# Study on nutritional status and incidence of sarcopenia in elderly patients with chronic heart failure

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## ABSTRACT

**Background and Objectives:** Elderly patients with chronic heart failure (CHF) are at high risk of malnutrition and sarcopenia. Therefore, nutritional screening, assessment, diagnosis, and management are particularly crucial for elderly CHF patients. Our study aims to investigate the nutritional status and the incidence characteristics and influencing factors of sarcopenia in elderly CHF patients. **Methods and Study Design:** A total of 122 elderly CHF patients admitted to The First Hospital of Hebei Medical University from March 2023 to January 2024 were enrolled. Within 24 hours after admission, demographic data, body composition analysis, nutritional status assessments, and laboratory parameter testing were conducted for all participants. Patients were divided into sarcopenia and non-sarcopenia groups. **Results:** A total of 122 patients were included, among whom 37 (30.33 %) were diagnosed with sarcopenia. The prevalence of malnutrition was significantly higher in sarcopenia group ($p < 0.05$). Patients with sarcopenia exhibited lower levels of albumin and hemoglobin, along with elevated Interleukin-6 (IL-6), Systemic Immune-Inflammation Index (SII), Neutrophil-to-Lymphocyte-Ratio (NLR), and Platelet-to-Lymphocyte-Ratio (PLR) ($p < 0.05$). Additionally, the sarcopenia group showed reduced fat-free mass, muscle mass, upper arm circumference, Phase Angle, and grip strength ($p < 0.05$). Multivariate logistic regression analysis revealed that BMI, protein, mineral, and triceps skinfold thickness were protective factors for sarcopenia in elderly CHF patients, after adjusting for confounding factors. **Conclusions:** Elderly CHF patients exhibit a higher risk of malnutrition and sarcopenia. There exists a correlation between age/BMI/protein/mineral and sarcopenia. The presence of sarcopenia correlates with poorer body composition outcomes and elevated inflammatory markers.


**Key Words: elderly patients, chronic heart failure, nutritional status, sarcopenia, body composition analysis**

## INTRODUCTION

CHF is a clinical syndrome caused by structural or functional abnormalities in the heart leading to reduced ejection capacity.[1] Characterized by high mortality rates, multiple comorbidities, and complex treatment requirements,[2] CHF has a prevalence rate as high as 10 % among the elderly.[3,4] Hospital mortality from CHF accounts for 40 % of total cardiovascular disease-related deaths, with approximately 50 % of patients dying within five years of diagnosis,[2] severely impacting patient quality of life.[5] Elderly CHF patients are

highly susceptible to malnutrition,[6,7] with severe CHF patients exhibiting malnutrition prevalence exceeding 90 %.[8] Malnutrition leads to higher readmission rates, increased mortality, significantly prolonged hospital stays, and elevated medical costs.[9] Therefore, nutritional screening, assessment, diagnosis, and treatment are particularly critical for elderly CHF patients. Sarcopenia, first proposed by Rosenberg in 1997,[10] is a progressive and generalized decline in skeletal muscle mass accompanied by decreased quality of life and adverse outcomes such as mortality.[11] With a prevalence ranging from 9.9 % to 40.4%,[12] sarcopenia significantly affects patient prognosis.[13,14] As a common comorbidity in heart failure patients, sarcopenia combined with malnutrition further increases its occurrence risk.[15] In recent years, sarcopenia has garnered increasing medical attention and has become a robust predictor of frailty and reduced survival rates in heart failure patients.[16,17]

Bioelectrical Impedance Analysis (BIA), as a clinical method for diagnosing sarcopenia, is characterized by its simplicity, safety, and cost-effectiveness, and has been applied in CHF-related research.[18,19] The Phase Angle (PA), derived from BIA,[20] serves as a predictive indicator for sarcopenia in cardiovascular disease patients.[21] Inflammatory cytokines can induce hypertrophy, apoptosis, and fibrosis in cardiomyocytes, activate protein degradation pathways, and ultimately lead to reduced muscle mass.[22,23] Chronic low-grade inflammation has been confirmed as a key contributor to muscle atrophy.[24] The PLR and NLR are emerging inflammatory biomarkers in cardiac patients.[25,26] Studies suggest that elevated PLR levels increase the risk of sarcopenia in older adults.[27] The SII, which comprehensively reflects host immune and inflammatory status, is considered as an excellent marker of both local immune responses and systemic inflammation.[28] SII has also been strongly associated with adverse outcomes in various cardiovascular diseases.[29]

This study aims to collect general demographic data, biochemical markers, echocardiographic findings, and body composition parameters in elderly CHF patients to analyze their nutritional status, disease characteristics, and influencing factors associated with sarcopenia. Furthermore, it explores the correlations among PA, inflammatory markers, nutritional parameters, and sarcopenia-related indices in this population. The findings are expected to provide novel insights for the clinical diagnosis and management of sarcopenia in elderly CHF patients.

## MATERIALS AND METHODS

A total of 122 elderly CHF patients were recruited at The First Hospital of Hebei Medical University between March 2023 and January 2024. The study was approved by the Ethics Committee of The First Hospital of Hebei Medical University (Approval No.: 2024039), and written informed consent was obtained from all participants.

Inclusion Criteria: Participants were eligible for inclusion if they met the following criteria: (1) primary diagnosis of CHF during hospitalization, confirmed according to the Chinese Guidelines for Diagnosis and Treatment of Heart Failure (2018),[30] (a) Left ventricular ejection fraction (LVEF) < 40 % for HFrEF or 40 - 49 % for HFmrEF or LVEF ≥ 50 % for HFpEF; (b) BNP ≥ 35 pg/mL or NT-proBNP ≥ 125 pg/mL; (2) age ≥ 60 years; and (3) willingness to participate with signed informed consent.

Exclusion Criteria: Participants were excluded if they had any of the following conditions: recent musculoskeletal disorders, fractures, abdominal or cranial trauma/surgery; Severe intellectual disabilities, psychiatric disorders, epilepsy, myasthenia gravis, significant limitations in activities of daily living, or presence of a cardiac pacemaker that precluded completion of required tests or movements; Limb edema due to non-cardiac causes (e.g., dermatomyositis, immune connective tissue diseases, lupus nephritis) that could not be distinguished from heart failure; Severe liver or renal dysfunction; Heart failure of non-ischemic or other etiologies (e.g., restrictive cardiomyopathy, Takotsubo syndrome); Malignant tumors.

Diagnostic Criteria for Sarcopenia: Sarcopenia was diagnosed based on the 2019 Asian Working Group for Sarcopenia (AWGS) screening and diagnostic criteria.[11]

### *Methods*

Basic demographic and clinical information, including age, gender, cardiac function classification, underlying diseases, etc., was collected. Within 24 hours of admission, fasting blood samples were obtained in the morning for routine blood tests and biochemical examinations, which were performed in the Clinical Laboratory of the First Hospital of Hebei Medical University.

#### Anthropometric measurements

Height and weight were measured using a height-weight scale (BSM370, South Korea); body composition was analyzed using a bioelectrical impedance analyzer (InbodyS10, South Korea); calf circumference and upper arm circumference were measured with a tape measure, and each was recorded three times, with mean value used for analysis; grip strength (GS) was

assessed with an electronic hand dynamometer (CAMRY-EH101), and the highest value from two trials was recorded.[31]

Nutritional risk screening and assessment: Mini Nutritional Assessment (MNA): MNA is a method specifically designed for the elderly to screen and assess nutritional risk, proposed by Guigoz Vallas and Gary in 1994;[32] Global Leadership Initiative on Malnutrition (GLIM): This standard classifies malnutrition as a disease, which is of great significance in guiding clinical diagnosis and medical insurance worldwide;[33] Geriatric Nutritional Risk Index (GNRI): GNRI = 1.489 × serum albumin (g/L) + 41.7 × (actual weight/ideal weight), where the weight of the patient when BMI = 22.0 kg/m² is defined as the ideal weight.34 In this study, patients were divided into three groups based on GNRI scores: no nutritional risk group (GNRI > 98), low malnutrition risk group (92 ≤ GNRI ≤ 98), and moderate or severe malnutrition risk group (GNRI < 92).

**Echocardiographic assessment**

Within 24 hours after admission, left ventricular ejection fraction, stroke volume, and other parameters were measured using color Doppler ultrasound, which was performed by physicians from the Ultrasound Department of the First Hospital of Hebei Medical University.

**Quality control**

All investigators received standardized training to ensure consistency in data collection and to minimize potential misunderstanding by participants during interviews. Questionnaires were reviewed for completeness, and missing data were addressed in a timely manner. All equipment, including scales and dynamometers, was calibrated before use. Equipment was routinely checked for signs of wear, malfunction, or abnormal values. Unified protocols were followed for all anthropometric and functional assessments to ensure data reliability and validity.

***Statistical analysis***

Statistical analysis was performed using SPSS 25.0. For continuous variables that were normally distributed, the data were expressed as mean ± standard deviation ($\bar{x}$ ± SD). Intergroup comparisons were conducted using the independent samples t-test, and correlation analysis was performed using Pearson correlation analysis. For continuous variables that were non-normally distributed, the data were expressed as median and interquartile range (M (Q1, Q3)). Intergroup comparisons were performed using the Wilcoxon rank sum test, and

correlation analysis was conducted using Spearman rank correlation. For categorical variables, the data were expressed as count and percentage, with intergroup comparisons performed using the chi-squared ($\chi^2$) test. Univariate Logistic regression was used to screen for statistically significant influencing factors, which were then further analyzed using multivariate Logistic regression. A $p$ value < 0.05 was considered statistically significant.

Missing data handling. C-reactive protein (CRP) and IL-6 have missing values. We addressed missing data for CRP and IL-6 as follows: (1) complete-case analysis was primarily used for variables with < 10 % missingness (e.g., CRP: 8 % missing). (2) For IL-6 (missingness: 15 %), multiple imputation (MI) with chained equations (MICE) was performed, incorporating auxiliary variables (e.g., age, comorbidities, other inflammatory markers) to preserve statistical power.

## RESULTS

### *Study population demographics study population demographics*

A total of 140 patients were enrolled in this study, after excluding 18 individuals (due to incomplete data), 122 patients were included in the final analysis. Among them, 37 patients were diagnosed with sarcopenia, accounting for 30.3 %. Based on the presence or absence of sarcopenia, patients were categorized into the sarcopenia group and the non-sarcopenia group. There was a statistically significant difference in age between the two groups ($p$ < 0.001, Table 1). However, no statistically significant differences were found in gender composition, smoking, alcohol consumption, or comorbidities (Table 1). There was no statistically significant difference in ejection fraction between the two groups (Table 1), while the stroke volume was significantly lower in the sarcopenia group compared to the non-sarcopenia group ($p$ < 0.001, Table 1).

### *Nutritional risk and malnutrition status of patients*

When assessing nutritional status using the GNRI scale, a total of 45 patients were identified as malnourished, with no statistically significant gender differences observed (Table 2). The sarcopenia group had a significantly lower median GNRI score and a higher proportion of patients with malnutrition compared to the non-sarcopenia group, both results were statistically significant ($p$ < 0.05, Table 3). When evaluating nutritional status using the MNA scale, the overall median score was 21 points, and 102 patients were diagnosed as nutritional risk (malnutrition). Again, no statistically significant gender difference was detected (Table 2). The median MNA score in the sarcopenia group was lower than that in the non-sarcopenia

group, and the proportion of patients with nutritional risk (malnutrition) was higher in the sarcopenia group than in the non-sarcopenia group; both results were statistically significant ($p < 0.05$, Table 3). When applying the GLIM criteria, 63 patients were diagnosed with malnutrition, accounting for 51.6 %, with no statistically significant gender difference (Table 2). The proportion of patients diagnosed with malnutrition in the sarcopenia group was higher than that in the non-sarcopenia group, and the result was statistically significant ($p < 0.05$, Table 3).

In our study, two instruments were employed: MNA classified 83.6 % of patients as at risk of malnutrition, whereas GLIM identified 51.6 % as malnourished (Table 2). The discrepancy between MNA and GLIM results is indeed notable and can be attributed to the following factors. 1. Tool Design Differences: the MNA is a screening tool focused on risk of malnutrition (including mild/moderate risk), while GLIM is a diagnostic criteria designed to confirm actual malnutrition (moderate/severe). This inherently leads to higher sensitivity in MNA. MNA includes subjective measures (e.g., appetite, mobility), whereas GLIM relies on objective phenotypic/etiologic criteria (e.g., weight loss, inflammation). 2. Clinical Utility: MNA is more suitable for rapid screening in community/outpatient settings due to its simplicity. GLIM provides a stricter, pathology-aligned diagnosis, making it preferable for clinical research or severe malnutrition identification.

***Laboratory and imaging indicators***

In terms of biochemical and blood routine indicators, albumin (ALB), triglycerides (TG), hemoglobin (HGB), and other indicators in the sarcopenia group were all lower than those in the non-sarcopenia group ($p < 0.05$, Table 4). In contrast, WBC was significantly higher in the sarcopenia group than in the non-sarcopenia group ($p < 0.05$, Table 4). Regarding heart failure indicators, BNP was higher in the sarcopenia group than in the non-sarcopenia group ($p < 0.05$, Table 4), while stroke volume was lower in the sarcopenia group than in the non-sarcopenia group ($p < 0.05$, Table 4). For inflammatory indicators, including NLR and IL-6 were higher in the sarcopenia group than in the non-sarcopenia group ($p < 0.05$, Table 4).

***Body composition indicators***

Indicators such as total body water (TBW), intracellular water (ICW), extracellular water (ECW), protein, mineral, body fat mass (BFM), fat-free mass (FFM), body mass index (BMI), basal metabolic rate (BMR), abdominal circumference, GS, arm circumference (AC), triceps skinfold thickness (TST), appendicular skeletal muscle mass (ASM), appendicular skeletal

muscle mass index (ASMI), calf circumference, and PA in the sarcopenia group were all lower than those in the non-sarcopenia group. Except for BFM, the differences in all other indicators were statistically significant ($p < 0.05$, Table 5). Additionally, the ECW/TBW ratio and visceral fat area (VFA) in the sarcopenia group were higher than those in the non-sarcopenia group, but only the ECW/TBW ratio showed a statistically significant difference ($p < 0.05$, Table 5). After stratified analysis by age, indicators such as PA, AC, protein, mineral, GS, BMR, and ECW/TBW still exhibited statistically significant differences between the two groups.

***Logistic regression analysis***

Univariate logistic regression analysis was performed on factors potentially influencing the occurrence of sarcopenia in patients. The results indicated that age, New York Heart Association (NYHA) functional class, protein, mineral, BMI, abdominal circumference, GS, AC, PA, TST, calf circumference, readmission within 30 days, readmission within one year, and stroke volume were all independent factors influencing the occurrence of sarcopenia in patients (Table 6). In the multivariate logistic regression analysis, after adjusting for factors such as age, gender, smoking, alcohol consumption, hypertension, coronary heart disease, myocardial infarction, and diabetes, BMI, protein, mineral, MNA, TST, and PA remained influencing factors for the occurrence of sarcopenia in patients and were identified as protective factors (Table 7).

***Correlation analysis***

PA was negatively correlated with GLIM and GNRI ($p < 0.05$, Table 8), and positively correlated with MNA, GS, ASM, ALB, and other indicators ($p < 0.05$, Table 8). MNA was positively correlated with GS, TST, ASM, ALB, and other indicators ($p < 0.05$, Table 8), and negatively correlated with inflammatory indicators such as PLR and IL-6 ($p < 0.05$, Table 8). GS was positively correlated with PA, MNA, ASM, and other indicators and negatively correlated with GLIM, PLR, and other indicators ($p < 0.05$, Table 8). IL-6 was negatively correlated with MNA, TST, and ALB and positively correlated with GNRI ($p < 0.05$, Table 8).

## DISCUSSION

CHF has emerged as a significant public health concern in China, with its incidence increasing with age,[35] and a strong association with malnutrition.[36,37] Its primary

characteristics include energy-protein malnutrition, muscle atrophy, and peripheral edema.[38-40] Although there is currently no universally accepted gold standard for diagnosing malnutrition in CHF patients, methods such as muscle ultrasound and body composition analysis can partially assess malnutrition.[41] The MNA scale identifies malnutrition as an independent predictor of mortality in CHF patients and serves as a useful tool for rapidly identifying malnutrition risk in elderly CHF patients.[42-44] Currently, the MNA scale and GLIM criteria are commonly used to assess malnutrition in elderly inpatients.[42,43] Our study results showed that among elderly CHF patients assessed using the MNA scale, 102 patients (83.6 %) had malnutrition risk, with 37 patients in the sarcopenia group (100 % malnutrition risk). These findings indicate the alarmingly high prevalence of malnutrition in elderly CHF patients, particularly those with comorbid sarcopenia; thus, nutritional risk screening and assessment are particularly important for this population.

Sarcopenia is one of the common geriatric syndromes clinically.[45] The prevalence of sarcopenia varies significantly across countries,[46-48] for example, the overall prevalence of sarcopenia in people aged 60 and older in western China is 9.8 %,[49] while in eastern regions, it is 28.8 %.[50] A study on the correlation between sarcopenia and heart failure in elderly patients reported that the prevalence of sarcopenia in the heart failure group (26.19 %) was higher than in the non-heart failure group (6.38 %).[51] Our study found a sarcopenia detection rate of 30.33 % in elderly CHF patients, further confirming that this population is at high risk of developing sarcopenia.

Previous studies have shown that cardiovascular disease combined with sarcopenia is common in the elderly, females, and individuals with low BMI,[52] which aligns with our findings. Nutrition deficiency and chronic inflammation play critical roles in the occurrence and progression of sarcopenia.[53] The International Sarcopenia Working Group has recommended using inflammatory, oxidative stress, and nutritional markers as diagnostic indicators for sarcopenia.[54] A study on health and aging trends in western China explored the diagnostic performance of laboratory indicators for sarcopenia and found that total protein, ALB, prealbumin, and TG were lower in sarcopenia patients than in the general population,[55] consistent with our results. We also observed that inflammatory indicators such as NLR and IL-6 were higher in the sarcopenia group compared to the non-sarcopenia group in elderly CHF patients. This may reflect metabolic changes, including abnormal fat and protein metabolism, caused by the coexistence of CHF and sarcopenia, leading to elevated inflammation levels.

Studies have reported differences in multiple BIA parameters between the sarcopenia and control groups.[56,57] Our results showed significant differences in muscle mass, protein, mineral, PA, and extracellular water-to-total body water ratio (ECW/TBW) between the two groups. A lower ECW/TBW ratio may be beneficial for muscle health,[58] which aligns with our finding that the non-sarcopenia group had a lower ECW/TBW ratio than the sarcopenia group. An international study also noted that the risk of sarcopenia increases with age and decreases in FFM,[59] consistent with our results. A study primarily involving elderly CHF patients with NYHA class I or II reported that patients with sarcopenia had a lower mean PA value ($4.9 \pm 0.9$ vs. $6.0 \pm 0.8$) than those without sarcopenia,[60] which matches our findings. Chinese researchers have summarized PA reference values for healthy populations in Switzerland, the United States, and other regions (ranging from 4.22 to 5.40), with differences potentially attributed to racial variations or measurement instrument errors.[61] In our study, median PA values were 4.2 in the sarcopenia group and 4.7 in the non-sarcopenia group among elderly CHF patients, indicating significant changes in cell membrane structure/function and overall health status following the coexistence of CHF and sarcopenia.

Numerous studies have demonstrated that sarcopenia is an age-related disease with increasing incidence as age advances.[62] Our analysis revealed potential links between sarcopenia and multiple modifiable factors including BMI, protein, mineral, and so on, along with the non-modifiable factor of age. While our research confirmed age maybe as a significant risk factor for sarcopenia among elderly CHF patients, and the potential mechanisms are as described below: (1) Anabolic Resistance: age-related decline in muscle protein synthesis efficiency. Reduced responsiveness to dietary protein and exercise stimuli. (2) Chronic Inflammation (Inflammaging): elevated pro-inflammatory cytokines (e.g., IL-6, CRP, TNF- α ) accelerating muscle catabolism. (3) Endocrine Changes: growth hormone/IGF-1 axis attenuation. Sex hormone depletion (e.g., sarcopenia in hypogonadism). (4) Multifactorial Synergy: Co-occurrence with comorbidities (e.g., diabetes, Chronic Kidney Disease) exacerbating nutritional risk. Whereas BMI, protein, mineral, MNA, TST, and PA were maybe identified as protective factors, consistent with the findings of Jiang Lu, Zhou Yanyan, and others.[63,64] Studies have shown that BMI is a protective factor against sarcopenia in elderly patients with hypertension,[45] which aligns with our conclusion that BMI was maybe a protective factor for sarcopenia in elderly CHF patients. However, it is important to note that patients with BMI exceeding the normal range should appropriately increase their skeletal muscle mass.[65]

PA is a parameter directly derived from BIA raw data,[66] reflecting cellular integrity and vitality,[67] and assisting in assessing nutritional status and health.[68] Its evaluation efficacy surpasses that of anthropometric and biochemical indicators.[69,70] Research has found that PA can predict clinical outcomes and mortality in patients with various diseases, including CHF,[71] as well as the incidence of sarcopenia, malnutrition, and cachexia in hospitalized cardiovascular disease patients.[21,72] Elderly CHF patients have lower PA, lean body mass, and FFM than healthy individuals,[73] and these parameters correlate with BMI, FFM, ALB, prealbumin, and other indicators.[74] Our findings revealed significantly lower PA in the sarcopenia group, and PA was positively associated with GS, ASM, and ALB, regardless of gender. Thus, higher PA is a protective factor for elderly CHF patients, and clinicians should closely monitor PA levels and implement timely nutritional interventions to improve patient prognosis.

Emerging evidence has indicated that inflammation, protein metabolism imbalance, and skeletal muscle fibrosis contribute to the pathophysiological process of sarcopenia in heart failure patients, with the inflammation theory being the most evidence-supported.13 CHF patients often present with systemic chronic inflammation, leading to muscle atrophy, reduced muscle strength, and decreased muscle mass.[75] Inflammatory cytokines are negatively correlated with GS and muscle mass.[76] Our study found that PLR was negatively correlated with PA and GS in elderly CHF patients, consistent with findings from Qiang Hu et al.,[77] indicating that the risk of sarcopenia increases with elevated inflammation levels.

We acknowledge three key limitations: (1) The Single-center design may introduce selection bias. (2) The sample size (n = 122) provides 80 % power to detect only medium effects (Cohen's f2 $\geq$ 0.15) in multivariate analysis. (3) Non-exclusion of acute decompensated HF (n = 9) and concurrent infections (n = 7) might have inflated inflammatory markers (median CRP levels were 2.3 mg/L higher in these subgroups). To address these limitations, we are currently conducting a prospective multicenter study enrolling 1000 patients from 10 centers across diverse regions (coastal/rural/mountainous), with standardized protocols for: LVEF assessment, Inflammatory marker processing, and Nutritional evaluation.

### *Conclusion*

This study demonstrates that elderly patients with CHF and concurrent sarcopenia, exhibit significantly increased nutritional risk, deteriorated body composition, and heightened inflammatory status. There exists a correlation between age, BMI, protein, mineral, and sarcopenia. Age may serve as a risk factor for sarcopenia in elderly CHF patients, whereas

BMI, protein, mineral, TST, and other factors maybe act as protective factors. PA, in particular, emerges as a reliable, comprehensive indicator of nutritional and health status, with the potential to predict the onset of sarcopenia and the degree of inflammatory burden, thereby enabling targeted nutritional interventions for elderly CHF patients. While PA showed a protective trend in unadjusted analyses, its effect was attenuated after adjusting for confounders, suggesting potential mediation by nutritional or inflammatory variables.

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**CONFLICT OF INTEREST AND FUNDING DISCLOSURE**

The authors declare no conflict of interest.

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**Table 1.** Baseline characteristics of elderly CHF patients with and without sarcopenia

| | Sarcopenia group | Non-sarcopenia group | *p* |
|---|---|---|---|
| Age (year) | 74.1 ± 7.5 | 69.3 ± 6.1 | < 0.001 |
| Sex | | | |
| Male, n (%) | 17 (46.0) | 45 (52.9) | |
| Females, n (%) | 20 (54.1) | 40 (47.1) | 0.479 |
| Smoking | | | |
| Yes, n (%) | 14 (37.8) | 35 (41.2) | 0.731 |
| Drinking | | | |
| Yes, n (%) | 15 (40.5) | 32 (37.7) | 0.764 |
| Educational level | | | |
| Junior secondary education or above, n (%) | 13 (35.2) | 41 (48.2) | 0.182 |
| Occupation | | | |
| Famer, n (%) | 27 (73.0) | 56 (65.9) | 0.442 |
| Comorbidity | | | |
| Hypertension, n (%) | 23 (62.2) | 49 (57.7) | 0.641 |
| Atrial fibrillation, n (%) | 14 (37.8) | 23 (27.1) | 0.234 |
| Alvular heart disease, n (%) | 8 (21.6) | 16 (18.8) | 0.721 |
| Dilated cardiomyopathy, n (%) | 1 (2.7) | 5 (5.9) | 0.666 |
| Myocardial infarction, n (%) | 8 (21.6) | 23 (27.1) | 0.526 |
| Coronary artery disease, n (%) | 26 (70.3) | 64 (75.3) | 0.562 |
| Diabetes mellitus, n (%) | 10 (27.0) | 32 (37.7) | 0.256 |
| NYHA class | | | |
| Class II, n (%) | 5 (13.5) | 31 (36.5) | |
| Class III, n (%) | 16 (43.2) | 29 (34.1) | |
| Class IV, n (%) | 16 (43.2) | 25 (29.4) | 0.036 |
| Echocardiography | | | |
| Ejection Fraction (%) | 52.0 (38.0, 58.5) | 51.0 (38.0, 59.0) | 0.601 |
| Stroke Volume (mL) | 53.0 (42.5, 60.0) | 56.5 (50.0, 65.8) | 0.025 |
| LVEF | | | |
| HFrEF, n (%) | 12 (32.4) | 23 (27.1) | |
| HFmrEF, n (%) | 5 (13.5) | 18 (21.2) | |
| HFpEF, n (%) | 20 (54.1) | 42 (49.4) | 0.564 |

NYHA: New York Heart Association, LVEF:Left Ventricular Ejection Fraction.

**Table 2.** Nutritional risk screening and assessment in elderly patients with CHF

| | Total (n = 122) | Male (n = 62) | Females (n = 60) | *p* |
|---|---|---|---|---|
| GNRI | | | | |
| Total Score | 101 (93.6, 101) | 102 (93.5, 101) | 100 (94.3, 109) | 0.889 |
| No nutritional risk, n (%) | 76 (62.3) | 40 (64.5) | 36 (60.0) | |
| Low nutritional risk, n (%) | 25 (20.5) | 13 (21.0) | 12 (20.0) | |
| Moderate/Severe nutritional risk, n (%) | 20 (16.4) | 9 (14.5) | 11 (18.3) | 0.828 |
| MNA | | | | |
| Total Score | 21.0 (16.5, 23.0) | 22.0 (17.5, 23.5) | 20.0 (16.0, 22.5) | 0.030 |
| Normal nutritional status, n (%) | 20 (16.4) | 14 (22.6) | 6 (10.0) | |
| At risk of malnutrition/Malnourished, n (%) | 102 (83.6) | 48 (77.4) | 54 (90.0) | 0.061 |
| GLIM | | | | |
| Normal nutritional status, n (%) | 59 (48.4) | 33 (53.2) | 26 (43.3) | |
| Malnutrition, n (%) | 63 (51.6) | 29 (46.8) | 34 (56.7) | 0.274 |

GNRI: Geriatric Nutritional Risk Index, MNA: Mini-Nutritional Asses, GLIM: Global Leadership Initiative on Malnutrition.

**Table 3.** Nutritional risk screening and assessment in elderly CHF patients

| | Sarcopenia group (n = 37) | Non-sarcopenia group (n = 85) | *p* |
|---|---|---|---|
| GNRI | | | |
| Total Score | 95.2 (91.5, 101) | 105 (97.6, 112) | < 0.001 |
| No nutritional risk, n (%) | 14 (37.9) | 63 (74.1) | |
| Low nutritional risk, n (%) | 12 (32.4) | 13 (15.3) | |
| Moderate/Severe nutritional risk, n (%) | 11 (29.7) | 9 (10.6) | 0.001 |
| MNA | | | |
| Total Score | 16.5 (14.5, 19.8) | 22.0 (19.8, 23.5) | < 0.001 |
| Normal nutritional status, n (%) | 0 (0.0) | 20 (23.5) | |
| At risk of malnutrition/Malnourished, n (%) | 37 (100) | 65 (76.5) | 0.001 |
| GLIM | | | |
| Normal nutritional status, n (%) | 9 (24.3) | 50 (58.8) | |
| Malnutrition, n (%) | 28 (75.7) | 35 (41.2) | < 0.001 |

GNRI: Geriatric Nutritional Risk Index, MNA: Mini-Nutritional Asses, GLIM: Global Leadership Initiative on Malnutrition.

**Table 4.** Laboratory and imaging profiles in sarcopenic vs non-sarcopenic elderly CHF patients

| | Sarcopenia group (n = 37) | Non-sarcopenia group (n = 85) | *p* |
|---|---|---|---|
| Biochemistry | | | |
| TP (g/L) | 62.2 (58.0, 65.8) | 62.6 (58.5, 67.3) | 0.668 |
| ALB (g/L) | 34.9 (31.8, 38.9) | 37.1 (34.9, 40.5) | 0.032 |
| AST (U/L) | 22.3 (16.2, 33.2) | 23.8 (17.9, 42.9) | 0.128 |
| ALT (U/L) | 18.0 (12.7, 36.8) | 22.3 (14.6, 43.3) | 0.096 |
| TBIL (μmol/L) | 14.4 (10.3, 19.7) | 14.6 (9.9, 17.5) | 0.978 |
| DBIL (μmol/L) | 3.5 (2.3, 3.5) | 3.4 (2.3, 5.3) | 0.920 |
| IBIL (μmol/L) | 10.3 (7.6, 12.7) | 10.2 (7.6, 13.2) | 0.856 |
| TC (mmol/L) | 4.0 ± 1.1 | 4.3 ± 1.3 | 0.362 |
| TG (mmol/L) | 1.0 (0.7, 1.4) | 1.2 (0.9, 1.5) | 0.020 |
| HDL (mmol/L) | 1.1 (0.9, 1.4) | 1.1 (0.9, 1.3) | 0.710 |
| LDL (mmol/L) | 2.3 (1.9, 2.8) | 2.4 (1.8, 3.2) | 0.578 |
| Complete blood count | | | |
| HGB (g/L) | 119 (99.0, 132) | 129 (114, 139) | 0.043 |
| WBC (*$10^9$ /L) | 6.8 (5.7, 7.4) | 6.0 (5.2, 7.1) | 0.044 |
| NEUT (*$10^9$ /L) | 4.5 (3.4, 5.8) | 4.0 (3.3, 5.2) | 0.110 |
| LYC (*$10^9$ /L) | 1.2 (1.0, 1.7) | 1.37 (1.1, 1.7) | 0.252 |
| RBC (*$10^{12}$ /L) | 4.0 (3.5, 4.4) | 4.1 (3.7, 4.5) | 0.287 |
| PCT (*$10^9$/L) | 190 (156, 266) | 192 (168, 220) | 0.991 |
| Heart failure biomarkers | | | |
| BNP (mg/L) | 386 (222, 906) | 205 (107, 535) | 0.045 |
| EF (%) | 48.0 (38.0, 58.5) | 51.0 (38.0, 59.0) | 0.601 |
| SV (mL) | 53.0 (42.5, 60.0) | 56.5 (50.0, 65.8) | 0.025 |
| Inflammatory markers | | | |
| NLR | 3.9 (2.3, 6.6) | 3.1 (2.1, 4.1) | 0.032 |
| PLR | 159 (113, 231) | 139 (104, 188) | 0.155 |
| SII | 751 (431, 1112) | 568 (391, 794) | 0.100 |
| CRP (ug/mL) | 43.4 (33.8, 133) | 40.9 (34.5, 107) | 0.521 |
| IL-6 (pg/mL) | 6.3 (1.2, 15.2) | 1.8 (0.4, 4.9) | 0.023 |

TP: Total Protein, ALB: Albumin, AST: Aspartate Aminotransferase, ALT: Alanine Aminotransferase, TBIL, Total Bilirubin, DBIL: Direct Bilirubin, IBIL: Indirect Bilirubin, TC: Total Cholesterol, TG: Triglycerides, HDL: High-Density Lipoprotein, LDL: Low-Density Lipoprotein, HGB: Hemoglobin, WBC: White Blood Cell Count, NEUT: Neutrophil Count, LYC: Lymphocyte Count, RBC: Red Blood Cell Count, Red Blood Cell Count: Plateletcrit, BNP: B-type Natriuretic Peptide, EF: Ejection Fraction, SV: Stroke Volume, NLR: Neutrophil-to-Lymphocyte Ratio, PLR: Platelet-to-Lymphocyte Ratio,SII: Systemic Immune-Inflammation Index, CRP: C-reactive Protein, IL-6: Interleukin-6.

**Table 5.** Body composition parameters in sarcopenic vs non-sarcopenic elderly CHF patients

| | Sarcopenia group (n = 37) | Non-sarcopenia group (n = 85) | *p* |
|---|---|---|---|
| Biochemistry | | | |
| TP (g/L) | 62.2 (58.0, 65.8) | 62.6 (58.5, 67.3) | 0.668 |
| ALB (g/L) | 34.9 (31.8, 38.9) | 37.1 (34.9, 40.5) | 0.032 |
| AST (U/L) | 22.3 (16.2, 33.2) | 23.8 (17.9, 42.9) | 0.128 |
| ALT (U/L) | 18.0 (12.7, 36.8) | 22.3 (14.6, 43.3) | 0.096 |
| TBIL (μmol/L) | 14.4 (10.3, 19.7) | 14.6 (9.9, 17.5) | 0.978 |
| DBIL (μmol/L) | 3.5 (2.3, 3.5) | 3.4 (2.3, 5.3) | 0.920 |
| IBIL (μmol/L) | 10.3 (7.6, 12.7) | 10.2 (7.6, 13.2) | 0.856 |
| TC (mmol/L) | 4.0 ± 1.1 | 4.3 ± 1.3 | 0.362 |
| TG (mmol/L) | 1.0 (0.7, 1.4) | 1.2 (0.9, 1.5) | 0.020 |
| HDL (mmol/L) | 1.1 (0.9, 1.4) | 1.1 (0.9, 1.3) | 0.710 |
| LDL (mmol/L) | 2.3 (1.9, 2.8) | 2.4 (1.8, 3.2) | 0.578 |
| Complete blood count | | | |
| HGB (g/L) | 119 (99.0, 132) | 129 (114, 139) | 0.043 |
| WBC (*$10^9$ /L) | 6.8 (5.7, 7.4) | 6.0 (5.2, 7.1) | 0.044 |
| NEUT (*$10^9$ /L) | 4.5 (3.4, 5.8) | 4.0 (3.3, 5.2) | 0.110 |
| LYC (*$10^9$ /L) | 1.2 (1.0, 1.7) | 1.37 (1.1, 1.7) | 0.252 |
| RBC (*$10^{12}$ /L) | 4.0 (3.5, 4.4) | 4.1 (3.7, 4.5) | 0.287 |
| PCT (*$10^9$/L) | 190 (156, 266) | 192 (168, 220) | 0.991 |
| Heart failure biomarkers | | | |
| BNP (mg/L) | 386 (222, 906) | 205 (107, 535) | 0.045 |
| EF (%) | 48.0 (38.0, 58.5) | 51.0 (38.0, 59.0) | 0.601 |
| SV (mL) | 53.0 (42.5, 60.0) | 56.5 (50.0, 65.8) | 0.025 |
| Inflammatory markers | | | |
| NLR | 3.9 (2.3, 6.6) | 3.1 (2.1, 4.1) | 0.032 |
| PLR | 159 (113, 231) | 139 (104, 188) | 0.155 |
| SII | 751 (431, 1112) | 568 (391, 794) | 0.100 |
| CRP (ug/mL) | 43.4 (33.8, 133) | 40.9 (34.5, 107) | 0.521 |
| IL-6 (pg/mL) | 6.3 (1.2, 15.2) | 1.8 (0.4, 4.9) | 0.023 |

TBW: Total Body Water, ICW: Intracellular Water, ECW: Extracellular Water, BFM: Body Fat Mass, FFM: Fat-Free Mass, BMI: Body Mass Index, ECW/TBW: ECW to TBW Ratio, BMR: Basal Metabolic Rate, VFA: Visceral Fat Area, WC: Waist Circumference, GS: Grip Strength, AC: Arm Circumference, TST: Triceps Skinfold Thickness, ASM: Appendicular Skeletal Muscle, ASMI: Appendicular Skeletal Muscle Index, CC: Calf Circumference, PA: Phase Angle

**Table 6.** Factors influencing sarcopenia in elderly CHF patients

| | *OR* | 95 % *CI* | *p* | Nagelkerke $R^2$ | AIC |
|---|---|---|---|---|---|
| Age | 1.11 | 1.05 - 1.19 | 0.001 | 0.38 | 285.7 |
| ALB | 0.95 | 0.88 - 1.02 | 0.120 | 0.35 | 287.2 |
| NYHA class | | | | | |
| Class II | 0.25 | 0.08 - 0.78 | 0.017 | 0.36 | 286.5 |
| Class III | 0.86 | 0.36 - 2.07 | 0.740 | 0.34 | 288.1 |
| TG | 0.54 | 0.25 - 1.17 | 0.117 | 0.35 | 287.4 |
| Protein | 0.41 | 0.28 - 0.59 | < 0.001 | 0.42 | 283.5 |
| Mineral | 0.16 | 0.06 - 0.41 | < 0.001 | 0.40 | 284.2 |
| BMI | 0.82 | 0.73 - 0.93 | 0.001 | 0.39 | 285.1 |
| WC | 0.97 | 0.95 - 1.00 | 0.048 | 0.36 | 286.8 |
| GS | 0.94 | 0.89 - 0.98 | 0.005 | 0.37 | 286.3 |
| AC | 0.75 | 0.66 - 0.86 | < 0.001 | 0.41 | 283.9 |
| TST | 0.92 | 0.85 - 0.99 | 0.024 | 0.36 | 286.6 |
| CC | 0.75 | 0.66 - 0.86 | < 0.001 | 0.41 | 283.8 |
| 30 - day readmission | 0.34 | 0.14 - 0.86 | 0.022 | 0.37 | 286.0 |
| 1 - year readmission | 0.41 | 0.18 - 0.92 | 0.031 | 0.36 | 286.7 |
| SV | 0.97 | 0.94 - 1.00 | 0.042 | 0.35 | 287.3 |
| PA | 0.50 | 0.32 - 0.79 | 0.003 | 0.43 | 282.9 |

ALB: Albumin, NYHA: New York Heart Association, TG: Triglycerides, BMI: Body Mass Index, WC: Waist Circumference, GS: Grip Strength, AC: Arm Circumference, TST: Triceps Skinfold Thickness, CC: Calf Circumference, SV: Stroke Volume, PA: Phase Angle

**Table 7.** Multivariate analysis of sarcopenia risk in elderly CHF patients

| | *OR* | 95 % *CI* | *p* | Nagelkerke $R^2$ | AIC |
|---|---|---|---|---|---|
| BMI | | | | | |
| Model 1 | 0.82 | 0.73 - 0.93 | 0.001 | 0.32 | 290.2 |
| Model 2 | 0.83 | 0.73 - 0.94 | 0.003 | 0.35 | 287.5 |
| Model 3 | 0.83 | 0.73 - 0.94 | 0.003 | 0.36 | 286.8 |
| Model 4 | 0.82 | 0.72 - 0.93 | 0.002 | 0.38 | 285.7 |
| CC | | | | | |
| Model 1 | 0.75 | 0.66 - 0.86 | < 0.001 | 0.40 | 283.4 |
| Model 2 | 0.78 | 0.68 - 0.89 | < 0.001 | 0.41 | 282.1 |
| Model 3 | 0.76 | 0.66 - 0.88 | < 0.001 | 0.42 | 281.5 |
| Model 4 | 0.78 | 0.67 - 0.90 | 0.001 | 0.42 | 281.3 |
| Protein | | | | | |
| Model 1 | 0.41 | 0.28 - 0.59 | < 0.001 | 0.45 | 278.9 |
| Model 2 | 0.20 | 0.10 - 0.38 | < 0.001 | 0.48 | 275.3 |
| Model 3 | 0.13 | 0.06 - 0.30 | < 0.001 | 0.50 | 273.1 |
| Model 4 | 0.01 | 0.05 - 0.28 | < 0.001 | 0.52 | 270.8 |
| Mineral | | | | | |
| Model 1 | 0.16 | 0.06 - 0.41 | < 0.001 | 0.44 | 279.5 |
| Model 2 | 0.13 | 0.04 - 0.43 | 0.001 | 0.46 | 277.2 |
| Model 3 | 0.09 | 0.02 - 0.34 | < 0.001 | 0.47 | 276.4 |
| Model 4 | 0.09 | 0.02 - 0.36 | 0.001 | 0.47 | 276.2 |
| PA | | | | | |
| Model 1 | 0.50 | 0.32 - 0.80 | 0.003 | 0.38 | 285.6 |
| Model 2 | 0.64 | 0.38 - 1.08 | 0.642 | 0.36 | 287.2 |
| Model 3 | 0.64 | 0.38 - 1.08 | 0.097 | 0.37 | 286.5 |
| Model 4 | 0.66 | 0.39 - 1.11 | 0.119 | 0.37 | 286.3 |
| TST | | | | | |
| Model 1 | 0.92 | 0.85 - 0.99 | 0.024 | 0.33 | 289.1 |
| Model 2 | 0.90 | 0.82 - 0.98 | 0.020 | 0.34 | 288.3 |
| Model 3 | 0.89 | 0.81 - 0.98 | 0.014 | 0.35 | 287.6 |
| Model 4 | 0.89 | 0.81 - 0.98 | 0.021 | 0.35 | 287.4 |

BMI: Body Mass Index, CC: Calf Circumference, PA: Phase Angle, TST: Triceps Skinfold Thickness.
Adjusted Covariates, Model 1: Unadjusted, Model 2: Model 1 + Demographic factors (Age),Model 3: Model 2 + Lifestyle factors (Smoking, Alcohol consumption), Model 4: Model 3 + Comorbidities (Hypertension, Coronary heart disease, Myocardial infarction, Diabetes).
Variable Selection Strategy: Full Model Inclusion: all clinically and statistically relevant variables identified in univariate analyses ($p < 0.10$) were initially included in the multivariate model. Manual Backward Elimination: non-significant covariates ($p \geq 0.05$) were sequentially removed, retaining only variables that improved model fit (assessed via AIC and likelihood ratio tests). Final Model Criteria: No multicollinearity (VIF < 5), Hosmer-Lemeshow test ($p > 0.05$), Adjusted for age, sex, and NYHA class as a priori confounders regardless of significance

**Table 8.** Interplay of PA, sarcopenia, nutrition, and inflammation in elderly CHF

| | PA | MNA | GLIM | GNRI | GS | TST | ASM | ALB | PLR | CRP | IL-6 |
|---|---|---|---|---|---|---|---|---|---|---|---|
| PA | | 0.47 ** | - 0.34 ** | - 0.33 ** | 0.48 ** | - 0.03 | 0.49 ** | 0.26 ** | - 0.16 | - 0.02 | - 0.16 |
| MNA | 0.47 ** | | - 0.56 ** | - 0.50 ** | 0.34 ** | 0.23 ** | 0.37 ** | 0.26 ** | - 0.34 ** | - 0.12 | - 0.26 * |
| GLIM | - 0.34 ** | - 0.56 ** | | 0.29 ** | - 0.28 ** | - 0.19 * | - 0.28 ** | - 0.19 * | 0.20* | - 0.13 | 0.04 |
| GNRI | - 0.33 ** | - 0.50 ** | 0.29 ** | | - 0.18 | - 0.26 ** | - 0.19 * | - 0.56 ** | 0.18* | 0.22 | 0.33 ** |
| GS | 0.48 ** | 0.34 ** | - 0.28 ** | - 0.18 | | - 0.09 | 0.66 ** | 0.13 | - 0.23 ** | 0.10 | - 0.01 |
| TST | - 0.03 | 0.23 ** | - 0.19 * | - 0.26 ** | - 0.09 | | - 0.10 | - 0.01 | - 0.07 | - 0.11 | - 0.23 * |
| ASM | 0.49 ** | 0.38 ** | - 0.28 ** | - 0.19 * | 0.66 ** | - 0.10 | | 0.09 | - 0.17 | 0.26 * | 0.05 |
| ALB | 0.26 ** | 0.26 ** | - 0.19 * | - 0.56 ** | 0.13 | - 0.01 | 0.09 | | - 0.10 | - 0.39 ** | - 0.32 ** |
| PLR | - 0.16 | - 0.34 ** | 0.20 * | 0.18 * | - 0.23 ** | - 0.07 | - 0.17 | - 0.10 | | 0.04 | 0.12 |
| CRP | - 0.02 | - 0.12 | - 0.13 | 0.22 | 0.10 | - 0.11 | 0.26 * | - 0.39 ** | 0.04 | | 0.72 ** |
| IL-6 | - 0.16 | - 0.26 * | 0.04 | 0.33 ** | - 0.01 | - 0.23 * | 0.05 | - 0.32 ** | 0.12 | 0.72 ** | |

PA: Phase Angle, MNA: Mini-Nutritional Asses, GNRI: Geriatric Nutritional Risk Index, GLIM: Global Leadership Initiative on Malnutrition, GS: Grip Strength, TST: Triceps Skinfold Thickness, ASM: Appendicular Skeletal Muscle, ALB: Albumin, PLR: Platelet-to-Lymphocyte Ratio, CRP: C-reactive Protein, IL-6: Interleukin-6.
* $p<0.05$, ** $p<0.01$