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Body roundness index trajectories in Chinese bariatric surgery patients: a retrospective longitudinal study

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Abstract

Objective To investigate the body roundness index (BRI) trajectory categories 12 months post-bariatric surgery and to explore the association between BRI and metabolic abnormalities.

Design and methods Subject data were pooled from a tertiary hospital at baseline, 3 and 12 months post-surgery. Anthropometric measurements included the BRI and body mass index (BMI). Metabolic biomarkers comprised triglycerides (TG), high-density lipoprotein cholesterol (HDL-C), low-density lipoprotein cholesterol (LDL-C), glucose (GLU), and uric acid (UA). The BRI level was categorized using growth mixture model, and a multilevel logistic regression model was employed to explore the relationship between BRI and metabolic risk.

Results A total of 669 patients were included in this study, comprising 286 males (42.8%) and 383 females (57.2%), with an average age of 31.70 ± 9.53 years (range of 18 to 65 years). Patients were classified into three BRI trajectory categories. Compared to the Low-gradual decline group, the High-rapid decline group had an increased risk of abnormal HDL-C (*OR* = 2.84 [95% *CI*, 1.73 ~ 4.67]), and had the highest proportion of sleeve gastrectomy plus jejunojejunal bypass (SG + JJB) and single anastomosis duodeno-ileal bypass with sleeve gastrectomy (SADI-S) ($P < 0.001$); while the High-gradual decline group had increased risk of abnormal TG (*OR* = 3.28 [95%*CI*,1.67–6.42]), HDL-C (*OR* = 4.30 [95%*CI*, 2.31 ~ 8.00]), LDL-C (*OR* = 2.10 [95%*CI*, 1.12 ~ 3.93]), and UA (*OR* = 2.33 [95%*CI*, 1.33 ~ 4.10]). After adjusting for demographics, lifestyle factors, and surgical procedures, the distribution of risk outcomes remained primarily consistent.

Conclusions Sleeve gastrectomy (SG) plus procedures could potentially be associated with improvements in abdominal obesity and metabolic status in patients with high BRI. The post-bariatric trajectories based on BRI may offer insights into the metabolic risk levels of Chinese bariatric patients, but further research is needed to confirm these findings.

Keywords Bariatric surgery, Body roundness index, Metabolic risk, Trajectory

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Study Importance.

What is already known?

The Body Roundness Index (BRI) has been established as a superior metric for assessing abdominal obesity and its associated metabolic risks compared to BMI. However, its application in evaluating outcomes following bariatric surgery remains unexplored.

What does this study add?

This study is the first to describe one-year BRI trajectories among Chinese bariatric surgery patients. It identified three distinct BRI decline patterns, which were associated with different levels of postoperative metabolic risk. SG plus procedures (e.g., SG + JJB, SADI-S) were predominantly observed in patients with high baseline BRI who subsequently exhibited the most rapid improvements in abdominal obesity and related metabolic indicators. These findings suggest that SG plus procedures could potentially be beneficial in addressing central obesity, particularly in patients with significant abdominal fat accumulation.

How might these results affect the direction of research or the focus of clinical practice?

These findings underscore the potential utility of BRI as a predictive tool for metabolic risk stratification and surgical outcome assessment. Future research should prioritize validating BRI's prognostic value in diverse bariatric populations, while clinical practice may benefit from incorporating BRI into preoperative evaluations to refine procedure selection and enhance postoperative metabolic management.

Introduction

Obesity rate in China has been increasing rapidly, with over 34.8% of the population now reaching overweight or obese levels [1], posing significant challenges to public health. For severely obese individuals, due to factors such as poor basal metabolic function and compensatory mechanisms in energy expenditure, interventions like drug therapy or lifestyle modifications often fail to reverse the trend of weight gain [2]. Bariatric surgery has emerged as the only long-term effective treatment for severe obesity [3]. In China, the annual number of bariatric surgery exceeded 6800 cases in 2022 [4], with an average percentage of excess weight loss (%EWL) reaching 75.9%, the average body mass index (BMI) decreased from 40.3 preoperatively to 28.1 five years postoperatively [5]. Bariatric surgery effectively improves comorbid conditions such as type 2 diabetes mellitus (T2DM), metabolic associated fatty liver disease (MAFLD), and obstructive sleep apnea (OSA) by reducing abdominal obesity levels in severely obese individuals [6–8]. Recent studies have also highlighted that improvements in blood vessel efficiency and obesity-related hormone secretion following bariatric surgery can provide long-term benefits to cognitive function and brain structure [9, 10].

High BMI and abdominal obesity have been identified as major risk factors for cardiovascular diseases (CVD) and metabolic disorders [11]. As simple and effective morphological indicators, BMI and its derivative indicator of %EWL, are widely used to evaluate weight loss outcomes following bariatric surgery [12, 13]. However, BMI has certain limitations: it does not reflect fat distribution, may underestimate obesity in individuals with low muscle mass, and has limited sensitivity in predicting abdominal obesity [14]. Additionally, BMI was derived from 19th-century European population data, and compared to Caucasians with the same BMI, Chinese individuals exhibit higher body fat percentages and increased CVD risk [15]. This suggests that BMI has relatively poor applicability within the Chinese population [16]. To address this issue, Thomas et al. introduced the Body Roundness Index (BRI) in 2013 [17]. Unlike BMI, which models the human body as a cylinder, BRI conceptualizes the body as an ellipsoid and calculates the body's relative height circumference (or roundness) based on eccentricity. The BRI value typically ranges from 1 to 16, with higher values indicating a more rounded physique. BRI emphasizes the accumulation of abdominal fat and is highly correlated with abdominal obesity and the risk of metabolic diseases [18]. Additionally, it requires only waist circumference and height measurements. These characteristics make BRI a promising tool for obesity screening and metabolic disease risk assessment in bariatric surgery patients. BRI has been demonstrated by multiple studies to outperform other anthropometric measures in predicting the risk of clinical endpoints such as CVD, renal diseases, and cancer [19–21]. However, to the best of our knowledge, there is currently a lack of research examining BRI in the bariatric surgery population, and the application of BRI in severely obese individuals as well as its association with metabolic risk remain to be investigated.

To address this gap, we aim to analyse one-year postoperative data from Chinese bariatric surgery patients to investigate the trajectory changes of BRI following surgery and to explore the association between BRI levels and improvements in metabolic biomarkers. This retrospective longitudinal study has been reported in line with the STROCSS gudelines [22].

Methods

This was a retrospective longitudinal study conducted in the Department of Bariatric Surgery in the First Affiliated Hospital of Nanjing Medical University. The study received ethical approval from the First Affiliated Hospital of Nanjing Medical University (2023-SR-581), all patients had previously signed informed consent for the use of clinical data in research [23–25]. The study was registered in the Chinese Clinial Trail Registry (ChiCTR2000033443).

Study participation

Patients who underwent bariatric surgery between January 2019 and January 2024 were retrospectively identified and included in this study. Each patient was followed for one year postoperatively, with data collected at baseline (T0), 3 months post-surgery (T3), and 12 months post-surgery (T12). Follow-up for the last enrolled patient was completed in January 2025. The inclusion criteria were: individuals aged ≥ 18 years, who had undergone bariatric surgery at our center for the first time, without severe cognitive or communication impairments, and with complete clinical data at all three time points. The exclusion criteria included having severe primary diseases of the heart, brain, lungs, kidneys, or hematologic system, the presence of malignant tumors, and having more than 20% missing data across key variables. These conditions were excluded to minimize potential confounding effects on postoperative BRI trajectories.

The approximate sample size requirement for detecting k latent classes using growth mixture model (GMM) with a medium effect size (Cohen's $f^2 = 0.20$), $\alpha = 0.05$, and power = 0.80, the required sample size can be estimated using the formula: $N = (8/f^2) \times (k-1)$. Based on this, a minimum of 400 participants is recommended when $k = 3$, which aligns with the sample size in our study.

Data collection

Patient data were retrospectively extracted from the hospital's electronic medical record system and the bariatric surgery follow-up database. This included demographic information (gender, age, marital status, employment status, and educational attainment), surgical details, baseline lifestyle factors (dietary behavior, physical activity, and sleep quality), anthropometric measurements, and laboratory test results. The anthropometric measurements and laboratory test results were collected at baseline (T0), 3 months post-surgery (T3), and 12 months post-surgery (T12). The demographic information, baseline lifestyle factors, and surgical details were extracted at baseline (T0).

Surgical technique and postoperative care

The surgical procedures performed on patients in this study include: (1) Sleeve gastrectomy (SG): The greater omentum is completely separated, and a 36–38 °F bougie is used. The greater curvature is resected from 2 to 6 cm from the pylorus to the left side of the cardia, ~ 1–2 cm from the angle of His. The fundus of stomach is completely removed. (2) Roux-en-Y gastric bypass (RYGB): A small gastric pouch (~ 30 ml) is created below the cardia. The jejunum is cut 100 cm from the ligament of Treitz and the distal end of the jejunum anastomosed with the small gastric pouch. A jejunojejunostomy is then performed 100 cm distally from the gastric pouch anastomosis. The mesenteric defect and Petersen's space are then closed. (3) SG plus jejunojejunal bypass (SG + JJB): After SG, the jejunum is resected 30 cm from the ligament of Treitz. After measuring 200 cm to the distal end, the proximal jejunum is anastomosed with the jejunum at the 200 cm mark. The mesenteric defect is then closed. (4) Single anastomosis duodeno-ileal bypass with SG (SADI-S): The SADI-S procedure begins with a sleeve gastrectomy using a 50 French bougie to create a 16.6 cm diameter gastric sleeve. The ileocecal valve is identified, and 250–300 cm of the jejunum is measured proximally. The duodenum is transected while preserving the pylorus. A manual end-to-side duodenoileal anastomosis is performed using double-layer sutures. Mesenteric defect is then closed. These procedures differ in anatomical structure and physiological effects, potentially leading to varied outcomes in fat reduction and metabolic improvement. All patients received standardized postoperative care, including unified nutrition, exercise, and follow-up protocols across all surgical groups.

Anthropometric measurements

Height was measured using a calibrated stadiometer with subjects standing barefoot, heels together, and head held in a horizontal position. Waist circumference (WC) was measured at the midpoint between the iliac crest and the lowest rib during normal respiration using a non-elastic tape measure. Weight was measured using a calibrated electronic scale, with subjects wearing lightweight clothing and no shoes. All measurements were taken three times, and the average value was used for calculations. Waist circumference and height were measured to the nearest 0.1 cm, and weight to the nearest 0.1 kg. BMI, BRI, percentage of total weight loss (%TWL), and %EWL were calculated using the following formulas:

$$BMI = \frac{weight\,(\mathrm{kg})}{height\,(\mathrm{m})^2}$$

$$\mathrm{BRI} = 364.2 - 365.5 \times \sqrt{1 - \frac{(WC(\,cm)/2\pi\,)^2}{0.5 \times \,height\,(cm)^2}}$$

$$\%\mathrm{TWL} = \frac{weight\,(kg)_{T0} - weight\,(kg)_{T12}}{weight\,(kg)_{T0}} \times \,100\%$$

$$\%\mathrm{EWL} = \frac{weight\,(kg)_{T0} - weight\,(kg)_{T12}}{weight\,(kg)_{T0} - Ideal\ body\ weight\,(kg)} \times \,100\%$$

According to the BMI classification criteria for the Chinese population [26], a BMI of 28 kg/m² indicates obesity, a BMI of 24 kg/m² indicates overweight, and the normal range is 18.5–23.9 kg/m². Therefore, the ideal body weight was calculated based on a BMI of 24 kg/m²:

$$Ideal\ body\ weight\ (\mathrm{kg}) = 24(\mathrm{kg/m2}) \times\ height\ (m)^2$$

Blood samples

Blood samples were collected from patients in a fasting state before 8:00 am on the day of admission (T0) or during postoperative follow-ups at 3 months (T3) and 12 months (T12). Medically trained staff obtained the blood specimens following standardized protocols. The metabolic biomarkers evaluated in this study included triglycerides (TG), high-density lipoprotein cholesterol (HDL-C), low-density lipoprotein cholesterol (LDL-C), glucose (GLU), and uric acid (UA), which reflect the patients' metabolic status. The normal reference ranges for each indicator were as follows: TG (< 1.7 mmol/L); HDL-C (men: >1.04 mmol/L, women: >1.3 mmol/L); LDL-C (< 3.4 mmol/L); GLU (3.9–6.1 mmol/L); and UA (men: 208–428 μmol/L, women: 155–357 μmol/L).

Baseline lifestyle factors

For baseline lifestyle factors, we extracted data on patients' dietary behavior, physical activity, and sleep condition to be used as adjustment variables in subsequent analysis. (1) Dietary behavior was assessed using the Dietary Adherence Scale after Bariatric Surgery (DASBS) [27]. DASBS was developed at our bariatric surgery center, with 16 items and four dimensions: dietary control, nutrient intake, fluid intake, and eating habits. Scores range from 16 to 80, with higher scores indicating better adherence to the recommended dietary patterns for bariatric surgery patients. This assessment was conducted at discharge after surgery. (2) Physical activity levels were evaluated using the International Physical Activity Questionnaire-Short Form (IPAQ-SF) [28]. IPAQ-SF measures physical activity duration across different intensity levels and calculates weekly physical activity amounts, categorizing patients as low, moderate, or high physical activity level. This assessment was conducted at admission day before surgery. (3) Sleep quality was assessed using the Pittsburgh Sleep Quality Index (PSQI) [29]. The PSQI consists of seven dimensions: sleep latency, sleep duration, sleep efficiency, sleep disturbances, subjective sleep quality, use of sleeping medication, and daytime dysfunction. Scores range from 0 to 21, with higher scores indicating poorer sleep quality. This assessment was conducted at admission day before surgery.

Statistical analysis

Statistical analysis were conducted using R version 4.2.3 (The R Foundation for Statistical Computing) and M-plus version 8.0 (Muthen&Muthen, Los Angeles, CA USA). Categorical variables are presented as n (%), and continuous variables are expressed as mean ± standard deviation. Group comparisons were performed using *t*-tests or analysis of variance (ANOVA) for single time-point continuous variables, repeated measures ANOVA for multiple time-point continuous variables, and chi-square tests for categorical data. Due to the absence of established reference ranges for the BRI, a growth mixture model (GMM) was utilized to classify patients into distinct groups based on their one-year postoperative BRI trajectory patterns. The fit indices evaluated included the Akaike Information Criterion (AIC), Bayesian Information Criterion (BIC), Entropy, Lo-Mendell-Rubin Likelihood Ratio Test (LMR), Bootstrap Likelihood Ratio Test (BLRT), and Class Probability. Lower AIC and BIC values indicate better model fit; an entropy value close to 1 suggests precise classification; LMR and BLRT values below 0.05 indicate that a model with k classes provides a significantly better fit than a model with k-1 classes. Additionally, each class's probability should exceed 5%. The most suitable trajectory model was selected by comparing the fit indices across models with varying numbers of classes.

Subsequently, logistic regression models were employed to calculate the odds ratios (*OR*) and 95% confidence intervals (*CI*) for TG, HDL-C, LDL-C, GLU, and UA exceeding abnormal ranges at T12 based on BRI trajectory categories. The analysis were adjusted for the following covariates to explore the stability of the results: Model 0 included only trajectory category as the independent variable; Model 1 adjusted for demographic variables (gender, age, marital status, employment status and educational attainment); Model 2 adjusted for baseline lifestyle factors (dietary behavior, physical activity and sleep quality); Model 3 adjusted for surgical procedures; Model 4 adjusted for all covariates in Model 1 ~ 3. Additionally, a subgroup analysis was conducted on patients who had exhibited abnormal metabolic biomarkers at baseline (T0) to enhance the precision of the results. Two-sided *p*-values < 0.05 were considered statistically significant.

Results

Baseline characteristics

A total of 1857 patients who underwent bariatric surgery and completed blood tests and anthropometric measurements were identified from the electronic medical record system. Among them, 669 patients completed follow-up assessments and repeated the above measurements at both 3 and 12 months postoperatively, and were included in the present analysis. These patients comprised 383 females (57.2%), with an average age of 31.70 ± 9.53 years. Among them, 384 patients (57.4%) underwent SG, 69 patients (10.3%) underwent RYGB, 183 patients (27.4%) underwent SG + JJB, and 33 patients (4.9%) underwent

SADI-S. Table 1 presented the distribution of patients' demographic characteristics across different surgical procedures. Significant differences were observed between surgical groups in terms of gender ($P<0.001$), age ($P<0.001$), marital status ($P<0.001$), employment status ($P=0.003$) and dietary behavior ($P=0.008$). Differences in educational attainment, phsical activity and sleep quality were not statistically significant ($P>0.05$).

To assess potential bias introduced by missing data, we conducted a sensitivity analysis comparing the baseline characteristics of patients with complete data ($n=669$) and those excluded due to missing follow-up information ($n=1188$). Apart from employment status ($P=0.041$) and baseline HDL-C ($P=0.022$), no other characteristics showed statistically significant differences, suggesting minimal impact of missing data (supplementary Table 1).

Changes in BRI and BMI across surgical procedures

The average BRI for all patients was 8.28 ± 2.34 at baseline (T0) and decreased to 3.79 ± 1.39 at 12 months postoperatively (T12). The average BMI was 39.25 ± 6.96 kg/m² at T0 and reduced to 25.95 ± 3.74 kg/m² at T12. Table 2 presented the BRI and BMI measurements for each surgical procedure at the three time points and compared the RYGB, SG + JJB, and SADI-S groups against the SG group. The main effects and between-subject effects for changes in both BRI and BMI were statistically significant ($P<0.001$). Significant interaction effects were observed for SG + JJB versus SG ($P<0.001$) and SADI-S versus SG (P_{BRI}=0.009, P_{BMI}=0.020). In the comparison between RYGB and SG, the difference in BMI was statistically significant ($P=0.048$), whereas the difference in BRI was not ($P=0.463$), indicating that the BRI improvement trends for RYGB and SG were relatively similar. Figure 1 illustrated the changes in BRI and BMI for each surgical procedure.

BRI trajectory classification based on GMM

Based on the fit indices (Supplementary Table 2), the three-class model demonstrated the optimal AIC, BIC, and Entropy values among the models that met the LMR and BLRT tests, and each class probability exceeded 5%. Therefore, the BRI trajectories of postoperative bariatric surgery patients were categorized into three groups. According to the actual meanings and trends of each trajectory, the categories were named High-rapid decline ($n=76$), High-gradual decline ($n=54$), and Low-gradual decline ($n=539$) (Fig. 2). The parameter estimates for each category are presented in Supplementary Table 3.

Participants with the High-rapid decline trajectory had a relatively higher proportion of males (52.6%, $P=0.033$), a higher proportion of SG + JJB procedures (61.8%, $P<0.001$), and higher baseline UA levels (477.46 ± 106.49, $P=0.003$). The High-rapid decline participants had the highest T0 BRI and BMI levels, achieving the greatest %TWL at T12, with BRI decreasing to 3.89 ± 1.08. However, their T12 BMI remained near the obesity threshold (27.62 ± 2.99). Participants in the High-gradual decline group had higher levels of obesity at T0, and still showed significant abdominal obesity at T12 (BRI = 6.70 ± 1.31). Participants in High-gradual decline group had the highest proportion of females (70.4%, $P=0.033$), the worst baseline dietary behavior (48.31 ± 11.6, $P<0.001$)、and the worst baseline sleep quality (7.43 ± 4.76, $P=0.011$).

Table 1 Baseline characteristics of patients with different surgical procedures

Variables		SG (n = 384)	RYGB (n = 69)	SG + JJB (n = 183)	SADI-S (n = 33)	F/χ^2	P
Gender	Male	137 (35.7%)	32 (46.4%)	100 (54.6%)	17 (51.5%)	19.835	< 0.001*
	Female	247 (64.3%)	37 (53.6%)	83 (45.4%)	16 (48.5%)		
Age		31.03 ± 9.90	36.22 ± 9.49	30.43 ± 7.36	37.00 ± 10.84	10.747	< 0.001*
Marital Status	Married	197 (51.3%)	45 (65.2%)	76 (41.5%)	28 (84.8%)	27.783	< 0.001*
	Unmarried	172 (44.8%)	21 (30.4%)	98 (53.6%)	5 (15.2%)		
	Divorced or Widowed	15 (3.9%)	3 (4.4%)	9 (4.9%)	0 (0%)		
Employment Status	Employed	262 (68.2%)	45 (65.2%)	147 (80.3%)	22 (66.7%)	20.241	0.003*
	Unemployed or Retired	66 (17.2%)	20 (29.0%)	23 (12.6%)	5 (15.1%)		
	Student	56 (14.6%)	4 (5.8%)	13 (7.1%)	6 (18.2%)		
Educational Attainment	Junior High School or Below	51 (13.3%)	8 (11.6%)	26 (14.2%)	8 (24.3%)	8.685	0.192
	High School or Vocational School	91 (23.7%)	12 (17.4%)	39 (21.3%)	11 (33.3%)		
	College Diploma or Above	242 (63.0%)	49 (71.0%)	118 (64.5%)	14 (42.4%)		
Baseline dietary behavior		54.10 ± 9.90	56.30 ± 11.93	56.89 ± 9.54	57.24 ± 10.63	3.956	0.008*
Baseline physical activity	low	106 (27.6%)	18 (26.1%)	58 (31.7%)	9 (27.3%)	3.972	0.680
	middle	130 (33.8%)	27 (39.1%)	60 (32.8%)	15 (45.4%)		
	high	148 (38.6%)	24 (34.8%)	65 (35.5%)	9 (27.3%)		
Baseline sleep quality		6.43 ± 3.87	6.28 ± 4.50	6.12 ± 4.00	6.27 ± 3.31	0.442	0.723

Notes: *indicates $P<0.05$. Abbreviations: SG, sleeve gastrectomy; RYGB, Roux-en-Y gastric bypass; SG + JJB, SG plus jejunojejunal bypass; SADI-S, single anastomosis duodeno-ileal bypass with SG

Table 2 Comparison of postoperative BRI and BMI trajectory changes across bariatric procedures

Variables		Surgical Procedures		Single time point Inter-group comparison		overall comparison					
						Main effects (time)		Between-subject effects		interaction effects (time * operation)	
		SG	**RYGB**	**t**	***P***	**F**	***P***	**F**	***P***	**F**	***P***
BRI	T0	7.69 ± 1.98	7.51 ± 2.11	0.694	0.488	637.811	< 0.001*	3519.104	< 0.001*	0.764	0.463
	T3	5.12 ± 1.72	5.17 ± 1.85	0.179	0.858						
	T12	3.65 ± 1.36	3.72 ± 1.24	0.383	0.702						
BMI	T0	37.50 ± 6.11	36.62 ± 5.66	1.113	0.266	1346.656	< 0.001*	11385.454	< 0.001*	3.525	0.048*
	T3	29.15 ± 4.67	29.08 ± 4.09	0.110	0.912						
	T12	25.42 ± 3.56	25.72 ± 2.96	0.649	0.516						
		SG	**SG + JJB**								
BRI	T0	7.69 ± 1.98	9.69 ± 2.43	9.744	< 0.001*	1825.404	< 0.001*	8436.727	< 0.001*	46.663	< 0.001*
	T3	5.12 ± 1.72	6.36 ± 1.98	7.504	< 0.001*						
	T12	3.65 ± 1.36	4.11 ± 1.45	3.648	< 0.001*						
BMI	T0	37.50 ± 6.11	43.61 ± 6.55	10.879	< 0.001*	3925.294	< 0.001*	24936.012	< 0.001*	98.090	< 0.001*
	T3	29.15 ± 4.67	33.49 ± 5.47	9.259	< 0.001*						
	T12	25.42 ± 3.56	26.98 ± 3.92	4.538	< 0.001*						
		SG	**SADI-S**								
BRI	T0	7.69 ± 1.98	8.85 ± 2.66	2.461	0.019*	453.804	< 0.001*	1962.977	< 0.001*	4.853	0.009*
	T3	5.12 ± 1.72	5.83 ± 2.01	2.202	0.028*						
	T12	3.65 ± 1.36	3.88 ± 1.50	0.908	0.365						
BMI	T0	37.50 ± 6.11	40.85 ± 9.47	1.994	0.054	808.079	< 0.001*	5719.671	< 0.001*	4.712	0.020*
	T3	29.15 ± 4.67	32.11 ± 6.56	2.538	0.016*						
	T12	25.42 ± 3.56	26.86 ± 4.91	1.642	0.110						

Notes: *indicates $P < 0.05$. Abbreviations: SG, sleeve gastrectomy; RYGB, Roux-en-Y gastric bypass; SG + JJB, SG plus jejunojejunal bypass; SADI-S, single anastomosis duodeno-ileal bypass with SG; BRI, body roundness index; BMI, body mass index; T0, baseline; T3, 3 months post-surgery; T12, 12 months post-surgery

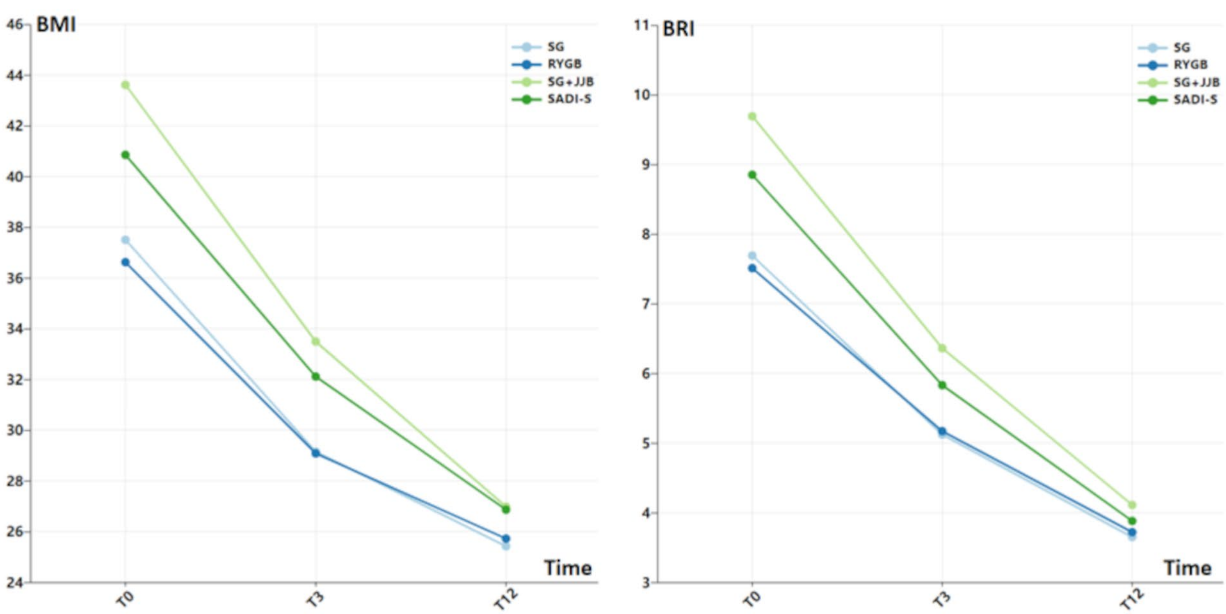

Fig. 1 One-year trajectories of BMI and BRI following various bariatric surgical procedures
Abbreviations: SG, sleeve gastrectomy; RYGB, Roux-en-Y gastric bypass; SG + JJB, SG plus jejunojejunal bypass; SADI-S, single anastomosis duodeno-ileal bypass with SG; BRI, body roundness index; BMI, body mass index; T0, baseline; T3, 3 months post-surgery; T12, 12 months post-surgery

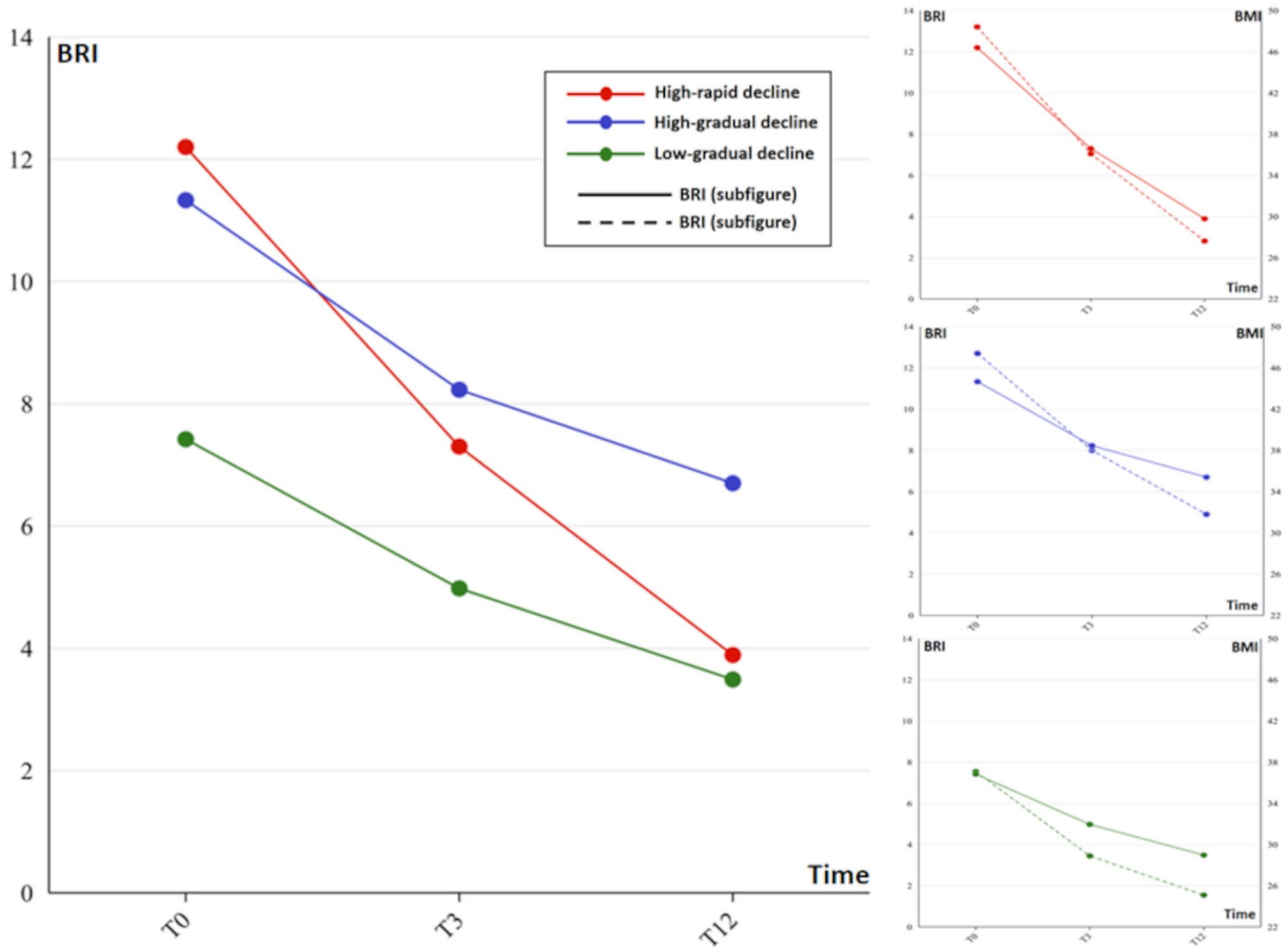

Fig. 2 One-year trajectories of different BRI change patterns after bariatric surgery
Abbreviations: BRI, body roundness index; BMI, body mass index; T0, baseline; T3, 3 months post-surgery; T12, 12 months post-surgery

Low-gradual decline participants had the lowest obesity levels at T0 and achieved the highest %EWL, with BRI decreasing to 3.49 ± 1.06 and BMI decreasing to 25.13 ± 3.18. This group's %TWL was similar to that of the High-gradual decline group. Participants in Low-gradual decline group reported relatively the best baseline dietary behavior (56.27 ± 9.49, $P < 0.001$), the highest proportion of baseline high intensity physical activity (39.0%, $P < 0.001$), and the best baseline sleep quality (6.10 ± 3.82, $P = 0.011$). (Table 3).

Association between BRI trajectories and risk of metabolic abnormalities

Given that the Low-gradual decline group had the lowest final BRI and BMI, it was used as the reference group. At 12 months post-bariatric surgery, the crude model (Model 0) showed that, compared to the Low-gradual decline group, the High-rapid decline group had 2.84 times higher odds of abnormal HDL-C (*OR* = 2.84 [95%*CI*, 1.73 ~ 4.67]), while the High-gradual decline group had 3.28 times higher odds of abnormal TG (*OR* = 3.28 [95% *CI*, 1.67 ~ 6.42]), 4.30 times higher odds of abnormal HDL-C (*OR* = 4.30 [95%*CI*, 2.31 ~ 8.00]), 2.10 times higher odds of abnormal LDL-C (*OR* = 2.10 [95%*CI*, 1.12 ~ 3.93]), and 2.33 times higher odds of abnormal UA (*OR* = 2.33 [95%*CI*, 1.33 ~ 4.10]). In Model 1, after adjusting for demographic variables (gender, age, marital status, employment status, educational attainment), and in Model 3 which adjusted for surgical procedures, the distribution of significant findings remained consistent with Model 0, with the level of increased risk for abnormal metabolic biomarkers also remaining close to that observed in Model 0. In Model 2, after adjusting for baseline lifestyle factors (dietary behavior, physical activity and sleep quality), and in Model 4 which adjusted all the covariates, the increased risk for abnormal HDL-C in High-rapid decline group, and the increased risk for abnormal TG, HDL-C, UA in High-gradual decline group remained statistically significant ($P < 0.05$); While the risk of abnormal LDL-C in the High-gradual decline group was no longer significant after adjustment for lifestyle factors ($P > 0.05$) (Table 4, all patients).

Table 3 Comparison of patient characteristics across different BRI change pattern classes

Characteristics			BRI trajectory			F/χ²	*P*
			High-rapid decline (*n* = 76)	High-gradual decline (*n* = 54)	Low-gradual decline (*n* = 539)		
Gender	Male		40 (52.6%)	16 (29.6%)	230 (42.7%)	6.832	0.033*
	Female		36 (47.4%)	38 (70.4%)	309 (57.3%)		
Age			30.04 ± 8.35	33.04 ± 10.19	31.80 ± 9.61	1.714	0.181
Marital Status	Married		30 (39.5%)	31 (57.4%)	285 (52.9%)	6.858	0.144
	Unmarried		41 (53.9%)	20 (37.0%)	235 (43.6%)		
	Divorced or Widowed		5 (6.6%)	3 (5.6%)	19 (3.5%)		
Employment Status	Employed		56 (73.7%)	44 (81.5%)	376 (69.8%)	3.615	0.461
	Unemployed or Retired		12 (15.8%)	6 (11.1%)	102 (18.9%)		
	Student		8 (10.5%)	4 (7.4%)	61 (11.3%)		
Educational Attainment	Junior High School or Below		16 (21.1%)	9 (16.7%)	68 (12.6%)	5.478	0.242
	High School or Vocational School		15 (19.7%)	15 (27.8%)	123 (22.8%)		
	College Diploma or Above		45 (59.2%)	30 (55.5%)	348 (64.6%)		
Baseline dietary behavior			52.87 ± 11.15	48.31 ± 11.65	56.27 ± 9.49	18.398	< 0.001*
Baseline physical activity	low		32 (42.1%)	27 (50.0%)	132 (24.5%)	24.663	< 0.001*
	middle		19 (25.0%)	16 (29.6%)	197 (36.5%)		
	high		25 (32.9%)	11 (20.4%)	210 (39.0%)		
Baseline sleep quality			7.12 ± 3.99	7.43 ± 4.76	6.10 ± 3.82	4.551	0.011*
Surgical Procedures		SG	19 (25.0%)	26 (48.1%)	339 (62.9%)	63.074	< 0.001*
		RYGB	4 (5.3%)	5 (9.3%)	60 (11.1%)		
		SG + JJB	47 (61.8%)	20 (37.0%)	116 (21.5%)		
		SADI-S	6 (7.9%)	3 (5.6%)	24 (4.5%)		
Baseline Metabolic Biomarkers		TG	2.16 ± 2.56	1.82 ± 1.00	2.14 ± 2.20	0.567	0.568
		HDL-C	1.05 ± 0.20	1.11 ± 0.25	1.10 ± 0.27	1.353	0.259
		LDL-C	3.28 ± 0.74	3.31 ± 0.75	3.26 ± 0.71	0.125	0.882
		GLU	6.14 ± 2.35	6.51 ± 2.88	6.31 ± 2.43	0.356	0.701
		UA	477.46 ± 106.49	443.50 ± 109.64	431.20 ± 111.19	5.920	0.003*
BRI	T0		12.20 ± 1.32	11.33 ± 1.59	7.42 ± 1.57	433.851	< 0.001*
	T3		7.30 ± 1.67	8.23 ± 1.67	4.98 ± 1.53	162.728	< 0.001*
	T12		3.89 ± 1.08	6.70 ± 1.31	3.49 ± 1.06	216.166	< 0.001*
BMI	T0		48.42 ± 5.54	47.39 ± 7.06	37.14 ± 5.30	205.572	< 0.001*
	T3		36.10 ± 4.55	37.99 ± 6.02	28.93 ± 4.01	185.249	< 0.001*
	T12		27.62 ± 2.99	31.79 ± 3.95	25.13 ± 3.18	116.009	< 0.001*
%EWL at T12			86.35 ± 12.16	66.90 ± 16.46	98.05 ± 30.80	32.885	< 0.001*
%TWL at T12			42.59 ± 6.05	32.22 ± 8.38	31.70 ± 8.12	63.030	< 0.001*

Notes: *indicates $P < 0.05$. Abbreviations: SG, sleeve gastrectomy; RYGB, Roux-en-Y gastric bypass; SG + JJB, SG plus jejunojejunal bypass; SADI-S, single anastomosis duodeno-ileal bypass with SG; BRI, body roundness index; BMI, body mass index; T0, baseline; T3, 3 months post-surgery; T12, 12 months post-surgery; TG, triglycerides; HDL-C, high-density lipoprotein cholesterol; LDL-C, low-density lipoprotein cholesterol; GLU, glucose; UA, uric acid; %EWL, percentage of excess weight loss; %TWL, percentage of total weight loss

A further subgroup analysis was conducted to examine participants with abnormal metabolic biomarkers at baseline (T0). Compared to the Low-gradual decline group, the High-rapid decline group showed a significantly increased risk of abnormal HDL-C, and in contrast to the overall analysis of all patients, the risk level of abnormalities in HDL-C decreased, and as more covariates were controlled for in the models, the odds ratios progressively decreased ($OR_{\text{model }0}$=2.61 [95%*CI*, 1.42 ~ 4.82]; $OR_{\text{model }1}$=2.51 [95%*CI*, 1.34 ~ 4.70]; $OR_{\text{model }2}$=2.50 [95%*CI*, 1.35 ~ 4.63]; $OR_{\text{model }3}$=2.39 [95%*CI*, 1.24 ~ 4.60]; $OR_{\text{model }4}$=2.11 [95%*CI*, 1.07 ~ 4.16]). The High-gradual decline group showed a significantly increased risk for abnormal TG, HDL-C, and LDL-C, while the risk for abnormal UA was no longer statistically significant; In Model 2, after adjusting for lifestyle factors, the risk of abnormal LDL-C was no longer significant. In Model 4, after adjusting for all covariates, the odds of abnormal TG were 3.33 times higher (*OR* = 3.33 [95%*CI*, 1.21 ~ 9.19]), the odds of abnormal HDL-C were 3.83 times higher (*OR* = 43.83 [95%*CI*, 1.68 ~ 8.70]), and the odds of abnormal LDL-C were 2.99 times higher

Table 4 Risk of metabolic abnormalities at T12 by BRI trajectory

Metabolic Biomarkers	BRI trajectory								
	All patients (*n* = 669)					Subgroup analysis of participants with abnormalities at T0 #			
	Low-gradual decline (*n* = 539)	High-rapid decline (*n* = 76)		High-gradual decline (*n* = 54)		High-rapid decline		High-gradual decline	
	OR(95%CI)	OR(95%CI)	*P*	OR(95%CI)	*P*	OR(95%CI)	*P*	OR(95%CI)	*P*
Model 0									
TG	1.00 (Ref)	1.93 (0.99 ~ 3.75)	0.051	3.28 (1.67 ~ 6.42)	0.001*	1.11 (0.43 ~ 2.85)	0.828	4.24 (1.77 ~ 10.18)	0.001*
HDL-C	1.00 (Ref)	2.84 (1.73 ~ 4.67)	< 0.001*	4.30 (2.31 ~ 8.00)	< 0.001*	2.61 (1.42 ~ 4.82)	0.002*	4.11 (1.90 ~ 8.90)	< 0.001*
LDL-C	1.00 (Ref)	1.03 (0.54 ~ 1.95)	0.929	2.10 (1.12 ~ 3.93)	0.020*	1.53 (0.69 ~ 3.38)	0.297	3.39 (1.34 ~ 8.61)	0.010*
GLU	1.00 (Ref)	1.63 (0.99 ~ 2.67)	0.052	1.09 (0.60 ~ 1.99)	0.783	2.24 (0.98 ~ 5.10)	0.055	1.05 (0.43 ~ 2.57)	0.909
UA	1.00 (Ref)	1.54 (0.95 ~ 2.51)	0.081	2.33 (1.33 ~ 4.10)	0.003*	1.33 (0.77 ~ 2.28)	0.311	1.88 (0.94 ~ 3.77)	0.073
Model 1									
TG	1.00 (Ref)	1.66 (0.84 ~ 3.29)	0.145	3.40 (1.68 ~ 6.85)	0.001*	1.05 (0.39 ~ 2.81)	0.909	4.47 (1.76 ~ 11.32)	0.002*
HDL-C	1.00 (Ref)	2.90 (1.74 ~ 4.85)	< 0.001*	4.40 (2.33 ~ 8.33)	< 0.001*	2.51 (1.34 ~ 4.70)	0.004*	4.40 (1.98 ~ 9.74)	< 0.001*
LDL-C	1.00 (Ref)	1.04 (0.54 ~ 2.02)	0.885	2.03 (1.06 ~ 3.87)	0.031*	1.62 (0.7 ~ 3.76)	0.258	3.90 (1.46 ~ 10.40)	0.006*
GLU	1.00 (Ref)	1.38 (0.82 ~ 2.33)	0.223	0.89 (0.47 ~ 1.67)	0.892	2.34 (0.88 ~ 6.19)	0.086	0.85 (0.31 ~ 2.30)	0.753
UA	1.00 (Ref)	1.38 (0.83 ~ 2.28)	0.209	2.61 (1.45 ~ 4.67)	0.001*	1.19 (0.67 ~ 2.08)	0.543	2.05 (0.99 ~ 4.18)	0.051
Model 2									
TG	1.00 (Ref)	1.69 (0.86 ~ 3.33)	0.128	2.63 (1.29 ~ 5.34)	0.008*	1.01 (0.39 ~ 2.66)	0.969	3.54 (1.38 ~ 9.10)	0.009*
HDL-C	1.00 (Ref)	2.67 (1.61 ~ 4.43)	< 0.001*	3.79 (2.01 ~ 7.16)	< 0.001*	2.50 (1.35 ~ 4.63)	0.004*	3.65 (1.66 ~ 8.05)	0.001*
LDL-C	1.00 (Ref)	0.87 (0.45 ~ 1.68)	0.678	1.57 (0.81 ~ 3.06)	0.179	1.28 (0.55 ~ 2.94)	0.559	2.57 (0.96 ~ 6.85)	0.058
GLU	1.00 (Ref)	1.62 (0.98 ~ 2.67)	0.058	1.07 (0.57 ~ 1.99)	0.820	2.26 (0.98 ~ 5.19)	0.054	1.13 (0.45 ~ 2.83)	0.795
UA	1.00 (Ref)	1.50 (0.91 ~ 2.47)	0.106	2.17 (1.21 ~ 3.88)	0.009*	1.27 (0.73 ~ 2.21)	0.396	1.67 (0.82 ~ 3.44)	0.157
Model 3									
TG	1.00 (Ref)	1.86 (0.92 ~ 3.76)	0.083	3.23 (1.64 ~ 6.38)	0.001*	1.10 (0.41 ~ 2.93)	0.838	4.00 (1.63 ~ 9.78)	0.002*
HDL-C	1.00 (Ref)	2.56 (1.52 ~ 4.32)	< 0.001*	4.18 (2.23 ~ 7.81)	< 0.001*	2.39 (1.24 ~ 4.60)	0.009*	4.09 (1.88 ~ 8.91)	< 0.001*
LDL-C	1.00 (Ref)	1.11 (0.56 ~ 2.18)	0.746	2.18 (1.15 ~ 4.12)	0.016*	1.53 (0.64 ~ 3.66)	0.330	3.47 (1.34 ~ 8.98)	0.010*
GLU	1.00 (Ref)	1.58 (0.92 ~ 2.73)	0.098	1.11 (0.60 ~ 2.04)	0.724	2.36 (0.98 ~ 5.63)	0.053	1.02 (0.41 ~ 2.54)	0.950
UA	1.00 (Ref)	1.64 (0.98 ~ 2.75)	0.057	2.39 (1.35 ~ 4.22)	0.003*	1.37 (0.77 ~ 2.46)	0.279	1.93 (0.96 ~ 3.89)	0.065
Model 4									
TG	1.00 (Ref)	1.35 (0.64 ~ 2.83)	0.427	2.66 (1.26 ~ 5.63)	0.010*	0.91 (0.32 ~ 2.53)	0.857	3.33 (1.21 ~ 9.19)	0.020*
HDL-C	1.00 (Ref)	2.35 (1.36 ~ 4.06)	0.002*	3.63 (1.88 ~ 7.01)	< 0.001*	2.11 (1.07 ~ 4.16)	0.030*	3.83 (1.68 ~ 8.70)	0.001*
LDL-C	1.00 (Ref)	0.83 (0.40 ~ 1.71)	0.628	1.52 (0.76 ~ 3.06)	0.233	1.16 (0.44 ~ 3.05)	0.755	2.99 (1.06 ~ 8.41)	0.037*
GLU	1.00 (Ref)	1.47 (0.83 ~ 2.58)	0.181	0.92 (0.47 ~ 1.78)	0.811	2.27 (0.79 ~ 6.52)	0.127	0.88 (0.30 ~ 2.56)	0.814
UA	1.00 (Ref)	1.43 (0.83 ~ 2.46)	0.191	2.52 (1.37 ~ 4.62)	0.003*	1.14 (0.61 ~ 2.11)	0.678	1.89 (0.89 ~ 4.00)	0.096

Notes: # indicates the sample size of participants with abnormalities at T0, the specific sample size: TG (*n* = 324), HDL-C (*n* = 465), LDL-C (*n* = 270), GLU (*n* = 255), UA (*n* = 439). *indicates $P < 0.05$. Model 0: crude model without any adjustments; Model 1: adjusted for demographic information (gender, age, marital status, employment status and educational attainment); Model 2: adjusted for baseline lifestyle factors (dietary behavior, physical activity and sleep quality); Model 3: adjusted for surgical procedures; Model 4: adjusted for Model 1 ~ 3. Abbreviations: T0, baseline; OR, odds ratio; TG, triglycerides; HDL-C, high-density lipoprotein cholesterol; LDL-C, low-density lipoprotein cholesterol; GLU, glucose; UA, uric acid;

($OR = 2.99$ [95%*CI*, 1.06 ~ 8.41]) (Table 4, subgroup analysis).

Discussion

In this study, we examined the BRI trajectories of 669 Chinese bariatric surgery patients. Three distinct BRI decline patterns were identified: High-rapid decline, High-gradual decline, and Low-gradual decline. The risk of abnormal metabolic biomarkers one year post-operatively varied significantly across these trajectory types. The Low-gradual decline group with the lowest BRI at endpoint (BRI = 3.49) exhibited the lowest risk of metabolic abnormalities. The High-rapid decline group with the highest initial BRI that experienced substantial reduction by endpoint (BRI = 3.89) showed a significant increase only in the risk of abnormal HDL-C, while improvements in other indicators were comparable to the Low-gradual decline group. For the High-gradual decline group whose BRI decreased only to 6.70 at endpoint, despite having trajectory patterns and %TWL similar to the Low-gradual decline group, the risks of abnormal TG, HDL-C, and LDL-C were significantly elevated. These metabolic abnormality risks remained significant after controlling for demographic factors, lifestyle factors and surgical procedures, as well as in subgroup analysis. The increased risk of abnormal HDL-C in the High-rapid decline group may be related to the timing of the surgery. Previous studies have indicated that HDL-C improvements peak approximately 12 months postoperatively in SG or RYGB procedures [30]. However, the High-rapid decline group predominantly underwent SG + JJB or SADI-S, which typically achieve optimal weight loss effects 2 ~ 3 years postoperatively [31, 32]. Meanwhile, this group had more severe baseline abdominal obesity, which may require a longer period for high-density lipoprotein synthesis and reverse cholesterol transport to adjust and adapt [33]. Additionally, HDL-C regulation is affected by multiple delayed physiological processes, including hepatic lipid metabolism, inflammatory resolution, and the recovery of insulin sensitivity—all of which may lag behind reductions in body fat [34]. Patients in the High-rapid decline group may also experience greater postoperative nutritional stress and reduced physical activity in the early recovery phase, which could transiently affect HDL-C metabolism before longer-term improvements occur [35].

Similarly, the High-gradual decline group, which also had a high baseline BRI, may have had insufficient improvement in abdominal obesity due to a lower proportion of combined surgical procedures, resulting in a persistently high risk of lipid metabolic abnormalities. Additionally, we found that after adjusting for baseline lifestyle factors, the risk of abnormal LDL-C in the High-gradual decline group was no longer significant. This suggests a potential moderating effect of lifestyle factors in the postoperative improvement of abdominal obesity. Patients in the High-gradual decline group had poorer baseline dietary behavior, lower physical activity levels, and worse sleep quality prior to surgery. In the absence of lifestyle interventions, these negative behaviors may have persisted postoperatively [36], thereby weakening the improvement in LDL-C. Poor dietary habits and physical inactivity may contribute to insulin resistance and fatty acid accumulation, which in turn increase LDL-C levels [37]. Poor sleep quality may exacerbate LDL-C abnormalities through alterations in hormone levels and inflammatory responses [38]. Nevertheless, the risk of metabolic abnormalities in TG and HDL-C across different BRI trajectory groups remained stable after adjustment for lifestyle factors.

With the global rise in obesity rates, abdominal obesity has been recognized as a significant metabolic risk factor for CVD [39]. Recent large-scale studies have also demonstrated the BRI's ability to reflect the degree of abdominal obesity and long-term health status. A study involving 9935 participants from the China Health and Retirement Longitudinal Study (CHARLS) identified three BRI trajectories and found that higher BRI levels were associated with an increased risk of CVD, suggesting that BRI could serve as a novel indicator to replace BMI in reflecting CVD risk [40]. Another study of 33,000 American adults used BRI as a measure of visceral fat distribution and found that a BRI range of 3.4 ~ 6.9 was associated with a lower mortality risk, and the narrower confidence intervals of the BRI model provided better sensitivity compared to BMI [41]. Furthermore, BRI values above 5.54 and 5.21 have been linked to increased all-cause and cardiovascular mortality respectively in American cohorts [42]. However, these thresholds were derived from general U.S. populations, and may not directly apply to Chinese individuals, who tend to exhibit different abdominal fat distribution patterns [15, 16]. At present, no established BRI cutoffs for metabolic risk have been validated in Chinese populations. Given this gap, our study adopted a trajectory-based approach to capture longitudinal BRI trends and explore their relationship with metabolic outcomes. The primary objective of bariatric surgery is to alleviate obesity to treat metabolic diseases and reduce the risk of CVD occurrence. Therefore, using BRI, an indicator that more accurately reflects abdominal obesity, to monitor surgical effectiveness may be of significant importance. Among the existing novel anthropometric indices for obesity, BRI has been noted to possess metabolic disease screening capabilities comparable to the abdominal volume index (AVI), lipid accumulation products (LAP), and A Body Shape Index (ABSI), while only requiring measurements of height and waist circumference, thereby offering both high accuracy and convenience [43, 44]. A study by Custers et al. also emphasized the potential of BRI as a practical tool for public health screening [10].

In our study, BRI demonstrated strong performance among the bariatric surgery population. After categorizing patients into three levels of abdominal obesity based on BRI, the groups exhibited minimal differences in demographic data while effectively highlighting variations in surgical procedures and the risk of metabolic abnormalities. Additionally, in Fig. 2, the endpoint BRI values for the High-rapid decline and Low-gradual decline groups were very close (3.89 vs. 3.49), whereas BMI differed by nearly 2.5 units (27.62 vs. 25.13). This suggests that in long-term postoperative efficacy evaluations, BMI may not fully capture patients' abdominal obesity alleviation effects as accurately as BRI, potentially limiting the true association between BMI and changes in postoperative metabolic risk. A large-scale cross-sectional study in Iran found that changes in BMI, WC, and %EWL post-bariatric surgery were significantly different between metabolically healthy morbidly obese (MHMO) individuals and metabolically unhealthy morbidly obese (MUMO) individuals. Further multivariate regression analysis indicated that only the delta changes in WC and %EWL were significantly different between the two groups, suggesting that the association between BMI and metabolic risk may be overshadowed by WC [45]. Additionally, a meta-analysis revealed that among diabetic patients with BMI below or above 35 kg/m^2, there was no significant difference in postoperative diabetes remission rates, and the only significant predictor of glycated hemoglobin A1c reduction was waist circumference [46]. In non-bariatric surgery populations, a cohort study showed that compared to UK residents, Chinese residents have lower BMI but higher BRI, and Cox regression analysis indicated that in the Chinese rural cohort, only BRI-related indicators were associated with ischemic stroke [47]. These findings suggest that WC is superior to BMI in reflecting changes in metabolic risk post-bariatric surgery; furthermore, BRI, an indicator which derived from WC, was applied for the first time in a bariatric surgery population and was significantly associated with the risk of metabolic abnormalities in this study.

Currently, the selection of surgical procedures in bariatric surgery typically adopts a cost-effectiveness approach, comprehensively considering factors such as baseline BMI, the presence of obesity-related comorbidities, age, patient weight loss expectations, and patient tolerance [23, 48–50]. These procedures differ not only in technical complexity but also in their physiological effects on fat metabolism and gastrointestinal hormone response, which may contribute to the observed variations in BRI trajectories and metabolic risk reduction. For example, in this study, patients undergoing SG + JJB had higher baseline BMI levels; older patients were more likely to receive RYGB or SADI-S treatments; and SG was performed most frequently due to its advantages of simplicity, shorter operative time, and not requiring gastrointestinal diversion (as shown in Table 1). Based on our results, patients with a higher degree of abdominal obesity can potentially be identified at baseline using BRI and considered for SG plus procedures, which may contribute to more significant reductions in metabolic risk. Supplementing SG with a jejunojejunal bypass (JJB) facilitates nutrient absorption at different intestinal sites, affecting the storage of abdominal fat [32]. Additionally, JJB induces significant changes in the secretion of GLP-1 and PYY, thereby improving insulin sensitivity, enhancing satiety, and inhibiting fat storage [51]. The added duodeno-ileal bypass in SADI-S also provides better control of lipid and glucose metabolism [52]. An animal model study demonstrated that SADI-S induces an increase in the adiponectin to leptin ratio, indicating that this bariatric surgical procedure can improve adipose tissue function [53]. In our study, the High-rapid decline group had the highest proportion of patients who underwent SG + JJB or SADI-S procedures, and tended to show the greatest reduction in BRI. Furthermore, except for HDL-C, all other indicators in this group reached levels comparable to the optimal group, indicating that SG plus procedures could potentially offer benefits in improving abdominal obesity. Therefore, future selection of bariatric surgical procedures should, in addition to traditional clinical factors, comprehensively consider the degree of abdominal obesity and expected metabolic improvements, and progressively incorporate BRI assessment into the decision-making process for procedure selection.

Strengths and limitations

The primary strength of this study lies in the use of the BRI as a rapid anthropometric measure to assess abdominal obesity from a morphological perspective. To date, few studies have employed BRI in populations with severe obesity or those undergoing bariatric surgery, and BRI's advantages over BMI are particularly pronounced in Asian populations. Under these circumstances, this study is the first to observe the one-year postoperative BRI trajectory in Chinese bariatric surgery patients and to explore the association between BRI levels and metabolic risks, providing valuable insights for future research. Additionally, we compiled data from a six-year cohort of patients treated at our bariatric center, with one-year postoperative follow-up for each of the 669 cases, providing good representativeness.

The main limitation of this study is the duration of follow-up, which is limited to one year for characterizing longitudinal trajectories. As shown in the figures, although the rate of BRI reduction tends to plateau at 12 months postoperatively, the BRI continues to improve especially in the High-rapid decline group. Existing studies have found that SG typically reaches optimal weight reduction at one year postoperatively [54], while combined bariatric procedures may take longer to achieve peak follow-up outcomes [55]. Due to data completeness constraints, we only included one-year postoperative observations. Nonetheless, longer-term follow-up (such as 2 ~ 3 years) would be valuable to evaluate the sustained impact of BRI trajectories on metabolic health, as postoperative changes may continue to evolve beyond the first year. Additionally, as a single-center study, our findings may have some limitations in generalizability due to variations in surgical practices and patient characteristics across different institutions. However, the results provide valuable insights within our specific cohort, and future multi-center studies with broader populations could offer further perspectives on these findings. It is also encouraging that our center is involved in the construction of the Chinese Obesity and Metabolic Surgery Database, which may help address some of these considerations moving forward.

Conclusion

This longitudinal study demonstrates that the one-year postoperative trajectories of bariatric surgery patients, fitted based on the Body Roundness Index (BRI), can effectively differentiate metabolic risk levels among Chinese bariatric patients. The trajectory category with the lowest BRI at endpoint exhibited the lowest risk of metabolic abnormalities. Combined procedures, such as SG plus, may be associated with improvements in abdominal obesity and metabolic status in patients with high baseline BRI, although improvements in HDL-C might require longer observation periods. The initial application of BRI in the Chinese bariatric surgery population suggests potential utility. Therefore, incorporating BRI assessment into the decision-making process for bariatric procedure selection may be considered.

Supplementary Information

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Supplementary Material 1: Supplementary Table 1. Baseline Characteristics of Included vs. Excluded Patients. Supplementary Table 2. Growth Mixture Model Fit Indices for Different Trajectory Categories. Supplementary Table 3. Parameter Estimates for Three BRI Trajectory Classes.

Supplementary Material 2

Author contributions
Dr Zhao, Dr Xu, Prof. Xu and Prof. Liang had full access of the data in the study and take responsibility for the integrity of the data and the accuracy of the data analysis.Concept and design: Z.K., S.WB., X.XY., Y.NL., L.H., X.Q.Acquisition, analysis, or interpretation of data: Z.K., S.WB., X.XY., L.H., X.Q.Drafting of the manuscript: Z.K., S.WB, X.XY.Critical review of the manuscript for important intellectual content: Z.K., Y.NL., L.H., Xu.Statistical analysis: Z.K., S. WB., X.XY. Obtained funding: Z.K.,X.Q.Administrative, technical, or material support: Z.K., Y.NL., L.H., X.Q.Supervision: L.H., X.Q.Qin Xu and Hui Liang are both corresponding authors of this work.Kang Zhao and Wenbing Shi contributed equally to this work.

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Data availability
De-identified data will bemade available upon request after approval by the study investigators.E-mails Dr. Zhao: zk1996@njmu.edu.cnProf. Liang: drhuiliang@126.comProf. Xu: qinxu@njmu.edu.cn.

Declarations

Ethics approval and consent to participate
The study received ethical approval from the First Affiliated Hospital of Nanjing Medical University (2023-SR-581).

Competing interests
The authors declare no competing interests.

Trail registration
Chinese Clinial Trail Registry (ChiCTR2000033443).

Informed consent statement
Written informed consent was obtained from the patient for publication of this study and accompanying images. A copy of the written consent is available for review by the Editor-in-Chief of this journal on request.

Additional contributions
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Role of the funder/sponsor
The funders had no role in the design and conduct of the study; collection, management, analysis, and interpretation of the data; preparation, review, or approval of the manuscript; and decision to submit the manuscript for publication.

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