebral perfusion, strictly managing comorbidities (such as hypertension and diabetes), encouraging cognitive stimulation activities, improving lifestyle (such as a healthy diet and regular exercise), and addressing mental health (such as depression management).The study findings underscore the importance of educating heart failure patients and their families/caregivers about the potential impact of heart failure on cognitive function. Making them aware of the additional risks associated with prolonged disease duration helps increase vigilance regarding cognitive changes, encourages proactive reporting of symptoms, and enhances adherence to treatment recommendations aimed at protecting

cognitive health (such as consistent medication adherence and participation in cognitive training). This also helps prepare in advance for care support that may be needed in the future.The findings highlight the value of long-term, systematic monitoring of cognitive function in heart failure patients, particularly long-term survivors. This should become an integral part of chronic heart failure management, facilitating timely adjustments to treatment regimens, preventing or delaying severe outcomes such as dementia, and ultimately improving patients' long-term quality of life and ability to live independently. Heart failure and cognitive impairment (including dementia) both represent significant public health burdens.This study reveals a strong, disease-course-based association between the two, suggesting that as the survival period of heart failure patients extends, the burden of associated cognitive impairment may increase significantly. This serves as a wake-up call for public health policymakers and healthcare resource planners, who need to proactively plan and allocate resources to address the challenges posed by this dual disease burden—for example, by developing integrated care models and support services.

This study has several limitations. First, the cross-sectional design can only reveal associations between variables; it cannot determine the temporal sequence or causal relationship between the course of heart failure and cognitive decline, nor can it rule out the possibility of reverse causality (i.e., cognitive impairment preceding heart failure).Second, the effective sample size in the heart failure group was only 172 cases, resulting in limited statistical power, which may have led to some true associations going undetected. Third, information on heart failure diagnosis and disease duration was based on self-reports and was not verified against medical records, potentially introducing recall bias.Fourth, the subgroup analysis was restricted to patients with a heart failure duration of ≥ 1 year (n = 172); therefore, the findings from this subgroup cannot be generalized to individuals with newly diagnosed heart failure.Fifth, cognitive impairment was defined using the 25th percentile of test scores rather than clinically recognized cut-off points (such as the MoCA or MMSE), which may affect the comparability of the results. Sixth, due to limitations of the NHANES data, this study was unable to account for secondary causes of cognitive impairment—such as stroke and Parkinson's disease—as well as potential confounding factors including the use of heart failure medications and heart failure functional classification.Seventh, the subgroup analyses were based on correlation analyses without adjustment for confounding factors, and given the limited sample sizes in each subgroup, the results should be considered exploratory findings. Future large-scale longitudinal studies are needed to validate the findings of this study and elucidate the causal relationship between heart failure and cognitive function.

Conclusion

In conclusion, we conclude that longer heart failure duration exacerbates cognitive impairment, which emphasizes the need for timely intervention. Future longitudinal studies should explore the bidirectional relationship between HF progression and cognitive decline.

Declarations

Declaration of conflicting interests

The authors declared no potential conflicts of interest with respect to the research, authorship, and/or publication of this article.

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Data Availability

No datasets were generated or analyzed during the current study.

Competing Interests

The authors declare no competing interests.

Ethical Approval and Informed Consent

The NHANES dataset is publicly available through its official website. The NHANES protocol was approved by the Institutional Review Board of the Centers for Disease Control and Prevention, and all participants provided written informed consent.

Author Contribution

W.R. and X.H. conceived the study, collected research data, and wrote the original manuscript draft.H.Z. performed data sorting and prepared all figures and tables.J.F. provided literature retrieval and manuscript revision suggestions.T.W. is the corresponding author, supervised the whole research work and critically revised the manuscript.All authors read and approved the final manuscript.

References

1. Cannata, A., Crespo-Leiro, M. G., Bromage, D. I., Ruschitzka, F., & McDonagh, T. A. (2026). Heart failure with reduced ejection fraction. Lancet (London, England), 407(10527),529–542. https://doi.org/10.1016/S0140-6736(25)01851-3

2. Matthews E. (2025). Heart Failure with Preserved Ejection Fraction. The American Journal of Nursing, 125(11),28–32. https://doi.org/10.1097/AJN.0000000000000184
3. Pérez Palmer, N., Trejo Ortega, B., & Joshi, P. (2022). Cognitive Impairment in Older Adults: Epidemiology, Diagnosis, and Treatment. The Psychiatric Clinics of North America, 45(4), 639–661. https://doi.org/10.1016/j.psc.2022.07.010
4. van Nieuwkerk, A. C., Delewi, R., Wolters, F. J., Muller, M., Daemen, M., Biessels, G. J., & Heart-Brain Connection Consortium (2023). Cognitive Impairment in Patients With Cardiac Disease: Implications for Clinical Practice. Stroke, 54(8), 2181–2191. https://doi.org/10.1161/STROKEAHA.123.040499
5. Liori, S., Arfaras-Melainis, A., Bistola, V., Polyzogopoulou, E., & Parissis, J. (2022). Cognitive impairment in heart failure: clinical implications, tools of assessment, and therapeutic considerations. Heart Failure Reviews, 27(4), 993–999. https://doi.org/10.1007/s10741-021-10118-5
6. Ludyga, S., Gerber, M., Pühse, U., Looser, V. N., & Kamijo, K. (2020). Systematic review and meta-analysis investigating moderators of long-term effects of exercise on cognition in healthy individuals. Nature Human Behaviour, 4(6), 603–612. https://doi.org/10.1038/s41562-020-0851-8
7. Woo, M. A., Palomares, J. A., Macey, P. M., Fonarow, G. C., Harper, R. M., & Kumar, R. (2015). Global and regional brain mean diffusivity changes in patients with heart failure. Journal of Neuroscience Research, 93(4), 678–685. https://doi.org/10.1002/jnr.23525
8. Uddin L. Q. (2021). Cognitive and behavioural flexibility: neural mechanisms and clinical considerations. Nature Reviews. Neuroscience, 22(3), 167–179. https://doi.org/10.1038/s41583-021-00428-w
9. Zhang, R., Shen, L., Miles, T., Shen, Y., Cordero, J., Qi, Y., Liang, L., & Li, C. (2020). Association of Low to Moderate Alcohol Drinking With Cognitive Functions From Middle to Older Age Among US Adults. JAMA Network Open, 3(6), e207922. https://doi.org/10.1001/jamanetworkopen.2020.7922
10. Goyal, P., Didomenico, R. J., Pressler, S. J., Ibeh, C., White-Williams, C., Allen, L. A., Gorodeski, E. Z., & HFSA Scientific Statement Committee Members (2024). Cognitive Impairment in Heart Failure: A Heart Failure Society of America Scientific Statement. Journal of Cardiac Failure, 30(3), 488–504. https://doi.org/10.1016/j.cardfail.2024.01.003
11. Gilstrap, L. G., Gorodeski, E. Z., & Goyal, P. (2022). Heart failure and cognitive impairment: Complexity that requires a new approach. Journal of the American Geriatrics Society, 70(6), 1652–1654. https://doi.org/10.1111/jgs.17779
12. Park, M. S., & Kim, E. J. (2023). A Correlative Relationship Between Heart Failure and Cognitive Impairment: A Narrative Review. Journal of Korean Medical Science, 38(39), e334. https://doi.org/10.3346/jkms.2023.38.e334
13. Wiese, L. A. K., Gibson, A., Guest, M. A., Nelson, A. R., Weaver, R., Gupta, A., Carmichael, O., Lewis, J. P., Lindauer, A., Loi, S., Peterson, R., Radford, K., Rhodus, E. K., Wong, C. G., Zuelsdorff, M., Saidi, L. G., Valdivieso-Mora, E., Franzen, S., Pope, C. N., Killian, T. S., … Babulal, G. M. (2023). Global rural health disparities in Alzheimer's disease and related dementias: State of the science. Alzheimer's &

Dementia: The Journal of the Alzheimer's Association, 19(9), 4204–4225. https://doi.org/10.1002/alz.13104

14. The SPSSAU project (2026). SPSSAU. (Version 26.0) [Online Application Software]. Retrieved from https://www.spssau.com.
15. Zhou J, Ma S P. Research Data Analysis Methods and Applications with SPSSAU (1st Edition) [M]. Beijing: Publishing House of Electronics Industry, 2024.
16. Allison P D. Logistic Regression Using the SAS System: Theory and Application[M]. Cary: SAS Institute Inc, 1999.
17. Peterson J. Regression Analysis of Count Data[J]. Technometrics, 1999, 41(4):307–308.
18. Wan C H, Luo J H. Advanced Medical Statistics[M]. Beijing: Science Press, 2014.
19. Gorodeski, E. Z., Goyal, P., Hummel, S. L., Krishnaswami, A., Goodlin, S. J., Hart, L. L., Forman, D. E., Wenger, N. K., Kirkpatrick, J. N., Alexander, K. P., & Geriatric Cardiology Section Leadership Council, AmAmpadu, J., & Morley, J. E. (2015). Heart failure and cognitive dysfunction. International Journal of Cardiology, 178, 12–23. https://doi.org/10.1016/j.ijcard.2014.10.087
20. American College of Cardiology (2018). Domain Management Approach to Heart Failure in the Geriatric Patient: Present and Future. Journal of the American College of Cardiology, 71(17), 1921–1936. https://doi.org/10.1016/j.jacc.2018.02.059
21. Cameron, J., Worrall-Carter, L., Page, K., Stewart, S., & Ski, C. F. (2013). Screening for mild cognitive impairment in patients with heart failure: Montreal cognitive assessment versus mini mental state exam. European Journal of Cardiovascular Nursing, 12(3), 252–260. https://doi.org/10.1177/1474515111435606
22. Roy B, Woo MA, Wang DJJ, Fonarow GC, Harper RM, Kumar R. Reduced regional cerebral blood flow in patients with heart failure. Eur J Heart Fail. 2017;19(10):1294–1302. doi: 10.1002/ejhf.874. Epub 2017 May 30. PMID: 28560737; PMCID: PMC5633487.
23. Frey A, Homola GA, Henneges C, Mühlbauer L, Sell R, Kraft P, Franke M, Morbach C, Vogt M, Müllges W, Ertl G, Solymosi L, Pirpamer L, Schmidt R, Pham M, Störk S, Stoll G. Temporal changes in total and hippocampal brain volume and cognitive function in patients with chronic heart failure-the COGNITION.MATTERS-HF cohort study. Eur Heart J. 2021;42(16):1569–1578. doi: 10.1093/eurheartj/ehab003. PMID: 33496311; PMCID: PMC8060058.
24. Alosco ML, Hayes SM. Structural brain alterations in heart failure: a review of the literature and implications for risk of Alzheimer's disease. Heart Fail Rev. 2015;20(5):561–71. doi: 10.1007/s10741-015-9488-5. PMID: 25896528; PMCID: PMC5543407.
25. Kritsilis M, Vanherle L, Rosenholm M, In 't Zandt R, Yao Y, Swanberg KM, Weikop P, Gottschalk M, Shanbhag NC, Luo J, Boster K, Nedergaard M, Meissner A, Lundgaard I. Loss of glymphatic homeostasis in heart failure. Brain. 2025;148(3):985–1000. doi: 10.1093/brain/awae411. PMID: 39693238; PMCID: PMC11884761.
26. Adelborg K, Horváth-Puhó E, Ording A, Pedersen L, Sørensen HT, Henderson VW. Heart failure and risk of dementia: a Danish nationwide population-based cohort study. Eur J Heart Fail.

2017;19(2):253–260. doi: 10.1002/ejhf.631. Epub 2016 Sep 9. PMID: 27612177; PMCID: PMC5522185.

Figures

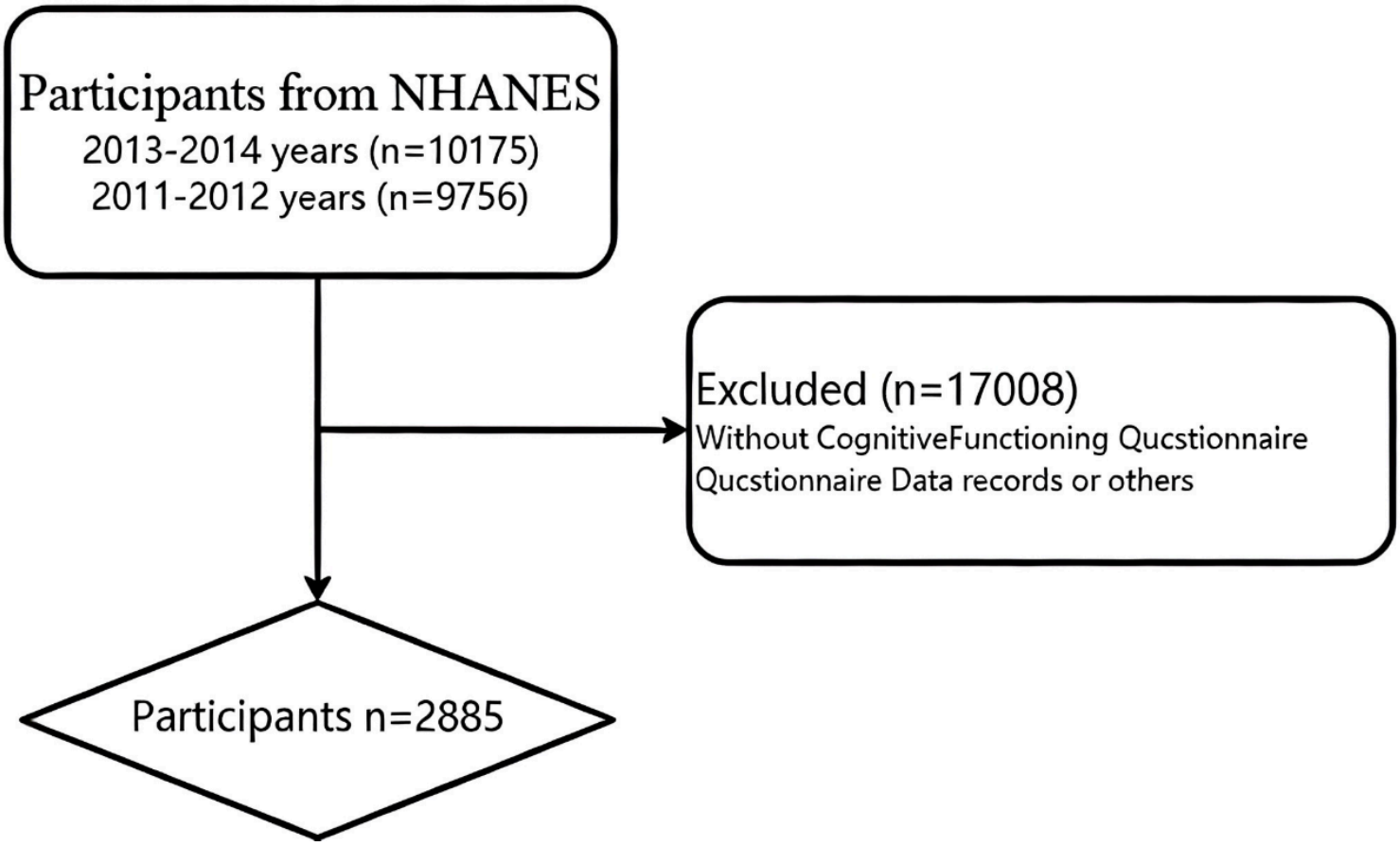


Figure 1

Flow diagram of the literature searching and study selection

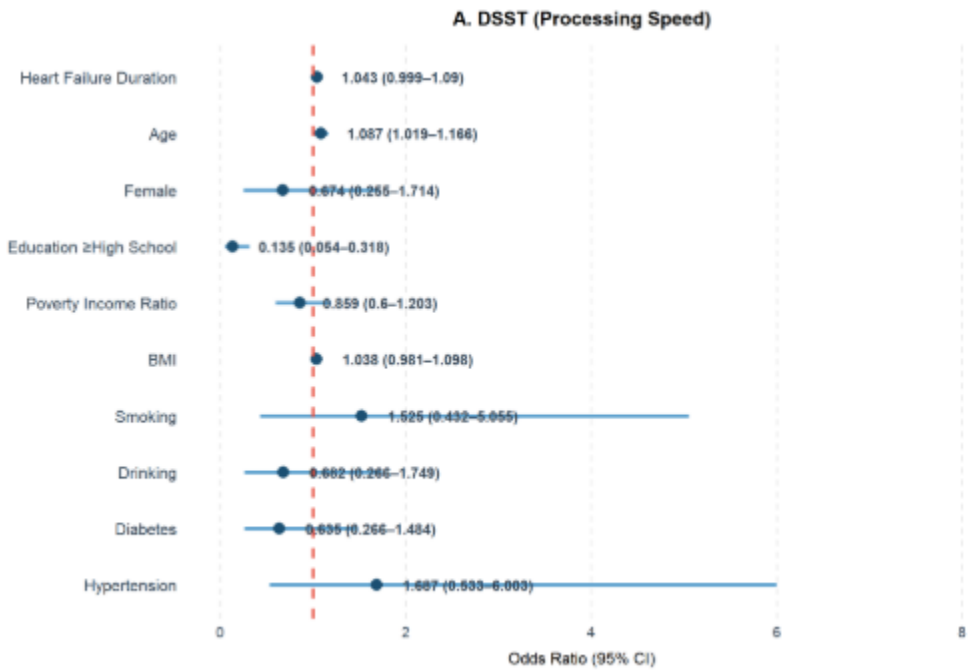


Figure 2

Forest plot of logistic regression analysis for the association between risk factors and DSST-defined cognitive impairment in heart failure patients

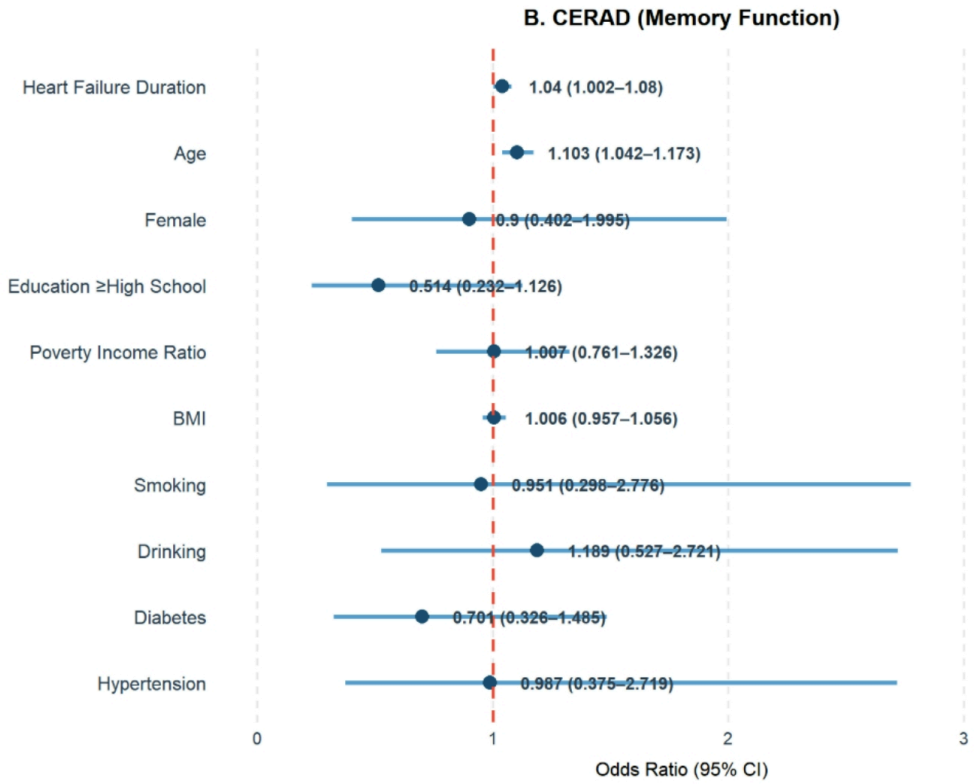


Figure 3

Forest plot of logistic regression analysis for the association between risk factors and AFT-defined cognitive impairment in heart failure patients

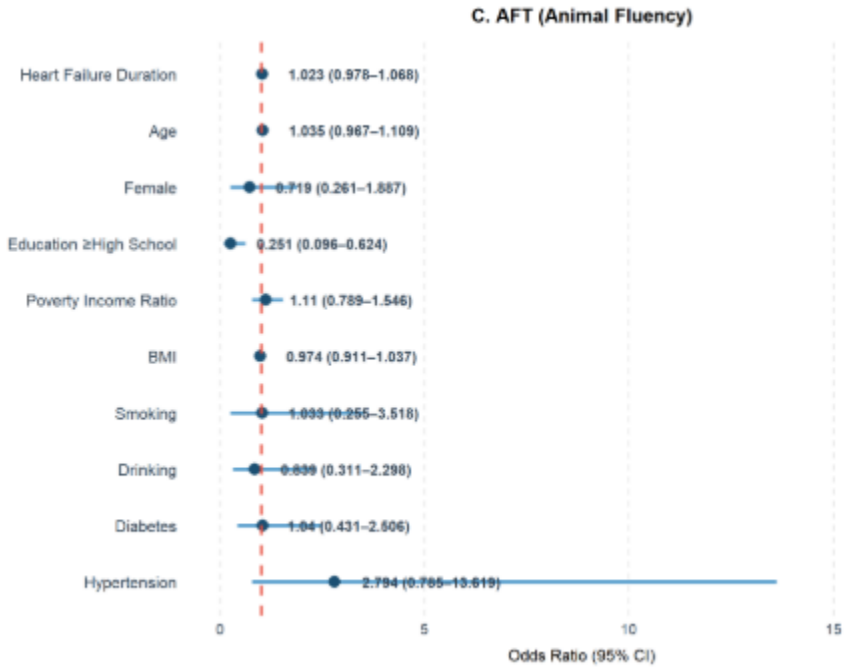


Figure 4

Forest plot of logistic regression analysis for the association between risk factors and CERAD-defined cognitive impairment in heart failure patients

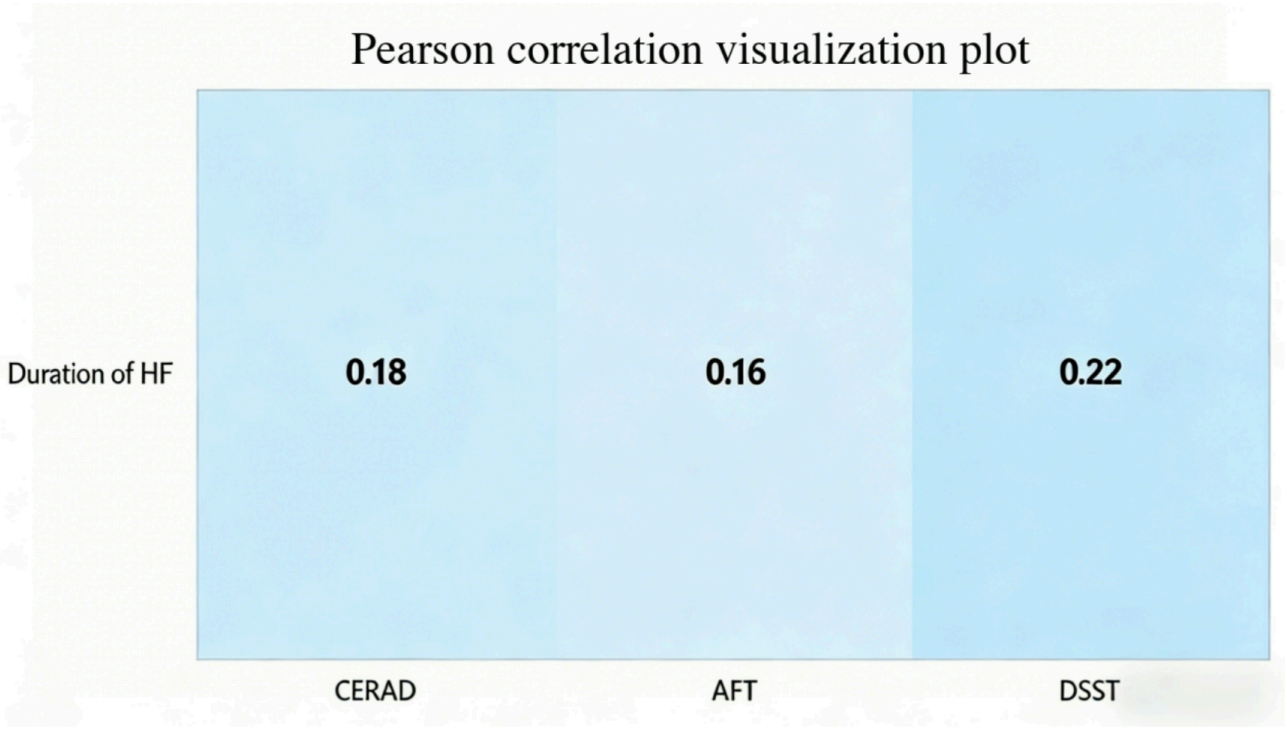


Figure 5

Visualization of Pearson Correlations Between Duration of HF and CERAD, AFT, DSST

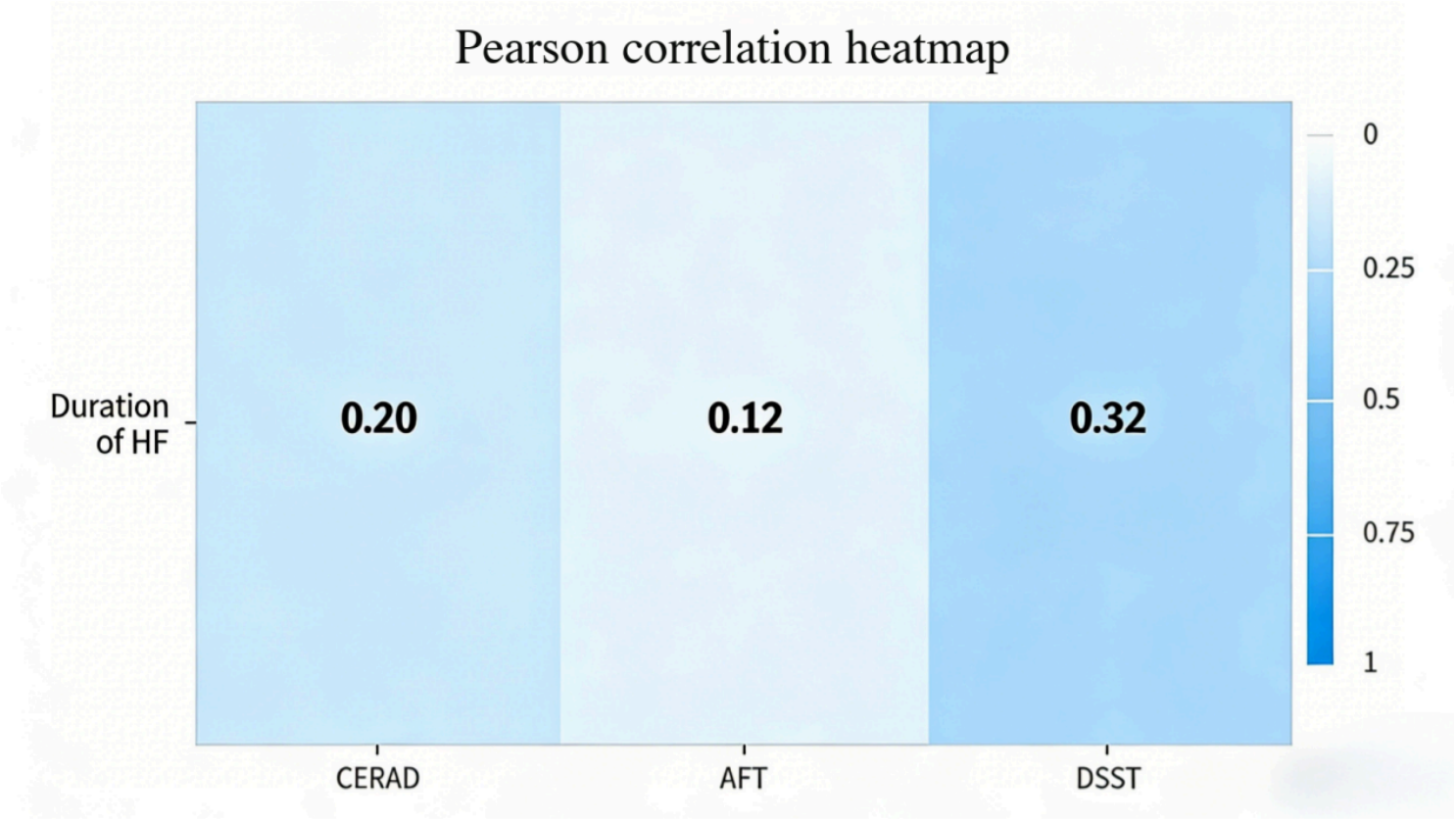


Figure 6

Pearson Correlation Between Duration of HF and Cognitive Function in Participants Aged ≤71 Years

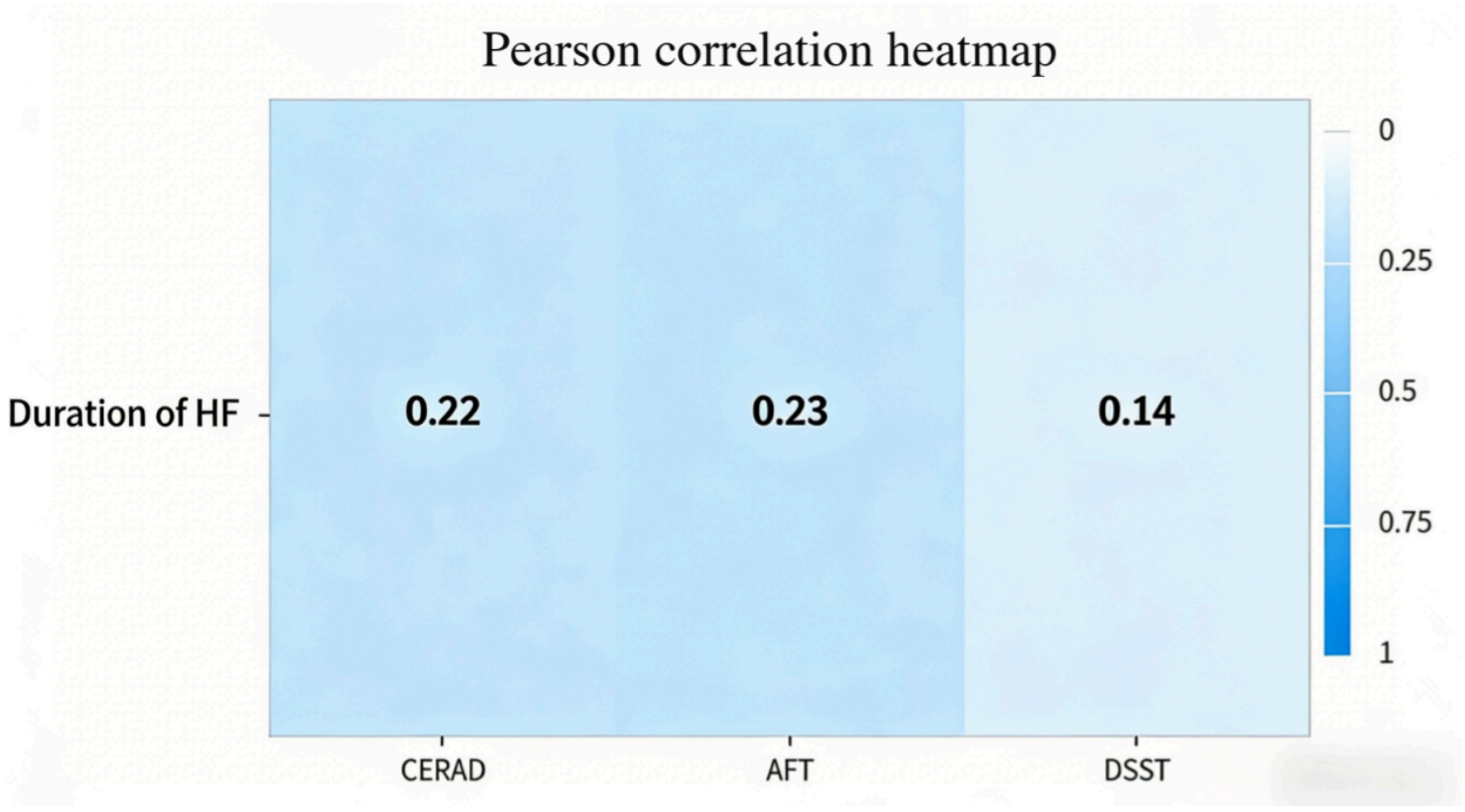


Figure 7

Pearson Correlation Between Duration of HF and Cognitive Function in Participants Aged >71 Years