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Original Article

Association of magnesium depletion score, triglyceride-glucose index, and C-reactive protein-albumin-lymphocyte index with diabetic sarcopenia: a cross-sectional study based on NHANES 2014-2018 data

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Abstract: Objective: To evaluate the predictive performance of three novel biomarkers - magnesium depletion score (MDS), triglyceride-glucose index (TyG), and C-reactive protein-albumin-lymphocyte index (CAL) - for diabetic sarcopenia. Methods: Data were obtained from 1,318 adult patients with type 2 diabetes mellitus (T2DM) from the National Health and Nutrition Examination Survey (NHANES) database (2014-2018). Sarcopenia was diagnosed according to the criteria of the European Working Group on Sarcopenia in Older People 2 (EWGSOP2), based on skeletal muscle mass index measured by dual-energy X-ray absorptiometry combined with grip strength and gait speed. Multivariate logistic regression analysis was performed, and receiver operating characteristic (ROC) curves with area under the curve (AUC) were used to compare and analyze the predictive efficacy of MDS, TyG, and CAL for diabetic sarcopenia. Results: The prevalence of diabetic sarcopenia was 22.1%. Levels of MDS, TyG, and CAL differed significantly between the sarcopenia and non-sarcopenia groups (all $P < 0.05$). Multivariate analysis identified age, body mass index, disease duration, MDS, TyG, and CAL as independent factors associated with sarcopenia in patients with T2DM. ROC curve analysis showed that the combined model incorporating MDS, TyG, and CAL achieved an AUC of 0.925 for identifying sarcopenia. Conclusion: Sarcopenia in T2DM patients is associated with baseline clinical characteristics. MDS, TyG, and CAL are independent factors associated with diabetic sarcopenia and demonstrate strong potential for its early identification.

Keywords: Diabetic sarcopenia, magnesium depletion score, triglyceride-glucose index, C-reactive protein-albumin-lymphocyte index level, prediction efficiency

Introduction

Diabetic sarcopenia, as one of the common chronic complications of diabetes, has gradually attracted clinical attention in recent years. Sarcopenia was initially defined as age-related progressive, extensive skeletal muscle mass and functional decline; however, increasing evidence shows that chronic metabolic disorders, especially type 2 diabetes mellitus (T2DM), can accelerate the occurrence and development of sarcopenia [1, 2]. Diabetic sarcopenia not only exacerbates glucose metabolism and increases the risk of falls and fractures, but is also closely associated with cardiovascular events, reduced quality of life, and increased all-cause mortality [3, 4]. With the rising global prevalence of diabetes, diabetic sarcopenia has emerged as a significant comorbidity affecting patient prognosis, imposing a heavy burden on public health systems [5].

The pathogenesis of diabetic sarcopenia has not been fully elucidated. Existing research suggests that insulin resistance represents a key pathological link between diabetes and sarcopenia [6]. Insulin resistance impairs skeletal muscle protein synthesis while promoting degradation and further aggravates muscle loss by inducing chronic low-grade inflammation, mitochondrial dysfunction, and oxidative stress [7, 8]. In addition, disturbances in mag-

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nesium metabolism have been shown to be closely associated with insulin resistance and muscle function. Magnesium deficiency can reduce insulin sensitivity and enhance inflammatory responses, thereby contributing to the occurrence of sarcopenia [9]. However, serum magnesium concentration is influenced by multiple factors, including renal regulation and dietary intake, limiting their ability to accurately reflect the body's overall magnesium status.

In recent years, the magnesium depletion score (MDS) has been proposed as a composite indicator that integrates multiple factors affecting magnesium metabolism, providing a more comprehensive assessment of magnesium deficiency risk. Compared to serum magnesium alone, MDS incorporates multidimensional information, including dietary magnesium intake, renal magnesium excretion capacity, and diuretic use, enabling more accurate identification of individuals at high risk for magnesium deficiency. MDS has been demonstrated to be significantly associated with insulin resistance, T2DM, and cardiovascular disease, highlighting its potential clinical use in metabolic diseases.

The triglyceride-glucose (TyG) index, as a surrogate marker of insulin resistance, has been widely used in the field of cardiovascular and metabolic disease research [10]. Studies have confirmed that an elevated TyG index is closely associated with the risk of T2DM, nonalcoholic fatty liver disease, and atherosclerosis; however, its expression pattern and predictive value in diabetic sarcopenia remain underexplored [11]. Furthermore, the interaction between inflammation and nutritional status plays an important role in the pathogenesis of sarcopenia. The C-reactive protein-albumin-lymphocyte (CAL) index has been proposed as an integrated indicator reflecting inflammatory burden, nutritional reserve, and immune status, and has been associated with poor prognosis in various chronic diseases [12]. Nevertheless, its clinical value in diabetic sarcopenia remains limited.

Given the above considerations, the present study utilized data from the National Health and Nutrition Examination Survey (NHANES) 2014-2018 database to systematically evaluate the independent and combined predictive value of MDS, TyG index, and CAL for diabetic sarcopenia, aiming to provide new evidence-based insights and practical assessment tools for the early identification and clinical intervention of diabetic sarcopenia.

Materials and methods

Study population

Data for this study were obtained from the NHANES database (https://wwwn.cdc.gov/nchs/nhanes/). Patients with diabetes from the 2014-2018 survey cycles were selected as the study subjects. This study was approved by the National Center for Health Statistics (NCHS) Ethics Review Committee, and all respondents have signed informed consent.

Inclusion criteria: (1) age ≥ 20 years old; (2) meeting the diagnostic criteria for diabetes [13]; (3) availability of complete data on demographic characteristics, laboratory indicators, muscle mass, and functional assessments. Exclusion criteria: (1) age < 20 years old; (2) presence of severe organ failure, malignant tumors, or acute infections; (3) pregnancy or lactation; (4) missing data on key indicators.

Finally, a total of 1,318 eligible adult patients with diabetes were included in this study. All NHANES data used in this study are publicly available and de-identified, with no involvement of personal privacy information.

Clinical data collection and grouping

General data collection: Basic characteristics of the participants were collected from the NHANES database, including age, sex, race, poverty income ratio (PIR), educational level, smoking status, alcohol consumption, duration of diabetes, and use of hypoglycemic drugs. According to the diagnostic criteria of sarcopenia, the 1,318 diabetic patients were divided into a sarcopenia group (n=291) and a non-sarcopenia group (n=1027).

Diagnostic criteria for sarcopenia: According to the 2019 Asian Working Group for Sarcopenia (AWGS) diagnostic criteria, participants were diagnosed with sarcopenia if they met all of the following conditions: (1) decreased appendicular skeletal muscle mass index (ASMI): male < 7.0 kg/m^2, female < 5.4 kg/m^2; (2) Reduced

grip strength: male < 28 kg, female < 18 kg; (3) Reduced gait speed: < 1.0 m/s.

Laboratory measurements

All blood samples were collected after an overnight fast on the morning of the examination day and were processed in strict accordance with standardized NHANES protocols.

MDS: In this study, the MDS was calculated as the sum of four dichotomous variables reflecting the following components: low dietary magnesium intake (below sex-specific recommended daily allowances), impaired renal function (estimated glomerular filtration rate < 60 mL/min/1.73 m^2), use of diuretics (thiazide or loop diuretics), and use of proton pump inhibitors. Each component was assigned 1 point, yielding a total MDS ranging from 0 to 4, with higher scores indicating a greater risk of magnesium depletion.

TyG index: The TyG index was calculated using the formula: TyG = ln [triglyceride (mg/dL) × fasting glucose (mg/dL)/2], where both triglyceride and fasting glucose levels were obtained from NHANES laboratory data [13].

CAL index: The CAL index calculated as follows: CAL = (hypersensitive C-reactive protein (mg/L) ×100)/(albumin (g/L) × lymphocyte count ($\times 10^9$)/L). This index comprehensively reflects combined status of systemic inflammation, nutritional reserve, and immune function. Higher values indicate more severe imbalance between inflammation and nutrition.

Statistical analysis

SPSS 26.0 statistical software and R software (version 4.2) were used for data analyses. Considering the complex, multistage, stratified cluster sampling design of the NHANES, all analyses were conducted in accordance with the guidelines recommended by the NCHS. Sampling weights (WTDR2D), stratification variables (SDMVSTRA), and clustering variables (SDMVPSU) were incorporated to generate nationally representative estimates. Survey-weighted analyses were performed using the *survey* package in R.

The normality of continuous variables was assessed using the Shapiro-Wilk test. Variables conforming to a normal distribution were expressed as mean ± standard deviation (SD), and comparisons between two groups were performed using the weighted independent sample t-test. Measured data not conforming to a normal distribution were expressed as median (interquartile range) [M (P25, P75)], and comparisons between groups were performed using the weighted Mann-Whitney U test. Enumerated data were expressed as counts and percentages [n (%)], and comparisons between groups were performed using the weighted chi-square test or Fisher's exact test, as appropriate.

Univariate analysis was first performed to identify potential factors associated with diabetic sarcopenia. Variables with $P < 0.10$ in univariate analysis were considered candidates for inclusion in the multivariate analysis. Before conducting multivariate Logistic regression analysis, multicollinearity among the independent variables was assessed using the variance inflation factor (VIF), with VIF < 10 indicating no significant multicollinearity. Multivariate logistic regression analysis with forward stepwise selection was used to identify independent risk factors for diabetic sarcopenia. The entry criterion for variable inclusion was set at $\alpha=0.05$, and the removal criterion was set at $\alpha=0.10$. Odds ratios (OR) and 95% confidence intervals (CI) were calculated.

Receiver operating characteristic (ROC) curves were constructed to evaluate the predictive performance of each individual index and the combined model, and the area under the curve (AUC) was calculated. A nomogram was developed based on the independent risk factors identified in the multivariate logistic regression analysis. Internal validation was performed using bootstrap resampling with 1,000 iterations to assess model performance. The AUC was calculated to evaluate discriminative ability, and calibration curves were plotted to assess the agreement between predicted and observed probabilities. A two-sided *P* value of < 0.05 was considered significant.

Results

Prevalence of diabetic sarcopenia

A total of 1,318 adult patients with diabetes were included in this study. Among them, 291

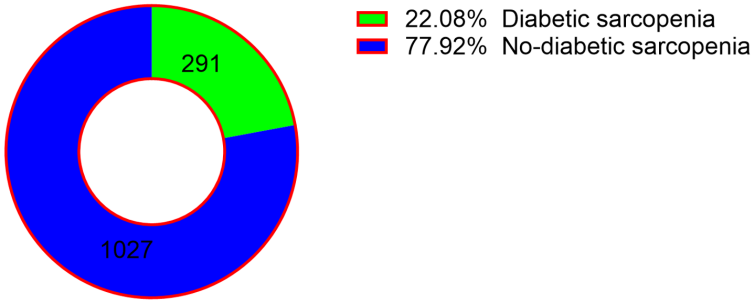

Figure 1. Prevalence of diabetic sarcopenia in the study population.

patients were diagnosed with diabetic sarcopenia, yielding an overall prevalence of 22.1% (**Figure 1**).

Comparison of baseline characteristics between the two groups

As shown in **Table 1**, compared to the non-sarcopenia group, patients in the sarcopenia group were significantly older (56.2 ± 13.5 years vs. 53.8 ± 14.1 years, P=0.007), had a significantly lower BMI (25.1 ± 4.2 kg/m^2 vs. 28.3 ± 4.4 kg/m^2, P=0.001), and had a significantly longer duration of diabetes (8.5 ± 5.5 years vs. 7.8 ± 5.4 years, P=0.049). No significant differences were observed between the two groups in sex, glycated hemoglobin, fasting blood glucose, systolic blood pressure, diastolic blood pressure, smoking history, drinking history, hypertension, or coronary heart disease (all P > 0.05).

Comparison of MDS, TyG, and CAL between the two groups

As presented in **Table 2**, the levels of MDS, TyG and CAL were significantly higher in the sarcopenia group than in the non-sarcopenia group (all P < 0.05).

Univariate and multivariate analyses of factors associated with diabetic sarcopenia

Univariate logistic regression analysis was first performed with sarcopenia as the dependent variable (**Tables 3**, **4**). The results showed that age, BMI, duration of diabetes, smoking history, coronary heart disease, MDS, TyG, and CAL were significantly associated with diabetic sarcopenia (all P < 0.05).

Variables that were significant in the univariate analysis were included in the multivariate logistic regression model (**Table 5**), and the confounding factors were adjusted. The results demonstrated that age (OR=1.028, 95% CI: 1.010-1.047, P=0.002), BMI (OR=0.868, 95% CI: 0.835-0.903, P < 0.001), duration of diabetes (OR=1.079, 95% CI: 1.050-1.109, P < 0.001), MDS (OR=1.702, 95% CI: 1.405-2.062, P < 0.001), TyG (OR=1.931, 95% CI: 1.550-2.405, P < 0.001), and CAL (OR=2.063, 95% CI: 1.593-2.672, P < 0.001) were independently associated with diabetic sarcopenia. Among them, the CAL index exhibited the strongest association with sarcopenia, as indicated by the highest OR.

Validation of the nomogram prediction model for diabetes sarcopenia

A nomogram prediction model for diabetic sarcopenia was further constructed based on age, BMI, duration of diabetes, MDS, TyG, and CAL. In this nomogram prediction model, each predictor was assigned a corresponding score, and the total score was calculated by summing the individual scores. The predicted probability of diabetic sarcopenia could then be determined based on the total score (**Figure 2**).

ROC curve analysis demonstrated that the model achieved an AUC of 0.925 (95% CI: 0.861-0.990), indicating excellent discriminative ability (**Figure 3**).

Internal validation and clinical utility of the prediction model for diabetes sarcopenia

The internal validation of the prediction model was assessed using goodness-of-fit analysis, calibration curves, and decision curve analysis (DCA).

As shown in **Figure 4**, the agreement between predicted and observed values was evaluated using a scatter plot with a fitted regression line. The results demonstrated a strong correlation (R^2=0.915), indicating good overall consistency between model predictions and observed outcomes.

The Hosmer-Lemeshow goodness-of-fit test yielded a chi-square value of 9.774 (P=0.283), suggesting an adequate model fit.

Table 1. Comparison of baseline data of diabetic patients between sarcopenia group and non-sarcopenia group

Indicator	Sarcopenia group (n=291)	Non-sarcopenia group (n=1027)	Statistical value	*P* value
Age (years)	56.2 ± 13.5	53.8 ± 14.1	2.712	0.007
Gender (male, %)	152 (52.2)	539 (52.5)	0.008	0.931
BMI (kg/m^2)	25.1 ± 4.2	28.3 ± 4.4	-8.712	0.001
Glycosylated hemoglobin (%)	7.4 ± 1.4	7.4 ± 1.4	0.000	1.000
Fasting blood glucose (mmol/L)	8.1 ± 2.2	8.0 ± 2.2	0.689	0.491
Duration of diabetes (years)	8.5 ± 5.5	7.8 ± 5.4	1.965	0.049
Systolic blood pressure (mmHg)	133.8 ± 16.2	133.2 ± 16.4	0.552	0.581
Diastolic blood pressure (mmHg)	79.6 ± 11.0	79.8 ± 11.2	-0.271	0.786
Smoking history (n, %)	124 (42.6)	437 (42.6)	0.000	0.986
Alcohol consumption history (n, %)	167 (57.4)	587 (57.2)	0.005	0.943
Hypertension (n, %)	176 (60.5)	611 (59.5)	0.093	0.760
Coronary heart disease (n, %)	46 (15.8)	156 (15.2)	0.067	0.796

Table 2. Comparison of MDS, TyG, and CAL between the two groups

Indicator	Sarcopenia group (n=291)	Non-sarcopenia group (n=1027)	Statistical	*P* value
MDS	3.42 ± 0.86	2.15 ± 0.74	24.316	< 0.001
TyG	9.38 ± 0.65	8.74 ± 0.59	15.842	< 0.001
CAL	1.86 ± 0.53	1.21 ± 0.42	21.573	< 0.001

Notes: MDS, Magnesium depletion score; TyG, Triglyceride-glucose index; CAL, C-reactive protein-albumin-lymphocyte index.

Table 3. Variable assignment

Variable	Assignment
Dependent Variable	
Sarcopenia	0 = No, 1 = Yes
Independent Variables	
Age	Continuous variable (years)
BMI	Continuous variable (kg/m^2)
Duration of diabetes	Continuous variable (years)
Drinking	0 = No, 1 = Yes
CHD	0 = No, 1 = Yes
MDS	Continuous variable
TyG	Continuous variable
CAL	Continuous variable

Notes: BMI, body mass index; MDS, Magnesium depletion score; TyG, Triglyceride-glucose index; CAL, C-reactive protein-albumin-lymphocyte index.

The calibration performance of the model was further evaluated using a calibration curve (**Figure 5**). The results showed that the predicted probabilities were closely aligned with the observed probabilities, indicating good calibration and agreement between predicted and actual outcomes.

Finally, decision curve analysis (DCA) (**Figure 6**) demonstrated that the model provided a positive net benefit across a wide range of threshold probabilities, supporting its potential clinical utility in predicting diabetic sarcopenia.

Discussion

With the acceleration of population aging and lifestyle changes, the global prevalence of diabetes has increased annually, making it a major public health concern [14]. Sarcopenia, a syndrome characterized by the progressive loss of skeletal muscle mass, strength, and physical performance, often coexists with diabetes, and its high prevalence in diabetic patients has attracted increasing clinical attention. Diabetic sarcopenia not only aggravates motor dysfunction and increases the risk of falls and fractures, but also disrupts metabolic homeostasis, accelerates the progression of diabetes-related complications, and increases the risk of adverse long-term prognosis [15]. Therefore, clarifying the prevalence of diabetic sarcopenia, identifying key associated factors, and

Table 4. Univariate logistic regression analysis of factors associated with diabetic sarcopenia

Variable	B	S.E.	Wald χ^2	OR (95% CI)	*P* value
Age	0.032	0.008	16.000	1.033 (1.017-1.049)	< 0.001
BMI	-0.153	0.018	72.250	0.858 (0.828-0.889)	< 0.001
Duration of diabetes	0.089	0.012	55.007	1.093 (1.068-1.119)	< 0.001
Alcohol consumption history (yes vs. no)	-0.098	0.099	0.980	0.907 (0.747-1.101)	0.322
Coronary heart disease (yes vs. no)	0.337	0.137	6.052	1.401 (1.071-1.833)	0.014
MDS	0.624	0.086	52.654	1.867 (1.577-2.210)	< 0.001
TyG	0.812	0.095	73.056	2.253 (1.870-2.714)	< 0.001
CAL	0.896	0.112	64.000	2.450 (1.967-3.051)	< 0.001

Notes: BMI, body mass index; MDS, Magnesium depletion score; TyG, Triglyceride-glucose index; CAL, C-reactive protein-albumin-lymphocyte index.

Table 5. Multivariate logistic regression analysis of influencing factors of diabetic sarcopenia

Variables	B	S.E.	Wald χ^2	OR (95% CI)	*P* value
Age	0.028	0.009	9.679	1.028 (1.010-1.047)	0.002
BMI	-0.142	0.020	50.410	0.868 (0.835-0.903)	< 0.001
Duration of diabetes	0.076	0.014	29.469	1.079 (1.050-1.109)	< 0.001
MDS	0.532	0.098	29.472	1.702 (1.405-2.062)	< 0.001
TyG	0.658	0.112	34.524	1.931 (1.550-2.405)	< 0.001
CAL	0.724	0.132	30.086	2.063 (1.593-2.672)	< 0.001

Notes: BMI, body mass index; MDS, Magnesium depletion score; TyG, Triglyceride-glucose index; CAL, C-reactive protein-albumin-lymphocyte index.

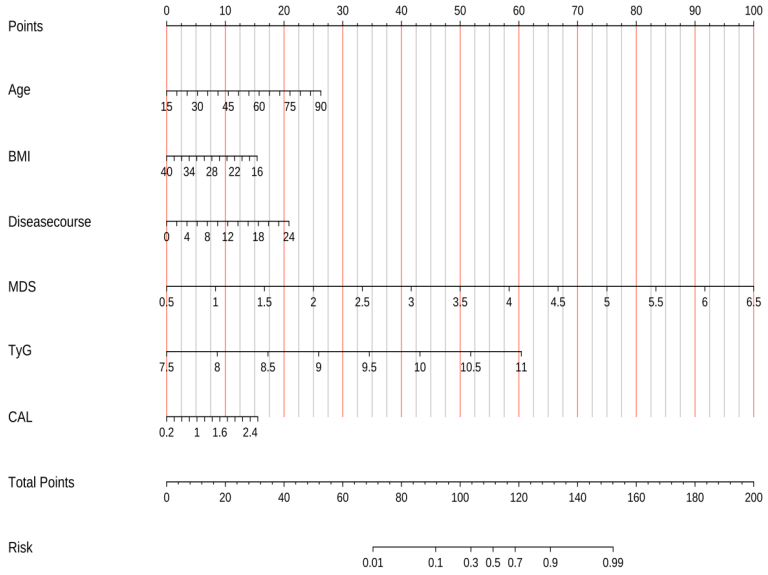

Figure 2. Nomogram for individualized prediction of diabetic sarcopenia risk.

developing reliable predictive models are of great significance for early risk stratification, targeted interventions, and improved patient prognosis.

In this study, the overall prevalence of diabetic sarcopenia was 22.1% (291/1318). Existing evidence indicated that the prevalence of diabetic sarcopenia ranges from 15.0% to 28.5%, and such variability may be related to the differences in age distribution, sex composition, duration of diabetes, BMI, and diagnostic criteria used for sarcopenia [16].

In contrast to some previous studies [17], the comparison of baseline characteristics between the sarcopenia and non-sarcopenia groups in this study revealed no statistically significant differences in age, sex, BMI, glycated hemoglobin (HbA1c), fasting blood glucose, duration of diabetes, systolic and diastolic blood pressure, smoking history, alcohol consumption, or prevalence of hypertension and coronary heart

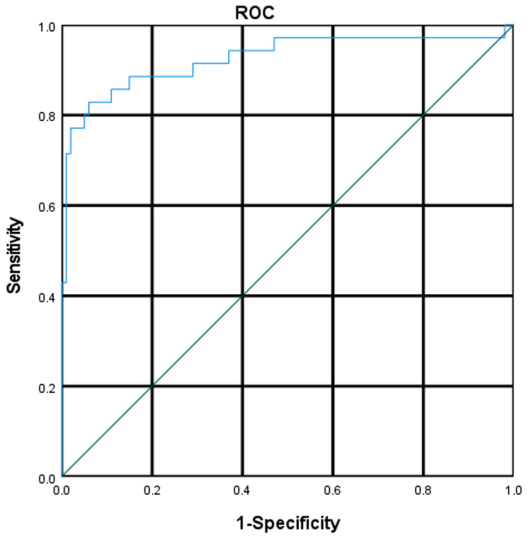

Figure 3. Receiver operating characteristic (ROC) curve analysis of the prediction model for diabetic sarcopenia.

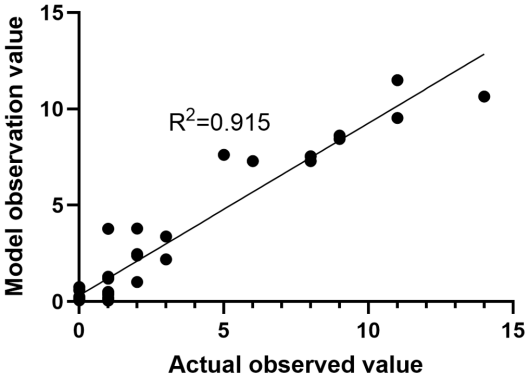

Figure 4. Agreement between predicted and observed values of the prediction model for diabetic sarcopenia.

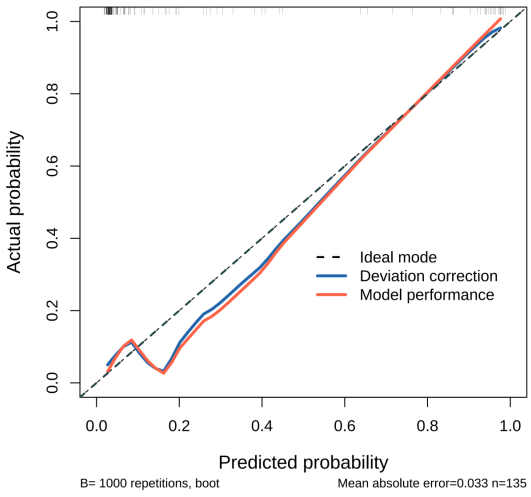

Figure 5. Calibration curve of the nomogram for predicting diabetic sarcopenia.

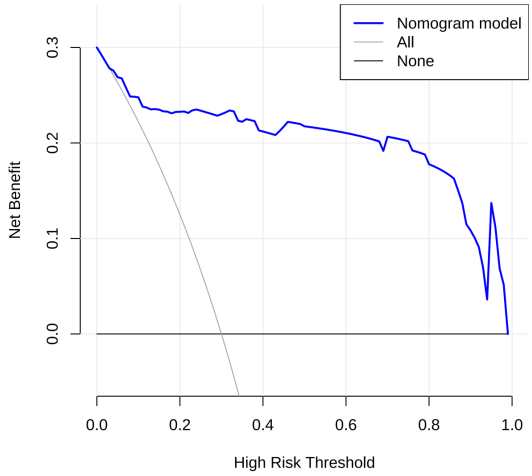

Figure 6. Decision curve analysis (DCA) of the nomogram for diabetic sarcopenia.

disease, indicating that the two groups were well-balanced in terms of conventional clinical characteristics. This finding may be related to differences in study design and population characteristics, such as the relatively large sample size and broad age range. It also suggests that traditional baseline variables alone may have limited discriminatory ability for diabetic sarcopenia, highlighting the needs of incorporating other biomarkers for comprehensive evaluation.

This study demonstrated that the levels of MDS, TyG and CAL were significantly higher in the sarcopenia group than in the non-sarcopenia group, suggesting that these novel biomarkers may be closely related to the occurrence and development of diabetic sarcopenia.

Magnesium, as an important trace element in the human body, is widely involved in the metabolism, contraction and energy generation process of skeletal muscle cells. Magnesium deficiency can impair skeletal muscle cell function, reduce protein synthesis, and accelerate muscle cell apoptosis, thereby inducing or aggravating sarcopenia [18, 19]. MDS is a composite index reflecting overall magnesium status, with higher scores indicating an increased risk of magnesium deficiency. In this

study, multivariate logistic regression analysis showed that MDS was an independent risk factor for diabetic sarcopenia, confirming that magnesium depletion is more prevalent in patients with diabetic sarcopenia, which is consistent with the previous studies indicating that magnesium deficiency is closely related to sarcopenia [20].

TyG is a simple and reliable indicator of insulin resistance that does not require additional detection of insulin levels. It has been widely used in the studies of metabolic-related diseases [21]. Persistent insulin resistance in diabetic patients can impair glucose uptake and utilization in skeletal muscle, leading to insufficient energy supply, reduced skeletal muscle protein synthesis, and enhanced protein degradation, ultimately contributing to decreased muscle mass and strength and the development of sarcopenia [22, 23]. In this study, the TyG index was significantly increased in the sarcopenia group, and multivariate analysis identified TyG as an independent risk factor for diabetic sarcopenia, suggesting that insulin resistance may represent an important link between diabetes and sarcopenia.

CAL is an integrated indicator that comprehensively reflects systemic inflammation, nutritional status, and immune function. Specifically, C-reactive protein is an inflammatory marker, albumin reflects nutritional status, and lymphocytes represents immune competence [24]. Diabetic patients are characterized by a chronic low-grade inflammatory state. Inflammatory factors can damage skeletal muscle cells and inhibit the proliferation and differentiation of muscle cells. At the same time, chronic inflammation may impair nutrient absorption and utilization, resulting in reduced protein synthesis and compromised immune function. These processes further aggravate skeletal muscle loss and contribute to the development of sarcopenia, consistent with previous research conclusions [25, 26]. In this study, CAL was significantly elevated in the sarcopenia group, and multivariate analysis also identified CAL as an independent risk factor for diabetic sarcopenia. Among the three novel biomarkers, CAL exhibited the strongest association with sarcopenia, as indicated by the highest OR value (2.063), followed by TyG (1.931) and MDS (1.702), confirming the important roles of systemic inflammation, nutritional status, and immune function in the pathophysiology of diabetic sarcopenia. It also suggested that the combined detection of these three biomarkers could improve the identification of high-risk individuals with diabetic sarcopenia, which is consistent with the previous research [27].

Additionally, univariate and multivariate logistic regression analyses identified age, BMI, duration of diabetes as independent factors associated with diabetic sarcopenia. Age is an independent risk factor, suggesting that the risk increases with advancing age, which may be related to age-associated skeletal muscle loss, decreased metabolic rate, hormonal alterations, and decreased nutrition absorption capacity [28]. BMI was inversely associated with sarcopenia, indicating that higher BMI may confer a protective effect to some extent. This highlights the importance of avoiding excessive weight loss and preserving muscle mass in patients with diabetes [29]. Duration of diabetes was also independently associated with sarcopenia, suggesting that the longer the course of diabetes, the higher the risk of sarcopenia. This may be attributed to the cumulative effects of chronic hyperglycemia, insulin resistance, and persistent low-grade inflammation on skeletal muscle over time [30].

Previous studies have primarily developed prediction models based on baseline clinical variables and biochemical indicators. In this study, a nomogram prediction model was constructed based on independent influencing factors identified through multivariate logistic regression analysis, including age, BMI, duration of diabetes, MDS, TyG, and CAL. The model showed good discrimination ability, with an AUC of 0.925 (95% CI: 0.861-0.990). The Hosmer-Lemeshow test showed an adequate model fit (χ^2=9.774, P=0.283), indicating no significant difference between predicted and observed outcomes. These findings are consistent with previous studies [31, 32].

The clinical applicability of prediction models is increasingly evaluated based on their potential net benefits. In this study, internal verification and clinical utility were assessed using calibration curves, goodness-of-fit test, and DCA. The calibration curve demonstrated good agreement between predicted and observed probabilities, indicating satisfactory calibration per-

formance. The goodness-of-fit analysis yielded an R^2 of 0.915, indicating that the model can explain 91.5% of the observed outcomes. DCA results further showed that the model provided a positive net benefit across a range of threshold probabilities, supporting its clinical utility in predicting diabetic sarcopenia. These results are consistent with previous findings that prediction models based on clinically accessible indicators have good practical applicability [33]. The variables included in the Nomogram model constructed in this study are routinely detected or easily accessible in clinical practice. The model is easy to implement and does not require specialized equipment, facilitating its application across medical institutions at all levels, especially in primary care for early screening and risk assessment of sarcopenia in diabetic patients.

Several limitations of this study should be acknowledged. First, the cross-sectional design precluded causal inferences, and the findings reflect only associations rather than prognostic predictions. Second, sarcopenia was defined according to the AWGS 2019 criteria, which were developed for Asian populations, whereas the present study was based on a U.S. population with diverse racial and ethnic backgrounds; this discrepancy may have affected the accuracy of sarcopenia identification and limit the generalizability of our findings. Third, this study primarily focused on identifying associations between biomarkers and diabetic sarcopenia, without delving into the underlying biological mechanisms. Fourth, the nomogram model was validated only using internal bootstrap resampling, and the absence of external validation may limit its generalizability to other populations. Despite these limitations, this study provided valuable insight into the association of MDS, TyG, and CAL with diabetic sarcopenia in a nationally representative adult population.

Conclusion

Diabetic sarcopenia is highly prevalent in adult patients with diabetes. Age, BMI, duration of diabetes, MDS, TyG, and CAL were independently associated with diabetic sarcopenia. The nomogram prediction model constructed based on these factors demonstrated good discrimination ability, calibration accuracy, and clinical utility, and may serve as a practical tool for early identification and risk stratification of sarcopenia in diabetic patients.

Disclosure of conflict of interest

None.

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