A novel nomogram for predicting successful weight loss following diet and exercise intervention in people with obesity

Lei Yu
Nanjing Drum Tower Hospital, The Affiliated Hospital of Nanjing University Medical School
Jing Wang
Nanjing Drum Tower Hospital, The Affiliated Hospital of Nanjing University Medical School
Zhendong Hu
Nanjing Drum Tower Hospital, The Affiliated Hospital of Nanjing University Medical School
Tiancheng Xu (drxutiancheng@foxmail.com)
Nanjing Drum Tower Hospital, The Affiliated Hospital of Nanjing University Medical School
Weihong Zhou
Nanjing Drum Tower Hospital, The Affiliated Hospital of Nanjing University Medical School

Research Article

Keywords: Obesity, weight loss, nomogram, prediction model

Posted Date: January 3rd, 2024

DOI: https://doi.org/10.21203/rs.3.rs-3774563/v1

Additional Declarations: No competing interests reported.

Abstract

Purpose

Obesity is a global health challenge. However, achieving successful weight loss remains challenging. Therefore, this study aims to identify potential factors for weight loss failure by analyzing pre-weight loss data.

Methods

We utilized data encompassing records of 2577 people with obesity who visited weight management clinics from 2013 to 2022, with 1276 having at least a 3-month follow-up visit. Data preprocessing involved selecting 1276 patients with follow-up data. After dietary and exercise interventions, 580 participants achieved successful weight loss. We then divided the participants into two groups to analyze their baseline, those who lost weight and those who did not.

Results

Statistical analysis was conducted using RStudio, 13 predictor variables were identified based on LASSO and logistic regression, and age emerged as the most influential predictor. A nomogram for predicting weight loss success was then developed. The nomogram demonstrated good predictive performance (AUC = 0.807) and clinical applicability, as validated by internal validation methods. Decision curve analysis (DCA) also demonstrated the nomogram's clinical utility in predicting weight loss success.

Conclusion

We developed a nomogram prediction model for successful weight loss. The nomogram is easy to use, highly accurate, and has excellent effect discrimination and calibration capabilities.

Introduction

Obesity is a chronic metabolic disease caused by both genetic and environmental factors that involves excessive total body fat content and/or increased local fat content with abnormal distribution[1]. The global prevalence of obesity has almost tripled in the past 40 years, and in 2016, the World Health Organization (WHO) estimated that 1.9 billion adults and more than 340 million children and adolescents aged 5–19 were overweight or obese[2]. The World Obesity Federation (WOF) predicts that by 2030, around one billion people globally will be obese, including one in five women and one in seven men[3].

Obesity is associated with a higher risk of early death, and it also increases overall mortality[4]. Furthermore, due to the mass effect of excess adipose tissue and its direct metabolic effects, obesity is

likewise associated with the occurrence of various chronic diseases, including diabetes, stroke, coronary artery disease, hypertension, respiratory disease, and obstructive sleep apnea[5–7]. Obesity is even associated with the occurrence of various tumors[8]. In addition, obesity is known to have adverse psychological and social consequences for individuals. Multiple studies have shown that there are more than 200 comorbidities associated with obesity, and that even small amounts of weight loss can improve them[9].

Approaches to weight loss include lifestyle changes, dietary changes, high-intensity physical activity, drugs, and surgery[10]. The cornerstone therapy is lifestyle intervention, but this approach is resource-intensive and difficult for many people to maintain over time[11]. In addition, due to the body's own "energy compensation" mechanism, the exercise weight loss effect for obese people is even worse than lifestyle changes[12]. Drug treatments for weight loss have lagged and are often out of reach[13]. The use of minimally invasive bariatric surgery has increased, but not all patients are candidates or desire surgery[14]. Ultimately, more than one way is needed to optimize disease control for the entire obese population.

With a reliable way to identify people likely to fail to lose weight, however, clinicians may be able to apply more comprehensive intervention measures earlier that can increase the success rate of weight loss. This study analyzed pre-weight loss data against post-weight loss outcomes in an attempt to identify early characteristics of populations prone to weight loss failure before attempted weight loss even begins.

Methods

Data

The records used in this study come from the database of the Health Management Center, Drum Tower Hospital Affiliated to Nanjing University Medical School, Nanjing, China. Weight loss records came from 2577 people with obesity who visited weight management clinics from 2013 to 2022, of whom 1276 had at least a 3-month follow-up visits. Participants in the study gave written informed consent to use their data, and this research have been performed in accordance with the Declaration of Helsinki. This research protocol was approved by the Nanjing Drum Tower Hospital Institutional Review Board.

Data preprocessing

First, the data of 1276 patients with at least a 3-month follow-up data were screened out from 2577 weight loss patients. Variables of interest included age, height, weight, BMI, waist to hip, obstetric history, diabetes history, hypertension history, alcohol consumption history, hypothyroidism, anxiety score, depression score, age at menarche, menstrual abnormality, hirsutism, acne, hair loss, galactorrhea, acanthosis nigricans, polycystic ovary (PCO), fatty liver, blood pressure, blood glucose, insulin, hemoglobin a1c (HbA1c), thyroid-stimulating hormone (TSH), free triodothyronine (FT3), free thyroxine (FT4), thyroglobulin antibody (TgAb), alanine aminotransferase (ALT), aspartate aminotransferase (AST), γ-glutamyl transferase (γ-GT), total bilirubin (TBIL), direct bilirubin (DBIL), uric acid (UA), blood urea

nitrogen (BUN), serum creatinine (SCr), triglyceride (TG), total cholesterol (TC), high density lipoprotein (HDL), low density lipoprotein (LDL), apoprotein (Apo), ca, dehydroepiandrosterone sulfate (DHEAS), sex hormone-binding globulin (SHBG), adrenocorticotropic hormone (ACTH)-8:00, cortisol (F)-8:00, vitamin D, albumin, c-reactive protein (CRP), and metformin treatment regimen (0: without; 1: with metformin). Anxiety and depression scores were derived from the GAD-7 and PHD-9 scales, respectively[15, 16], and PCO and fatty liver were diagnosed by ultrasound. Through dietary and exercise interventions, those with impaired glucose tolerance or T2DM were treated with metformin. After 3 months to 1 year of follow-up, 580 of them successfully lost weight, which was defined as a weight loss of more than 5%[17]. After this result we divided the patients in to groups according to whether their weight loss was successful (weight loss success group and weight loss failure group).

Statistical analysis

The methods described here have been reported previously[18] and are outlined briefly below. This study used RStudio (https://www.rstudio.com) for all statistical analysis after expressing all data as follows. All participant characteristics were expressed as mean (SD) for continuous variables and frequency (percentage) for categorical variables. One-way ANOVA with Kruskal-Wallis test was used to analyze the difference between normally and skewed continuous variables, and chi-squared tests were performed to help analyze categorical variables.

Eight predictors of weight loss failure were selected using LASSO, and nine predictors were selected using backward analysis of logistic regression. A total of 12 predictors were screened out based on these two methods, and together with age a risk prediction nomogram model for successful weight loss was drawn based on these 13 predictors.

Results

Baseline characteristics

Of the 1276 patients in the cohort who had follow up 580 successfully lost weight. Table 1 plots the baseline data for the 580 successes and 696 failures.

Table 1
Baseline clinical and laboratory data characteristics of people with obesity in weight loss failure and weight loss success groups.

Characteristic	Weight loss failure (n = 696)	Weight lose success (n = 580)	*P* value
Age (year)	30.38 (4.442)	30.37 (4.239)	0.996
Height (cm)	160.32 (5.714)	159.77 (5.670)	0.449
Weight (kg)	80.89 (11.032)	77.06 (7.858)	0.003
BMI (kg/m2)	31.47 (3.940)	30.25 (2.690)	0.009
Waist to hip (%)	0.96 (0.053))	0.95 (0.048)	0.094
Obstetric history	42 (43.75%)	79 (43.89%)	0.982
Diabetes history	1 (1.04%)	4 (2.22%)	0.492
Hypertension history	1 (1.04%)	4 (2.22%)	0.492
Alcohol consumption history	2 (2.08)	6 (3.33%)	0.566
Hypothyroidism	14 (14.58%)	19 (10.56%)	0.328
Anxiety score	4.65 (4.693)	4.09 (4.036)	0.309
Depression score	4.08 (4.010)	3.80 (3.770)	0.568
Age at merche (year)	13.60 (1.475)	13.47 (1.442)	0.484
Menstrual abnormality	18 (18.75%)	37 (20.56%)	0.722
Hirsutism	16 (16.67%)	39 (21.67%)	0.310
Acne	7 (7.29%)	16 (8.89%)	0.649
Hair loss	25 (26.04%)	30 (16.67%)	0.072
Galactorrhea	2 (2.08%)	2 (1.11%)	0.515
Acanthosis nigricans	6 (6.25%)	10 (5.56%)	0.807
PCO	3 (3.13%)	2 (1.11%)	0.296
Fatty liver	60 (62.50%)	107 (59.44%)	0.796
SBP (mmHg)	124.11 (11.337)	122.92 (14.097)	0.458
DBP(mmHg)	82.27 (10.037)	80.78 (10.836)	0.275
Blood glucose during OGTT(mg/dL)			
0 min	5.72 (1.751)	5.32 (1.005)	0.017

Characteristic	Weight loss failure (n = 696)	Weight lose success (n = 580)	*P* value
30 min	9.31 (2.400)	8.55 (1.739)	0.003
60 min	9.70 (3.139)	8.86 (2.701)	0.026
120 min	8.07 (3.457)	7.56 (2.714)	0.180
Blood insulin during OGTT(uU/mL)			
0 min	23.86 (11.526)	19.51 (9.508)	0.000
30 min	119.96 (68.958)	121.80 (87.079)	0.861
60 min	148.55 (89.051)	132.42 (87.905)	0.159
120 min	148.45 (99.466)	129.084 (107.751)	0.160
HOMA IR	6.50(5.94)	4.73(2.84)	0.001
HOMA β	250.98(120.77)	193.45(493.88)	0.177
HbA1c(%)	5.697 (1.176)	5.43 (0.650)	0.049
TSH(mIU/L)	3.21 (1.743)	3.13 (2.840)	0.811
FT3(pmol/L)	4.89 (0.849)	4.99 (0.453)	0.308
FT4(pmol/L)	17.03 (2.288)	17.04 (2.536)	0.974
TgAb(IU/mL)	16.30 (13.497)	19.43 (25.709)	0.266
ALT(U/L)	43.99 (29.761)	37.50 (33.030)	0.111
AST(U/L)	22.59 (7.495)	22.90 (14.354)	0.843
γ-GT(U/L)	72.28 (20.911)	69.44 (25.941)	0.361
TBIL(umol/L)	11.37 (17.704)	9.99 (6.219)	0.351
DBIL(umol/L)	2.84 (1.940)	3.38 (8.185)	0.530
UA(umol/L)	374.43 (78.694)	369.93 (87.704)	0.676
BUN(mmol/L)	4.50 (1.099)	4.56 (1.157)	0.699
SCr(umol/L)	49.30 (8.223)	50.20 (7.612)	0.367
TG(mmol/L)	1.79 (1.141)	1.64 (1.063)	0.287
TC(mmol/L)	4.69 (1.002)	4.60 (0.866)	0.453
HDL(mmol/L)	1.21 (0.421)	1.19 (0.347)	0.671
LDL(mmol/L)	2.66 (0.783)	2.62 (0.636)	0.711

Characteristic	Weight loss failure (n = 696)	Weight lose success (n = 580)	*P* value
Apo-A(g/L)	1.07 (0.196)	1.09 (0.236)	0.445
Apo-B(g/L)	0.97 (0.335)	0.89 (0.206)	0.021
Ca(mmol/L)	2.43 (0.200)	2.46 (0.131)	0.119
DHEAS(umol/L)	230.32 (117.525)	234.49 (111.011)	0.778
SHBG(nmol/L)	27.26 (16.156)	30.08 (22.072)	0.287
ACTH-8:00(pmol/L)	6.84 (3.785)	6.66 (4.363)	0.731
F-8:00(nmol/L)	354.96 (124.783)	336.71 (139.961)	0.298
Vitamin D(ng/mL)	17.83 (5.599)	17.93 (6.212)	0.898
Albumin(g/L)	45.95 (3.753)	46.51 (3.766)	0.247
CRP(mg/L)	4.07 (4.730)	2.87 (3.651)	0.046
Metformin treatment regimen (0: without; 1: with metformin)	69 (71.88%)	114 (59.44%)	0.146

Data are shown as means (SD), *P* value

PCO, Polycystic ovary; SBP, Systolic blood pressure; DBP, Diastolic blood pressure;

Homeostatic model assessment of insulin resistance, HOMA IR; Homeostatic model assessment of β-cell function, HOMA β; Hemoglobin A1C, HbA1c; TSH, Thyroid-stimulating hormone; FT3, Free triodothyronine; FT4, Free thyroxine; TgAb, Thyroglobulin antibody; ALT, Alanine aminotransferase; AST, Aspartate aminotransferase; γ-GT, γ-Glutamyl transferase; TBIL, Total bilirubin; DBIL, Direct bilirubin; UA, Uric acid; BUN, Blood urea nitrogen; SCr, Serum creatinine; TG, Triglyceride; TC, Total cholesterol; HDL, High Density Lipoprotein; LDL, Low Density Lipoprotein; Apo, Apoprotein; DHEAS, Dehydroepiandrosterone sulfate; SHBG, Sex hormone-binding globulin; ACTH, Adrenocorticotropic hormone; F, Cortisol; CRP, C-reactive protein.

Development of role selection and personalization prediction models

For the baseline data, we reduced the 61 features in the Lasso regression model to 8 potential predictors with nonzero coefficients, including hirsutism, hair loss, BMI, blood glucose at 0 min, insulin at 0 min, blood glucose at 60 min, ALT, and Ca (Fig. 1a and b). We additionally filtered out 9 by backward analysis of logistic regression predictor variables, including blood glucose at 0 min, ALT, TC, LDLC, Ca, F-8:00, HOMA β, hirsutism, and hair loss. 12 predictor variables were then obtained based on the two screening methods together, and along with age, there were a total of 13 predictor variables (Table 2). Based on

these 13 predictor variables, we developed a nomogram to predict weight loss success, as shown in Fig. 2.

Table 2
Multivariate logistic regression analysis of 13 predictor variables in the final model.

	β	Odds ratio(95% CI)	*P* value
Age	-0.074	0.928	0.783
Hair loss	-0.971	0.379	0.006
Hirsutism	-0.242	0.785	0.183
ALT	-0.587	0.556	0.025
BMI	0.671	1.956	0.009
Insulin at 0 min	0.428	1.536	0.016
Blood glucose at 0 min	-0.263	0.769	0.134
Blood glucose at 60 min	-0.400	0.670	0.153
TC	0.892	2.441	0.020
LDL	-0.230	0.795	0.194
Ca	-0.448	0.639	0.061
F-8:00	-0.154	0.857	0.558
HOMA β	-0.400	0.803	0.259

Nomogram performance

The nomogram calibration curve showed good agreement across the cohort (Fig. 3a). Using a bootstrap sampling method for internal validation, we found that the AUC of the nomogram was 0.807 (95% CI: 0.736–0.868), indicating that the model has good predictive power (Fig. 3b).

Nomogram decision curve

Decision curve analysis (DCA) is a method to evaluate the clinical benefit of alternative therapies, and is applied to nomograms by quantifying the net benefit at different threshold probabilities. DCA of our weight loss success prediction nomogram model is shown in Fig. 4. The abscissa is the threshold probability, and the ordinate is the net benefit after deducting pros and cons. Two reference curves (sloping and horizontal lines) were drawn based on the net benefit when all participants were considered successful at losing weight and all received the intervention (representing the highest clinical cost), and when all participants were considered unsuccessful at losing weight (representing no clinical benefit).

Therefore, in comparing the model curve with these two lines, the farther the model curve is from these two lines, the better the clinical benefit of the nomogram. The DCA from this study demonstrate that the nomogram is a good predictor of clinically successful weight loss.

Discussion

Obesity is a major cause of poor health worldwide[19]. Since this problem is made worse by the fact that the success rate of weight loss is low, we constructed a nomogram to predict successful weight loss. Validation of the nomogram demonstrated its good effect discrimination and calibration capabilities. Furthermore, the weight loss success prediction model constructed in this study can be applied before weight loss attempts begin, thereby providing more individualized weight loss guidance for people at different risks and possibly improving the weight loss success rate.

Obesity is associated with an increased risk of type 2 diabetes, cardiovascular disease, certain cancers, and premature death[20]. In addition to adverse health outcomes, obesity also impacts the healthcare system, creating direct costs related to healthcare as well as indirect costs such as lost productivity[21]. Once weight is gained, it is extremely difficult to lose it again, with only 40% of those who attempt losing weight losing ≥ 5% and 20% losing ≥ 10%. However, most people have difficulty maintaining such weight loss, with reported weight regain of 30–50% within 1 year[22]. Failure to maintain weight loss is usually attributed to lack of adherence to the initial weight loss diet, so we sought to predict the success rate of weight loss before it is even begun, thereby possibly helping people with weight loss difficulties strengthen behavioral, dietary, and other interventions to that can improve their chances of success. There are currently few risk models that predict successful weight loss. In this study, however, 12 variables were selected based on LASSO regression and logistic regression and included in the nomogram together with age. The line segment corresponding to each variable is marked with a scale, which represents the possible value range of the variable, and the total score of the corresponding individual scores after all variables are added up is called the Total Points. The length of the line segment reflects the contribution of the factor to the outcome event. In our model age is the most important predictor, followed by LDL, blood glucose at 0 min, HOMA β, TC, hair loss, F-8:00, hirsutism, Ca, blood glucose at 60min, ALT, BMI, and insulin at 0 min.

Our nomogram also showed that hair loss and hirsutism are important factors, and their effects may even exceed those of BMI and fasting insulin. This shows that the more hair you have, the more likely you are to lose weight successfully. Excessive body hair may be due to the body's sensitivity to androgens, indicators of abdominal obesity in men are negatively correlated with testosterone levels. Unlike men, high androgen levels in women are usually a high risk factor for obesity and are closely related to the occurrence of abdominal obesity[23].This study also identified ALT as a prognostic factor using, with lower ALT being more likely to result in successful weight loss. Finally, the calibration curve showed that the nomogram was well calibrated and the AUC (0.807) showed its statistical accuracy. However, accuracy does not necessarily mean it has clinical application. To this end, we also performed DCA, which showed that the nomogram indeed has good clinical utility.

Although the model's predictions were good, three major limitations of this study are that the follow-up period was too short and did not incorporate the effects of regaining weight after weight loss. Another key limitation is the limited number of people who attended the weight management clinic, thus limiting the sample size for this study and resulted in only internal validation but no external validation. The third limitation is that only diet and exercise interventions were studied without other intervention methods such as drugs and surgery. For many people, although they want to lose weight, they are not actively engaged in weight loss due to the perceived difficulty and low probability of success. Therefore, more and more accurate weight loss success prediction models need to be developed to improve people's perceptions of weight loss success. In addition, this study did not include sleep[24], support from friends and family[25], eating habits[26], reasons for weight loss, or other factors that may affect the success of weight loss.

In summary, based on baseline data from a population that a weight management clinic, we developed a nomogram prediction model to predict successful weight loss following diet and exercise intervention. The nomogram is easy to use, highly accurate, and has excellent effect discrimination and calibration capabilities. Therefore, this nomogram may help clinicians make personalized predictions about the probability of weight loss success for each people with obesity and in doing so provide more individualized weight loss intervention that may improve their chances of success.

Declarations

Competing Interests

The authors declared no conflict of interest.

Ethical Approval

Participants in the study gave written informed consent to use their data. This research protocol was approved by the Nanjing Drum Tower Hospital Institutional Review Board.

Funding

Not applicable.

Author Contribution

LY was responsible for writing the article. JW was responsible for patient recruitment and data collection. ZDH was responsible for the final modification. TCX was responsible for the design and analysis of the project, and WHZ was responsible for data compilation.

Acknowledgments

The authors thank AiMi Academic Services (www.aimieditor.com) for English language editing and review services.

Data Availability

All relevant data can be requested through the corresponding author.

Availability of data and materials

All relevant data and materials can be requested through the corresponding author.

References

1. Jepsen CH, Bowman-Busato J, Allvin T, Arthurs N, Goossens GH, et al. Achieving consensus on the language of obesity: a modified Delphi study. EClinicalMedicine 2023;62:102061.
2. Updike WH, Pane O, Franks R, Saber F, Abdeen F, et al. Is it Time to Expand Glucagon-like Peptide-1 Receptor Agonist Use for Weight Loss in Patients Without Diabetes? Drugs 2021;81:881–893.
3. Goh GBB, Tham KW. Combating obesity: a change in perspectives. Singapore Med J 2023;64:153–154.
4. Ahirwar R, Mondal PR. Prevalence of obesity in India: A systematic review. Diabetes Metab Syndr 2019;13:318–321.
5. Powell-Wiley TM, Poirier P, Burke LE, Després JP, Gordon-Larsen P, et al. Obesity and Cardiovascular Disease: A Scientific Statement From the American Heart Association. Circulation 2021;143:e984-e1010.
6. Piché ME, Tchernof A, Després JP. Obesity Phenotypes, Diabetes, and Cardiovascular Diseases. Circ Res 2020;126:1477–1500.
7. Petermann-Rocha F, Yang S, Gray SR, Pell JP, Celis-Morales C, et al. Sarcopenic obesity and its association with respiratory disease incidence and mortality. Clin Nutr 2020;39:3461–3466.
8. Pati S, Irfan W, Jameel A, Ahmed S, Shahid RK. Obesity and Cancer: A Current Overview of Epidemiology, Pathogenesis, Outcomes, and Management. Cancers (Basel) 2023;15.
9. Pedersen MH, Bøgelund M, Dirksen C, Johansen P, Jørgensen NB, et al. The prevalence of comorbidities in Danish patients with obesity - A Danish register-based study based on data from 2002 to 2018. Clin Obes 2022;12:e12542.
10. Paixão C, Dias CM, Jorge R, Carraça EV, Yannakoulia M, et al. Successful weight loss maintenance: A systematic review of weight control registries. Obes Rev 2020;21:e13003.
11. Bray GA, Frühbeck G, Ryan DH, Wilding JP. Management of obesity. Lancet 2016;387:1947–1956.

12. Careau V, Halsey LG, Pontzer H, Ainslie PN, Andersen LF, et al. Energy compensation and adiposity in humans. Curr Biol 2021;31:4659–4666.e4652.
13. Kushner RF. Weight Loss Strategies for Treatment of Obesity: Lifestyle Management and Pharmacotherapy. Prog Cardiovasc Dis 2018;61:246–252.
14. Lee WJ, Almalki O. Recent advancements in bariatric/metabolic surgery. Ann Gastroenterol Surg 2017;1:171–179.
15. Levis B, Benedetti A, Thombs BD. Accuracy of Patient Health Questionnaire-9 (PHQ-9) for screening to detect major depression: individual participant data meta-analysis. Bmj 2019;365:l1476.
16. Byrd-Bredbenner C, Eck K, Quick V. GAD-7, GAD-2, and GAD-mini: Psychometric properties and norms of university students in the United States. Gen Hosp Psychiatry 2021;69:61–66.
17. Tahrani AA, Morton J. Benefits of weight loss of 10% or more in patients with overweight or obesity: A review. Obesity (Silver Spring) 2022;30:802–840.
18. Xu T, Yu D, Zhou W, Yu L. A nomogram model for the risk prediction of type 2 diabetes in healthy eastern China residents: a 14-year retrospective cohort study from 15,166 participants. Epma j 2022;13:397–405.
19. Perdomo CM, Cohen RV, Sumithran P, Clément K, Frühbeck G. Contemporary medical, device, and surgical therapies for obesity in adults. Lancet 2023;401:1116–1130.
20. Lega IC, Lipscombe LL. Review: Diabetes, Obesity, and Cancer-Pathophysiology and Clinical Implications. Endocr Rev 2020;41.
21. Schwartz MW, Seeley RJ, Zeltser LM, Drewnowski A, Ravussin E, et al. Obesity Pathogenesis: An Endocrine Society Scientific Statement. Endocr Rev 2017;38:267–296.
22. Knell G, Li Q, Pettee Gabriel K, Shuval K. Long-Term Weight Loss and Metabolic Health in Adults Concerned With Maintaining or Losing Weight: Findings From NHANES. Mayo Clin Proc 2018;93:1611–1616.
23. Navarro G, Allard C, Xu W, Mauvais-Jarvis F. The role of androgens in metabolism, obesity, and diabetes in males and females. Obesity (Silver Spring) 2015;23:713–719.
24. Chaput JP, McHill AW, Cox RC, Broussard JL, Dutil C, et al. The role of insufficient sleep and circadian misalignment in obesity. Nat Rev Endocrinol 2023;19:82–97.
25. Utter J, Denny S, Dixon R, Ameratunga S, Teevale T. Family support and weight-loss strategies among adolescents reporting sustained weight loss. Public Health Nutr 2013;16:499–504.
26. Moschonis G, Trakman GL. Overweight and Obesity: The Interplay of Eating Habits and Physical Activity. Nutrients 2023;15.

Figures

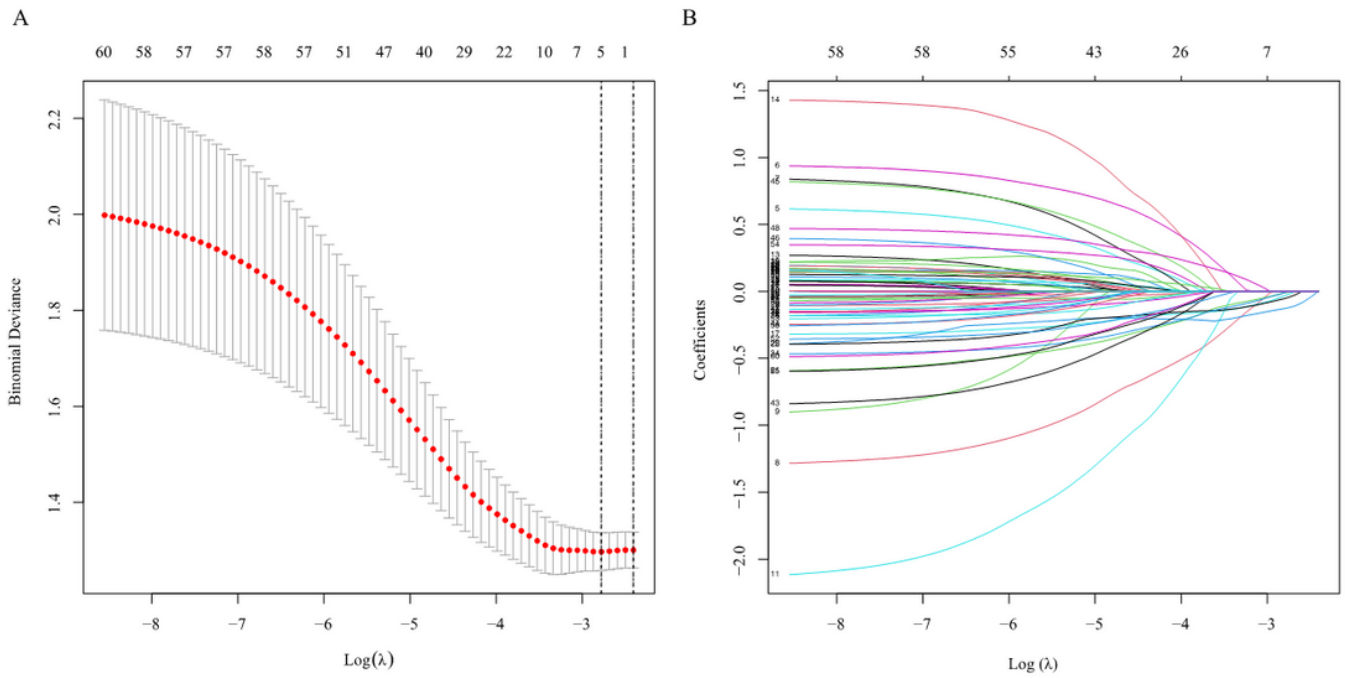

Figure 1

LASSO model for feature selection in successful weight loss prediction. A. Determine the optimal coefficient lambda (λ) in the LASSO model by 10-fold cross-validation. B. Distribution plot of LASSO coefficients for 13 features. The LASSO coefficient curve depicts how each characteristic related to weight loss success changes as lambda varies. The optimal lambda, marked by non-zero coefficients, is crucial for constructing a predictive model.

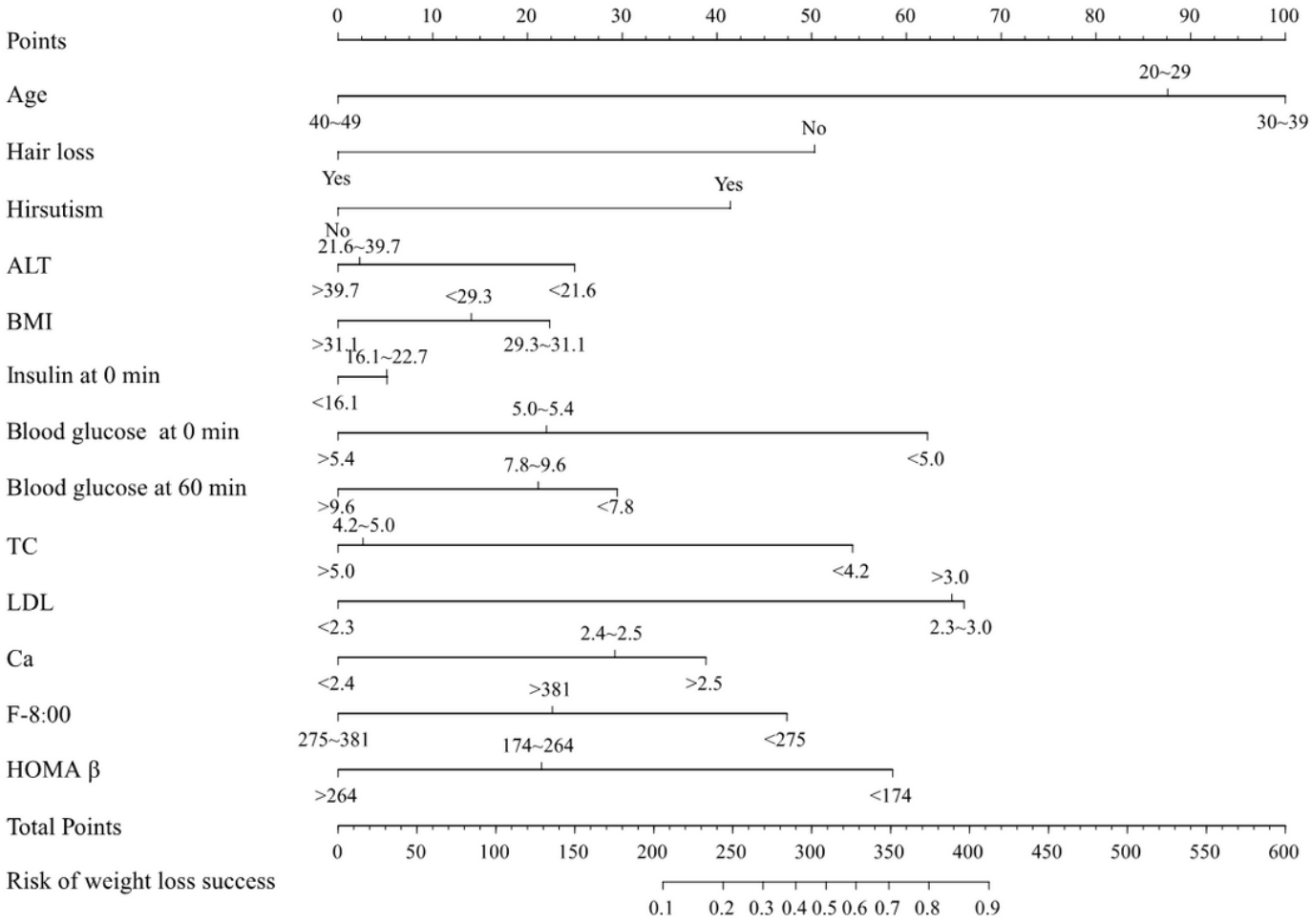

Figure 2

Nomogram for predicting risk of successful weight loss in people with obesity. Each variable contributes to a corresponding score, which is then summed to calculate the total score. This total score is then used to determine the probability of successful weight loss for each individual.

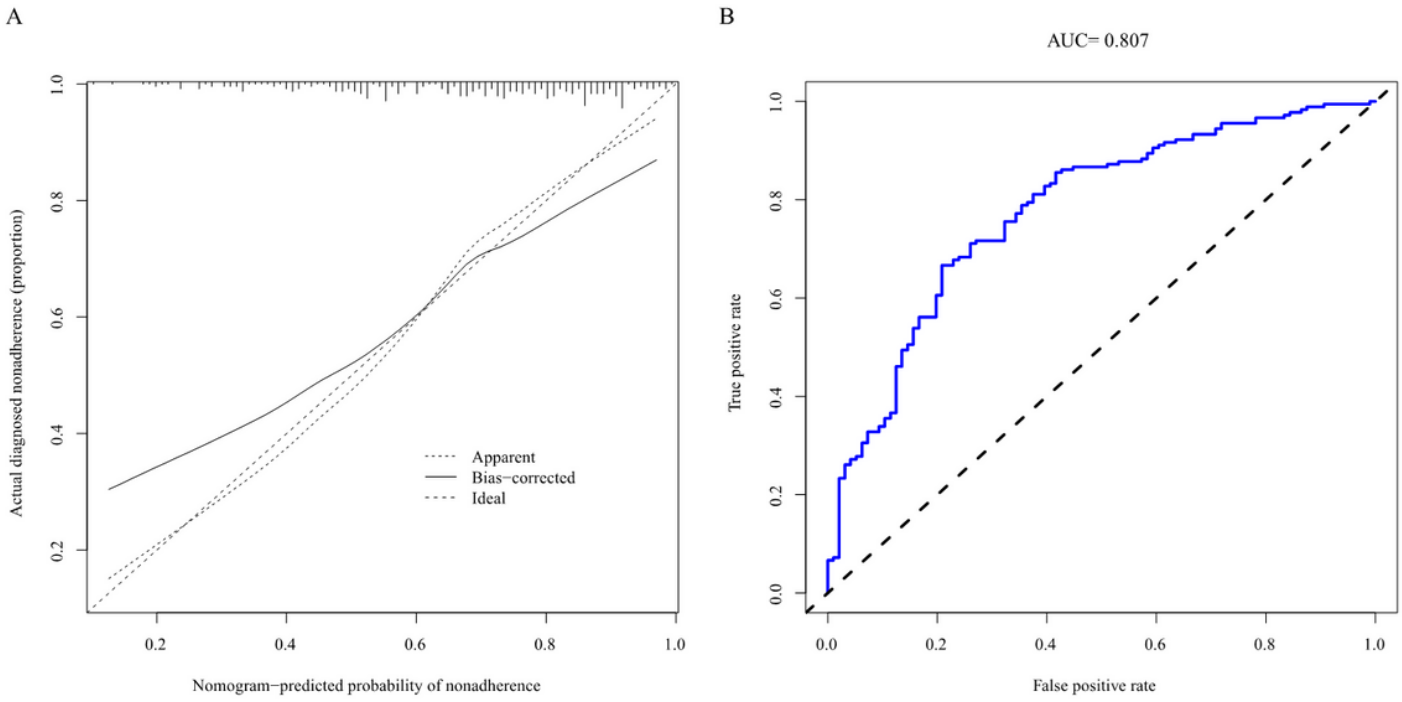

Figure 3

Calibration and ROC curve of the nomogram. A. Calibration curve of nomogram. The x-axis represents the nomogram predicted probability and the y-axis represents the actual probability of successful weight loss. The dashed line at a 45-degree angle represents perfect prediction, while the solid line represents observed nomogram performance corrected for bias using bootstrapping (B = 1000 replicates). B. ROC curve of the nomogram. When using bootstrap resampling (number = 500), the nomogram achieved an AUC of 0.807 (95% CI: 0.736–0.868).

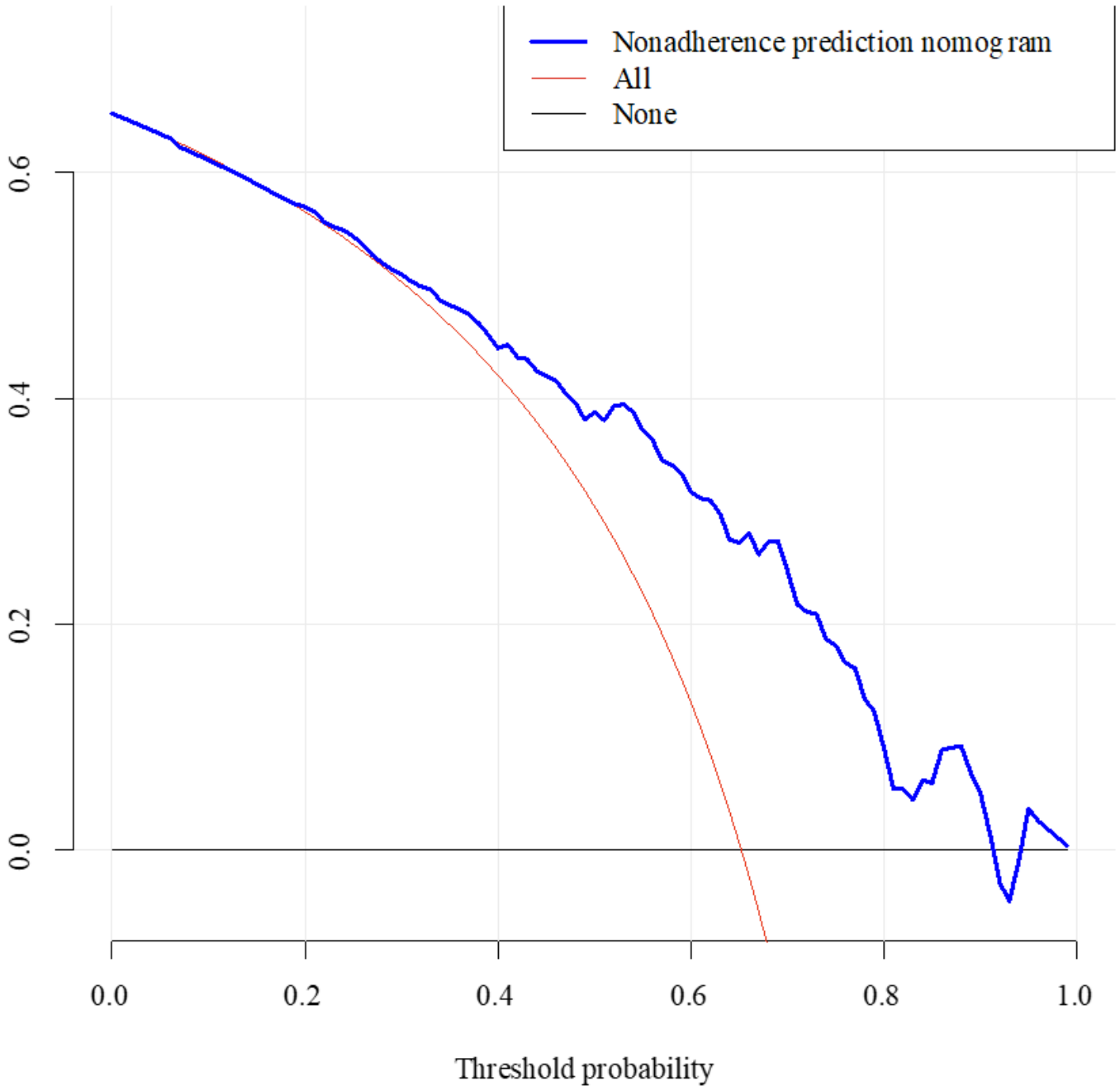

Figure 4

Decision curve analysis for the nomogram. The black horizontal line represents a net benefit of 0 when all obese individuals are not predicted according to the nomogram. The solid red line shows the scenario where all obese individuals are treated according to the nomogram. The area enclosed by the three lines (black, red, and blue) signifies the clinical utility of the nomogram. A larger area indicates greater clinical value in using the nomogram.