Original Article

Weight loss scale calendar postbariatric surgery: call for standardized prediction

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ABSTRACT

Background: Candidates for bariatric surgery need realistic targets for weight loss after surgery and the surgeons need to ensure that the patients are on the way to successful weight loss. This study aimed to present a weight loss calendar estimating the average loss in BMI per week after the surgery and to introduce a simple formula to help make an easy and reliable prediction of the weight loss outcome after bariatric surgery.

Patients and Methods: This is a retrospective study that included patients who were consecutively recruited for bariatric surgery. During the postoperative follow-up visits, the patients' weight loss data were recorded and analyzed. The study cohort was randomly split into a training group (to derive the regression models) and a validation group (to validate the obtained model).

Results: The mean preoperative BMI was 47.8 ± 8.3 kg/m^2. At the 12-month follow-up, the mean BMI was 30.04 ± 5.3 kg/m^2, the mean percentage of excess weight loss (EWL %) was 80.9 ± 18.7 and the mean percentage of total weight loss % was 36.9 ± 5.8. The regression equation was formulated as follows: 1-year EWL % = 139.71 + (- 0.291 × age) + (- 0.981 × baseline BMI) + (0.95 × 2-week EWL %) + (- 17.151 × previous bariatric procedure). The regression formula was: 1-year BMI = (- 3.61) + (- 0.079 × age) + (0.539×baseline BMI) + (4.977 × previous bariatric procedure).

Conclusion: The patient's age, baseline BMI and history of previous bariatric procedures were significant predictors of the 1-year BMI. The same variables, combined with the early postoperative EWL %, significantly predicted the 1-year EWL %.

Keywords: Bariatric surgery, early prediction, multiple regression models, weight loss outcome.

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INTRODUCTION

Obesity is a heterogeneous disorder that is related to various medical complications, which certainly elevate all-cause mortality risks[1]. The current globally high rates of obesity that are still continuously rising, together with the ultimately limited success of treatment with lifestyle modifications and medical therapy, have led to the wide acceptance of bariatric surgery as the most definitive treatment for obesity and its associated medical complications[2–4].

Postbariatric surgery weight loss is commonly the most decisive objective for patients undergoing bariatric surgery and it is the primary outcome for performing surgeons. Weight loss outcomes are widely variable across patients. Optimization and standardizing the postbariatric surgery weight loss over the postoperative follow-up visits, as far as possible, is crucial for patients and surgeons[5, 6]. Candidates for bariatric surgery need realistic targets for weight loss after surgery and the surgeons need to ensure that the patients are on the way to successful weight loss after surgery. Thus, they can plan an alternative procedure for those who fail to achieve optimum weight loss in atimely manner[5, 6].

Some previous studies have proposed models for weight loss prediction[7–13]. However, as far as we know, no previous studies have constructed a model for standardized postbariatric surgery prediction in Egyptian patients. We believe that the weight loss outcome is partially affected by ethnic and cultural issues, including dietary habits and lifestyles. Therefore, this study aimed to present a weight loss calendar estimating the average loss in BMI per week after the surgery and to introduce a simple formula to help make an easy and reliable prediction of the weight loss outcome after bariatric surgery. This would aid in tracking patients' lags in their weight loss targets as precisely as possible.

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PATIENTS AND METHODS

This is a retrospective study that included an analysis of the prospectively collected data of patients who were consecutively recruited for bariatric surgery in Department of General Surgery, Faculty of Medicine, Cairo University and in Department of General Surgery in Military Production Specialized Medical Centre during the period from July 2011 to October 2020. The study was initiated after approval by the Research Ethics Committee and adhered to the Declaration of Helsinki.

The study patients underwent dedicated assessment by a multidisciplinary team. The same surgical team indeed operated all cases. The patient's eligibility for bariatric surgery was checked according to the standards proposed by the 1991 National Institutes of Health Consensus[14] and customized by the International Federation for the Surgery of Obesity, the European Association for the Study of Obesity and the American Society for Metabolic and Bariatric Surgery[15 – 17]. A particular surgery type was selected based on the patients' preferences after consultation with the surgeon.

All patients were subjected to the routine preoperative clinical examination, which included full history taking, multidisciplinary clinical assessment, laboratory investigations, abdominal ultrasound and upper gastrointestinal tract endoscopy. Written informed consent was obtained from the included patients before surgery. Patients not completing at least 1 year of follow-up were excluded from the study.

The surgery was performed as previously standardized. The patients' demographic and clinical data were obtained. Regular postoperative follow-up visits were scheduled at 2, 5 weeks, 3, 6, 9 and 12 months, during which the patient's weight and BMI were recorded.

The BMI loss velocity per week was calculated by subtracting the BMI value at each follow-up time point minus the prior reading and dividing the result by the interval between the two-time points in weeks.

The percentage of total excess weight loss (EWL %) was calculated using the equation: [(baseline weight−follow-up weight)/(baseline weight–ideal weight)] × 100. The ideal weight was calculated based on the patient's height using a BMI of 25 kg/m^2.

The percentage of total weight loss % was assessed using the equation: [(baseline weight−follow-up weight)/(baseline weight)] × 100.

Statistical analysis and validation of the obtained models

The patients' data was analyzed using SPSS statistical software (IBM Corp., Armonk, New York, USA), version 28. Independent t tests and analysis of variance tests were used to compare the numerical values according to the number of tested groups. The χ^2 test and z test for proportion were used to compare categorical values as appropriate. A linear regression analysis was performed to determine the predictors of 1-year BMI and EWL %. Factors that were clinically relevant or statistically significant in the univariate analysis were incorporated into multiple regression models. For the validation of the tested models, the study cohort was randomly split into a training group (to test the regression models) and a validation group (to validate the obtained model). Multicollinearity diagnostics were conducted to determine multicollinear variables and readjust the regression model. Factors with variance inflation factor values less than 10 were considered noncollinear. A P value less than 0.05 was considered statistically significant.

RESULTS

The present study included 452 patients consecutively submitted to bariatric surgery at multiple governmental and private healthcare settings from July 2011 to October 2021. The patients' ages ranged from 18 to 60 years, with a mean of 37.2 ± 9.5 years. There was a sex preference for females, who constituted 70.6 % of the included patients (n = 319). The mean preoperative weight was 132.3 29.9 kg and the mean BMI was 47.8 ± 8.3 kg/m^2. At the 12-month follow-up, the mean BMI was 30.04 ± 5.3 kg/m2, the mean EWL % was 80.9 ± 18.7 and the mean total weight loss % was 36.9 ± 5.8. Comparison of the weight data at baseline and postoperatively showed no statistically significant difference according to the surgery type (Table 1).

Table 1: Baseline demographic data and weight loss according to the surgery type:

	RYGB	Long biliary limb gastric bypass	OAGB	SG	*P* value
Age (years)	39.5 ± 7.5	35.9 ± 8.8	37.1 ± 10.6	36.3 ± 9.7	0.928
Baseline weight (kg)	129.7 ± 41.9	140.01 ± 28.7	130.4 ± 25.8	135.4 ± 28.5	0.937
Baseline BMI (kg/m²)	48.7 ± 10.6	46.8 ± 8.2	46.5 ± 7.7	48.4 ± 8.4	0.402
12-month BMI (kg/m²)	29.2 ± 6.2	30.5 ± 5.7	29.3 ± 4.9	30.2 ± 6	0.904
12-month EWL %	89.02 ± 23.9	78.9 ± 23.3	81.5 ± 21.1	81.03 ± 18.3	0.689
12-month TWL %	39.6 ± 5.6	34.5 ± 8.6	36.5 ± 8.4	37.3 ± 6.8	0.504

EWL, excess weight loss; OAGB, one anastomosis gastric bypass; RYGB, Roux-en-Y gastric bypass; SG, sleeve gastrectomy; TWL, total weight loss.
P value was based on analysis of variance test.

As calculated at several postoperative time points, the BMI loss velocity showed a gradual reduction until the end of the follow-up period. The first two weeks, the loss rate was −1.73 kg/m²/week. This steeply declined to reach a rate of - 0.16 kg/m²/week. The baseline BMI and the rate of loss per week were significantly different according to the patient's sex at the first 3 months, with higher mean values seen in males. This significant difference was not shown in the rest of the follow-up period (Table 2, Figure 1).

A comparison between the training group (n = 346) and the validation group (n = 106) is presented in Table 3. Both groups were comparable in the baseline and postoperative weight loss data (*P* > 0.05).

Table 2: Baseline demographic data and BMI loss velocity according to the patients' sex:

	All patients	Females	Males	*P* value
Age (years)	37.2 ± 9.5	36.4 ± 10.3	37.7 ± 10.7	0.507
Baseline weight (kg)	132.3 ± 29.9	124.6 ± 20.2	156 ± 29.6	< 0.001*
Baseline BMI (kg/m²)	47.8 ± 8.3	47.03 ± 7.24	49.6 ± 8.9	0.002*
BMILV at first 2 weeks (kg/m²/week)	- 1.73 ± 0.54	- 1.77 ± 0.64	- 2.06 ± 0.83	< 0.001*
BMILV between 2 and 5 weeks (kg/m²/week)	- 0.66 ± 0.36	- 0.603 ± 0.34	- 0.694 ± 0.42	0.030*
BMILV between 5 weeks and 3 months	- 0.52 ± 0.2	- 0.487 ± 0.19	- 0.6 ± 0.23	< 0.001*
BMILV between 3 and 6 months (kg/m²/week)	- 0.32 ± 0.15	- 0.337 ± 0.15	- 0.378 ± 0.17	0.088
BMILV between 6 and 9 months (kg/m²/week)	- 0.23 ± 0.11	- 0.232 ± 0.12	- 0.282 ± 0.14	0.102
BMILV between 9 and 12 months (kg/m²/week)	- 0.162 ± 0.08	- 0.165 ± 0.13	- 0.167 ± 0.12	0.947
12-month BMI (kg/m2)	30.04 ± 3	29.09 ±.07	30.5 ± 5.04	0.296

BMILV, BMI loss velocity. *P* value was based on independent t test. * is statistical significant.

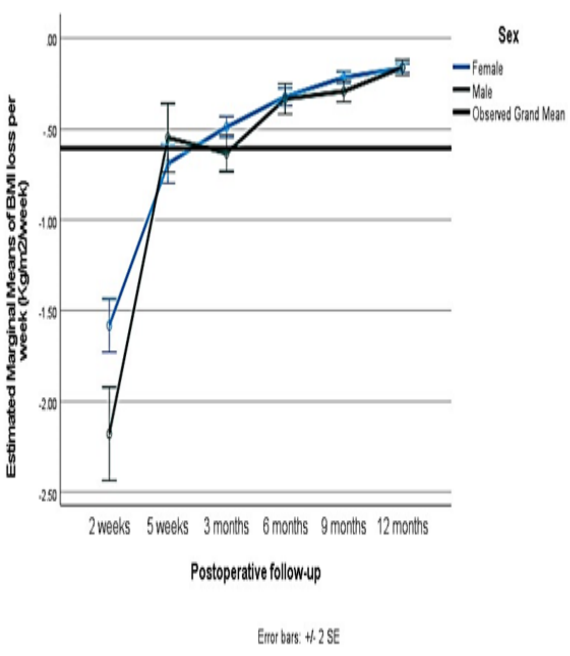

Figure 1: BMI loss velocity after surgery according to sex.

Table 3: Baseline demographic data and weight loss outcome of the study patients:

	Study patients (N=452)		
	Training group (N = 346)	**Validation group (N = 106)**	
	Mean ± SD/n (%)	**Mean ± SD/n (%)**	***P* value**
Age (year)	36.07 ± 10.6	36.5 ± 9.9	0.691[a]
Sex			
Male	100 (28.9)	33 (32.1)	0.659[b]
Female	246 (71.1)	73 (68.9)	
Comorbidities			
Type 2 diabetes mellitus	49 (14.2)	20 (18.9)	0.239[c]
Hypertension	60 (17.3)	17 (16)	0.755[c]
Dyslipidemia	63 (18.2)	14 (13.2)	0.231[c]
GERD	34 (9.8)	9 (8.5)	0.682[c]
Bronchial asthma	30 (8.7)	5 (4.7)	0.183[c]
Ischemic heart disease	1 (0.3)	1 (0.9)	0.374[c]
Weight (kg)			
Baseline	133.8 ± 26.9	134.2 ± 29.1	0.885[a]
2 weeks	123.1 ± 24.1	124.3 ± 27.3	0.685[a]
3 months	108.1 ± 22.2	107.7 ± 22.1	0.899[a]
6 months	96.6 ± 20.8	96.98 ± 23.5	0.615[a]
12 months	84.4 ± 17.96	83.3 ± 18.6	0.521[a]
BMI (kg/m2)			
Baseline	47.8 ± 8.3	48.2 ± 8.9	0.512[a]
2 weeks	44.3 ± 7.7	44.7 ± 8.3	0.367[a]
3 months	38.7 ± 6.9	38.8 ± 7	0.782[a]
6 months	34.8 ± 6.02	34.6 ± 7.3	0.947[a]
12 months	30.04 ± 5.3	30.3 ± 6.9	0.587[a]
EWL %			
2 weeks	13.2 ± 8.6	14.2 ± 7.3	0.799[a]
3 months	39.2 ± 12.8	40.04 ± 11.7	0.586[a]
6 months	55.8 ± 16.4	58.97 ± 16.5	0.164[a]
12 months	79.97 ± 19.5	81.8 ± 18.9	0.521[a]
TWL %			
2 weeks	7.8 ± 2.4	7.7 ± 1.99	0.700[a]
3 months	19.2 ± 4.02	19.6 ± 3.8	0.465[a]
6 months	27.3 ± 4.9	28.6 ± 5.1	0.073[a]
12 months	36.7 ± 6.9	37.8 ± 8.1	0.291[a]
Surgery type			
Roux-en-Y gastric bypass	5 (1.4)	2 (1.9)	0.452[b]
Long biliary gastric bypass	11 (3.2)	7 (6.6)	
One anastomosis gastric bypass	63 (18.2)	19 (17.9)	
Sleeve gastrectomy	267 (77.2)	78 (73.6)	
Previous bariatric procedure			
Yes	8 (2.3)	1 (0.9)	0.377[b]
No	338 (97.7)	105 (99.1)	

EWL, excess weight loss; GERD, gastroesophageal reflux disease; TWL, total weight loss.
[a]Independent t test.
[b]χ^2 test.
[c]z test for proportion.

Univariate regression analysis obtained significant parameters (Table 4) that were incorporated into multiple regression analysis, which revealed that a model constructed of the patient's age, baseline BMI, EWL % at 2 weeks after surgery and if the patient had had a previous bariatric procedure was the best fitting model to predict the 1-year EWL % (Table 5, Figure 2).

Table 4: Univariate linear regression analysis for the prediction of excess body weight loss% and BMI at the 12-month follow-up:

	Unstandardized coefficients		Standardized coefficients		
	B	**SE**	**Beta**	**t test**	***P* value**
Univariate linear regression analysis for the prediction of EBWL% at the 12-month follow-up					
Age	- 0.410	0.131	- 0.216	- 3.138	0.002*
Sex	- 4.005	3.012	- 0.093	- 1.330	0.185
Baseline BMI	- 1.328	0.146	- 0.539	- 9.100	< 0.001*
2 weeks EWL %	1.298	0.159	0.518	8.167	< 0.001*
DM	- 0.684	3.927	- 0.012	- 0.174	0.862
Hypertension	- 1.419	3.453	- 0.029	- 0.411	0.682
Dyslipidemia	- 0.066	0.038	- 0.112	- 1.762	0.079
GERD	- 6.134	5.083	- 0.085	- 1.207	0.229
Bronchial asthma	- 9.740	5.573	- 0.122	- 1.748	0.082
IHD	- 20.064	19.587	- 0.072	- 1.024	0.307
Number of comorbidities	1.014	1.441	0.049	0.704	0.482
Surgery type	- 2.349	2.207	- 0.075	- 1.064	0.288
Primary vs. revisional surgery	- 19.884	7.996	- 0.172	- 2.487	0.014*
Univariate linear regression analysis for the prediction of BMI at the 12-month follow-up					
Age	0.102	0.033	0.179	3.089	0.002*
Sex	0.772	0.738	0.061	1.047	0.296
Baseline BMI	0.559	0.025	0.791	21.971	< 0.001*
DM	0.058	0.922	0.004	0.063	0.950
Hypertension	- 0.830	0.872	- 0.056	- 0.952	0.342
Dyslipidemia	0.151	0.886	0.010	0.170	0.865
GERD	- 0.152	1.234	- 0.007	- 0.123	0.902
Bronchial asthma	0.266	1.258	0.012	0.211	0.833
IHD	0.028	5.801	0.000	0.005	0.996
Number of comorbidities	- 0.199	0.366	- 0.032	- 0.544	0.587
Surgery type	0.230	0.530	0.026	0.434	0.665
Primary vs. revisional surgery	6.176	2.186	0.164	2.826	0.005*

DM, diabetes mellitus; EWL, excess weight loss; GERD, gastroesophageal reflux disease; IHD, ischemic heart disease.

The regression equation could be formulated as follows: 1-year EWL % = 139.71 + (- 0.291 × age) + (- 0.981 × baseline BMI) + (0.95 × 2-week EWL %) + (- 17.151 × previous bariatric procedure).

This formula had an R value of 0.669, an R^2 of 0.447 and an adjusted R^2 of 0.435. This result denotes that the model could explain about half of the 1-year EWL %.

Fitting the same model to the validation group ensured the model's accuracy with higher predictive power (R = 0.721, R^2 = 0.52 and adjusted R^2 = 0.485).

For prediction of the 1-year BMI, a model formed of the patient's age, baseline BMI and if the patient had had a previous bariatric procedure showed the best goodness of fit (Table 5, Figure 3).

Table 5: Linear regression analysis for the prediction of excess body weight loss %:

	Unstandardized coefficients				95.0 % confidence interval for B		
	B	SE	Beta	*P* value	Lower bound	Upper bound	VIF
Multiple regression model for prediction of the 12-month EWL% (training group)							
Constant	139.701	11.554		< 0.001	116.901	162.501	
2-week EWL %	0.950	0.147	0.379	< 0.001	0.659	1.240	1.117
Baseline BMI	0-.981	0.147	- 0.389	< 0.001	- 1.270	- 0.691	1.096
Age	- 0.291	0.105	- 0.156	0.006	- 0.497	- 0.084	1.028
Previous bariatric procedure	- 17.151	6.589	- 0.145	0.010	- 30.154	- 4.149	1.005
R^2 = 0.447, adjusted R^2 = 0.435; *P* < 0.001							
Multiple regression model for prediction of the 12-month EWL% (validation group)							
Constant	187.007	21.876		< 0.001	143.167	230.848	
2-week EWL %	0.950	0.147	0.379	< 0.001	0.659	1.240	1.117
Baseline BMI	- 0.933	0.197	- 0.464	< 0.001	- 1.328	- 0.538	1.101
Age	- 0.638	0.218	- 0.287	0.005	- 1.075	- 0.201	1.100
Previous bariatric procedure	- 47.112	14.020	- 0.324	0.001	- 75.208	- 19.015	1.067
R^2 = 0.520, adjusted R^2 = 0.485; *P* < 0.001							
Multiple regression model for prediction of the 12-month BMI (training group)							
Constant	- 3.610	1.965		0.068	- 7.483	0.263	
Baseline BMI	0.539	0.027	0.782	< 0.001	0.486	0.592	1.001
Age	0.079	0.020	0.152	< 0.001	0.039	0.119	1.000
Previous bariatric procedure	4.977	1.299	0.150	< 0.001	2.416	7.538	1.001
R^2 = 0.668, adjusted R^2 = 0.663; *P* < 0.001							
Multiple regression model for prediction of the 12-month BMI (validation group)							
Constant	- 15.553	5.301		0.005	- 26.137	- 4.969	
Baseline BMI	0.589	0.051	0.782	< 0.001	0.488	0.691	1.005
Age	0.165	0.052	0.219	0.002	0.061	0.268	1.055
Previous bariatric procedure	10.894	3.950	0.190	0.008	3.008	18.779	1.051
R^2 = 0.703, adjusted R^2 = 0.689; *P* < 0.001							

EWL, excess weight loss; VIF, variance inflation factor.

The regression formula was: 1-year BMI = (- 3.61) + (- 0.079 × age) + (0.539 × baseline BMI) + (4.977 × previous bariatric procedure).

This formula had an R value of 0.817, indicating a substantial correlation between the predicted and actual values of 1-year BMI. The R^2 value was 0.668 and the adjusted R^2 was 0.663, denoting the high accuracy of the model.

Testing the model's validity confirmed its accuracy with higher predictive power (R = 0.838, R^2 = 0.703 and adjusted R^2 = 0.689).

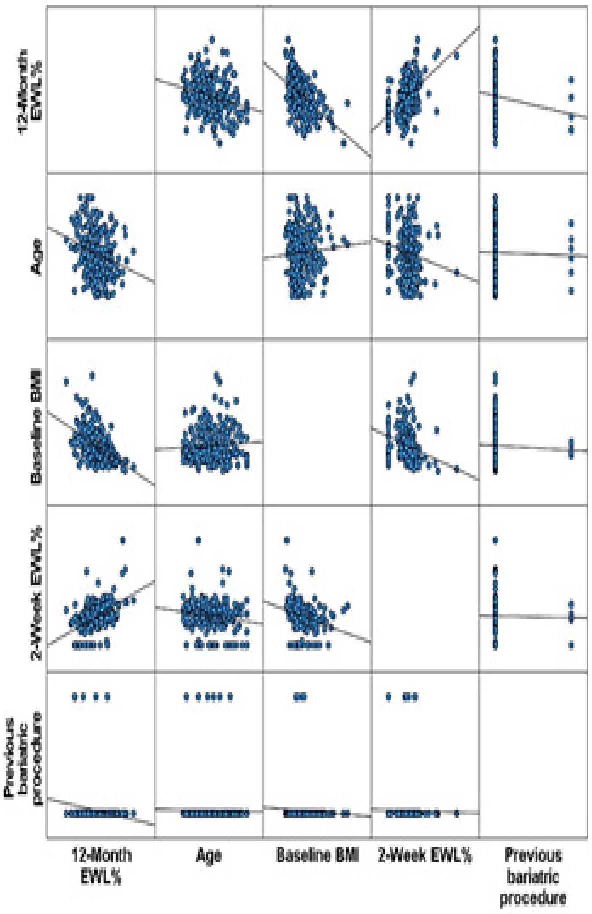

Figure 2: One-year percentage of excess weight loss (EWL%) prediction.

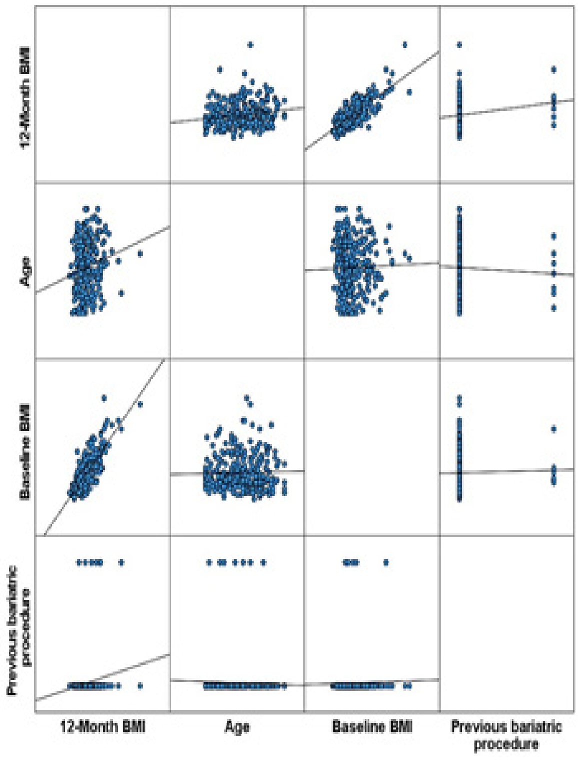

Figure 3: One-year BMI prediction.

DISCUSSION

Bariatric surgery has become a shield against the continuously rising prevalence of obesity and its related medical complications, which have a certain hand in the rising mortality rates in this population. Adjustment and the probable postoperative achievement of weight loss preclude far-reaching expectations that might be met with disappointment for the patient and the physician when they do not come true. Also, the early catchment of cases with unsatisfactory weight loss would help with early intervention and strict follow-up to ensure adherence to the appropriate protocols.

This is the first study from Egypt attempting to propose simple models for predicting the 1-year weight loss outcome. In our cohort, the equation for EWL % prediction included age, baseline BMI, history of previous bariatric procedures and the early postoperative (2 weeks) EWL %. A more accurate and simpler formula was used to predict the 1-year BMI. The obtained formula consisted only of preoperative parameters, with a near-complete correlation between the predicted and actual 1-year BMI values.

Several formulas were previously established to predict postoperative weight loss based on data obtained from real-world experiences. Similar to our findings, researchers in previous studies have observed an obvious positive correlation between the baseline and the final postoperative BMI values, with the initial BMI being a main component of the prediction formulae[8, 10 – 12, 18, 19].

Our study finding regarding the negative association of the patient's age with the 1-year BMI and EWL % agrees with the data derived from the studies of Still *et al.*[19] and Scozzari *et al.*[20], who reported that the older patients had significantly higher rates of failed weight loss than those younger in age.

For 1-year EWL % prediction, an additional parameter showed statistical significance, the early postoperative EWL %. In consistency with this finding, Manning *et al.*[21] and Silveira *et al.*[22] have stated that bariatric surgery success can be predicted during the early postoperative follow-up assessment.

This study included a variable not previously implemented in a weight loss outcome prediction formula, which was the previous submission to a bariatric procedure. This variable was found impact the weight loss outcome negatively. A meta-analysis study conducted by Pędziwiatr *et al.*[23] investigated the difference in weight loss outcomes between primary and revisional surgery. A pooled analysis of 21 studies, including 14 763 patients, showed that revisional surgery yielded significantly lower EWL %, with a mean difference of 19.9 %. This could be attributed to the fact that patients requiring a second bariatric method might have already lost some excess weight after the previous procedure and their initial BMI is not an initial one.

This study presented approximate values for the expected BMI loss every week after surgery. Finally, our proposed models were validated and exhibited good performance in predictingf weight loss outcomes at 1 year postoperatively. Surgeons should consider the patient's age, initial BMI, early postoperative EWL % and history of previous bariatric procedures when formulating the weight loss targets for the bariatric surgery candidates to provide realistic goals that contribute to the patient' satisfaction and adherence to the lifestyle modification strategies and give an early warning about those who are susceptible to insufficient weight loss.

While our study provides valuable insights into predictive models for weight loss outcomes after bariatric surgery, some limitations should be considered. Our study focused on Egyptians, limiting how broadly our findings can apply to other racial groups. Nevertheless, our study not only introduces a novel predictive model tailored to the Egyptian population that benefits local medical practices but also contributes to the refinement of postsurgical care strategies and could serve as a foundation for similar studies in other regions with unique patient characteristics. Addressing postbariatric surgery weight loss trends in diverse populations is an integral to personalizing treatment approaches and optimizing patient outcomes. Further research involving more racially diverse cohorts is crucial to confirm, refine, or expand upon our findings. The present work is also limited by being a retrospective study and including variable surgical types. However, this variability did not significantly affect the weight loss outcome. Moreover, our study is strengthened by being multicentered and by validating the obtained formulas on a randomly split cohort.

CONCLUSION

The patient's age, baseline BMI and history of previous bariatric procedures were significant predictors of the 1-year BMI. The same variables, combined with the early postoperative EWL%, significantly predicted the 1-year EWL%.

CONFLICTS OF INTEREST

There are no conflicts of interest.

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