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ORIGINAL RESEARCH

Establishing a Prediction Model for Weight Loss Outcomes After LSG in Chinese Obese Patients with BMI ≥ 32.5 Kg/m^2 Using Body Composition Data

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Background: Laparoscopic sleeve gastrectomy (LSG) is associated with sustained and substantial weight loss. However, suboptimal results are observed in certain patients.

Objective: Drawing from body composition data at our center, clinically accessible predictive factors for weight loss outcomes were identified, leading to the development and validation of a preoperative predictive model for weight loss following LSG.

Methods and Materials: A retrospective analysis was conducted on the general clinical baseline and body composition data of obese patients (body mass index [BMI] ≥ 32.5 kg/m^2) who underwent LSG between December 2016 and December 2022. Independent predictors for weight loss outcomes were selected through univariate logistic regression, random forest analysis, and multivariate logistic regression. Subsequently, a nomogram was developed to predict weight loss outcomes and was evaluated for discrimination, accuracy, and clinical utility, with validation performed in a separate cohort.

Results: A total of 473 patients with mean BMI were included. The preoperative resting energy expenditure to body weight ratio (REE/BW), fat-free mass index (FFMI), and waist circumference (WC) emerged as independent predictive factors for weight loss outcomes at one year post-LSG. These body composition parameters were incorporated into the construction of an Inbody predictive nomogram, which yielded area under the curve (AUC) values of 0.868 (95% CI: 0.826–0.902) for the modeling cohort and 0.829 (95% CI: 0.756–0.887) for the validation cohort. Calibration curves, decision curve analysis (DCA), and clinical impact curves (CIC) from both groups demonstrated the model's robust discrimination, accuracy, and clinical utility.

Conclusion: In obese Chinese patients with a BMI ≥ 32.5 kg/m^2, the Inbody-based nomogram integrating REE/BW, FFMI, and WC offers an effective preoperative tool for predicting weight loss outcomes one year after LSG, facilitating surgical planning and postoperative management.

Keywords: laparoscopic sleeve gastrectomy, prognostic prediction, metabolic bariatric surgery, obesity, body composition data

Introduction

In recent years, the prevalence of obesity has been steadily rising, with approximately 16.5% of adults in China classified as obese.[1] Metabolic bariatric surgery(MBS) has emerged as the most effective and sustained treatment for obesity and its associated complications.[2] Among these procedures, laparoscopic sleeve gastrectomy (LSG) is the most commonly performed weight-loss surgery worldwide and has demonstrated safety and efficacy through numerous studies.[3,4] However, not all obese patients undergoing LSG achieve satisfactory weight loss outcomes.[4–6]

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Obesity is typically diagnosed based on body mass index (BMI). However, BMI fails to accurately reflect the distribution of body fat, muscle, and other tissues. Individuals with the same BMI can exhibit substantial differences in fat distribution, leading to varying risks of metabolic diseases.[7,8] As a result, body composition analysis provides a more comprehensive and clinically relevant assessment of a patient's health and metabolic status.[7–9] Bahadori et al demonstrated that skeletal muscle mass (SMM) is an independent predictor of percentage excess weight loss (%EWL) six months after laparoscopic Roux-en-Y gastric bypass (LRYGB), with each additional kilogram of muscle mass corresponding to a 1.418% reduction in %EWL.[10] Arnaud et al observed that in patients undergoing LRYGB, preoperative fat mass (FM) was negatively correlated with %EBMIL one year postoperatively ($R = -0.23$, $p = 0.02$). [11] Fangcen et al reported that patients with lower preoperative Body Adiposity Index (BAI) exhibited better weight loss outcomes, with BAI predicting % EWL at twelve months after LRYGB, showing an area under the curve (AUC) of 0.773.[12] Other preoperative factors, including age, gender, BMI, waist circumference (WC), neck circumference (NC), fasting blood glucose, HbA1c, triglycerides, blood pressure, and total cholesterol, have also been associated with weight loss outcomes.[13–15] Based on these correlations, several predictive models have been developed.[13,14,16–24] While many of these models demonstrate some degree of predictive capability, they often suffer from small sample sizes, and their applicability in broader populations remains uncertain.

In conclusion, certain body composition data may hold considerable predictive potential for weight loss outcomes following MBS. However, there is a lack of research focused on predictive models incorporating body composition data, particularly in Chinese patients undergoing LSG. This study aims to identify key body composition indicators that can predict weight loss outcomes in Chinese patients undergoing LSG and to establish a preoperative predictive model, providing valuable insights for clinical decision-making by bariatric surgeons.

Materials and Methods

Study Design

Screen the subjects for research based on the following criteria. Inclusion criteria: Underwent LSG;BMI ≥ 32.5 kg/m^2; Chinese nationality;Underwent body composition assessment using the Inbody 770 device preoperatively. All the patients who undergo MBS here are in compliance with the NIH consensus, which have remained unchanged since 1991. Exclusion criteria: Incomplete follow-up data at one year post-surgery; Major illnesses during the follow-up period, including mental disorders, malignancies, or pregnancy. Furthermore, the researchers evaluated the relevant conditions of the patients before and after the surgery.

Clinical data collection was conducted with informed consent from all patients. The study was approved by the Medical Ethics Committee of Peking University Ninth Clinical Medical College (Approval No. sjtkyll-lx-2022 (076)), and it adhered to the principles outlined in the Declaration of Helsinki.

Definitions and Standards

For Chinese populations, the standard BMI cutoff is established at 23 kg/m ^{2}.[25–27] T2DM Diagnosis: In individuals presenting with typical symptoms, the diagnosis of T2DM is confirmed by a random blood glucose ≥ 11.1 mmol/L, fasting blood glucose ≥ 7.0 mmol/L, or an OGTT 2-hour glucose ≥ 11.1 mmol/L, or HbA1c ≥ 6.5%. Patients who merely take type 2 diabetes drugs will be diagnosed by the internist. In asymptomatic individuals, confirmation requires repeat testing.[28] Hypertension Diagnosis: The condition is diagnosed when systolic blood pressure exceeds 140 mmHg or diastolic blood pressure surpasses 90 mmHg, measured in the morning without the use of antihypertensive medications.[29] Dyslipidemia Diagnosis: The diagnosis is based on fasting serum levels of total cholesterol ≥ 5.2 mmol/L, triglycerides ≥ 1.7 mmol/L, LDL cholesterol ≥ 3.4 mmol/L, or HDL cholesterol < 1 mmol/L.[30] Nausea and Vomiting Criteria: Chronic symptoms that interfere with daily life, including at least one episode of vomiting per week, with exclusion of self-induced vomiting or eating disorders, define the condition.[31] Functional Dyspepsia: This condition is characterized by recurrent upper abdominal pain or discomfort with no identifiable underlying cause.[31] Weight Loss Definition: A postoperative BMI < 18.5 kg/m^2. Hair Loss Assessment: Based on the Ludwig classification.[32] Weight Loss Outcomes: According to the most recent IFSO consensus on obesity management and clinical practice guidelines, a percentage excess weight loss (%EWL) ≥ 50% within one year after surgery is considered "optimal initial clinical response" indicating successful weight reduction, while %EWL < 50% within one year after surgery is deemed "suboptimal initial clinical response" indicating failure in achieving weight loss.[33,34] In further analyses, patients demonstrating optimal clinical response were categorized as Group A, while those with suboptimal response were classified as Group B.

BIA for Measuring Body Composition

The InBody 770 (Biospace Co., Ltd., Korea) body composition analyzer was employed in the current study. This device employs bioelectrical impedance analysis (BIA) technology to assess the body composition of patients before the surgery. BIA operates by applying a low-level alternating current through the body, with the differing conductivity of various tissues allowing for the estimation of body component content, including water and fat. Prior to testing, patients were instructed to abstain from alcohol and strenuous physical activity for 24 hours. On the day of the test, patients were required to void their bladder and wear minimal clothing. A case manager assisted in entering the patient's identification number, age, gender, and height into the device. After removing their socks, patients stood barefoot on the electrode plates and grasped the hand electrodes, maintaining their arms straight and slightly elevated to avoid contact with the torso, ensuring maximal comfort. The device then automatically initiated the measurement, recording parameters including height, weight, WC, body fat percentage, muscle mass, FM, visceral fat area, and intracellular water content. Relevant data was exported and organized for subsequent analysis. Resting energy expenditure to body weight ratio (REE/BW) was calculated using the formula: $REE = 19.7 \times FFM + 413$.[35,36]

The surgical procedures, postoperative care, and follow-up protocols adhered to those described in the existing literature.[16,18]

Surgical Technique

There surgeons performed all LSG procedures with a standardized approach. Patients adopted a reverse Trendelenburg and left-side-up position with their legs separated to form the "A" shape. The gastric greater curvature was fully dissociated from approximately 3 cm above the gastric pylorus to the His angle, and a 36-Fr Bougie tube was placed into the stomach via the mouth. After the tip of the tube reached across the pylorus, 60-mm endoscopic staples were placed. The gastric antrum was incised using cartridges attached to the Bougie tube, and the gastric tissue was gradually separated from approximately 3 cm above the pylorus to the angle of His, with excision of the entire gastric fundus. Approximately 1–1.5 cm of stomach tissue was preserved in the His angle to reduce the incidence of gastroesophageal reflux disease. The drainage tube was not routinely placed postoperatively. Finally, absorbable 2–0 sutures were placed to close all fascial defects. All the surgeries were performed by the same surgeon.

Selection Method for Predictive Factors of Weight Loss Outcomes

For initial screening, univariate logistic regression analysis was conducted using a binary outcome of optimal versus suboptimal clinical response at one year postoperatively. Variables with a p-value < 0.05 were incorporated into the random forest (RF) model. The top five variables, each with an importance value greater than 5 according to the RF model, were subjected to multivariate logistic regression analysis, with a p-value threshold of < 0.1 used to identify independent predictive factors for the construction of a nomogram model. All statistical analyses were performed using the "RandomForest" package in R.

Construction, Evaluation, and Validation of the Nomogram Prediction Model

The "pROC" package in R was utilized to generate ROC curves and calculate AUC values for assessing the model's discriminatory ability. Calibration curves were constructed using the "rms" package, while the model's accuracy was evaluated through the Hosmer-Lemeshow test. Decision curve analysis (DCA) was performed using the "rmda" package to evaluate the clinical utility of the model. External validation was conducted with data from the validation group to assess the model's discrimination, calibration, and clinical effectiveness, thereby determining its stability.

Development of the Web-Based Calculator

To facilitate practical clinical use, an interactive, web-based nomogram calculator was developed using the "Dyn Nom" "Shiny" and "rsconnect" packages in R.

Statistical Methods

The Kolmogorov–Smirnov test was initially applied to assess the distribution of continuous variables. Normally distributed data were presented as mean ± standard deviation, with inter-group comparisons conducted using independent samples *t*-tests. Non-normally distributed data were expressed as median (interquartile range), with comparisons made using rank-sum tests. Categorical data were presented as frequency (percentage), with comparisons made using the Chi-square test or Fisher's exact test. Statistical significance was set at $p < 0.05$. All statistical and graphical analyses were conducted using R (version 4.3.1), MedCalc v 19.2.6 (MedCalc, Inc., Mariakerke, Belgium), GraphPad Prism v 8.4.3 (GraphPad Software Inc., San Diego, CA, USA), and SPSS (v26.0; IBM Corp., Armonk, NY, USA).

Results

Initiative Patient Demographics and Baseline Characteristics

A total of 474 patients were enrolled in the study, with 332 assigned to the modeling group and 141 to the validation group. The preoperative BMI of the modeling group was 39.73 (36.20, 46.03) kg/m^2, including 127 males (38.3%). The prevalence of preoperative comorbidities was as follows: 34.3% had T2DM, 41.0% had hypertension, 63.9% had dyslipidemia, 76.8% had hyperuricemia, and 96.1% had fatty liver disease. A comparison of the general clinical baseline data and body composition parameters between the modeling and validation groups is provided in Table 1 and Table 2, with no statistically significant differences observed between the two groups.

Surgical Metrics and Complications

Surgical outcomes, including duration, intraoperative blood loss, postoperative hospital stay, hospitalization costs, and time to first liquid intake, were as follows: 90 (60, 100) minutes, 20 (5, 50) mL, 3 (2, 5) days, 67,223.94 ± 16,855.34 RMB, and 2 (2, 4) days, respectively. Detailed surgical-related metrics are outlined in Table 3.

No severe complications, such as stapple link leakages, sleeve stricture, mortality, or significant bleeding, occurred. The incidence rates for other complications were: nausea and vomiting (31.63%), weight loss (0.50%), hypoalbuminemia

Table 1 Comparison of General Clinical Baseline Characteristics Between the Modeling Group and Validation Group

Variable	Model Group (n=332)	Validation Group (n=141)	χ^2/z Statistics	*P* value
Age(year)	32(26,39)[a]	32(25,37.5)	−1.042	0.298
Gender				
Male(%)	127(38.3%)[b]	48(34.0%)	0.753	0.223
Female(%)	205(61.7%)	93(66.0%)		
Preoperative BMI(Kg/m^2)	39.73(36.20,46.03)	41.20(36.42,45.44)	−0.004	0.997
Preoperative glucose(mmol/L)	5.58(5.01,6.43)	5.74(5.10,6.91)	−1.431	0.152
Preoperative C-peptide(ng/mL)	3.79(3.01,4.69)	3.77(3.11,4.74)	−0.309	0.758
Preoperative insulin(μIU/mL)	29.66(20.24,39.42)	29.14(21.35,38.58)	−0.216	0.829
Preoperative HbA1c(%)	6.00(5.70,6.75)	6.10(5.70,7.01)	−1.224	0.221
T2DM(%)	114(34.3%)	59(41.8%)	2.404	0.075
Hypertension(%)	136(41.0%)	45(31.9%)	3.430	***0.039***
Hyperlipidemia(%)	212(63.9)	100(70.9%)	2.201	0.083
Hyperuricemia(%)	255(76.8)	106(75.2%)	0.145	0.393
Fatty liver(%)	319(96.1)	139(98.6%)	2.010	0.126

Notes: [a]Median (Upper and Lower Quartiles), [b]Number (Percentage); Italics and bold indicate that this index is statistically significant.

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Table 2 Comparison of Body Composition Data Between the Modeling Group and Validation Group

Variable	Model Group (n=332)	Validation Group (n=141)	χ^2/z Statistic	*P* value
TBW(L)	45.45(39.63,54.80)[a]	44.10(39.10,53.55)	−1.056	0.291
ICW(L)	28.10(24.50,33.78)	27.00(23.95,33.20)	−1.068	0.285
Protein(Kg)	12.15(10.70,14.60)	11.70(10.40,14.35)	−1.094	0.274
Minerals(Kg)	4.10(3.63,4.99)	3.95(3.57,4.72)	−1.049	0.294
BFM(Kg)	52.30(43.05,66.70)	53.80(46.15,63.20)	−0.374	0.708
SLM(Kg)	58.40(50.93,70.45)	56.40(50.10,68.85)	−1.063	0.288
REE/BW(kcal/day/kg)	14.24(12.90,15.35)	14.05(13.05,14.67)	−0.995	0.340
SMM(Kg)	34.65(30.00,42.00)	33.30(29.25,41.30)	−1.074	0.283
PBF(%)	46.75(42.33,51.10)	47.30(42.70,50.95)	−0.709	0.479
FFM% of Trunk	107.95(103.33,112.10)	107.60(103.70,111.35)	0.894	0.383
TBW of Trunk(L)	22.00(19.50,26.70)	21.60(19.15,25.40)	−0.980	0.327
ICW of Trunk(L)	13.55(12.10,16.48)	13.30(11.75,15.90)	−0.965	0.334
ECW/TBW	0.38(0.38,0.39)	0.38(0.38,0.39)	−0.864	0.387
BFM% of Trunk	479.85(414.78,576.33)	493.80(412.85,572.25)	−0.269	0.788
BMR(kcal/d)	1703.00(1533.25,1976.75)	1657.00(1513.00,1950.50)	−1.064	0.287
BCM(Kg)	40.25(35.10,48.30)	38.70(34.30,47.60)	−1.076	0.282
BMC(Kg)	3.38(2.96,4.06)	3.26(2.93,3.89)	−1.109	0.267
TBW/FFM	73.60(73.40,73.90)	73.70(73.40,73.90)	−0.991	0.322
FFM(Kg)	61.70(53.90,74.40)	59.60(52.95,73.20)	−1.061	0.289
FFMI(Kg/m^2)	21.75(19.90,24.60)	21.70(19.65,24.10)	−0.900	0.368
FMI(Kg/m^2)	18.35(15.40,22.98)	18.80(16.20,22.20)	−0.464	0.642
SMI(Kg/m^2)	9.30(8.33,10.50)	9.10(8.30,10.10)	−0.778	0.437
VFA(cm^2)	232.80(201.03,254.10)	238.10(215.75,258.15)	−1.594	0.111
AC(cm)	42.30(39.00,49.18)	42.90(39.20,47.45)	−0.286	0.775
AMC(cm)	33.65(31.33,38.70)	33.50(31.05,37.30)	−0.682	0.495
NC(cm)	44.70(42.00,48.08)	45.00(42.55,48.65)	−0.483	0.629
CC(cm)	118.20(111.90,127.05)	118.70(111.35,124.80)	−0.358	0.720
WC(cm)	123.25(114.53,135.15)	125.40(118.30,132.75)	−1.075	0.282
HC(cm)	120.70(114.80,131.15)	122.30(114.55,128.75)	−0.413	0.680
WHR	1.02(0.97,1.06)	1.02(0.98,1.07)	−0.825	0.409

Note: [a]Median (upper and lower quartiles).

Abbreviations: TBW, Total body water; ICW, Intracellular water; ECW, Extracellular water; BFM, Body fat mass; SLM, Soft lean mass; FFM, Fat free mass; REE, Resting energy expenditure; REE/BW, REE on body weight ratio; SMM, Skeletal muscle mass; PBF, Body fat percentage; BMR, Basal metabolic rate; BCM, Body cell mass; AC, Arm circumference; AMC, Arm muscle circumference; BMC, Bone mineral content; FFMI, Fat free mass index; FMI, Fat mass index; SMI, Skeletal muscle mass index; NC, Neck circumference; CC, Chest circumference; WC, Waist circumference; HC, Hip circumference; WHR, Waist hip ratio.

Table 3 Surgery-Related Metrics

Surgical Indicators	Numerical value
Surgical duration (minutes)	90(60,100)[a]
Intraoperative blood loss (milliliters)	20(5,50)
Postoperative hospital stay (days)	3(2,5)
Hospitalization cost (RMB)	67223.94±16,855.34[b]
Time to initiate liquid diet (days)	2(2,4)

Note: [a]Median (Upper and Lower Quartiles), [b]Mean ± Standard Deviation.

(4.22%), anemia (3.92%), hair loss (30.72%), functional dyspepsia (13.55%), hypoglycemia (6.63%), gallstones (7.53%), hypotension (2.11%), hypocalcemia (3.92%), iron deficiency (4.82%), folate deficiency (3.01%), vitamin B12 deficiency (1.51%), and other rare complications (2.71%). All complications were effectively managed with symptomatic treatment and did not significantly affect patients' quality of life. The full list of postoperative complications is provided in Table 4.

Table 4 Postoperative Complications

Surgical Complications	Incidence Rate
Death	0(0)[a]
Anastomotic fistula	0(0)
Bleeding	0(0)
Anastomotic stricture	0(0)
Nausea, Vomiting	105(31.63%)
Wasting	1(0.5%)
Anemia	10(3.92%)
Hypoalbuminemia	14(4.22%)
Hair loss	102(30.72%)
Functional dyspepsia	45(13.55%)
Hypoglycemia	22(6.63%)
Gallstones	25(7.53%)
Hypotension	7(2.11%)
Hypocalcemia	13(3.92%)
Iron deficiency	16(4.82%)
Folate deficiency	10(3.01%)
Vitamin B12 deficiency	5(1.51%)
Other rare complications	9(2.71%)

Note: [a]Number (Percentage).

BMI and %EWL Changes Post-Surgery

In the modeling group, preoperative BMI values and measurements at 3, 6, and 12 months post-surgery were 39.73 (36.20, 46.03), 33.57 (30.12, 39.15), 29.64 (26.64, 34.48), and 28.38 (25.66, 31.67), respectively. The %EWL at 3, 6, and 12 months postoperatively was 35.55 (26.19, 46.56), 59.00 (45.31, 72.58), and 68.57 (56.43, 81.49), respectively (Figure 1). Most patients exhibited the most significant weight loss during the first three months post-surgery, followed by a deceleration in the rate of weight loss between three and six months, and a further gradual decrease in weight loss between six and twelve months. A small proportion of patients did not experience weight loss compared to their preoperative weight.

Within the modeling group, 278 patients (Group A) achieved an optimal clinical response one year post-surgery, while 54 patients (Group B) had a suboptimal response. The BMI and EWL of the group A at 1 year after surgery were 27.12 (24.03, 30.25) and 75.56 (64.31, 88.98), and the BMI and EWL of the group B after one year of surgery were 35.35

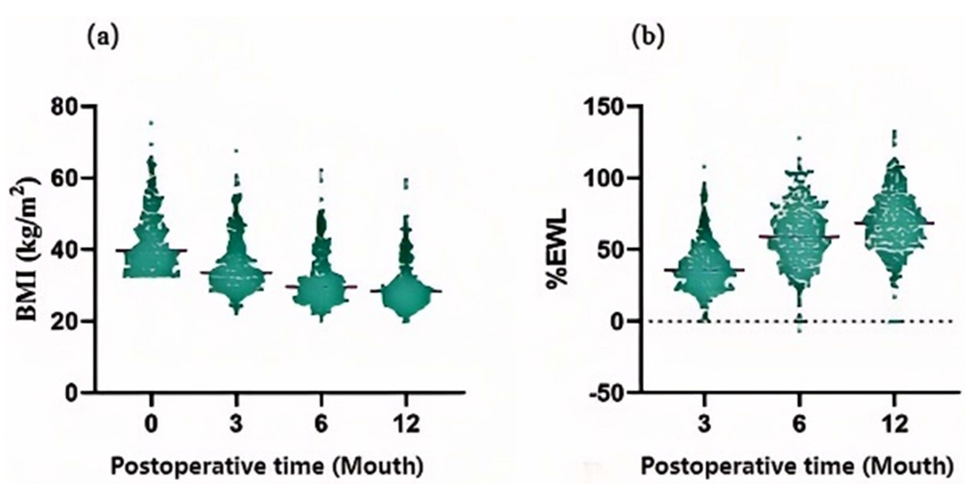

Figure 1 Postoperative Changes in BMI and %EWL for Patients in the Modeling Group. (**a**) BMI Change Trend Chart. (**b**) %EWL Change Trend Chart.
Notes: In each chart, every green dot represents an individual patient, and the red horizontal line represents the median.

(31.56, 45.02) and 32.14 (21.23, 46.25), respectively. Significant differences were observed in gender and preoperative BMI between the two groups. Moreover, most body composition parameters showed substantial differences between the groups. Details of these findings are provided in Table 5.

Table 5 Comparison of Baseline Characteristics Between Group A and Group B in the Modeling Group (n=332)

Variable	A Group (n=278)	B Group (n=54)	χ^2/z Statistic	*P* Value
Age(year)	33(27,39.25)[a]	31(25,38)	−1.350	0.177
Gender				
Male(%)	95(34.2)[b]	32(59.3)	12.048	***0.001***
Female(%)	183(65.8)	22(40.7)		
Preoperative BMI(Kg/m^2)	38.59(32.56,69.45)	52.07(45.44,56.00)	−8.237	***<0.001***
T2DM(%)	94(33.8)	20(37)	0.208	0.378
Hypertension (%)	112(40.3)	24(44.4)	0.323	0.337
Hyperlipidemia (%)	176(63.3)	36(66.7)	0.221	0.380
Fatty liver(%)	265(95.3)	54(100)	2.628	0.095
TBW(L)	42.80(38.80,52.53)	57.20(48.63,65.63)	−6.847	***<0.001***
ICW(L)	26.55(24.00,32.50)	34.80(29.95,40.23)	−6.717	***<0.001***
Protein(kg)	11.50(10.40,14.03)	15.05(12.95,17.35)	−6.724	***<0.001***
Minerals(kg)	3.99(3.53,4.78)	4.87(4.18,5.70)	−5.331	***<0.001***
BFM(%)	49.20(41.68,60.35)	78.95(66.20,88.25)	−8.531	***<0.001***
SLM(kg)	54.95(49.80,67.63)	72.90(62.45,84.13)	−6.820	***<0.001***
FFM(kg)	58.25(52.78,71.03)	76.80(65.93,88.63)	−6.768	***<0.001***
REE/BW	14.51(13.44,15.55)	12.39(11.88,13.22)	−7.837	***<0.001***
SMM(Kg)	32.65(29.28,40.40)	43.35(37.03,50.45)	−6.711	***<0.001***
PBF(%)	46.00(41.30,50.10)	51.35(46.43,53.20)	−5.167	***<0.001***
FFM% of Trunk	107.85(103.68,112.10)	108.40(101.23,113.40)	−0.386	0.700
TBW of Trunk(L)	21.10(19.10,25.23)	27.45(23.63,30.85)	−6.882	***<0.001***
ICW of Trunk(L)	13.05(11.80,15.83)	16.65(14.50,19.03)	−6.675	***<0.001***
ECW/TBW	0.38(0.38,0.39)	0.39(0.38,0.39)	−3.903	***<0.001***
BFM% of Trunk	460.20(408.35,538.98)	619.15(521.35,685.48)	−6.418	***<0.001***
BMR(kcal/d)	1628.50(1509.75,1904.50)	2029.50(1793.00,2284.25)	−6.768	***<0.001***
BCM(kg)	38.05(34.30,46.50)	49.80(42.88,57.58)	−6.714	***<0.001***
BMC(kg)	3.28(2.91,3.90)	3.96(3.41,4.63)	−5.007	***<0.001***
TBW/FFM	73.60(73.40,73.80)	73.90(73.50,74.30)	−4.151	***<0.001***
FFMI(Kg/m^2)	21.10(19.70,23.30)	25.60(23.38,26.83)	−7.353	***<0.001***
FMI(Kg/m^2)	17.60(14.98,21.23)	25.75(21.90,29.23)	−7.759	***<0.001***
SMI(Kg/m^2)	9.00(8.30,10.00)	10.85(9.93,11.73)	−7.147	***<0.001***
VFA(cm^2)	223.70(197.33,249.05)	256.95(238.38,276.85)	−5.606	***<0.001***
AC(cm)	41.30(38.60,46.00)	57.10(49.13,67.00)	−8.302	***<0.001***
AMC(cm)	32.70(30.80,36.05)	45.90(38.95,54.18)	−8.148	***<0.001***
NC(cm)	44.00(41.60,47.00)	50.15(47.80,54.48)	−7.656	***<0.001***
CC(cm)	115.80(111.10,124.10)	130.35(126.28,135.25)	−8.031	***<0.001***
WC(cm)	121.60(113.85,130.60)	137.80(129.95,144.78)	−6.472	***<0.001***
HC(cm)	118.80(113.88,127.53)	137.80(130.95,141.75)	−8.244	***<0.001***
WHR	1.02(0.97,1.06)	1.02(0.95,1.08)	−0.226	0.821
Preoperative glucose(mmol/L)	5.56(5.02,6.51)	5.71(4.99,6.30)	−0.013	0.989
Preoperative C-peptide(ng/mL)	3.52(2.90,4.54)	4.63(3.94,5.65)	−5.180	***<0.001***
Preoperative insulin(µIU/mL)	28.20(19.28,38.38)	34.82(29.00,44.27)	−3.609	***<0.001***
HbA1c(%)	6.00(5.66,6.70)	6.25(5.70,7.01)	−1.023	0.306

Notes: [a]Median (Upper and Lower Quartiles), [b]Number (Percentage); Italics and bold indicate that this index is statistically significant.

Univariate and Multivariate Analyses of Predictors

Using optimal and suboptimal clinical responses at one year post-surgery as binary outcomes, variables exhibiting statistical differences were incorporated into a univariate logistic regression analysis. The findings revealed that preoperative BMI and gender were significantly different between Groups A and B, with the majority of body composition indicators also showing statistically significant disparities. Further details are provided in Table 6.

In the univariate analysis, 31 variables were identified as potential predictors for weight loss outcomes, including preoperative BMI (BMI0), gender, BCM, BFM, BFM% of trunk, BMC, BMR, ECW/TBW, FFM, fat-free mass index (FFMI), FMI, ICW, ICW of trunk, minerals, PBF, protein, REE/BW, SLM, SMI, SMM, TBW, TBW of trunk, TBW/FFM, VFA, AC, AMC, CC, HC, NC, WC, and preoperative C-peptide. To further refine the selection of representative and characteristic indicators, these 31 variables were entered into an RF model. A plot illustrating the relationship between model error and the number of trees (ntree) was generated (Figure 2), revealing that model error stabilized at ntree = 200,

Table 6 Univariate Logistic Regression Analysis for Selection of Predictive Factors

Variable	OR(95% CI)	*P* value
Preoperative BMI(Kg/m^2)	0.84(0.80–0.88)	***<0.001***
Gender		
Male	1.00(Reference)	
Female	2.80(1.54–5.09)	***<0.001***
BCM(Kg)	0.90(0.87–0.93)	***<0.001***
BFM(Kg)	0.92(0.91–0.94)	***<0.001***
BFM% of Trunk	0.99(0.99–0.99)	***<0.001***
BMC(Kg)	0.45(0.32–0.63)	***<0.001***
BMR(kcal/d)	0.99(0.99–0.99)	***<0.001***
ECW/TBW	0.00(0.00–0.00)	***<0.001***
FFM(Kg)	0.94(0.92–0.96)	***<0.001***
FFMI(Kg/m^2)	0.70(0.63–0.78)	***<0.001***
FMI(Kg/m^2)	0.80(0.75–0.85)	***<0.001***
ICW(L)	0.86(0.82–0.91)	***<0.001***
ICW of Trunk(L)	0.71(0.64–0.79)	***<0.001***
Minerals(Kg)	0.48(0.36–0.64)	***<0.001***
PBF(%)	0.85(0.79–0.91)	***<0.001***
Protein(Kg)	0.71(0.64–0.79)	***<0.001***
REE/BW(kcal/day/kg)	2.61(1.98–3.44)	***<0.001***
SLM(Kg)	0.93(0.91–0.95)	***<0.001***
SMI(Kg/m^2)	0.51(0.41–0.63)	***<0.001***
SMM(Kg)	0.89(0.86–0.93)	***<0.001***
TBW(L)	0.91(0.89–0.94)	***<0.001***
TBW of Trunk(L)	0.80(0.75–0.86)	***<0.001***
TBW/FFM	0.25(0.13–0.46)	***<0.001***
VFA(cm^2)	0.98(0.97–0.99)	***<0.001***
AC(cm)	0.93(0.91–0.96)	***<0.001***
AMC(cm)	0.93(0.90–0.96)	***<0.001***
CC(cm)	0.88(0.84–0.91)	***<0.001***
HC(cm)	0.89(0.86–0.91)	***<0.001***
NC(cm)	0.84(0.79–0.89)	***<0.001***
WC(cm)	0.92(0.90–0.94)	***<0.001***
Preoperative C-peptide(ng/mL)	0.64(0.52–0.79)	***<0.001***
Preoperative insulin(μIU/mL)	0.99(0.97–1.00)	0.051

Note: Italics and bold indicate that this index is statistically significant.

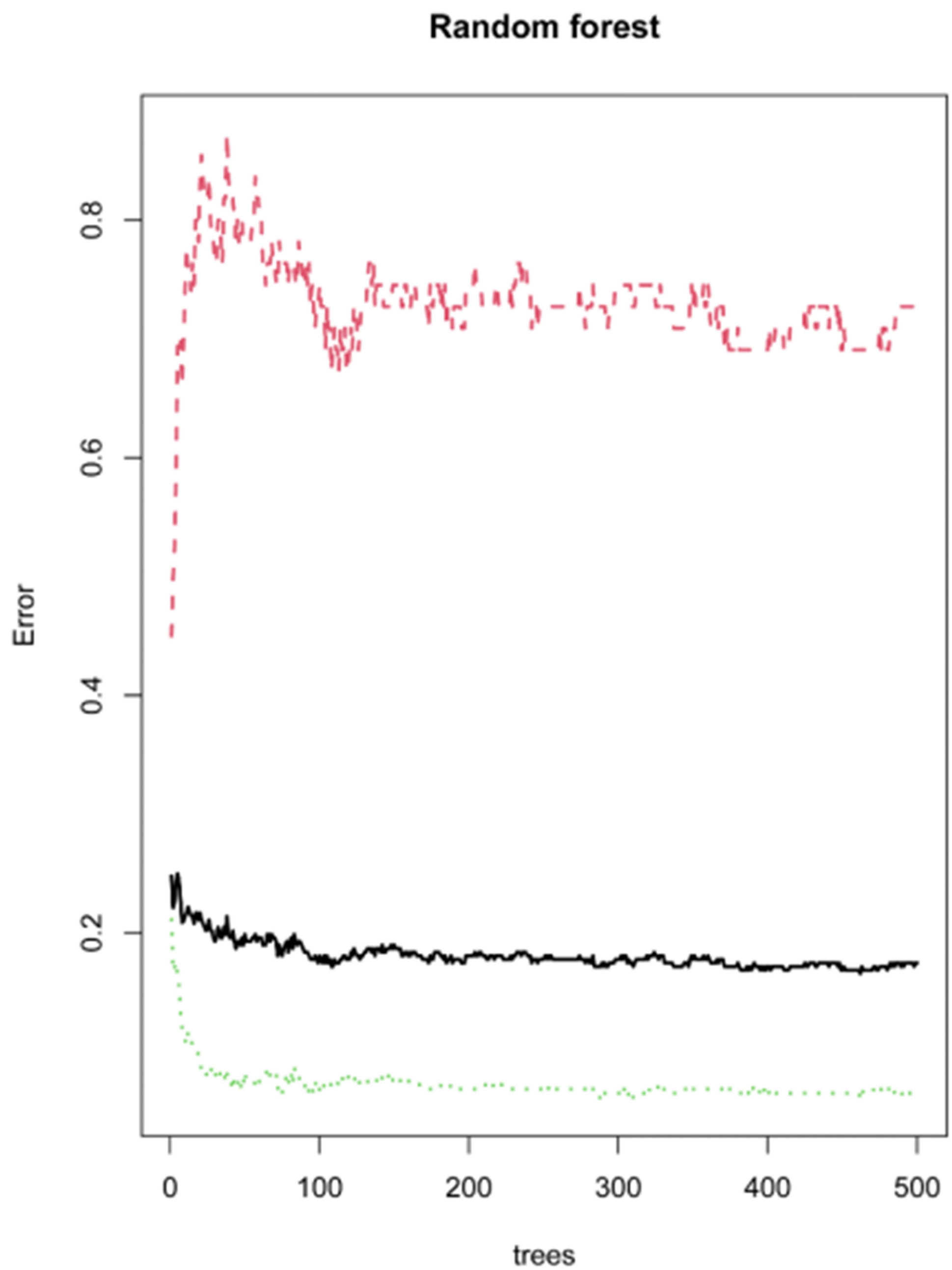

Figure 2 Relationship between Random Forest Model Error and Number of Decision Trees.

Notes: "Trees" represents the number of decision trees (ntree) in the random forest, with a default of 500. The red dashed line shows the training error curve, where the training error decreases as the number of trees increases due to multiple fits by the model. The black line represents the out-of-bag (OOB) error, used to evaluate the model's generalization performance and determine the optimal ntree value. The green dashed line represents the test error curve, indicating the model's performance on unseen data. The test error reaches a minimum value as ntree increases, then tends to stabilize or slightly increase. As shown in the figure, the model error stabilizes when ntree is set to around 200.

which was set as the optimal parameter for the analysis. The importance of each variable in predicting weight loss outcomes was assessed using the MeanDecreaseGini metric, resulting in the ranking of variables (Figure 3). The top five variables with the highest impact on weight loss outcomes were identified as FFMI, NC, REE/BW, WC, and gender.

The five most influential variables were subsequently included in a multivariate logistic regression model, which indicated that REE/BW, FFMI, and WC were independent predictors of weight loss outcomes. Detailed results of the analysis are presented in Table 7. Based on these three variables, an Inbody nomogram was constructed to predict weight

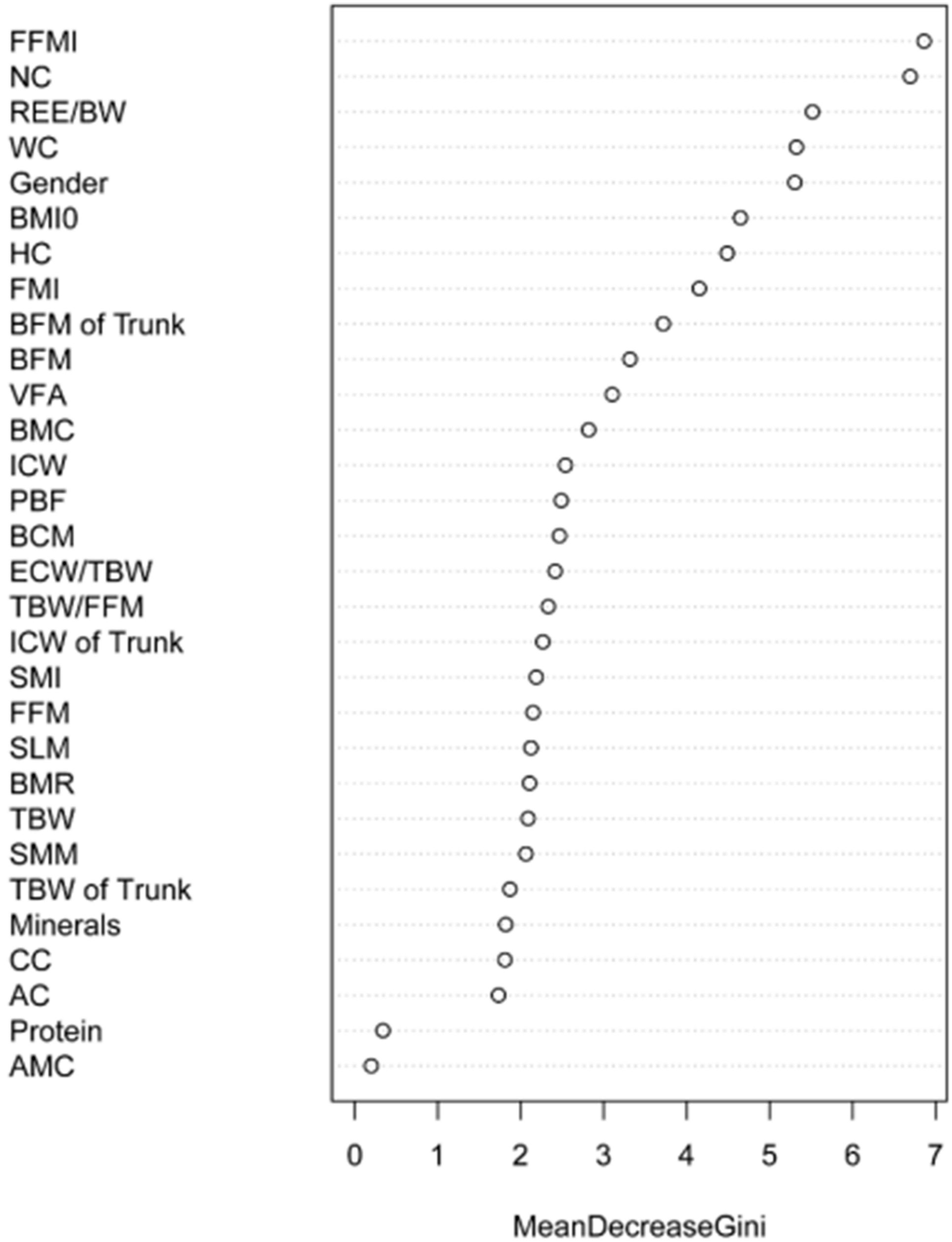

Figure 3 Feature Importance Ranking in the Random Forest Model.

Notes: The horizontal axis represents the Gini coefficient, indicating the importance value of each variable in the random forest model. The vertical axis lists the variables in descending order of importance, from top to bottom.

loss outcomes (Figure 4). The nomogram calculates a total score by summing individual scores for each variable, which corresponds to the predicted probability of achieving an optimal clinical response following LSG.

To assess the performance of the nomogram, an ROC curve was generated using optimal clinical response at one year post-surgery as a binary outcome. Additionally, ROC curves for each of the three predictive factors—REE/BW, FFMI, and WC—were plotted (Figure 5). The results demonstrated that the nomogram exhibited strong discriminatory ability, with a cutoff value for optimal clinical response of 0.806 and an AUC of 0.868 (95% CI: 0.826–0.902). The sensitivity and specificity of the nomogram were 80.9% and 81.5%, respectively, yielding a Youden index of 0.62 ($p < 0.001$). AUC values for the individual ROC curves of the predictive factors were 0.837 (95% CI: 0.793–0.875) for REE/BW, 0.816 (95% CI:

Table 7 Multivariate Logistic Regression Analysis for Selection of Predictive Factors

Variable	OR(95% CI)	*P value*
REE/BW(kcal/day/kg)	1.68(1.13–2.49)	***0.011***
FFMI(Kg/m^2)	0.85(0.71–1.01)	0.066
NC(cm)	0.95(0.88–1.03)	0.950
WC(cm)	0.95(0.92–0.99)	***0.007***
Gender		
Male	1.00(Reference)	
Female	0.83(0.30–2.28)	0.715

Note: Italics and bold indicate that this index is statistically significant.

0.770–0.856) for FFMI, and 0.778 (95% CI: 0.730–0.822) for WC. The AUC for the combined nomogram was higher than that of the individual predictors, with the differences being statistically significant. Detailed results are provided in Table 8.

Model Validation and Predictive Accuracy

To evaluate the calibration and clinical utility of the Inbody prediction nomogram model, this study conducted internal validation by plotting the calibration curve, DCA curve, and CIC curve, as shown in Figure 6a–c, respectively (Figure 6). As seen in Figure 6a, the model's predicted outcomes are in good agreement with the actual outcomes, indicating a high level of predictive accuracy. As seen in Figure 6b and c, compared to all being identified as the best clinical response and suboptimal clinical response, the model provides benefits at different decision thresholds, indicating that the prediction model has high clinical utility.

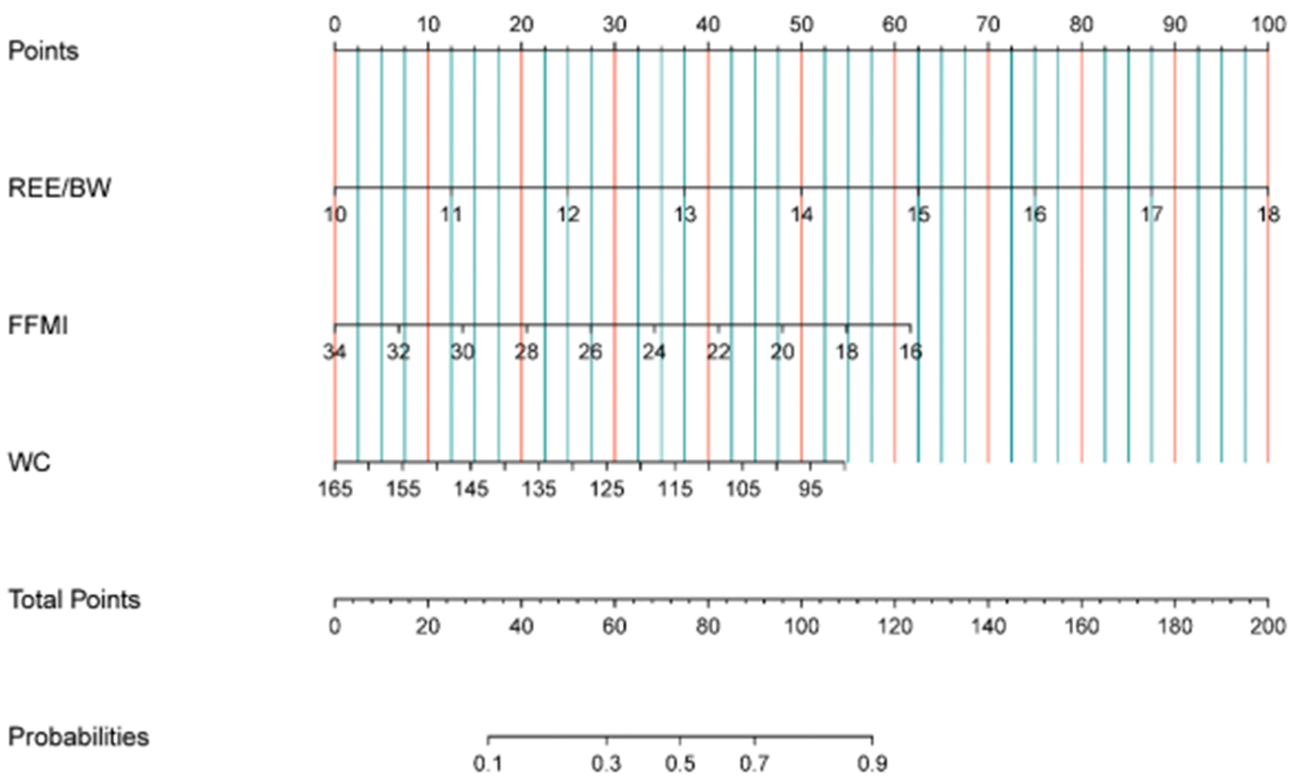

Figure 4 Inbody Nomogram for Predicting Weight Loss Outcomes in LSG Based on Body Composition Indicators.
Notes: For each value of REE/BW, FFMI, and WC, draw a vertical line upward to the corresponding "Score" axis to obtain the score for that factor. Add the scores of the three factors to calculate the "Total Score." Draw a vertical line downward from the Total Score to the "Probabilities" axis at the bottom. The point where this line intersects the Probabilities axis indicates the likelihood of achieving an optimal clinical response.

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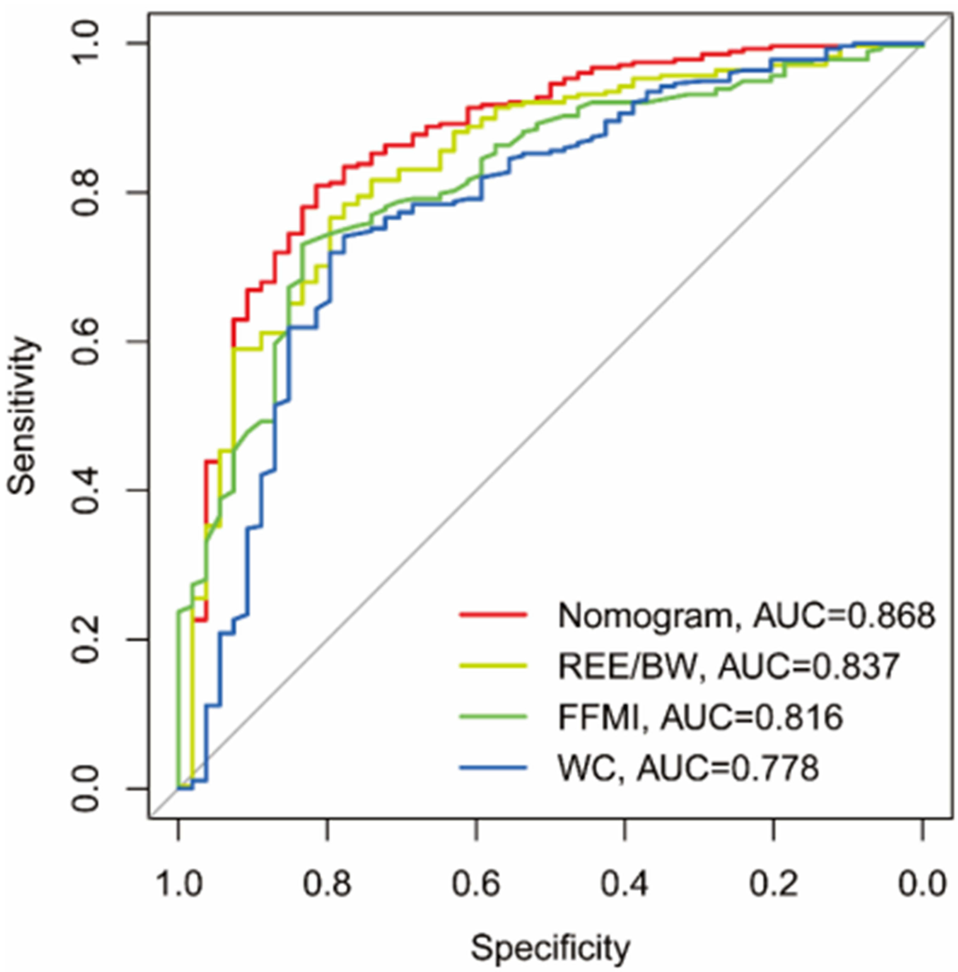

Figure 5 Comparison of ROC Curves for Internal Validation of the Inbody Predictive Nomogram Model and Individual Predictors.

In the external validation group consisting of 141 patients, 21 patients exhibited suboptimal clinical responses one year post-surgery, while 120 patients achieved optimal clinical responses. The ROC curve for this validation group was plotted (Figure 7), revealing an AUC of 0.829 (95% CI: 0.756–0.887), with a sensitivity of 72.5% and specificity of 85.71%. The predictive model demonstrated robust discrimination, outperforming the individual predictive capabilities of the three factors when assessed separately.

Further evaluation was performed through calibration curves, DCA curves, and CIC for the validation group, as depicted in Figure 8a–c. These analyses confirm that the model retains high predictive accuracy and clinical utility within the validation cohort.

Table 8 Comparison of AUC Values Between the Nomogram and Individual Predictors in ROC Curve Analysis

	Nomogram vs REE/BW	Nomogram vs FFMI	Nomogram vs WC
Difference	0.031	0.051	0.089
Standard error	0.015	0.024	0.031
(95% CI)	0.002–0.059	0.005–0.098	0.028–0.150
Z *value*	2.108	2.154	2.860
P *value*	***0.035***	***0.031***	***0.004***

Note: Italics and bold indicate that this index is statistically significant.

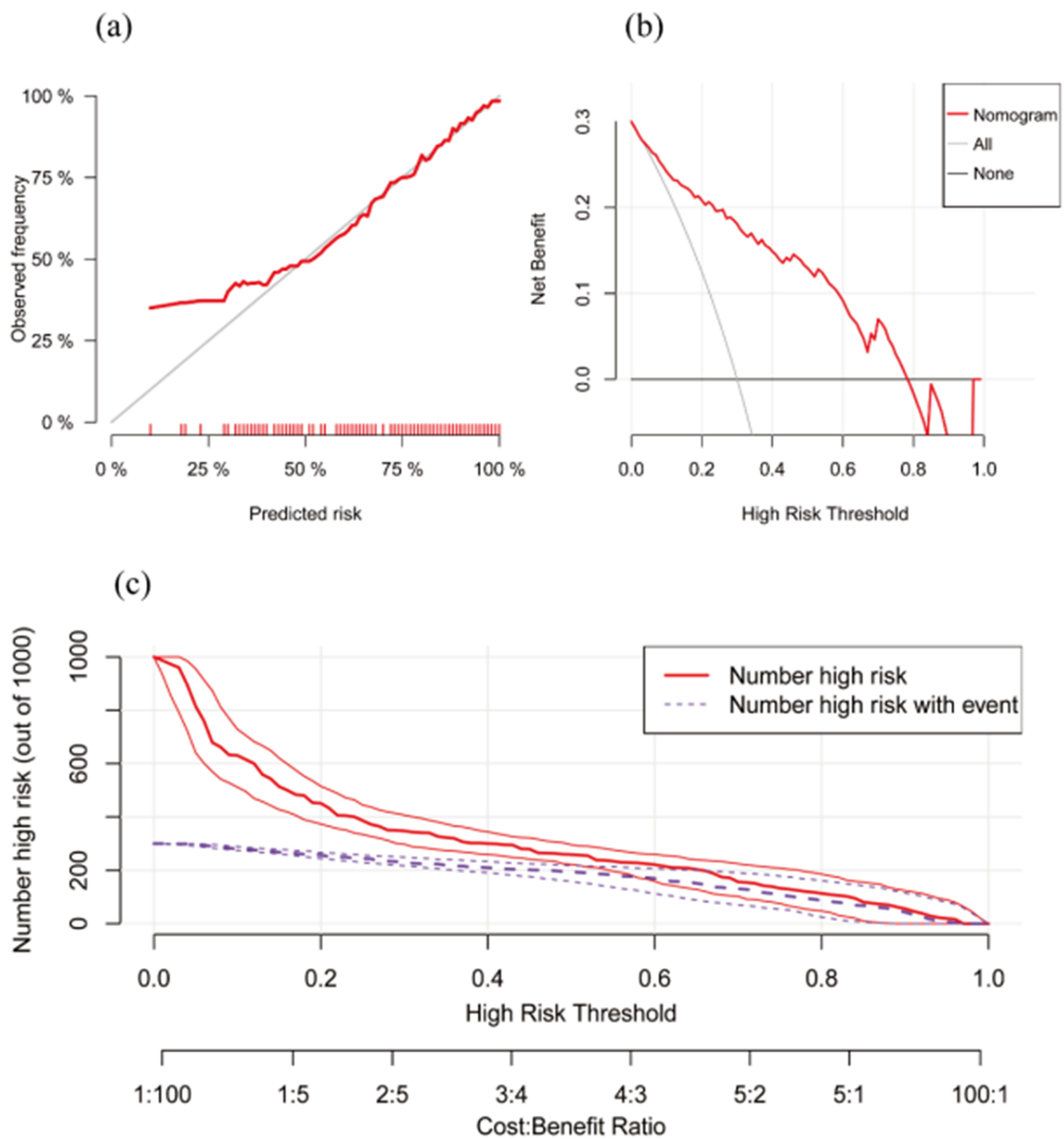

Figure 6 Internal Validation of the Inbody Predictive Nomogram Model. (**a**) Calibration Curve: The closer the red curve is to the diagonal line, the better the model's goodness-of-fit. (**b**) Decision Curve Analysis (DCA): The horizontal axis represents the probability threshold, and the vertical axis represents the net benefit. The further the red line is from the gray and black lines, the higher the clinical utility of the model. (**c**) Clinical Impact Curve (CIC): The horizontal axis represents the probability threshold, and the vertical axis represents the number of patients. The red line shows the number of patients predicted by the model to experience the outcome at different probability thresholds, while the purple line indicates the number of patients who are both predicted and actually experience the outcome. The bottom row shows the benefit ratio, reflecting the ratio of benefit to harm at different probability thresholds.

Development of the Online Predictive Tool

Additionally, this study developed a web-based predictive nomogram using the Shiny framework in R (https://sqing.shinyapps.io/sq_770/). By inputting specific values for the relevant patient variables, the website automatically calculates the weights for the predictive model and generates the probability of achieving an optimal clinical response one year

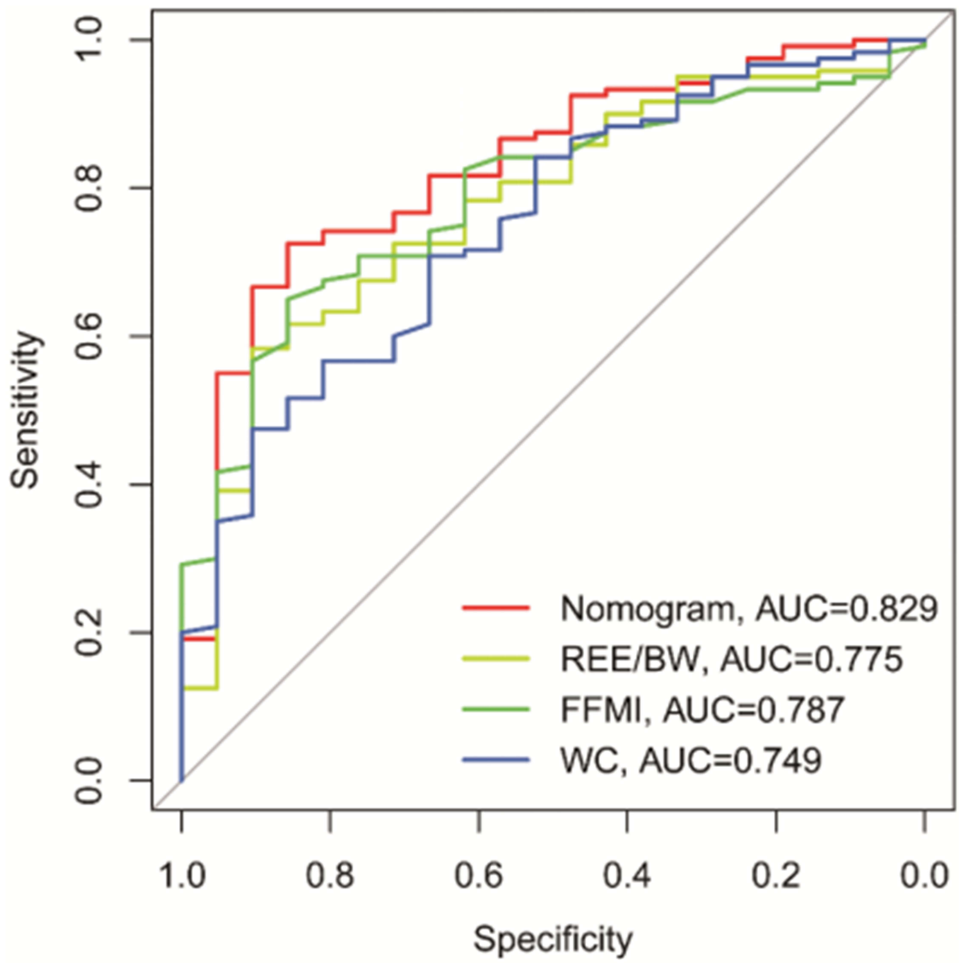

Figure 7 Comparison of ROC Curves for External Validation of the Inbody Predictive Nomogram Model and Individual Predictors.

following LSG. A screenshot of the main page of the online tool is shown in Figure 9. For instance, if an obese patient measures body composition with the Inbody 770, obtaining REE/BW of 14 kcal/kg/d, FFMI of 22 kg/m^2, and WC of 125 cm, the probability of achieving optimal clinical response one year post-LSG would be 92.2%.

Discussion

LSG is currently the most prevalent weight-loss surgery worldwide, with its safety and efficacy supported by extensive literature.[4,5,37] However, approximately 30% of patients undergoing LSG fail to achieve satisfactory weight loss outcomes.[5] Consequently, identifying potential low responders preoperatively is essential for optimizing preoperative assessment, procedure selection, weight loss goal setting, and personalized postoperative care, ultimately reducing the need for revision surgeries. This study identified significant differences in preoperative body composition and clinical indicators between patients who achieved optimal clinical responses and those with suboptimal outcomes post-LSG. While including all these differing indicators could improve predictive accuracy, it would also increase computational burden and resource consumption. Therefore, to pinpoint the most representative independent predictors, random forest analysis was employed on significant indicators from univariate analysis, resulting in the selection of the five most impactful variables: gender, WC, NC, REE/BW, and FFMI. Multivariate logistic regression analysis, with a p-value threshold of 0.1, revealed that gender and NC were not independent predictors. Ultimately, the InBody predictive nomogram for LSG weight loss outcomes was developed using REE/BW ($p = 0.011$), FFMI ($p = 0.066$), and WC ($p = 0.007$). This model achieved an optimal cutoff value of 0.806, with an AUC of 0.868 (95% CI: 0.826–0.902), sensitivity of 80.9%, specificity of 81.5%, and a Youden index of 0.62 ($p < 0.001$). Both internal and external validation

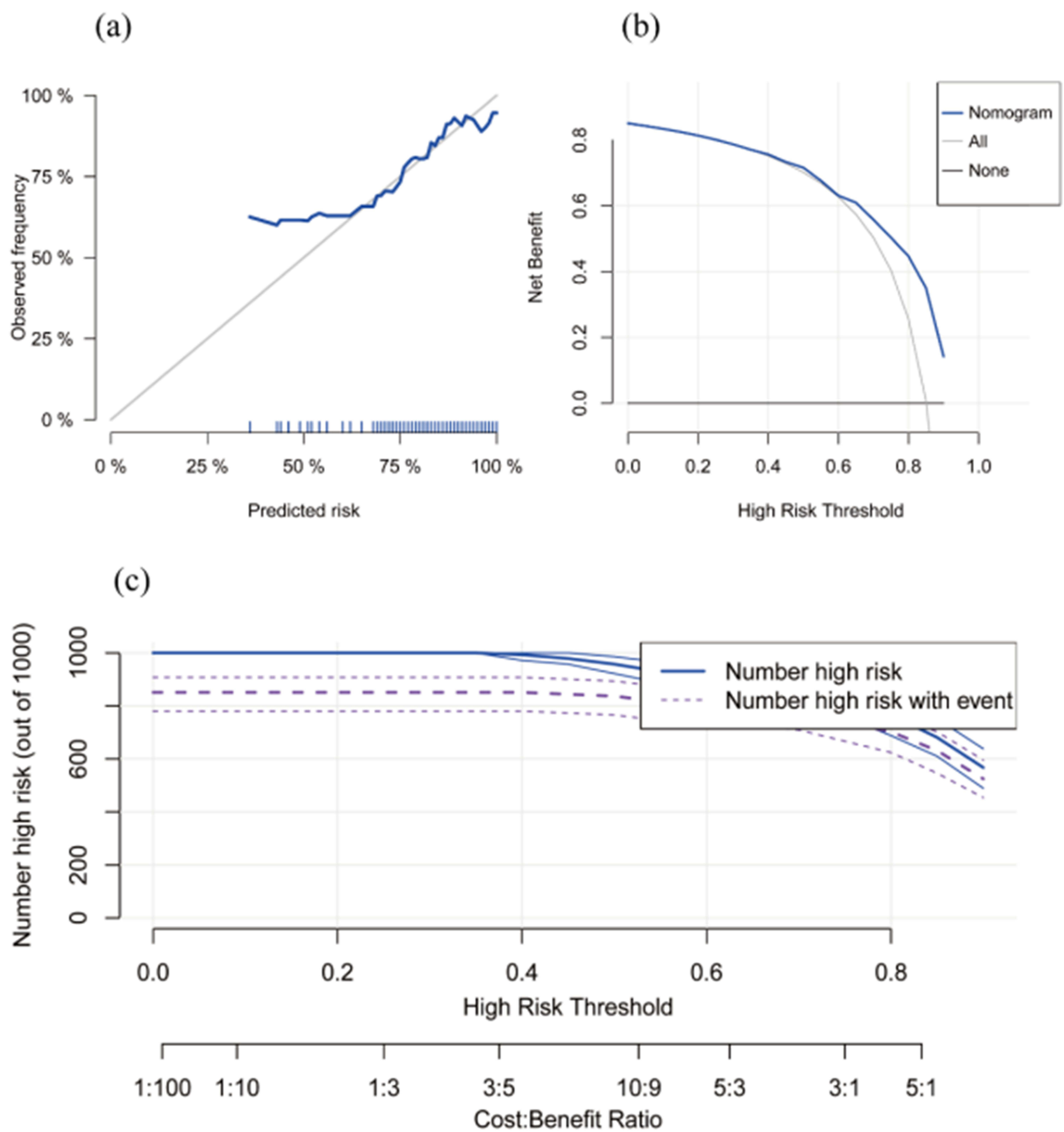

Figure 8 External Validation of the Inbody Predictive Nomogram Model. (**a**) Calibration Curve: The closer the blue curve is to the diagonal line, the better the model's goodness-of-fit. (**b**) Decision Curve Analysis (DCA): The horizontal axis represents the probability threshold, and the vertical axis represents the net benefit. The further the blue line is from the gray and black lines, the higher the clinical utility of the model. (**c**) Clinical Impact Curve (CIC): The horizontal axis represents the probability threshold, and the vertical axis represents the number of patients. The blue line shows the number of patients predicted by the model to experience the outcome at different probability thresholds, while the purple line indicates the number of patients who are both predicted and actually experience the outcome. The bottom row shows the benefit ratio, reflecting the ratio of benefit to harm at different probability thresholds.

confirmed the model's strong predictive performance and clinical applicability. In conclusion, the combination of REE/BW, FFMI, and WC provides a relatively accurate preoperative prediction of weight loss outcomes one year post-LSG.

Methods for assessing body composition include dual-energy X-ray absorptiometry (DXA), isotope dilution, magnetic resonance imaging (MRI), and bioelectrical impedance analysis (BIA). Among these, DXA is considered the gold standard due to its high accuracy and precision.[38] However, its cost and the associated radiation exposure make it impractical for long-term

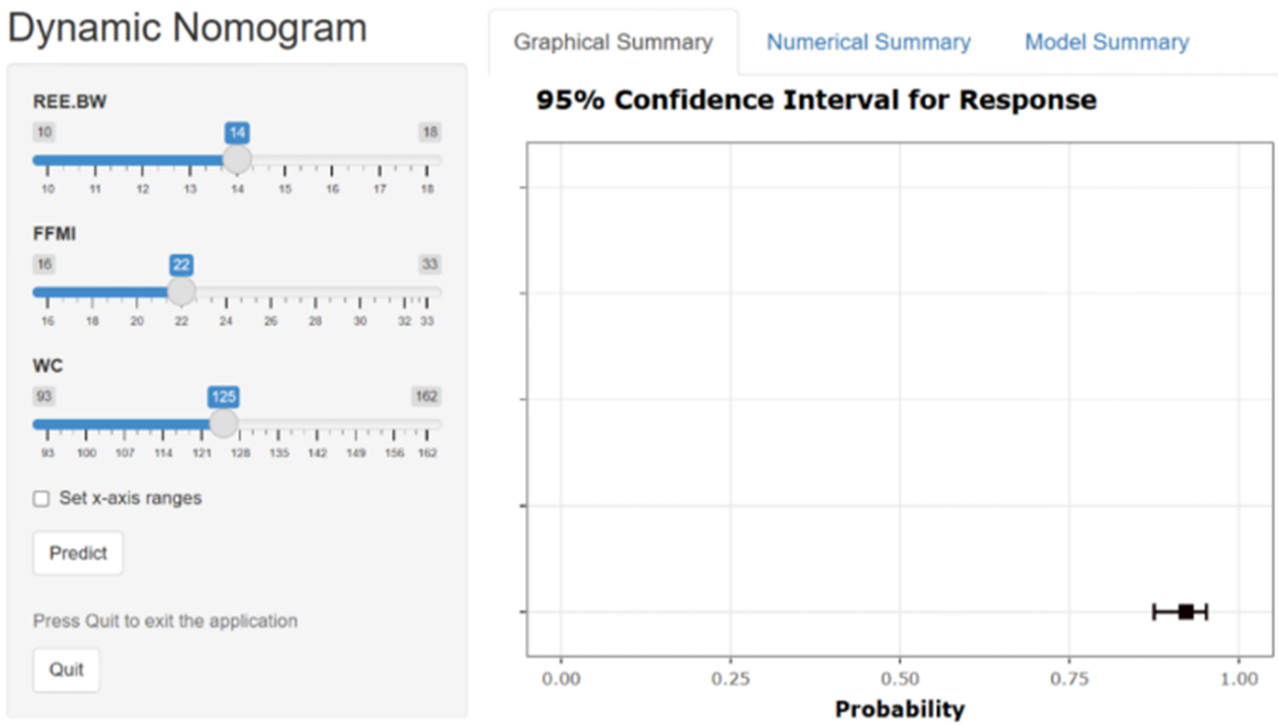

Figure 9 Web Application of the Inbody Predictive Nomogram Model for LSG Weight Loss Outcomes.

monitoring in the general population.[39] In contrast, BIA estimates body composition based on differences in the electrical conductivity of various body tissues. Its accuracy is comparable to DXA while being more cost-effective, non-invasive, and easier to operate. As a result, BIA has become widely used for body composition assessment in weight loss, nutrition, and fitness research.[40,41] This study utilized the InBody body composition analyzer, which is based on BIA technology, to identify three key body composition indicators for predicting weight loss outcomes following LSG.

REE represents the energy expended by the body during wakefulness and rest. In the literature, REE is often used interchangeably with resting metabolic rate (RMR).[42] Fat-free mass (FFM), particularly SMM, is a major determinant of REE and plays a significant role in weight loss outcomes.[43–45] Much of the research in MBS has focused on the effect of weight loss procedures on REE.[46,47] Studies suggest that weight loss surgery generally results in a reduction in REE, though this decrease is less pronounced compared to weight loss achieved through dieting, and the extent of reduction tends to be similar across various surgical techniques.[48] As noted, REE is closely related to total body weight. Although the average REE decreases following LSG, total body weight also significantly decreases postoperatively. Therefore, adjusting REE based on total body weight yields the corrected REE, or REE/BW, which provides a more objective assessment of the impact of weight loss surgery on REE, particularly in comparative studies.[49,50] The trend in postoperative REE/BW changes varies considerably across studies. For example, Bettini et al found no significant change in REE/BW one year after LSG,[51] while Rickard et al reported an increase in REE/BW among younger patients post-surgery.[46] Overall, changes in REE/BW following weight loss surgery remain controversial. Few studies have examined the effect of preoperative REE/BW on weight loss outcomes following surgery. Sans et al observed a positive correlation between preoperative albumin levels and %EBMIL one year after LRYGB ($R = 0.27$, $p = 0.006$).[11] Kehagias et al observed LSG results in fundus resection, significantly reducing levels of the orexigenic hormone ghrelin, which contributes to the energy balance.[52] Albumin levels reflect nutritional status and are indirectly associated with FFM, a key determinant of REE. Thus, FFM likely plays a pivotal role in weight loss.[53,54] Their study also demonstrated that an increase in REE/BW one year post-LRYGB was positively correlated with %EBMIL ($R = 0.47$, $p < 0.001$). Furthermore, when considering FFM alone, the correlation between FFM/BW and %EBMIL was even stronger ($R = 0.71$, $p < 0.001$). Consequently, the authors emphasized that optimal preoperative nutritional status and the preservation of FFM during the postoperative weight loss period are beneficial for weight reduction.[11] This conclusion is corroborated by other studies, which suggest that a high-protein diet both preoperatively and postoperatively helps maintain FFM, thereby supporting metabolic health and energy expenditure, which positively influences weight loss after MBS.[55] It is evident that a higher REE/BW ratio is likely associated with better weight loss outcomes, suggesting that REE/BW could serve as a predictor of weight loss success. In conclusion, the findings of this study are consistent with previous research.

FFMI represents the ratio of FFM to the square of height, calculated similarly to BMI, with the primary distinction being the substitution of FFM for total body weight. FFMI is commonly employed to diagnose protein-energy malnutrition in populations with low FFM.[56] Previous studies have shown that in cohorts with relatively low body fat percentages, reduced fat is associated with higher FFMI, with values around 25 kg/m^2 often reflecting the upper limit of natural muscle accrual through exercise.[57] However, in obese individuals, both FM and FFM (encompassing muscle, skin, and bone) are elevated, resulting in correspondingly higher FFMI values.[58] For example, a study of 36 Japanese professional sumo wrestlers reported an average FFMI of 26.6 kg/m^2, with some individuals reaching values as high as 37 kg/m^2.[59] It is critical to note that while FFMI quantifies the ratio of FFM to height squared, it does not provide insight into the proportion of FFM within the body or the distribution of body fat. Multiple studies have demonstrated a negative correlation between BMI and weight loss outcomes.[18,20,60,61] Typically, individuals with higher BMI also exhibit higher FFMI, suggesting that FFMI shares characteristics similar to those of BMI. This study posits that FFMI is inversely correlated with %EWL, implying that individuals with higher FFMI are more likely to experience suboptimal clinical responses following LSG.

WC serves as an effective surrogate marker for abdominal obesity. The findings of this study suggest that larger WC values are associated with an increased likelihood of suboptimal clinical responses following MBS. Visceral and subcutaneous fats, the two primary adipose depots in the body, are key contributors to obesity-related metabolic disturbances. The risk of such dysfunction is closely linked to the distribution of these fat depots and their intrinsic characteristics.[62–64] An elevated WC is indicative of a greater accumulation of visceral fat, which significantly heightens the risk of obesity-associated complications, such as cardiovascular diseases, atherosclerosis, and type 2 diabetes mellitus (T2DM).[65] For instance, Koning et al demonstrated that for each additional centimeter of WC, the relative risk of cardiovascular events rises by 2%.[66] Even among individuals with normal weight, central obesity—regardless of BMI—has been linked to lower long-term survival rates compared to those with more favorable fat distribution patterns.[67] These findings underscore that WC may serve as an important proxy for metabolic health. Furthermore, WC plays a pivotal role in determining the variability in weight loss surgery outcomes. Numerous studies have established that patients with larger WC generally experience less favorable responses to MBS.[11,13,21,68,69] For instance, Arnaud et al found a negative correlation between preoperative WC and %EBMIL one year after LRYGB in obese women ($R = -0.3$, $p < 0.001$),[11] suggesting that higher WC prior to surgery is predictive of poorer weight loss outcomes. Similarly, a study involving 407 patients who underwent LSG or LRYGB also reported a negative correlation between WC and %EWL one year post-surgery, particularly when BMI was excluded from the multivariate regression model.[13] These results corroborate the conclusions drawn in the current study.

This study developed a preoperative predictive model for weight loss outcomes following LSG by integrating three key indicators: REE/BW, FFMI, and WC. This model provides an early assessment tool for bariatric surgeons to predict potential weight loss outcomes, enhancing preoperative decision-making. The discussion further emphasizes that prior research supports the prognostic value of these indicators for weight loss outcomes post-MBS, further validating the robustness of the present findings. To balance predictive accuracy with computational efficiency, a variable reduction approach was employed, systematically selecting the most relevant features from a broader set of body composition data. This strategy ultimately retained the three most significant predictors, optimizing both clarity and effectiveness for clinical application.

Previous studies have investigated the predictive value of preoperative body composition indicators for weight loss outcomes following MBS. For instance, Arnaud et al analyzed preoperative body composition data and follow-up records from 103 women who underwent LRYGB. Their study found a negative correlation between preoperative FM and % EBMIL one year after surgery ($R = -0.23$, $p = 0.02$), while the correlations between preoperative fat-free mass (FFM) and REE/BW with %EBMIL were not significant. However, an increase in REE/BW post-surgery was positively correlated with %EBMIL ($R = 0.47$, $p < 0.001$).[11] Similarly, the present study found that patients with suboptimal clinical responses after LSG had higher preoperative FM, although FM was not included in the final predictive model. Notably, this study confirmed that baseline REE/BW is a predictor of weight loss outcomes, aligning with the findings of Arnaud's study, albeit in a different population. Arnaud's cohort consisted of 103 French women undergoing LRYGB, while this study involved 473 Chinese patients undergoing LSG, suggesting that disparities in findings may stem from differences in surgical techniques, patient demographics, and sample sizes. Effat et al analyzed data from 54 obese patients who underwent LRYGB and identified baseline skeletal muscle mass (SMM) as an independent predictor of %EWL six months post-surgery, with each additional kilogram of SMM correlating to a 1.418% decrease in %EWL.[10] Although the surgical procedures in this study differed from those in Effat's, this research also found that patients with suboptimal clinical responses had higher baseline SMM, a correlation observed in univariate analysis but excluded during the variable reduction process. To enhance model clarity and balance predictive accuracy with computational efficiency, this study systematically filtered the body composition data, retaining only the three most significant predictors. Consequently, while SMM showed potential as a predictor, its exclusion from the final model suggests the need for further exploration in future research. Fabio et al defined weight loss failure as %EWL ≤50% six months after surgery and identified several predictors, including NC ≥ 44 cm, WC ≥ 142 cm, age ≥ 50 years, fasting blood glucose ≥ 118 mg/dL, and the presence of obstructive sleep apnea/hypopnea syndrome (OSAHS). They later excluded WC and OSAHS in multivariate logistic analysis, resulting in the development of a NAG (Neck Circumference, Age, Glucose) score with an AUC of 0.713, which was subsequently validated.[70] This study similarly found that larger NC and WC were associated with poorer weight loss outcomes, but NC was excluded from the multivariate analysis, leaving WC as a key predictor. Fabio's cohort comprised 300 Caucasian patients, including 233 LSG and 67 LRYGB patients, with NC and WC treated as categorical variables. In contrast, the current study analyzed NC and WC as continuous variables in a cohort of 473 Chinese patients who underwent LSG. Thus, the differences in conclusions between the two studies may reflect variations in ethnicity, surgical techniques, sample sizes, and statistical methodologies.

In summary, the value of this study is underscored by several key aspects: 1. Predictive Accuracy: This research establishes a nomogram based on body composition data to predict weight loss outcomes one year post-LSG for Chinese patients with obesity and a BMI ≥ 32.5 kg/m^2. By utilizing just three critical body composition indicators, the model provides accurate predictions that are non-invasive, convenient, cost-effective, and easy to interpret. 2. Timeliness: The model can be applied preoperatively using InBody analysis to forecast outcomes after LSG, facilitating the identification of optimal candidates for surgery. Additionally, it supports preoperative assessments, expectation management, and individualized postoperative follow-up. 3. Stability and Reliability: To mitigate the impact of excessive preoperative BMI variability on postoperative %EWL, the study focused on patients with a BMI above 32.5 kg/m^2, ensuring the model's stability, scientific rigor, and reliability. 4. Sample Size Enhancement: This research addresses the limitations of prior studies, which often had small sample sizes, thereby strengthening the validity of the findings. 5. Web-based Predictive Tool: A web-based version of the predictive nomogram has been developed, allowing clinicians to input relevant data and receive predictions easily. Integrating this tool into body composition analyzers could provide instant predictive reports during preoperative assessments, representing a promising direction for clinical application.

This study does have several limitations. First, as a retrospective analysis, it is susceptible to recall bias, and the findings require validation through prospective clinical trials. Second, the follow-up period was relatively short, allowing for predictions of weight loss outcomes only one year post-LSG. However, weight loss generally stabilizes within this timeframe, with minimal likelihood of significant changes thereafter.[71,72] Therefore, predicting weight loss after one year is of substantial clinical relevance. Considering that long-term weight loss outcomes may be influenced by additional body composition factors, extended follow-up studies will be conducted to investigate the predictive role of preoperative body composition indicators on long-term postoperative weight loss. Moreover, the model focuses solely on weight loss and does not account for the alleviation of obesity-related comorbidities. Since post-surgical weight loss is a key factor in metabolic improvement,[73] future research at our center will aim to identify predictors for the resolution of obesity-related conditions. Finally, the model was developed using data exclusively from our center, involving Chinese obese patients, which may limit its generalizability to patients in other countries. It has not yet been externally validated across other weight loss centers, and its applicability to broader populations remains to be confirmed through further studies with larger sample sizes across diverse centers.

Conclusions

In obese Chinese patients with a BMI ≥ 32.5 kg/m^2, REE/BW, FFMI, and WC can predict weight loss outcomes one year after LSG.

Author Contributions

All authors made significant contributions to the reported work, including conception, study design, execution, data acquisition, analysis and interpretation, or in all these areas. They participated in drafting, revising, or critically reviewing the article, provided final approval for the version to be published, agreed on the journal to which the article was submitted, and are accountable for all aspects of the work.

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Disclosure

Liang Wang, Yilan Sun and Qing Sang are co-first authors for this study. The authors report no conflicts of interest in this work.

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