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ORIGINAL ARTICLE

Cross-Sectional Evaluation of Risk Factors and Preliminary Development of a Sarcopenia Risk Scoring Model in Patients with Type 2 Diabetes Mellitus

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Abstract

OBJECTIVE: This cross-sectional study aimed to identify clinical factors associated with sarcopenia in adults with type 2 diabetes mellitus (T2DM) aged ≤ 65 years and to develop a preliminary nomogram-based risk scoring model using routinely collected clinical indicators.

METHODS: We enrolled 81 patients with T2DM aged ≤ 65 years who were admitted to Huzhou Central Hospital between July 2023 and September 2025. Demographic characteristics, anthropometric measurements, and laboratory parameters were collected. Appendicular skeletal muscle mass, handgrip strength, and gait speed were measured, and sarcopenia was diagnosed according to Asian Working Group for Sarcopenia criteria. Univariate analysis, least absolute shrinkage and selection operator (LASSO) regression, and multivariable logistic regression were used to identify independent risk factors and construct a nomogram-based prediction model. Model performance was evaluated using receiver operating characteristic (ROC) analysis, calibration plots, and decision curve analysis (DCA).

RESULTS: Compared with patients without sarcopenia, those with sarcopenia had lower HDL-C and albumin levels and higher HbA1c concentrations (all $p < 0.05$). LASSO regression identified HDL-C, HbA1c, height, and BMI as key predictors, and multivariable analysis confirmed low HDL-C, high HbA1c, shorter height, and lower BMI as independent risk factors. The nomogram demonstrated good discrimination (AUC = 0.844) and calibration, and decision curve analysis indicated favorable clinical net benefit.

CONCLUSION: Reduced height, lower BMI, elevated HbA1c, and decreased HDL-C are significant risk factors for sarcopenia in patients with T2DM. The developed risk scoring model demonstrated good discriminative ability within this single-center cohort and may serve as a preliminary tool for clinical risk stratification, but it requires validation in larger, independent samples.

INTRODUCTION

Diabetes mellitus is a prevalent chronic metabolic disorder influenced by genetic, environmental, and lifestyle related factors (Sun *et al.* 2023b). Type 2 diabetes mellitus (T2DM) accounts for approximately 90–95% of diabetes cases, and its global prevalence is projected to increase from 422 million in 2014 to 592 million by 2035, with substantial health and economic consequences (Demir *et al.* 2021; American Diabetes Association Professional Practice Committee, 2022; Xenos *et al.* 2026). Individuals with T2DM face an elevated risk of complications, including cardiovascular disease, renal failure, and vision loss, which contribute to higher healthcare expenditures and reduced quality of life (Demir *et al.* 2021).

Individuals with T2DM face an elevated risk of complications, including cardiovascular disease, renal failure, and vision loss, which in turn contribute to higher healthcare expenditures and a marked reduction in quality of life (Demir *et al.* 2021).

T2DM is a chronic metabolic disease characterized by insulin resistance and persistent hyperglycemia. Prolonged disruption of glucose homeostasis is closely associated with reductions in skeletal muscle mass and deterioration of muscle function, particularly among older adults with T2DM (Mesinovic *et al.* 2019). Evidence from studies on sarcopenia indicates that T2DM adversely affects muscle health through several interrelated pathophysiological mechanisms. These include impaired muscle protein synthesis secondary to insulin resistance, chronic low-grade inflammation, excessive accumulation of advanced glycation end products, and increased oxidative stress. Together, these metabolic disturbances compromise both the structural integrity and metabolic capacity of skeletal muscle, resulting in progressive losses of muscle mass and strength and, consequently, a heightened risk of sarcopenia in individuals with T2DM (Tang *et al.* 2025). The presence of sarcopenia in the context of T2DM is associated with a marked decline in quality of life, while the accompanying economic burden further contributes to reduced overall survival quality (Jiang *et al.* 2023).

Existing studies suggest that older adults with T2DM and concomitant sarcopenia face a significantly higher risk of developing dementia compared to their counterparts without sarcopenia. This association may be linked to multiple factors, including reduced levels of physical activity, impaired cerebral perfusion, neuroinflammation, alterations in neurotrophic signaling, and progressive neurodegeneration (Sun *et al.* 2023b; Kalinkovich & Livshits, 2017). In addition, studies conducted in the United States have identified an inverse J-shaped association between the skeletal muscle mass index and all-cause mortality among individuals with T2DM and sarcopenia, suggesting that abnormal muscle mass is associated with a significantly increased risk of death in this population (Zhao *et al.* 2025).

Previous research has demonstrated that sarcopenia is prevalent among adults with diabetes mellitus and is associated with disease progression, functional decline, and reduced quality of life. However, most studies have focused on older or heterogeneous populations and have described isolated risk factors rather than integrated tools. There is no practical, routine data–based instrument to identify adults with T2DM aged ≤ 65 years who are at risk of, or currently exhibit, sarcopenia. Developing a screening tool based on routinely available clinical parameters for rapid risk assessment and stratification may improve clinical workflows and facilitate timely intervention.

In this cross-sectional study, we applied least absolute shrinkage and selection operator (LASSO) regression followed by multivariable logistic regression to systematically assess clinical factors associated with sarcopenia in adults with T2DM. We then developed a nomogram-based risk scoring model using routinely collected anthropometric and laboratory indicators. The model is intended as an adjunctive screening tool to help clinicians rapidly identify adults with T2DM aged ≤ 65 years who may be at increased risk of sarcopenia and warrant further assessment of muscle function. The findings are anticipated to offer a practical basis for clinical risk stratification and to provide a foundation for future prospective studies focused on validating the predictive utility of the model.

MATERIAL AND METHODS

Study population and inclusion/exclusion criteria

A total of 81 patients with T2DM aged ≤ 65 years who received treatment at Huzhou Central Hospital between July 2023 and September 2025 were enrolled. This cohort represents a relatively younger T2DM population in whom early identification of sarcopenia is clinically relevant. All patients fulfilled the diagnostic criteria for diabetes mellitus as defined by the American Diabetes Association (ADA) in 2023 (American Diabetes Association Professional Practice Committee, 2022).

The exclusion criteria were as follows: (1) presence of severe hepatic insufficiency or moderate to severe renal insufficiency; (2) serious medical conditions, including malignant tumors involving multiple tissues or organ systems (such as the respiratory, digestive, nervous, hematologic, skeletal, and connective tissue systems), acute cerebral infarction, severe infections, or significant physical dysfunction; and (3) comorbid metabolic diseases (including hyperthyroidism, hypothyroidism, or parathyroid diseases), leukemia, or rheumatic and immune-mediated diseases. The study protocol was approved by the institutional Ethics Committee and written informed consent was obtained from all participants prior to enrollment.

Diagnostic criteria for sarcopenia

Sarcopenia was diagnosed in accordance with the criteria established by the Asian Working Group for Sarcopenia (Chen *et al.* 2020). Diagnosis required the presence of low appendicular skeletal muscle mass index (ASMI) and/or reduced handgrip strength in combination with reduced gait speed.

(1) Appendicular skeletal muscle mass (ASM) was measured using a body composition analyzer (InBody 770 model, manufacturer). ASM was defined as the sum of skeletal muscle mass in both the upper and lower limbs. ASMI was calculated by dividing ASM (kg) by height squared (m^2).
(2) Handgrip strength was assessed with a handgrip dynamometer. During testing, participants were seated with both feet resting naturally on the floor, knees flexed at 90°, and elbows bent at 90° and positioned adjacent to the torso. The forearms were maintained in a neutral position, and the wrists were positioned between 0° and 30° of extension. Three measurements were obtained from each hand, and the highest recorded value was used for analysis, expressed in kilograms.
(3) Physical performance was evaluated using the 6-meter walking test. A 12-meter straight walkway was delineated on level ground, with markers placed at the starting point, 3-meter, 9-meter, and the endpoint. Timing began as participants crossed the 3-meter mark and ended at the 9-meter mark. Each participant completed a minimum of three trials, with the fastest time selected as the final result.

Low ASMI was defined as 7.0 kg/m^2 in men and less than 5.7 kg/m^2 in women. Low handgrip strength was defined as < 28 kg for men and < 18 kg for women. Reduced gait speed was defined as < 1.0 m/s.

Grouping of cases

Based on the established diagnostic criteria for sarcopenia, participants were categorized into two groups: patients with T2DM without sarcopenia (n = 52; 42.31% women) and patients with T2DM and sarcopenia (n = 29; 58.62% women).

Data collection

General characteristics

All participants underwent an overnight fast of 8–10 hours. Anthropometric measurements, including height and body weight, were measured in the morning under fasting conditions, with participants minimally clothed and barefoot. Body mass index (BMI) was calculated as weight (kg) divided by height squared (m^2).

Laboratory Measurements

Following an 8–10 hour fast, venous blood samples were collected in the morning. Biochemical parameters, including fasting plasma glucose, triglycerides (TG), low-density lipoprotein cholesterol, high-density lipoprotein cholesterol (HDL-C), total cholesterol (TC), glycated hemoglobin (HbA1c), creatinine, uric acid, total bilirubin (TBIL), and albumin were measured using an automated biochemical analyzer (Roche, Switzerland).

Statistical analysis

Data with a normal distribution are expressed as mean ± standard deviation ($\bar{x} \pm s$) with corresponding sample size (percentage), whereas non-normally distributed data are reported as median (P25, P75) and sample size (percentage). Comparisons of normally distributed continuous variables were performed using the independent samples t-test, while non-parametric tests were used for skewed continuous data. Categorical variables were analyzed using the chi-squared test.

Because several clinical variables were right-skewed, continuous predictors were initially log-transformed using a base 10 function ($\log_{10}$) before inclusion in the logistic regression models. For descriptive tables and clinical interpretation, transformed values were mapped back to their corresponding cut-off points in the original measurement units where relevant. This approach was adopted to reduce the impact of outliers, improve model stability, and facilitate the comparison of effect sizes in multivariate analysis. No missing data were encountered during the transformation process, and the transformed variables were dimensionless.

To preserve clinical interpretability and avoid complexity associated with transformed variables, key predictors identified during preliminary screening (univariate analysis and LASSO regression) were converted into binary variables. Cut-off values were determined by combining clinical judgment with optimal thresholds derived from ROC curve analysis. As a result, all variables incorporated into the final multivariate logistic regression model and nomogram construction were either binary or retained in clinically meaningful units.

Model performance was assessed in terms of discrimination, calibration, and clinical applicability using ROC curves, calibration plots, and decision curve analysis (DCA), respectively. Internal validation was performed using the bootstrap resampling with 1,000 iterations. Statistical significance was defined as $p < 0.05$, and all p values were two-tailed. All statistical analyses were conducted using GraphPad Prism and R software.

RESULTS

Comparison of general characteristics between T2DM patients with and without sarcopenia

A total of 81 patients with T2DM aged ≤ 65 years were included in the analysis, with a median age of 55 years (interquartile range [IQR] 46–60). Of these, 52 participants (64%) were classified as having T2DM without

Tab. 1. Clinical characteristics of participants with type 2 diabetes mellitus (T2DM) with and without sarcopenia

Variable	T2DM without sarcopenia (n = 52)	T2DM with sarcopenia (n = 29)	*p*-value
Age (years)	53(41,59.25)	56(52.5,60.5)	0.0303
Female (%)	22(42.31)	17(58.62)	0.189
FPG	0.87±0.15	0.89±0.15	0.6288
Triglycerides	0.11±0.26	0.17±0.32	0.3247
LDL-C	0.36±0.14	0.40±0.16	0.3174
HDL-C	0.08±0.10	0.03±0.08	0.0266
CHO	0.63±0.08	0.66±0.11	0.3127
HbA1c	0.88(0.83,0.97)	0.97±0.12	0.0073
Creatinine	1.84±0.08	1.83±0.07	0.4323
Uric acid	2.46±0.12	2.45±0.14	0.8378
Total bilirubin	1.08(1.00,1.23)	1.12±0.20	0.4728
Albumin	1.64±0.03	1.61±0.05	0.025
Grip strength	1.46±0.13	1.32±0.18	0.0002
Gait speed	-0.08±0.10	-0.08±0.07	0.0359
Height	2.22±0.02	2.21±0.02	0.0024
SMI	0.86±0.05	0.79(0.74,0.84)	<0.001
BMI	1.38±0.05	1.36±0.05	0.0419

Continuous variables are presented after $\log_{10}$ transformation where applicable; higher values correspond to higher original measurements in the corresponding clinical units.

Tab. 2. Optimal cut off values of continuous variables for predicting sarcopenia in patients with type 2 diabetes mellitus (T2DM)

Variable	AUC (95% CI)	*p*-value	Optimal Cut-off	Sensitivity (%)	Specificity (%)	Youden Index
Age (years)	0.645(0.523-0.767)	0.031	1.70	0.862	0.442	0.304
Height	0.703(0.579-0.827)	0.003	2.20	0.552	0.827	0.379
HDL-C	0.648(0.525-0.771)	0.028	0.05	0.690	0.577	0.267
HbA1c	0.679(0.559-0.800)	0.008	0.85	0.897	0.404	0.300
Albumin	0.635(0.498-0.772)	0.045	1.60	0.379	0.923	0.302
BMI	0.610(0.484-0.737)	0.101	1.36	0.552	0.673	0.224

Optimal cut off values of $\log_{10}$ transformed continuous variables for discriminating sarcopenia status in patients with T2DM. Corresponding clinical cut off values in the original measurement units were used in the multivariable logistic regression model.

Tab. 3. Multivariable logistic regression analysis of independent predictors of sarcopenia in patients with type 2 diabetes mellitus (T2DM) (n = 81)

Variable	β (Coefficient)	Standard Error	*p*-value	OR (Odds Ratio)	OR (Odds Ratio)
HDL-C	-3.0530	1.4460	0.0347	0.0472	(0.002,0.648)
HbA1c	0.3777	0.1608	0.0188	1.4590	(1.088,2.062)
Height	-0.1165	0.0392	0.0029	0.8900	(0.819,0.957)
BMI	-0.4272	0.1349	0.0015	0.6523	(0.487,0.831)

sarcopenia and 29 (36%) as having T2DM with sarcopenia. Compared with the non-sarcopenia group, patients with sarcopenia were older, more often women, and had lower BMI and shorter stature (all $p < 0.05$). They also had lower HDL-C and serum albumin levels and higher HbA1c concentrations (Table 1).

Univariate analysis of factors associated with sarcopenia in T2DM

In comparison with the non-sarcopenia group, patients with T2DM and concomitant sarcopenia exhibited statistically significant differences in HDL-C, HbA1c, albumin levels, height, age, and BMI (all $p < 0.05$). ROC curve analysis was subsequently conducted to evaluate

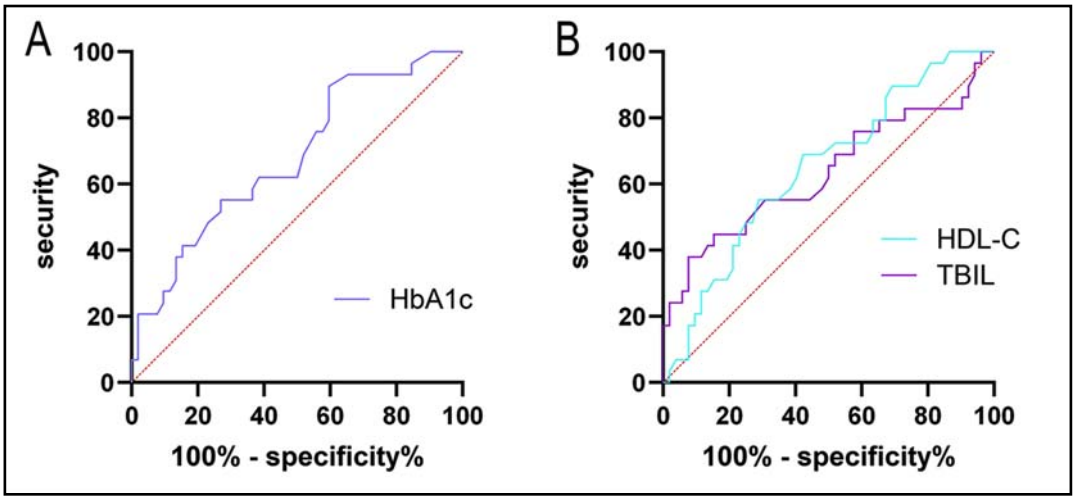

Fig. 1. Receiver operating characteristic (ROC) curves of glycated hemoglobin (HbA1c), high density lipoprotein cholesterol (HDL C), and total bilirubin (TBIL) for predicting sarcopenia in patients with type 2 diabetes mellitus (T2DM). Panel A shows the ROC curve for HbA1c, and panel B shows ROC curves for HDL C and TBIL.

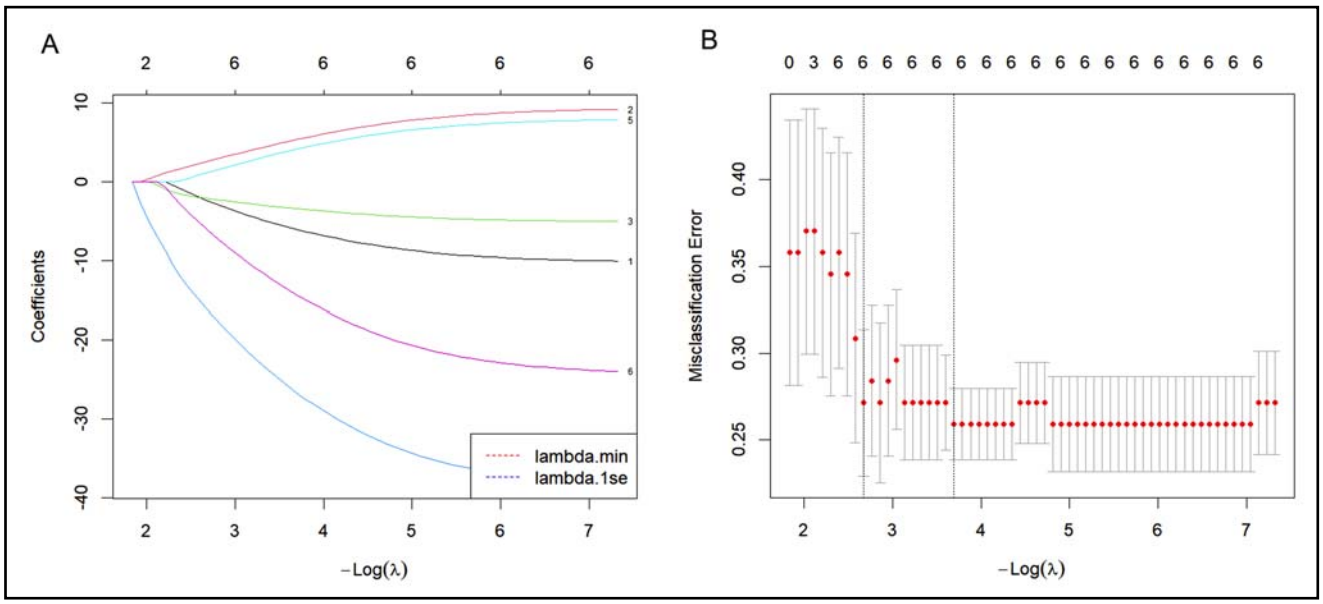

Fig. 2. Least absolute shrinkage and selection operator (LASSO) regression analysis for variable selection. Panel A shows coefficient profiles of candidate predictors as a function of the regularization parameter (log λ). Panel B shows the ten fold cross validation curve used to select the optimal penalty parameter. The dashed lines indicate λmin (left) and the λ1 SE criterion (right); the λ1 SE value was chosen for model construction.

the diagnostic efficacy of HDL-C, albumin, and HbA1c in identifying sarcopenia among patients with T2DM.

As shown in Figure 1A, HbA1c demonstrated an area under the curve (AUC) of 0.679 (95% CI 0.559–0.800, p = 0.008), with 89.7% sensitivity and 40.4% specificity at the optimal threshold. Among the evaluated biomarkers, HDL-C exhibited the largest AUC (0.648; 95% CI 0.525–0.771, p = 0.028), with 69.0% sensitivity and 57.7% specificity for distinguishing between patients with and without sarcopenia (Figure 1B).

Detailed results of the ROC curve analyses are summarized in Table 2. Optimal cut-off values for variables such as HDL-C, HbA1c, height, and BMI were determined based on the maximum Youden's index derived from the ROC curves. The corresponding optimal thresholds identified in this study were 0.05 for $\log_{10}$(HDL-C), 0.85 for $\log_{10}$(HbA1c), 2.20 for $\log_{10}$(height), and 1.36 for $\log_{10}$(BMI); based on these values, the clinically meaningful cut-offs used in the final model were HDL-C < 1.14 mmol/L, HbA1c > 7.05%, height < 1.58 m, and BMI < 23.05 kg/m² (Tables 2 and 3).

Identification of risk factors for sarcopenia in T2DM

Variables demonstrating statistical significance in the univariate analysis were included in the LASSO regression model. As the log-transformed penalty parameter (log λ) increased, the regression coefficients of less contributory variables approached zero. The optimal penalty parameter (λ) was selected using 10-fold cross-validation. In this analysis, the left and right dashed lines represent λmin (λ = 0.0630, log λ = −2.76) and λ1 SE (λ = 0.0914, log λ = −2.39), respectively. We selected the λ1 SE value as the optimal parameter for model construction to obtain a more parsimonious model (Figure 2).

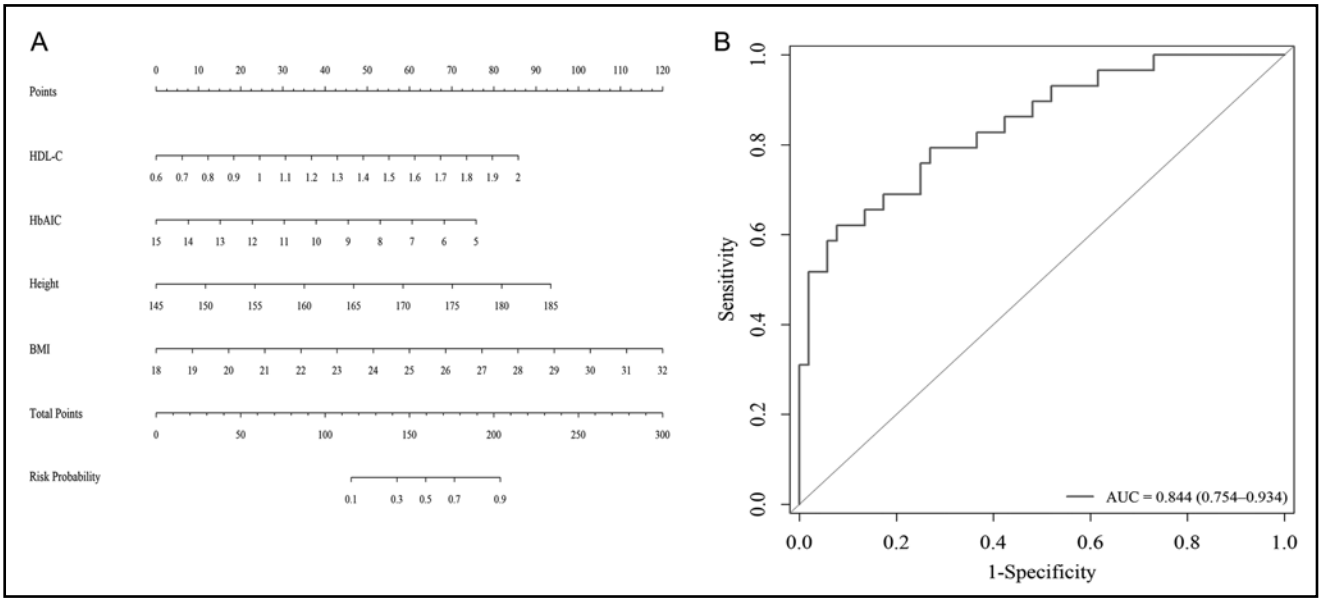

Fig. 3. Nomogram-based sarcopenia risk scoring model and its discriminative performance in patients with T2DM. Panel A presents the nomogram incorporating HDL C, HbA1c, height, and BMI. Panel B shows the receiver operating characteristic (ROC) curve of the final model.

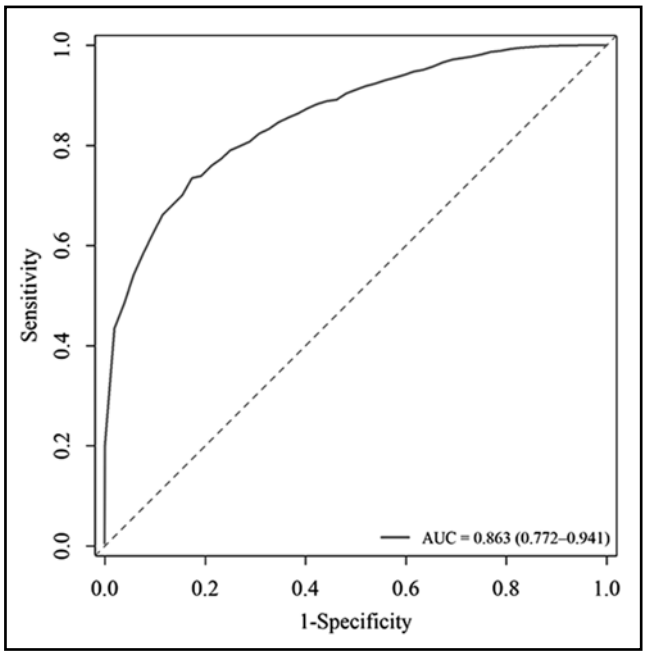

Fig. 4. Receiver operating characteristic (ROC) curve of the sarcopenia risk scoring model obtained from internal bootstrap validation with 1,000 resamples.

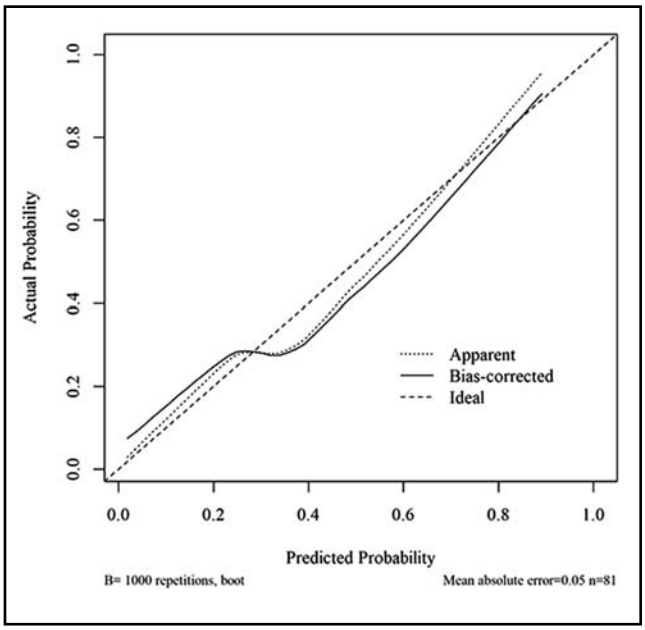

Fig. 5. Calibration curve of the nomogram-based sarcopenia risk scoring model showing agreement between predicted and observed probabilities of sarcopenia.

Based on this criterion, six predictors were retained (HDL-C, HbA1c, TBIL, BMI, height, and age) and entered into a multivariate logistic regression model using a forward stepwise approach. In the final model, HDL-C < 1.14 mmol/L, HbA1c > 7.05%, height < 1.58 m, and BMI < 23.05 kg/m² emerged as independent risk factors for sarcopenia in patients with T2DM.

Development, evaluation, and validation of the sarcopenia risk scoring model

A nomogram was constructed based on the identified risk factors to visually estimate the probability of sarcopenia among patients with T2DM (Figure 3A). Model discrimination was assessed using ROC curve analysis, which demonstrated an AUC of 0.844 (95% CI 0.754–0.934) in the derivation cohort, indicating good apparent discriminative performance (Figure 3B).

Internal validation using bootstrap resampling with 1,000 iterations yielded an optimism corrected AUC

of 0.863 (95% CI 0.772–0.941), supporting the internal stability of the model within this sample (Figure 4). Calibration assessment showed good agreement between predicted and observed probabilities of sarcopenia (Figure 5). Decision curve analysis demonstrated favorable net clinical benefit across threshold probabilities from 0.08 to 0.97, suggesting potential clinical utility for risk stratification of sarcopenia in patients with T2DM, pending confirmation in external cohorts (Figure 6).

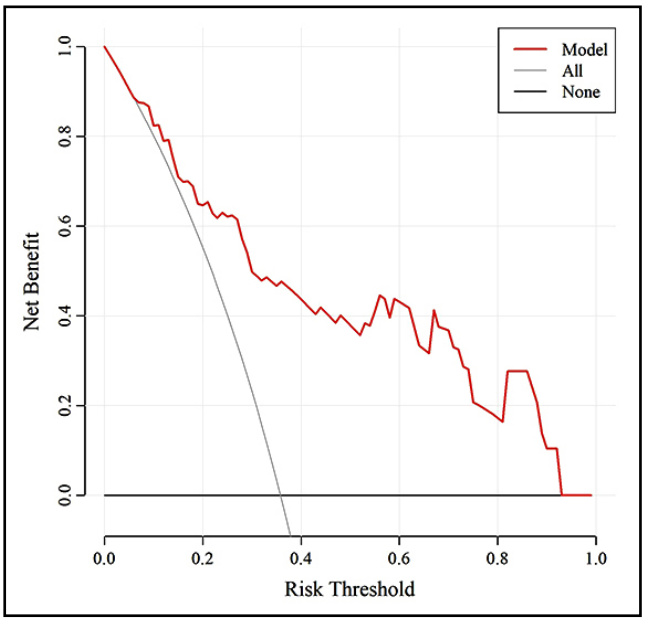

Fig. 6. Decision curve analysis (DCA) of the nomogram-based sarcopenia risk scoring model based on 1,000 bootstrap resamples, illustrating the net clinical benefit across a range of threshold probabilities.

DISCUSSION

In this cross-sectional study, we analyzed 81 patients with T2DM aged ≤ 65 years (median 55 years; IQR 46–60). Among them, 52 patients (64%) were classified as having T2DM without sarcopenia and 29 patients (36%) were identified as having concomitant sarcopenia. Compared with the non-sarcopenia group, patients in the sarcopenia group were older, had lower BMI, shorter stature, and a higher proportion of women.

Using LASSO regression followed by multivariable logistic regression, four independent predictors of sarcopenia in patients with T2DM were identified: HDL-C < 1.14 mmol/L, HbA1c > 7.05%, height < 1.58 m, and BMI < 23.05 kg/m² (all $p < 0.05$). ROC curve analysis further demonstrated moderate discriminative ability for HbA1c and HDL-C, with AUCs of 0.679 and 0.648, respectively, suggesting their clinical relevance as biomarkers for identifying individuals at risk of sarcopenia in the context of T2DM.

Age demonstrated borderline statistical significance in the multivariable logistic regression analysis, with a p-value of 0.055 (Table 3). This finding may be attributable to the limited sample size and the relatively narrow age distribution, which was skewed towards older adults. Such constraints can introduce variability in model estimates, resulting in wider confidence intervals and reduced statistical significance. However, sarcopenia is a progressive condition that is closely associated with advancing age and is characterized by a gradual reduction in skeletal muscle mass and/or muscle strength. As age increases, adipose tissue progressively accumulates within skeletal muscle and bone marrow, altering body composition and contributing to decline in both muscle mass and bone mineral density (Wang *et al.* 2020).

HDL-C may serve as a protective factor against the development of sarcopenia in patients with T2DM. The present findings are consistent with those reported by Wang *et al.* (2024), who observed that serum HDL-C levels were associated with incident sarcopenia in a 4-year longitudinal cohort of middle-aged and older Chinese adults. Similarly, an investigation involving 3,483 older participants from the Korea National Health and Nutrition Examination Survey identified that high levels of TC and TG, together with low HDL-C, as independent risk factors for sarcopenic obesity in males (Baek *et al.* 2014). The protective role of HDL-C may be mediated through several biological mechanisms, such as anti-inflammatory properties, enhancement of insulin sensitivity, and facilitation of reverse cholesterol transport (Lund *et al.* 2024; Siebel *et al.* 2015; Von Bank *et al.* 2021). Although these intermediary pathways were not directly assessed in this study, the findings underscore the clinical significance of HDL-C as a potential marker of muscle health in patients with T2DM. Further research incorporating inflammatory and metabolic biomarkers is warranted to clarify the specific mechanisms linking HDL-C and sarcopenia in the diabetic population.

HbA1c is a key biomarker in the management of diabetes mellitus and is routinely used to evaluate long-term glycemic status. Incremental increases in HbA1c have been shown to correlate inversely with total lean body mass, including appendicular and trunk skeletal muscle (Kalyani *et al.* 2014; Truijen *et al.* 2021). Prior investigations have demonstrated a close association between HbA1c levels, nutritional status, and muscle health in older adults with diabetes. On one hand, abnormally low HbA1c levels may reflect underlying malnutrition, which can contribute to reductions in skeletal muscle mass and body weight, thereby increasing the risk of sarcopenia in older populations (Yoon *et al.* 2016). On the other hand, elevated HbA1c levels indicate insulin resistance and poor glycemic control (Lin *et al.* 2021), conditions that may exacerbate muscle atrophy by promoting

protein degradation while suppressing muscle protein synthesis.

The findings of the present analysis are consistent with the longitudinal results reported by Lin *et al.* (2021), in which elevated HbA1c levels were significantly associated with an increased risk of sarcopenia among individuals with T2DM. In addition, a study by Chang *et al.* (2021) demonstrated that elevated HbA1c levels were linked to increased severity of albuminuria, a clinical indicator of systemic metabolic disturbances and microvascular damage, factors that may further contribute to the progression of sarcopenia. Collectively, these observations underscore the importance of HbA1c as a marker of metabolic disturbance with potential prognostic utility for the early detection and risk stratification of sarcopenia in individuals with T2DM (Wang & Gao, 2024; Yamada *et al.* 2023).

In the present analysis, both height and BMI were associated with sarcopenia, with shorter stature and lower BMI independently linked to increased risk of sarcopenia. Height serves as an important anatomical determinant of skeletal muscle mass, as greater stature is generally associated with a higher muscle reserve . Within the T2DM cohort, shorter stature may reflect a lower peak muscle mass, which could predispose individuals to an earlier onset of sarcopenia when exposed to metabolic stressors such as chronic hyperglycemia.

Notably, BMI was significantly lower among patients with sarcopenia, a finding consistent with the observations reported by Yamada *et al.* (2023). Although elevated BMI is considered a risk factor for numerous chronic conditions, accumulating evidence suggests that BMI values within the normal range may confer a protective effect against sarcopenia (Yamada *et al.* 2023). This phenomenon, often referred to as the "obesity paradox," implies that greater body mass may be associated with more favorable outcomes in certain clinical contexts (Barrett *et al.* 2020). Previous studies suggest that a higher BMI within the normal range may represent better nutritional reserves and, consequently, greater muscle reserves (Imai *et al.* 2008; Bahat *et al.* 2012; Alfaro-Alvarado *et al.* 2023). In contrast, excessive obesity may impair muscle function through pathways such as chronic low-grade inflammation, lipotoxicity, and insulin resistance (Galicia-Garcia *et al.* 2020; Sun *et al.* 2023a). These findings highlight the complex pathophysiological mechanisms between obesity and sarcopenia, involving hormonal regulation, inflammatory pathways and physical activity (Imai *et al.* 2008). Further mechanistic studies are needed to clarify the underlying pathways linking body composition and sarcopenia.

The nomogram developed in this study demonstrated good discriminative performance, with an AUC of 0.844 (95% CI 0.754–0.934). Internal validation using bootstrap resampling (1,000 iterations) indicated robust discrimination and calibration, and decision curve analysis confirmed a net clinical benefit across a wide range of threshold probabilities. Collectively, these findings suggest that the proposed risk scoring system may serve as a practical tool for assessing the risk of sarcopenia in clinical settings and may help optimize patient specific treatment strategies.

This study characterized clinical features associated with sarcopenia in patients with T2DM and established a preliminary risk scoring model derived from routinely collected clinical parameters within a single-center cohort. Within this single-center cohort, the model demonstrated acceptable discriminatory performance and may serve as an adjunctive screening tool for identifying patients with T2DM who are at elevated risk of sarcopenia. The findings may help to inform risk stratification strategies and support earlier consideration of sarcopenia assessment in clinical practice, although prospective studies are required to determine their impact on patient outcomes. Future research should aim to expand the sample size and incorporate data from multiple centers to enable external validation and to strengthen the model's performance and generalizability.

Several limitations should be acknowledged. First, the overall sample size was relatively small, with only 29 patients in the sarcopenia group. This may contribute to model instability, increase the risk of overfitting, and reduce the precision of the estimated odds ratios; therefore, the findings and the risk scoring model should be regarded as preliminary. Second, all patients were recruited from a single medical center, which may limit the generalizability of the model to other clinical settings or populations, and highlights the need for validation in larger, independent cohorts. Third, the cross-sectional design precludes determination of temporal relationships or causality between the identified risk factors and sarcopenia, and longitudinal studies are needed to evaluate the model's predictive performance over time. Finally, the study did not include detailed measurements of inflammatory biomarkers, hormonal profiles, or molecular markers of muscle metabolism, which restricts exploration of the underlying mechanisms linking HDL-C, HbA1c, body size, and sarcopenia within this cohort.

DECLARATIONS

Ethics approval and consent to participate

This study was conducted with approval from the Ethics Committee of Huzhou Central Hospital (Approval Number: 202209026-01) and in accordance with the Declaration of Helsinki. Written informed consent was obtained from all participants.

Consent for publication

Not applicable.

Conflict of interests

The authors declare that they have no conflict of interests.

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Availability of data and materials

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

Authors' contributions

Ru-Le Shen: Conceptualization, Formal Analysis, Software, Writing – original draft. Shu-Ying Zheng: Formal Analysis, Writing – original draft, Writing – review & editing. Xiao-Xi Zhou: Formal Analysis, Software. Ling Liu: Data curation, Software. Chao Tang: Data curation, Writing – review & editing. Zhang-Ning Zhou: Data curation, Formal Analysis. Xiao-Hui Zhou: Conceptualization, Data curation, Funding acquisition, Writing – original draft, Writing – review & editing. All authors read and approved the final draft.

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Not applicable.

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