Obesity Surgery (2019) 29:230–238
https://doi.org/10.1007/s11695-018-3524-1

ORIGINAL CONTRIBUTIONS

Pre- and Postbariatric Subtypes and Their Predictive Value for Health-Related Outcomes Measured 3 Years After Surgery

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Published online: 24 September 2018

Abstract

Background Although bariatric surgery is the most effective treatment for severe obesity, a subgroup of patients shows insufficient postbariatric outcomes. Differences may at least in part result from heterogeneous patient profiles regarding reactive and regulative temperament, emotion dysregulation, and disinhibited eating. This study aims to subtype patients based on these aspects before and 2 years after bariatric surgery and tests the predictive value of identified subtypes for health-related outcomes 3 years after surgery.

Methods Within a prospective multicenter patient registry, $N = 229$ bariatric patients were examined before bariatric surgery, 2 and 3 years postoperatively via clinical interviews and self-report questionnaires. Pre- and postbariatric subtypes were differentiated by temperament, emotion dysregulation, and disinhibited eating using latent profile analyses (LPA). The predictive value of pre- and postbariatric subtypes for surgery outcomes measured 3 years postoperatively was tested via linear regression analyses.

Results LPA resulted in five prebariatric and three postbariatric subtypes which were significantly associated with different levels of general and eating disorder psychopathology. Post- versus prebariatric subtypes explained more variance regarding eating disorder psychopathology, depression, and quality of life assessed 3 years postoperatively, whereas neither pre- nor postbariatric subtypes predicted postbariatric weight loss. Patients with prebariatric deficits in self- and emotional control had an increased risk for showing these deficits postoperatively.

Electronic supplementary material The online version of this article (https://doi.org/10.1007/s11695-018-3524-1) contains supplementary material, which is available to authorized users.

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Conclusions A re-evaluation of patients' psychological status after bariatric surgery is recommended to detect patients with potential risk for adverse psychological surgery outcomes in the long term.

Keywords Bariatric surgery outcome · Temperament · Impulsivity · Emotion regulation · Predictors · Cluster

Introduction

Bariatric surgery has demonstrated to be effective to achieve sustained long-term weight loss along with improvements in physical and psychosocial functioning in individuals with severe obesity (body mass index [BMI] ≥ 40 kg/m^2 or ≥ 35 kg/m^2 with obesity-related comorbidities) [1, 2]. However, there is a subset of bariatric patients (20–30%) which shows insufficient postbariatric weight loss (often defined as less than 50% of excess weight loss) [3] or fails to maintain initial weight loss over the years after surgery [4, 5]. Psychologically, previous research sought to elucidate patients' specific temperament traits that are associated with poorer postbariatric surgery outcomes [6–11], using different theoretical models and varying measures of impulsivity. According to Gray's biopsychological theory of personality [12], impulsivity is expressed by high reward and punishment sensitivity (i.e., reactive temperament) and low self-control (i.e., regulative temperament). Even if assessed with different self-report questionnaires (e.g., [13–16], recent studies consistently indicated that patients with poor impulse control are at greater risk for insufficient postbariatric weight loss in the long term (e.g., [17, 18]). Importantly, patients' impulsive temperament is related to disinhibited eating behaviors, mainly triggered by external factors (e.g., appearance of food) or emotional reasons (i.e., dealing with negative affect [18]), which makes it a key psychological factor, especially for bariatric surgery.

Previous cluster studies, using temperament traits assessed by the Neuroticism, Extraversion, Openness-Five Factor Inventory (NEO-FFI) or the Behavioral Inhibition and Behavioral Activation System (BIS/BAS) and the Effortful Control scale of the Adult Temperament Questionnaire (ATQ-EC), reliably identified two distinct patient subtypes in three prebariatric samples with sample sizes ranging from $N = 102$ to $N = 156$ [13, 16, 19]: an "emotionally dysregulated/undercontrolled" subtype characterized by low levels of self-control and high emotional lability and a "resilient" subtype with functional self-regulation and emotional stability. "Emotionally dysregulated/undercontrolled" patients reported higher eating disorder psychopathology and greater psychological impairment than "resilient" patients suggesting that patients from this subtype are more likely to show general and food-specific impulsivity, especially in combination with negative affect [7, 20, 21].

Recently, a more refined cluster analysis with prebariatric patients, including both variables on temperament traits, emotion dysregulation, and disinhibited eating behaviors, identified a five-cluster model in a large multicenter sample ($N = 370$) with higher accuracy in cluster assignment, discriminant validity, and a gain in explained variance compared to previous temperament-based models [22]. Lowest levels of effortful control and increased levels of emotion dysregulation and disinhibited eating were detected in subtypes with "moderately reduced control (RC)" and "severely RC." Although patients of the "resilient" and "slightly RC" subtype similarly had functional levels of self- and emotion regulation, patients of the "slightly RC" subtype reported greater disinhibited eating. A minority of patients was classified as "food-specifically RC" with functional levels of self- and emotion regulation, but very high levels of disinhibited eating. Due to the nature of their profiles, prebariatric patients of the "severely RC," "moderately RC," and "food-specifically RC" subtypes were expected to be at high risk for insufficient postbariatric weight loss in the long term; however, longitudinal data were not available.

The predictive value of prebariatric psychological profiles for surgery outcome has only been examined in a recent study in $N = 130$ patients which were subtyped based on temperament traits [19]. While prebariatric patients of the "emotionally dysregulated/undercontrolled" versus "resilient" subtypes were found to report more depressive symptoms and lower quality of life 12 months after bariatric surgery, patient subtype did not predict weight loss and eating disorder psychopathology at 12-month follow-up [19]. In addition, nothing is known about the stability of patients' psychological profiles after bariatric surgery. As bariatric surgery has a deep impact on many psychological factors (e.g., eating behavior, depression) [1, 23], changes in patients' psychological profiles after bariatric surgery are to be expected. In this context, postbariatric subtypes might be more relevant for predicting long-term weight loss and health-related outcomes than prebariatric subtypes [10, 11]. However, there is a lack of studies subtyping patients based on temperament, emotion dysregulation, and disinhibited eating and, furthermore, comparing the predictive value of post- versus prebariatric subtypes.

Extending a previous study on prebariatric subtypes [22], this is the first study identifying both prebariatric and 2-year postbariatric subtypes based on temperament traits, emotion dysregulation, and disinhibited eating behaviors and comparing their predictive value for weight- and health-related surgery outcomes assessed 3 years postoperatively. It was hypothesized that post- versus prebariatric subtypes would explain more variance of psychological variables assessed

3 years after surgery. Furthermore, patients with severe deficits in self-control and emotion regulation before and 2 years after surgery were expected to achieve significantly worse long-term surgery outcomes regarding weight loss, psychopathology, and quality of life than resilient patients characterized by functional self- and emotion regulation.

Materials and Methods

Participants

This study was part of the longitudinal Psychosocial Registry for Bariatric Surgery (PRAC), which prospectively assesses psychosocial parameters in a consecutive bariatric sample in six German surgery centers (for a detailed description, see [24]). The PRAC study was approved by the authorized ethics committees, and written informed consent was obtained from all patients prior to study enrollment. All measures were administrated before bariatric surgery (T0), as well as 2 years (T1) and 3 years (T2) after bariatric surgery.

Measures for Subtyping

Reactive and Regulative Temperament Patients' reactive temperament was assessed by the total scores of the Behavioral Inhibition System (BIS) scale and the Behavioral Activation System (BAS) scale [25]. The BIS scale (Cronbach's α in this study's sample at all assessment points = .78–.79) measures the dispositional sensitivity to punishment, whereas the BAS scale (α = .84–.85) assesses the dispositional approach tendency towards impending reward (i.e., reward sensitivity). Regulative temperament was assessed by the total score of the Effortful Control subscale of the Adult Temperament Questionnaire-Short Form (ATQ-EC [26]; α = .78–.80). Effortful control (i.e., self-control) enables an individual to suppress reactive approach tendencies in order to act purposefully (e.g., the capacity to delay gratification).

Emotion Dysregulation Deficits in emotion regulation were assessed using the total score of the Difficulties in Emotion Regulation Scale (DERS [27]; α = .93–.95).

Disinhibited Eating Behaviors Disinhibited eating behaviors were assessed using the total score of the Emotional Eating subscale of the Dutch Eating Behavior Questionnaire (DEBQ-EE [28]; α = .95–.96; German version by Grunert [29]) and the total score of an adapted version of the Eating in the Absence of Hunger (EAH [30]; α = .87–.89; German translation by AH—unpublished manuscript) scale which assesses eating caused by negative feelings, fatigue/boredom, or external cues.

Measures for External Validation

Binge-Eating Episodes Binge eating is characterized by the feeling of loss of control over eating either an objectively large (objective binge eating) or subjectively large amount of food (subjective binge eating) [31]. The binge-eating disorder module of the Eating Disorder Examination (EDE [32]) interview was applied to determine the mean number of objective and subjective binge-eating episodes per month over the past 3 months.

Eating Disorder Psychopathology Eating restraint and concerns about eating, body shape, and body weight were assessed by patients' global score of the Eating Disorder Examination-Questionnaire (EDE-Q [33]; α = .87–.94).

Depression The Patient Health Questionnaire Depression Scale (PHQ-9 [34]; α = .84–.90), which scores each of the nine DSM-5 criteria for depression, was administered and patients' total score was computed.

Quality of Life Patients' total score of the Impact of Weight on Quality of Life-Lite (IWQoL-Lite [35]; α = .95–.96) was used to assess the quality of life in five domains: physical function, self-esteem, sexual life, public distress, and work.

Body Mass Index Body Mass Index (BMI, kg/m^2) was calculated from measured weight and height for n = 225 patients at T0, n = 145 patients at T1, and n = 109 patients at T2. If measured weight and height were not available, patients' self-reported weight and height were used due to very high correlations between measured and self-reported BMI at all assessment points (r = .95–.98).

Percentage of Total Body Weight Loss Postoperative weight outcome was determined by the percentage of total body weight loss (%TBWL) at T1 and T2. It was estimated as %TBWL = 100 − (100 × weight at follow-up visit/weight at baseline).

Weight Regain Postbariatric weight changes between T1 and T2 were calculated as weight regain = %TBWL T1 − %TBWL T2.

Data Analytic Plan

The analyses included three steps: First, in order to identify prebariatric subtypes, latent profile analyses (LPAs) were conducted based on patients' preoperative scores (T0) of the previously used six indicator variables, namely reactive temperament (BIS, BAS), regulative temperament (ATQ-EC), emotion dysregulation (DERS), emotional eating (DEBQ-EE), and eating in the absence of hunger (EAH) [22]. Second,

postbariatric subtypes were identified by LPAs using the same indicators measured at T1. Third, the predictive value of both prebariatric and postbariatric subtypes for weight- and health-related surgery outcomes (%TBWL, binge-eating episodes, eating disorder psychopathology, depression, quality of life) measured at T2 were determined and compared with each other in terms of explained variance. Forth, the odds ratios for all prebariatric subtypes to be classified as "severely RC" at T1 were determined by conducting logistic regression analysis with the prebariatric "resilient" subtype serving as reference group.

LPAs were carried out using Latent Gold Version 4.5 [36]. Patients were included in the LPAs if they completed at least four out of six indicators at T0 and T1. All LPAs were performed with one to eight clusters. The appropriate number of clusters was indicated by the lowest value of the Bayesian information criterion (BIC) [37]. Furthermore, entropy values were reported with higher values indicating better classification accuracy. After determining the number of clusters, patients were assigned to a cluster based on their highest probability of belonging to a certain class.

Multivariate analyses of variance (MANOVAs) and χ^2 tests were used to compare the empirically derived clusters at T0 (prebariatric subtypes) and T1 (postbariatric subtypes). Post hoc tests with Bonferroni's correction were conducted to examine pair-wise differences if omnibus tests were significant. To determine the predictive value of pre- and postbariatric subtypes for weight- and health-related variables assessed at T2, linear regression analyses were used. All statistical tests, carried out using SPSS version 23.0 (IBM Corp. Released 2015. IBM SPSS Statistics for Windows, Version 23.0. Armonk, NY: IBM Corp), were two-tailed, and significance level was set at $\alpha = .05$.

Results

Sample Description

Until August 2017, $N = 317$ patients of the PRAC study had bariatric surgery and were scheduled for T1. From these patients, $n = 88$ patients were excluded from analyses because at least three of the six indicator variables for subtyping were missing at T0 ($n = 19$) or T1 ($n = 65$), or follow-up data were biased by an existing pregnancy ($n = 4$). From the total sample, 229 patients (70.7% women) with a mean age of $M =$ 46.06 years ($SD = 10.49$) and a mean preoperative BMI of $M = 48.99$ kg/m^2 ($SD = 7.69$) were included in the final analyses. At the time of analysis, T2 data were available for $n =$ 159 patients. Both measured and self-reported BMI were missing for $n = 2$ patients (0.9%) at T0, $n = 18$ patients (7.9%) at T1, and $n = 56$ patients (24.5%) at T2. Four different surgical procedures were used in the present sample, including gastric bypass (68.1%), sleeve gastrectomy (29.6%), gastric balloon with a subsequent sleeve gastrectomy 6 to 7 months later (1.8%), and gastric band (0.4%).

Prebariatric Subtypes

LPAs resulted in a five-cluster solution. The final model explained $R^2 = .80$ of variance by clusters and had an entropy value of .82.

Figure 1 (left side) depicts the profile plots of the five detected prebariatric subtypes characterized by their *z*-transformed scores of the six indicator variables assessed at T0. Indicators' total scores and group differences between prebariatric subtypes are displayed in Table S1 (online Supporting Information). As the five clusters correspond to the "resilient," "slightly RC," "moderately RC," "severely RC," and "food-specifically RC" subtypes found in previous research, the reader is referred to Schäfer et al. [22] for a more detailed description of each cluster.

Postbariatric Subtypes

LPAs yielded three postbariatric subtypes at T1. The model explained $R^2 = .80$ of variance and had an entropy value of .81. Profile plots of the three postbariatric subtypes based on their *z*-transformed indicator scores assessed at T1 are depicted in Fig. 1 (right side). Indicators' total scores and group differences between postbariatric subtypes regarding validation variables are summarized in Table 1.

Cluster 1 was characterized by the lowest levels of BIS, DERS, EAH, and DEBQ-EE and the highest levels of ATQ-EC and was labeled as the "resilient" subtype. *Cluster 2* showed a similar profile as the "resilient" subtype, as both clusters did not differ significantly in BIS, BAS, and ATQ-EC (*ps* = .074–.273). However, patients from this cluster reported significantly higher scores of DERS ($p = .004$), EAH, and DEBQ-EE (*ps* < .001) compared to the "resilient" patients and, therefore, were labeled "slightly RC." Highest scores of BIS, DERS, EAH, and DEBQ-EE and lowest scores of ATQ-EC compared to the other subtypes were found in *Cluster 3* (*ps* < .001), which was labeled "severely RC" subtype.

No significant differences among subtypes were detected in terms of prebariatric age and postbariatric weight loss at T1 or weight regain at T2 (*ps* = .116–.949). However, patients from the "severely RC" subtype differed significantly from "resilient" and "slightly RC" patients as they reported the highest levels of eating disorder psychopathology and depression, the lowest quality of life (*ps* < .001), and more binge-eating episodes ($p = .016$) than the "resilient" group at T1. Although the "slightly RC" subtype showed descriptively higher impairment in general and eating disorder psychopathology compared to the "resilient" subtype, both groups differed significantly in the EDE-Q global score only ($p < .001$).

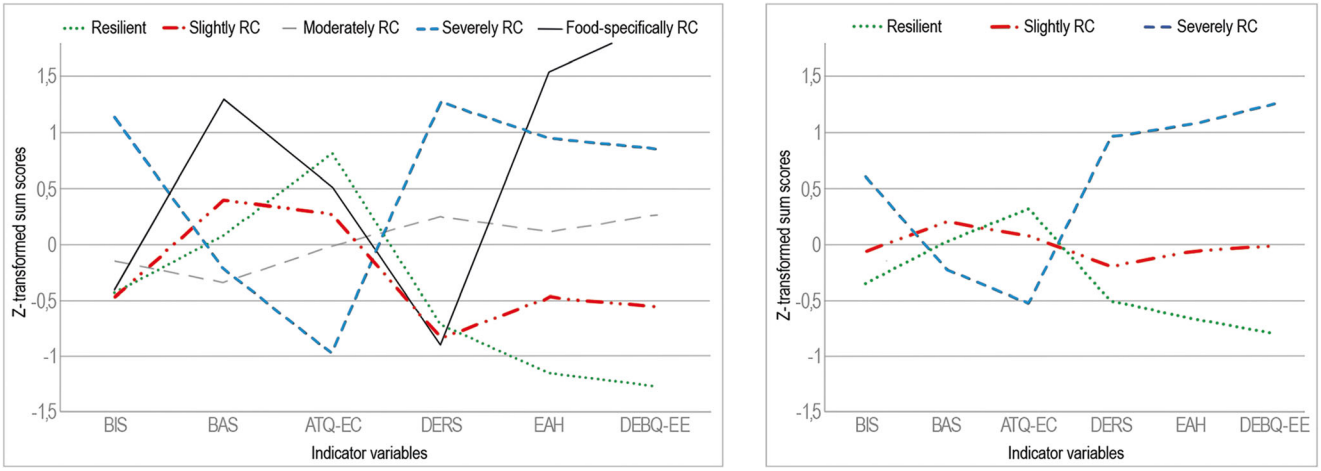

Fig. 1 Profile plots of the prebariatric (left side) and postbariatric subtypes (right side). The figure depicts the standardized scores of the six indicator variables for each of the five prebariatric and three postbariatric clusters, respectively. RC, reduced control; BIS, Behavioral Inhibition System; BAS, Behavioral Activation System; ATQ-EC, Effortful Control of the Adult Temperament Questionnaire; DERS, Difficulties in Emotion Regulation Scale; EAH, Eating in the Absence of Hunger; DEBQ-EE, Emotional Eating of the Dutch Eating Behavior Questionnaire

Predictive Value of Bariatric Subtypes

Table 2 shows the results of the linear regression analyses to predict weight- and health-related outcomes at T2 by pre- and postbariatric subtype. Neither pre- ($p = .410$) nor postbariatric subtypes ($p = .111$) predicted weight loss or weight regain at T2. The pre- and the postbariatric "severely RC" as well as the prebariatric "moderately RC" subtypes significantly predicted levels of depression ($ps < .001$ and $p = .030$) at T2. Eating disorder psychopathology at T2 was predicted by the pre- and the postbariatric "severely RC" subtypes ($p = .002$ and $p < .001$) and the postbariatric "slightly RC" subtype ($p = .044$). For quality of life and binge-eating episodes, only the postbariatric "severely RC" subtype was a significant predictor ($p < .001$ and $p = .007$).

Odds Ratios for Prebariatric Subtypes to Be Subtyped as "Severely RC" Postoperatively

Among all prebariatric subtypes, patients of the "severely RC" subtype (OR = 12.8) and the "moderately RC" subtype (OR = 6.4) showed a significantly increased risk of being categorized as "severely RC" subtype at T1 (Table 3).

Discussion

As expected, the study provided first evidence that postbariatric psychological subtypes were more reliable predictors for psychosocial long-term surgery outcomes than prebariatric subtypes, while weight outcomes were unrelated to patients' pre- and 2-year postbariatric psychological status. Specifically, it was found that patients who showed deficits in self- and emotion regulation coupled with disinhibited eating after bariatric surgery were at high risk for presenting with adverse psychological surgery outcomes 3 years postoperatively including pathological eating behaviors, increased eating disorder psychopathology and depression scores, and lower quality of life. Consistent with previous findings [19], none of the pre- and postbariatric subtypes significantly predicted weight loss or weight regain 3 years after bariatric surgery, although there was a trend for postbariatric patients with a "severely RC" profile to present with less weight loss 2 years after bariatric surgery compared to the other subtypes. This is in line with previous findings emphasizing that postbariatric but not prebariatric problematic eating behaviors were predictive of poor weight loss and health-related outcomes in the long term after bariatric surgery [39].

As previously reported [22], levels of temperament, emotion dysregulation, and disinhibited eating were found to subtype prebariatric patients into five clusters ("resilient," "slightly RC," "moderately RC," "severely RC," "food-specifically RC"). Two years after bariatric surgery, only three of these subtypes were replicated, specifically the "resilient" subtype with functional levels of self- and emotion regulation and no disinhibited eating, the "slightly RC" subtype with similar levels of self-control but significantly greater emotion dysregulation and disinhibited eating compared to the "resilient" subtype, and the "severely RC" subtype with the lowest levels of self-control and the highest levels of emotion dysregulation and disinhibited eating among all subtypes. Accordingly, "severely RC" patients reported significantly higher levels of eating disorder psychopathology, binge eating, depression, and lower quality of life than "resilient" and "slightly RC" patients 2 years after bariatric surgery. The reduced number of postbariatric subtypes, including the absence of the "food-

Table 1 Characterization of postbariatric subtypes with regard to personality and psychopathological values

	Resilient ($n = 98$) *M* (*SD*)	Slightly RC ($n = 65$) *M* (*SD*)	Severely RC ($n = 66$) *M* (*SD*)	*F*	*df*	η^2
Temperament						
BIS T1	18.12 (3.75)[a]	19.25 (4.13)[a]	21.95 (3.27)[b]	20.98***	2, 226	.16
BAS T1	40.84 (5.56)[ab]	41.81 (5.30)[a]	39.42 (5.84)[b]	3.04*	2, 222	.01
ATQ-EC T1	95.69 (14.92)[a]	92.16 (13.33)[a]	83.29 (13.26)[b]	15.61***	2, 224	.12
Emotion dysregulation						
DERS T1	62.42 (13.92)[a]	68.85 (13.31)[b]	92.73 (21.85)[c]	69.79***	2, 226	.38
Disinhibited eating						
EAH T1	7.76 (0.79)[a]	10.23 (2.10)[b]	14.91 (4.85)[c]	122.30***	2, 225	.52
DEBQ-EE T1	11.58 (1.84)[a]	19.21 (3.87)[b]	31.61 (9.11)[c]	267.01***	2, 224	.70
Sociodemographics						
Age (years) T0	46.23 (11.59)	46.12 (9.46)	45.74 (9.86)	0.05	2, 226	.00
%TBWL T1	31.36 (10.75)	32.36 (10.35)	28.43 (10.84)	2.27	2, 209	.02
Weight regain T2	1.41 (4.61)	0.94 (4.43)	0.85 (5.48)	0.24	2, 165	.00
Eating disorder psychopathology						
Binge-eating episodes T1	0.03 (0.13)[a]	0.17 (0.61)[ab]	0.48 (1.73)[b]	3.77*	2, 203	.04
EDE-Q global T1	0.82 (0.84)[a]	1.36 (0.98)[b]	2.26 (1.24)[c]	40.02***	2, 224	.26
Depression						
PHQ-9 T1	3.48 (3.57)[a]	4.51 (2.88)[a]	9.20 (5.45)[b]	41.80***	2, 226	.27
Quality of life						
IWQoL-Lite T1	42.17 (13.47)[a]	44.21 (16.51)[a]	61.57 (24.00)[b]	24.79***	2, 222	.18

Superscripts that differ display significant differences between subtypes after post hoc comparisons with Bonferroni's corrections. Effect size partial η^2 classification according to Cohen (small effect, $.01 \leq \eta^2 < .06$; medium, $.06 \leq \eta^2 < .14$; large, $\eta^2 \geq .14$) [38]. Weight regain T2 = %TBWL T1 − %TBWL T2; RC = reduced control; T0 = assessed prior to surgery; T1 = assessed at *2*-year follow-up; T2 = assessed at *3*-year follow-up; BIS = Behavioral Inhibition System (7–28*, less favorable scores are asterisked); BAS = Behavioral Activation System (13–52*); ATQ-EC = Effortful Control of the Adult Temperament Questionnaire (19*-133); DERS = Difficulties in Emotion Regulation Scale (36–180*); EAH = Eating in the Absence of Hunger (7–35*); DEBQ-EE = Emotional Eating of the Dutch Eating Behavior Questionnaire (10–50*); %TBWL = Percentage of total body weight loss; EDE-Q = Eating Disorder Examination-Questionnaire (0–6*); PHQ-9 = Public Health Questionnaire-Depression (0–27*); IWQoL-Lite = Impact of Weight on Quality of Life-Lite (31–155*)

***$p < .001$, *$p < .05$

specifically RC" profile after bariatric surgery, might indicate that the anatomical restriction of the stomach and metabolic changes following bariatric surgery generally led to a reduction of food-related impulsivity at least within the first years after bariatric surgery [40]. Although postbariatric patients were found to be psychologically more homogeneous than prebariatric patients, they still differed in terms of self- and emotional control as well as eating disorder and general psychopathology.

Notably, it was found that postbariatric subtypes, specifically the "severely RC" profile, reliably predicted binge eating, eating disorder psychopathology, depression, and impaired quality of life 3 years after bariatric surgery, substantially extending previous cross-sectional evidence in postbariatric patients [18]. The fact that neither pre- nor postbariatric subtypes significantly predicted weight loss or weight regain 3 years after bariatric surgery may mirror the predominant effects of surgery (i.e., anatomical restriction with its profound metabolic and metabolomic changes) that can be observed in nearly all postbariatric patients within the first 2 years (i.e., "honeymoon phase") [4, 41]. Differences in weight loss due to patients' psychological profiles might become more apparent in long-term follow-ups (e.g., 5 or 10 years after bariatric surgery) [42] when the physical effects of surgery attenuate while patients' intrapersonal factors (i.e., levels of self- and emotion regulation) persist. Although prebariatric subtypes were less suited than postbariatric subtypes to predict health outcomes 3 years postoperatively, patients with a prebariatric "severely RC" and "moderately RC" profile were 12.8 and 6.4 times more likely than "resilient" prebariatric patients to be categorized as "severely RC" postoperatively. Accordingly, it is plausible to suggest that severe deficits in self- and emotion regulation cannot be modified by bariatric surgery and are still present in postbariatric patients if not treated additionally.

A major strength of this study is the empirical identification of pre- and postbariatric subtypes using LPAs in a large multicenter, prospective sample. Nonetheless, it is important to

Table 2 Linear regression analyses on psychosocial outcomes at T2 by pre- and postbariatric subtypes

Dependent variables	Independent variables	*B* (*SE*)	R^2	*F*	*df*
%TBWL T2	Prebariatric subtypes		.02	1.00	4, 168
	Postbariatric subtypes		.03	2.23	2, 170
Weight regain T2	Prebariatric subtypes		.05	1.95	4, 163
	Postbariatric subtypes		.00	0.24	2, 165
Binge-eating episodes T2	Prebariatric subtypes		.04	1.49	4, 154
	Postbariatric subtypes		.05*	3.91	2, 156
	Severely RC	1.08 (0.40)**			
EDE-Q global T2	Prebariatric subtypes		.12**	5.31	4, 150
	Severely RC	1.02 (0.33)**			
	Postbariatric subtypes		.25***	25.46	2, 152
	Slightly RC	0.43 (0.21)*			
	Severely RC	1.58 (0.22)***			
PHQ-9 T2	Prebariatric subtypes		.16***	7.12	4, 152
	Moderately RC	2.52 (1.15)*			
	Severely RC	4.54 (1.24)***			
	Postbariatric subtypes		.22***	21.17	2, 154
	Severely RC	5.55 (0.87)***			
IWQoL-Lite T2	Prebariatric subtypes		.04	1.53	4, 150
	Postbariatric subtypes		.17***	15.52	2, 152
	Severely RC	18.77 (3.68)***			

Effect size R^2 classification according to Cohen (small effect, $.02 \leq R^2 < .13$; medium, $.13 \leq R^2 < .26$; large, $R^2 \geq .26$) [38]. Weight regain T2 = %TBWL T1 − %TBWL T2; RC = reduced control; T2 = assessed at *3*-year follow-up; %TBWL = *p*ercentage of total body weight loss; EDE-Q = Eating Disorder Examination-Questionnaire; PHQ-9 = Public Health Questionnaire-Depression; IWQoL-Lite = Impact of Weight on Quality of Life-Lite

*$p < .05$, **$p < .01$, ***$p < .001$

note that the interpretation of the results is limited by the use of self-report questionnaires instead of neuropsychological tests to assess reactive and regulative temperament. Additionally, patients' somatic comorbidities and medication intake were not examined within this study although they may have an effect on the investigated psychological variables.

Table 3 Odds ratios for being subtyped as severely RC at T1 according to patients' prebariatric subtype classification

	No. of subjects categorized as severely RC at T1/total no. (%)	Odds ratio (95% CI)	*p*
Resilient T0	2/35 (5.7)	1.0	
Slightly RC T0	5/62 (8.1)	1.4 (0.3–7.9)	.669
Moderately RC T0	23/72 (31.9)	6.4 (2.4–17.2)	< .001
Severely RC T0	33/52 (63.5)	12.8 (5.7–28.9)	< .001
Food-specifically RC T0	3/8 (37.5)	2.3 (0.5–10.5)	.268

For all odds ratios, the resilient subtype at T0 served as the reference group. RC = reduced control; CI = confidence interval; T0 = subtyped at baseline; T1 = subtyped at 2-year follow-up

Overall, the present findings emphasize that bariatric patients show heterogeneous profiles regarding self- and emotion control and disinhibited eating not only before but also 2 years after bariatric surgery. Most strikingly, patients showing severe deficits in self-control and emotion regulation, especially after bariatric surgery, were at high risk for presenting with adverse health-related surgery outcomes 3 years postoperatively. Future studies should investigate the predictive value of pre- and postbariatric subtypes on bariatric surgery outcomes at longer follow-ups in order to test whether significant subtype differences in postbariatric weight loss may be observable in the long-term. Clinically, the results suggest re-evaluating patients' levels of reactive and regulative temperament, emotion dysregulation, and disinhibited eating behaviors after bariatric surgery for identifying postbariatric patients with potential risk for adverse surgery outcomes in the long term. Especially patients with a "severely RC" profile should receive additional psychological interventions for improving emotion regulation and self-control towards food (e.g., cognitive-behavioral therapy) [43, 44], as this may help to strengthen postbariatric diet compliance, improve psychopathology, greater weight loss, and higher quality of life in the long term.

Acknowledgments The authors thank Christine Stroh, M.D.; Wolfgang Tigges, M.D.; Christian Jurowich, M.D.; Sabrina Baldofski; Kathrin Hohl; Martina Pabst, M.D.; Petra Börner; Yvonne Sockolowsky; Marlen Schmidt; and Sylvia Lellwitz for their support in data collection at the study centers, and Ricarda Schmidt, Ph.D., for her editing of the manuscript.

Funding This work was supported by the Federal Ministry of Education and Research (BMBF), Germany, FKZ: 01EO1501.

Compliance with Ethical Standards

The authors assert that all procedures contributing to this work comply with the ethical standards of the relevant national and institutional committees on human experimentation and with the Helsinki Declaration of 1975, as revised in 2008.

Conflict of Interest The authors declare that they have no conflicts of interest.

References

1. Burgmer R, Legenbauer T, Müller A, et al. Psychological outcome 4 years after restrictive bariatric surgery. Obes Surg. 2014;24(10):1670–8.
2. Puzziferri N, Roshek TB, Mayo HG, et al. Long-term follow-up after bariatric surgery: a systematic review. JAMA. 2014;312(9):934–42.
3. Chevallier JM, Paita M, Rodde-Dunet MH, et al. Predictive factors of outcome after gastric banding: a nationwide survey on the role of center activity and patients' behavior. Ann Surg. 2007;246(6):1034–9.
4. Courcoulas AP, Christian NJ, Belle SH, et al. Weight change and health outcomes at 3 years after bariatric surgery among individuals with severe obesity. JAMA. 2013;310(22):2416–25.
5. Magro DO, Geloneza B, Delfini R, et al. Long-term weight regain after gastric bypass: a 5-year prospective study. Obes Surg. 2008;18(6):648–51.
6. Bordignon S, Aparício MJG, Bertoletti J, et al. Personality characteristics and bariatric surgery outcomes: a systematic review. Trends Psychiatry Psychother. 2017;39(2):124–34.
7. Claes L, Müller A. Temperament and personality in bariatric surgery – resisting temptations? Eur Eat Disord Rev. 2015;23(6):435–41.
8. García-Ruiz-de-Gordejuela A, Agüera Z, Granero R, et al. Weight loss trajectories in bariatric surgery patients and psychopathological correlates. Eur Eat Disord Rev. 2017;25(6):586–94.
9. Livhits M, Mercado C, Yermilov I, et al. Preoperative predictors of weight loss following bariatric surgery: systematic review. Obes Surg. 2012;22(1):70–89.
10. Sheets CS, Peat CM, Berg KC, et al. Post-operative psychosocial predictors of outcome in bariatric surgery. Obes Surg. 2015;25(2):330–45.
11. Wimmelmann CL, Dela F, Mortensen EL. Psychosocial predictors of weight loss after bariatric surgery: a review of the recent research. Obes Res Clin Pract. 2014;8(4):e299–313.
12. Gray JA. The psychology of fear and stress. Cambridge: Cambridge University Press; 1987.
13. Müller A, Claes L, Wilderjans TF, et al. Temperament subtypes in treatment seeking obese individuals: a latent profile analysis. Eur Eat Disord Rev. 2014;22(4):260–6.
14. Marek RJ, Ben-Porath YS, Dulmen MHMV, et al. Using the presurgical psychological evaluation to predict 5-year weight loss outcomes in bariatric surgery patients. Surg Obes Relat Dis. 2017;12(3):514–21.
15. Marek RJ, Ben-Porath YS, Merrell J, et al. Predicting one and three month postoperative somatic concerns, psychological distress, and maladaptive eating behaviors in bariatric surgery candidates using the Minnesota multiphasic personality Inventory-2 restructured form (MMPI-2-RF). Obes Surg. 2014;24(4):631–9.
16. Claes L, Vandereycken W, Vandeputte A, et al. Personality subtypes in female pre-bariatric obese patients: do they differ in eating disorder symptoms, psychological complaints and coping behaviour? Eur Eat Disord Rev. 2013;21(1):72–7.
17. Kulendran M, Borovoi L, Purkayastha S, et al. Impulsivity predicts weight loss after obesity surgery. Surg Obes Relat Dis. 2017;13(6):1033–40.
18. Schag K, Mack I, Giel KE, et al. The impact of impulsivity on weight loss four years after bariatric surgery. Nutrients. 2016;8(11):E721.
19. Peterhänsel C, Linde K, Wagner B, et al. Subtypes of personality and 'locus of control' in bariatric patients and their effect on weight loss, eating disorder and depressive symptoms, and quality of life. Eur Eat Disord Rev. 2017;25(5):397–405.
20. Giel KE, Teufel M, Junne F, et al. Food-related impulsivity in obesity and binge eating disorder – a systematic update of the evidence. Nutrients. 2017;9(11):E1170.
21. Leehr EJ, Krohmer K, Schag K, et al. Emotion regulation model in binge eating disorder and obesity – a systematic review. Neurosci Biobehav Rev. 2015;49:125–34.
22. Schäfer L, Hübner C, Carus T, et al. Identifying prebariatric subtypes based on temperament traits, emotion dysregulation, and disinhibited eating: a latent profile analysis. Int J Eat Disord. 2017;50(10):1172–82.
23. Meany G, Conceição E, Mitchell JE. Binge eating, binge eating disorder and loss of control eating: effects on weight outcomes after bariatric surgery. Eur Eat Disord Rev. 2014;22(2):87–91.
24. Baldofski S, Tigges W, Herbig B, et al. Nonnormative eating behavior and psychopathology in prebariatric patients with binge-eating disorder and night eating syndrome. Surg Obes Relat Dis. 2015;11(3):621–6.
25. Carver CS, White TL. Behavioral inhibition, behavioral activation, and affective responses to impending reward and punishment: the BIS/BAS scales. J Pers Soc Psychol. 1994;67(2):319–33.
26. Derryberry D, Rothbart MK. Arousal, affect, and attention as components of temperament. J Pers Soc Psychol. 1988;55(6):958–66.
27. Gratz K, Roemer L. Multidimensional assessment of emotion regulation and dysregulation: development, factor structure, and initial validation of the difficulties in emotion regulation scale. J Psychopathol Behav Assess. 2004;26(1):41–54.
28. Van Strien T, Frijters JER, Bergers GPA, et al. The Dutch eating behavior questionnaire (DEBQ) for assessment of restrained, emotional, and external eating behavior. Int J Eat Disord. 1986;5(2):295–315.
29. Grunert SC. Ein Inventar zur Erfassung von Selbstaussagen zum Ernährungsverhalten [an inventory of the assessment of self-reported eating behavior]. Diagnostica. 1989;35:167–79.
30. Tanofsky-Kraff M, Ranzenhofer LM, Yanovski SZ, et al. Psychometric properties of a new questionnaire to assess eating in the absence of hunger in children and adolescents. Appetite. 2008;51(1):148–55.
31. Goldschmidt AB, Conceição EM, Thomas JG, et al. Conceptualizing and studying binge and loss of control eating in bariatric surgery patients-time for a paradigm shift? Surg Obes Relat Dis. 2016;12(8):1622–5.
32. Fairburn CG, Cooper Z, O'Connor M. Eating disorder examination (17.0D). New York: Guilford Press; 2014.

33. Fairburn CG, Beglin SJ. Eating disorder examination questionnaire (6.0). In: Fairburn CG, editor. Cognitive behavior therapy and eating disorders. New York: Guilford Press; 2008. p. 309–14.
34. Spitzer RL, Kroenke K, Williams JB. Validation and utility of a self-report version of PRIME-MD: the PHQ primary care study. JAMA. 1999;282(18):1737–44.
35. Kolotkin RL, Crosby RD. Psychometric evaluation of the impact of weight on quality of life-Lite questionnaire (IWQOL-LITE) in a community sample. Qual Life Res. 2002;11(2):157–71.
36. Vermount JK, Madison J. Latent GOLD 4.0 User's Guide. Belmont: Statistical Innovations Inc; 2005.
37. Schwarz G. Estimating the dimension of a model. Ann Stat. 1978;6(2):461–4.
38. Cohen J. Statistical power analysis for the behavioral sciences. 2nd ed. Hillsdale: Erlbaum; 1988.
39. Conceição EM, Mitchell JE, Pinto-Bastos A, et al. Stability of problematic eating behaviors and weight loss trajectories after bariatric surgery: a longitudinal observational study. Surg Obes Relat Dis. 2017;13(6):1063–70.
40. Giel KE, Rieber N, Enck P, et al. Effects of laparoscopic sleeve gastrectomy on attentional processing of food-related information: evidence from eye-tracking. Surg Obes Relat Dis. 2014;10(2):277–82.
41. Buchwald H, Buchwald JN, McGlennon TW. Systematic review and meta-analysis of medium-term outcomes after banded Roux-en-Y gastric bypass. Obes Surg. 2014;24(9):1536–51.
42. Lynch A. "When the honeymoon is over, the real work begins:" gastric bypass patients' weight loss trajectories and dietary change experiences. Soc Sci Med. 2016;151:241–9.
43. Paul L, van der Heiden C, Hoek HW. Cognitive behavioral therapy and predictors of weight loss in bariatric surgery patients. Curr Opin Psychiatry. 2017;30(6):474–9.
44. Wild B, Hünnemeyer K, Sauer H, et al. Psychotherapeutic interventions following bariatric surgery. Implications from the BaSE study. Psychotherapeut. 2017;62:222–9.