# Identifying pre-bariatric subtypes based on temperament traits, emotion dysregulation, and disinhibited eating: A latent profile analysis

Running head: Pre-bariatric subtypes

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## Abstract

Objective: The efficacy of bariatric surgery has been proven; however, a subset of patients fails to achieve expected long-term weight loss postoperatively. As differences in surgery outcome may be influenced by heterogeneous psychological profiles in pre-bariatric patients, previous subtyping models differentiated patients based on temperament traits. The objective of the present study was to expand these models by additionally considering emotion dysregulation and disinhibited eating behaviors for subtyping, as these factors were associated with maladaptive eating behaviors and poor post-bariatric weight loss outcome.

Methods: Within a prospective multicenter registry, *N* = 370 pre-bariatric patients were examined using interview and self-report questionnaires. A latent profile analysis was performed to identify subtypes based on temperament traits, emotion dysregulation, and disinhibited eating behaviors.

Results: Five pre-bariatric subtypes were identified with specific profiles regarding self-control, emotion dysregulation, and disinhibited eating behaviors. Subtypes were associated with different levels of eating disorder psychopathology, depression, and quality of life. The expanded model increased variance explanation compared to temperament-based models.

Conclusion: By adding emotion dysregulation and disinhibited eating behaviors to previous subtyping models, specific pre-bariatric subtypes emerged with distinct psychological deficit patterns. Future investigations should test the predictive value of these subtypes for post-bariatric weight loss and health-related outcomes.


*Keywords: bariatric surgery, temperament, impulsivity, emotion regulation, eating disorder psychopathology, cluster, latent profile analysis*

# Introduction

Bariatric surgery is the most effective treatment option for patients with obesity grade III (body mass index, BMI ≥ 40.0 kg/m$^2$) and grade II (35.0 kg/m$^2$ ≤ BMI < 40.0 kg/m$^2$) with obesity-related comorbidities (e.g., type II diabetes, hypertension, sleep apnea), leading to a clinically relevant excess weight loss and decrease of physical and psychological disorders in the long term.[1-3] Though, 20-30% of bariatric patients achieve less than 50% excess weight loss after surgery,[4,5] which is one of the key indicators for successful post-bariatric weight outcome.

Differences in bariatric weight loss outcome were discussed to be influenced by heterogeneous psychological profiles in pre-bariatric patients regarding general psychopathology (i.e., depression, anxiety), disinhibited eating behaviors, and associated temperament traits, particularly impulsivity.[6-8] Impulsivity is a multifaceted temperament trait, which involves the tendency to act rashly and spontaneously without consideration of consequences (i.e., disinhibition).[9] Impulsive behavior is closely connected to affective states, either accompanied by highly positive (i.e., extraversion/sensation seeking) or highly negative affect (i.e., neuroticism/negative urgency).[9,10] For individuals with obesity and especially for bariatric patients, impulsivity is likely to be triggered by food cues and is particularly associated with negative affect.[11-14] In addition, pre-bariatric patients often present a range of clinical and subclinical pathological eating behaviors, e.g., binge-eating disorder (BED)[15] and emotional eating, which are characterized by emotion dysregulation,[13,16-18] defined as deficits in recognizing and managing negative affect.

Latent profile analysis (LPA) is an empirical technique that aims to identify latent subgroups or profiles of individuals on the basis of observed variables (i.e., indicators).[19] During the last years, LPA has increasingly gained relevance in eating disorder research; for example, for describing different phenotypical profiles in individuals with BED,[20] bulimia nervosa,[21] anorexia nervosa,[22,23] and other non-normative eating behaviors.[24,25] The characterization of distinct subtypes in these samples allows to detect patients' specific psychological pattern and may help to develop treatment programs tailored to individuals' particular needs. Indeed, there is first evidence for the predictive value of empirically derived personality subtypes for treatment outcome (e.g., objective binge-eating episodes and purging frequency) in bulimia nervosa.[26] In pre-bariatric patients, LPA would be valuable for identifying subgroups which are at risk for insufficient surgery outcome. However, a cluster analytic approach has only been applied in two studies so far[27,28] which subtyped patients based on temperament traits.

Using the Big Five personality traits (i.e., neuroticism, extraversion, openness to experience, agreeableness, and conscientiousness),[27] two clusters in $N$ = 102 pre-bariatric women were found by using K-means cluster analysis: a 'resilient/high functional' subtype with a normal personality profile and a 'dysregulated/undercontrolled' subtype. Patients of the latter cluster, characterized by high neuroticism, low extraversion, and low conscientiousness, showed higher negative affect, less cognitive control, and a greater general and eating disorder psychopathology than the 'resilient' subtype. Müller et al.[28] replicated these two clusters by using latent profile analysis: they investigated temperament traits measured by the Behavioral Inhibition System and Behavioral Activation System (BIS/BAS) scales and the Effortful Control subscale of the Adult Temperament Questionnaire-Short Form (ATQ-EC) in a clinical sample of $N$ = 156 patients with obesity mostly seeking for bariatric treatment. Patients from the first cluster, referred to as 'emotionally dysregulated/undercontrolled' subtype, showed significantly higher levels of reward and punishment sensitivity and lower levels of effortful control in comparison to the second cluster, referred to as 'resilient/high functional' subtype. Furthermore, the first cluster demonstrated more eating disorder psychopathology, higher occurrence of BED, greater depression, and a higher probability of adult attention-deficit/hyperactivity disorder than the ‘resilient/high functional’ subtype.

Notably, both previous cluster models lack the inclusion of emotion dysregulation and disinhibited eating behaviors for subtyping pre-bariatric patients, although the predictive value of these intrapersonal factors for post-bariatric weight outcome was suggested.[29-32] This study aimed to provide a fine-grained analysis of pre-bariatric subtypes by additionally taking emotion dysregulation and disinhibited eating behaviors into account. First, the temperament-based model was tested with the expectation to replicate the two previously found subtypes. Second, the temperament-based model was extended by including emotion dysregulation and disinhibited eating behaviors as indicators for clusters. We hypothesized that the extended model would explain more variance compared to the temperament-based model. Ultimate goal of this pre-bariatric subtyping is to help identify patients at high risk for low post-bariatric weight loss and increased need for targeted psychological intervention.

## Materials and Methods

### *Participants*

This study was part of the multicenter Psychosocial Registry for Bariatric Surgery (PRAC) study, which longitudinally assesses psychosocial aspects in a consecutive sample of bariatric surgery patients (for a detailed description, see[16]). The study included preoperative data of $N$ = 370 patients who applied for bariatric surgery in six participating study centers in Germany from March 2012 to August 2016. All patients provided written informed consent before study participation according to procedures approved by the authorized ethics committee of each study center. Data collection proceeded independently of clinical treatment, and all patients were informed that study data would be treated as strictly confidential and inaccessible to the surgical team.

*Measures for Cluster Identification*

*Reactive temperament – punishment and reward sensitivity.* To measure patients' reactive temperament, total scores of the Behavioral Inhibition System (BIS) scale and the Behavioral Activation System (BAS) scale[33] were used. The BIS scale (Cronbach's α in this study's sample = .72) measures individual dispositional differences in punishment sensitivity, whereas the BAS scale (α = .82) assesses the dispositional sensitivity to reward.

*Regulative temperament – effortful control.* Regulative temperament was assessed by computing the total score of the effortful control subscale of the Adult Temperament Questionnaire-Short Form (ATQ-EC[34]; α = .77). Effortful control allows performing an act even in the presence of strong avoidance tendencies and regulates the reactive temperament.

*Emotion dysregulation.* The total score of the Difficulties in Emotion Regulation Scale (DERS[35]; α = .94) was used to assess deficits in recognizing and managing negative affect.

*Disinhibited eating behaviors.* Emotional eating (EE) and eating in the absence of hunger (EAH) were assessed to determine disinhibited eating behaviors in patients. For EE, the total score of the emotional eating subscale of the Dutch Eating Behavior Questionnaire (DEBQ-EE[36]; α = .95; German version by Grunert[37]) was computed. EAH (i.e., starting or continuing eating due to negative affect, fatigue/boredom, or external cues) was assessed by an adapted version (α = .88) of the Eating in the Absence of Hunger scale (EAH[38]; German translation by AH – unpublished manuscript). Total scores were computed.

*Measures for Cluster Validation*

*Eating disorder diagnoses.* The semi-structured Eating Disorder Examination interview (EDE)[39] was applied and its diagnostic items were analyzed in order to derive a diagnosis of BED according to the fifth edition of the Diagnostic and Statistical Manual of

Mental Disorders (DSM-5).[15] In addition, an EDE module for the night eating syndrome (NES)[16] was used to diagnose NES according to DSM-5.[15] Based on previous recommendations, NES was defined as having at least two excessive evening and/or night eating episodes per week during the last three months.[40]

*Eating disorder psychopathology.* Patients' concerns and behaviors related to eating restraint, body shape, and weight were measured by the global score of the Eating Disorder Examination-Questionnaire (EDE-Q[41]; α = .86).

*Food addiction.* Addictive eating was measured by the Yale Food Addiction Scale (YFAS[42]; α = .90), which assesses seven food addiction symptoms (e.g., tolerance, withdrawal). Food addition was diagnosed if patients fulfilled more than two symptoms and reported clinically significant distress.

*Depression.* The total score of the Patient Health Questionnaire Depression Scale (PHQ-9[43]; α = .85), which covers each of the nine DSM-5 criteria for depression,[15] was computed and a cut-off of 15 was applied to determine probable cases of depression.[44]

*Quality of life.* The total score of the Impact of Weight on Quality of Life-Lite (IWQoL-Lite[45]; α = .94) was used to assess individual's quality of life regarding physical function, self-esteem, sexual life, public distress, and work.

*Weight status.* Body Mass Index (BMI, $kg/m^2$) was calculated from measured weight and height for $n$ = 320 patients (86.5%). If measured weight and height were not available, self-reported weight and height were used based on the very high correlation between measured and self-reported BMI in this study's sample ($r$ = .95).

### *Data Analytic Plan*

Analyses comprised three steps: first, the temperament-based model was tested by performing latent profile analysis (LPA) on the basis of reactive (BIS, BAS) and regulative

(ATQ-EC) temperament as indicator variables (Model 1). Second, LPA was repeated by adding three additional indicator variables, including emotion dysregulation (DERS), emotional eating (DEBQ-EE), and eating in the absence of hunger (EAH), to the prior model (Model 2). Third, the expanded model was validated by comparing the identified subtypes with regard to sociodemographic variables, BED and NES diagnosis, eating disorder psychopathology, food addiction, depression diagnosis, and quality of life.

LPAs were carried out using Latent Gold Version 4.5.[46] Total scores of the indicator variables were available for all patients. LPAs were performed with one to eight clusters and the most parsimonious number of latent classes was determined by examining the Bayesian information criterion (BIC).[47] BIC was chosen as primary fit index as it is more conservative than the indices based on the Akaike information criterion (AIC), which tend to overestimate the true number of clusters.[48] Additionally, the Akaike information criterion (AIC),[49] the Akaike information criterion 3 (AIC3),[50] and entropy-values were reported. Lowest values of the three information criteria are indicative for the best-fitting model and higher entropy values indicate better classification accuracy. In addition to global measures of model fit, bivariate residuals as local fit indices were examined. High bivariate residuals indicate remaining correlations between two indicators within clusters that were not adequately explained by the model. In this case, the conditional independence assumption is not met. In the present study, direct effects, demonstrated by bivariate residuals larger than 3.84,[46] were added to the model if this procedure resulted in a more parsimonious cluster solution. After determining the number of clusters, participants were assigned to a cluster on the basis of their highest probability.

Univariate analyses of variance (ANOVAs), $\chi^2$ tests and, in terms of violation of normality and homogeneity of variances, non-parametric tests were used to compare and validate the clusters identified in Model 2. Post-hoc tests with Bonferroni correction were applied to examine pair-wise differences if omnibus tests were significant. Significant differences in explained variances $R^2$ between Model 1 and Model 2 were examined by *z* tests for correlation coefficients with a two-tailed α of .05 using *z*-transformed *R*.[51] 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 considered significant when $p$ values were < .05.

## Results

### *Sample Description*

Data from $N$ = 370 pre-bariatric patients (68.1% women) with a mean age of $M$ = 45.15 years ($SD$ = 11.10) and a mean BMI of $M$ = 48.59 kg/m$^2$ ($SD$ = 7.71) were included in the LPA. Obesity grade III was present in the majority of patients ($n$ = 316; 85.4%), followed by obesity grade II ($n$ = 24; 6.5%) and obesity grade I ($n$ = 4; 1.1%). For $n$ = 26 patients (7.0%), both measured and self-reported BMI was missing.

### *Latent Profile Analysis: Temperament-based Model (Model 1)*

Fit indices of the LPA models based on temperament traits for the one- to eight-cluster solutions are displayed in Table 1. The BIC was lowest for the two-cluster model, whereas the AIC and AIC3 indicated a three- and four-cluster solution, respectively. The two-cluster solution was chosen as it was selected by BIC and represented the most parsimonious model. The selected model explained $R^2$= .51 of variance by cluster membership and had an entropy value of .46.

The clusters differed significantly in terms of BIS, BAS, and ATQ-EC. Compared to Cluster 2 ($n$ = 142), Cluster 1 ($n$ = 228) showed significant lower levels of BIS, $F$(1, 368) = 164.56, $p$ < .001, and higher levels of BAS, $F$(1, 368) = 14.82, $p$ < .001, and ATQ-EC, $F$(1,

368) = 342.65, *p* <. 001. Cluster 1 was labeled as ‘Resilient/high functioning’ and Cluster 2 as ‘Emotionally dysregulated/undercontrolled’ subtype.

*Latent Profile Analysis: Extended Model (Model 2)*

The fit indices for the extended LPA models are displayed in Table 2. The BIC suggested a model with five clusters due to BIC and the principle of parsimony. The AIC indicated an eight-cluster solution, whereas the AIC3 indicated a model with seven clusters. The direct effect between the indicators DEBQ-EE and EAH, indicated by the bivariate residual of 13.80, was included. The final model explained $R^2$ = .73 of variance and had an entropy value of .76. Accordingly, the five-cluster solution of Model 2 explained significantly more variance than the two-cluster solution found in Model 1, $z$ = 5.10, $p$ < .001.

*Characterization of Pre-bariatric Subtypes (Model 2)*

Figure 1 depicts the profile plots of the five detected clusters of Model 2 characterized by their *z*-transformed scores of the six indicator variables. Indicators’ total scores and group differences between pre-bariatric subtypes are summarized in Table 3.

*Cluster 1* comprised 17.6% (*n* = 65) of the sample and was characterized by the lowest levels of BIS, DERS, EAH, and DEBQ-EE compared to the other subtypes. Patients from this cluster were labeled as *‘Resilient’* as they also reported the highest levels of ATQ-EC, together with those from Cluster 5.

*Cluster 2* (*n* = 109; 29.5%) showed a similar profile as the ‘Resilient’ subtype, as both clusters did not differ significantly in BIS, BAS, and DERS (*p*s = .358 - .808). However, patients from this cluster, referred to as *‘Slightly reduced control (RC)’* subtype, reported significantly lower levels of ATQ-EC (*p* = .026) and higher levels of EAH and DEBQ-EE (*p*s < .001) compared to the ‘Resilient’ cluster.

*Cluster 3* (*n* = 114; 30.8%), which was labeled as *'Moderately RC'* subtype, was characterized by moderate levels of BIS, DERS, EAH, and DEBQ-EE and showed the second lowest level of all clusters with regard to ATQ-EC values. In addition, this subtype had the lowest BAS scores of all subtypes, however, they did not differ significantly from those found in Cluster 4 ($p$ = .289) and Cluster 5 ($p$ = .073).

*Cluster 4*, referred to as *'Severely RC'* subtype, comprised 18.4% (*n* = 68) of the sample and showed the highest levels of BIS and DERS and the lowest level of ATQ-EC compared to all other subtypes (*p*s < .001). Furthermore, patients of this subtype reported the second highest levels of EAH and DEBQ-EE.

*Cluster 5* comprised the minority of the sample (*n* = 14; 3.8%). Patients of this cluster were characterized by low levels of DERS and the highest levels of ATQ-EC. In this regard, total scores of this cluster did not differ significantly from those reported in the 'Resilient' subtype (DERS: $p$ = .639; ATQ-EC: $p$ = .140). However, patients of this cluster showed the same pattern as the 'Severely RC' subtype in regard to EAH ($p$ = .380), and even significantly higher levels of DEBQ-EE ($p$ = .015) and, therefore, were labeled *'Food-specifically RC'*. BIS scores of these patients were low, but significant differences solely emerged in comparison to the 'Severely RC' subtype ($p$ < .001), whereas the reported BAS scores of these patients did not differ significantly from those found in all other pre-bariatric subtypes (*p*s = .073 - .801).

*Validation of Pre-bariatric Subtypes (Model 2)*

As presented in Table 4, there were no differences among the subtypes with respect to age, BMI, sex, and education (*ps* = .081 - .664). Descriptively, BED and NES were most prevalent in the 'Severely RC' cluster (*n* = 10, 17.2% and *n* = 9, 15.5%, respectively), followed by the 'Moderately' (*n* = 3, 2.9% and *n* = 8, 7.8%, respectively) and 'Slightly RC' subtype (*n* = 3, 3.0% and *n* = 5, 5.0%, respectively). No cases of BED and NES were reported in the ‘Resilient’ and ‘Food-specifically RC’ subtype. In this regard, both subtypes differed significantly from the ‘Severely RC’ cluster (*ps* = .001 - .024). Half of the ‘Severely RC’ patients (*n* = 36, 52.9%) met criteria for food addiction. High rates of food addiction were also found in the ‘Food-specifically RC’ (*n* = 5, 35.7%) subtype, which did not differ significantly in this respect from the ‘Severely RC’ (*p* = .240) and ‘Moderately RC’ group (*n* = 34, 30.1%; *p* = .667), whereas food addiction occurred significantly less in the ‘Resilient’ (*n* = 10, 9.3%) and ‘Slightly RC’ subtype (*n* = 4, 6.2%; *ps* = .001 - .005). Accordingly, highest levels of eating disorder psychopathology were reported by patients from the ‘Severely’ and ‘Food-specifically RC’ subtype, which did not differ significantly from each other (*p* = .480), while the ‘Resilient’ and ‘Slightly RC’ subtype reported the lowest values compared to the other groups (*ps* = .001 - .002). Depression was most prevalent in the ‘Severely RC’ cluster (*n* = 30, 44.1%), followed by the ‘Moderately RC’ (*n* = 14, 12.3%) and ‘Food-specifically RC’ subtypes (*n* = 1, 7.1%), while both clusters did not differ significantly from each other in this respect (*p* = .573). Little to no cases of depression were reported in the Slightly RC’ and ‘Resilient’ group, which did not show any significant group differences (*p* = .177). With regard to quality of life, lowest levels were found in patients of the ‘Severely RC’ subtype, followed by the ‘Food-specifically’, ‘Moderately’, and ‘Slightly RC’ cluster, whereas the ‘Resilient’ patients significantly reported the highest levels compared to the remaining clusters (*ps* = .001- .036).

## Discussion

Based on a large multicenter sample of pre-bariatric patients, the present study provides first evidence that temperament traits, emotion dysregulation, and disinhibited eating behaviors are key features in pre-bariatric patients, accounting for almost three quarters of the heterogeneity in psychological profiles in this sample. Using LPA, five subtypes with distinct psychological profiles were identified and associated with different prevalence rates of eating disorder diagnoses and varying levels of eating and general psychopathology. Based on the high accuracy and gain in explained variance by assigning pre-bariatric patients to one of five psychological profiles, the present investigation showed more favorable results than previous subtyping studies using temperament traits only.[27,28]

Most patients were classified as ‘Moderately RC’ subtype, characterized by low levels of effortful control and high levels of punishment sensitivity, emotion dysregulation, as well as frequent disinhibited eating, including emotional eating and eating in the absence of hunger. Patients belonging to the ‘Severely RC’ subtype showed psychological profiles similar to the ‘Moderately RC’ subtype, although they were even higher in impairment. The profiles of these two subtypes correspond to the ‘emotionally dysregulated/undercontrolled’ cluster of pre-bariatric patients derived from temperament-based models.[27,28] Thus, the present study provided a more precise picture of different levels of self-control and emotion regulation in pre-bariatric patients by distinguishing the ‘Resilient’ and ‘Slightly RC’ subtypes at the healthier end of the spectrum from the ‘Moderately RC’, ‘Severely RC’, and ‘Food-specifically RC’ subtypes at the more pathological, less controlled end. Most cases of BED, NES, food addiction, and highest levels of eating disorder psychopathology were found among patients of the ‘Severely RC’ subtype, followed by the ‘Moderately’ and ‘Slightly RC’ subtype. This is consistent with previous findings indicating that deficits in self-control and emotion regulation in pre-bariatric patients are closely connected to a range of pathological eating behaviors.[16-18,53,54] Further, previous studies revealed that pre- and post-bariatric BED, binge eating, loss of control eating,[55-57] and emotional eating[58] are negative predictors for post-bariatric weight loss outcome in the long term. Consequently, patients of the ‘Severely RC’ subtype are expected to be at higher risk for unfavorable weight loss, disturbed eating behaviors, and psychological impairments after surgery compared to the other subtypes. Thus, longitudinal investigations are required to test the predictive value of the five subtypes in terms of surgery outcome.

In accordance with temperament-based models,[27,28] 'Resilient' patients did not report deficits in self- and emotion regulation, little to no disinhibited eating, and no cases of BED and NES were found. The prevalence of food addiction in this cluster (6.2%) was lower than those found in other pre-bariatric samples (14.0-16.5).[54,59] A small group of patients showed functional levels of self- and emotion regulation, which were comparable with the 'Resilient' group, but high levels of emotional eating and eating in the absence of hunger. This subtype, termed 'Food-specifically RC', did not differ from the 'Severely' and 'Moderately RC' subtypes in terms of eating disorder psychopathology and prevalence rates of food addiction. However, there were no cases of BED and NES in this group suggesting that patients from this cluster might rather show subclinical eating disturbances, such as grazing and snacking, instead of meeting full-syndrome criteria for an eating disorder, although this was not assessed in the current study. As subclinical eating disturbances are highly prevalent in pre-bariatric patients and associated with negative surgery outcome,[56,60] future investigations are warranted to examine whether patients of the 'Food-specifically RC' cluster are at risk for poor weight outcome in the long term.

Regarding general psychopathology, highest rates for probable cases of depression were found in the 'Severely RC' subtype, followed by the 'Moderately' and 'Food-specifically RC' group. Current depression rates in 'Severely RC' patients (44.1%) were considerably higher than those found in other pre-bariatric samples (3.4-25.3%),[8] indicating that this cluster should receive particular attention of clinicians. Previous research indicated that negative mood was associated with uncontrolled eating in pre-bariatric patients with both impulsive personality and deficits in emotion regulation,[12,13] suggesting that patients of the

'Severely RC' subtype show problematic eating behaviors in order to regulate their negative feelings as they may lack alternative, healthier strategies. Of note, little to no probable cases of depression were detected in the 'Slightly RC' and 'Resilient' group which is in line with the results on eating disorder diagnoses. Regarding quality of life, subtypes characterized by frequent disinhibited eating and increased eating disorder psychopathology (i.e., 'Severely RC', 'Food-specifically RC', and 'Moderately RC' subtypes) reported poorer quality of life than patients from the 'Resilient' and 'Slightly RC' subtypes, which is in accordance with previous research.[61]

Major strengths of this study include the application of LPA as an empirically driven approach to subtype pre-bariatric patients in a large multicenter sample. Well-established instruments were used to assess eating disorder diagnoses and psychopathology, independent from clinical routines related to surgery. As a limitation, the cross-sectional design of the study does not allow for evaluating the predictive value of the identified subgroups on diverse surgery outcomes (e.g., weight loss, quality of life). In addition, several factors which may have an effect on the analyzed variables were not examined, such as medication intake and somatic comorbidities. Finally, for $n$ = 26 patients, BMI was calculated by using the self-reported body weight and height. However, correlation analyses of objective and subjective BMI data of $n$ = 164 patients revealed high agreement between these two types of sources ($r$ = .95), thus preventing from strong measurement biases.

Overall, the present findings highlight that pre-bariatric patients show heterogeneous psychological profiles in terms of temperament traits, emotion regulation, and disinhibited eating behaviors. Future studies are needed to replicate the identified subtypes in other pre-bariatric samples, including the rather small cluster of 'Food-specifically RC' patients. In addition, more research is needed to longitudinally investigate trajectories of psychological profiles after bariatric surgery, because it has been shown that the majority of bariatric patients improve significantly in terms of depressive symptoms[1,2] and disinhibited eating behaviors[62] already six months after surgery. Further, future studies should compare several cluster solutions on different pre- and post-bariatric time points in order to detect the subtyping model with the highest predictive value for post-bariatric excess weight loss outcome and other psychological aspects (e.g., patients' adherence at follow-up) and, accordingly, determining the optimal assessment point for psychological evaluation to detect and treat high-risk patients as early as possible.

Several clinical implications derive from the present findings. Clinicians may be advised to systematically assess temperament, emotion dysregulation, and disinhibited eating behaviors during pre-operative psychological evaluation in order to detect pre-bariatric patients showing profiles of potential vulnerability for post-bariatric maladaptive eating behaviors, insufficient weight loss, and psychosocial impairment. For orientation, clinicians may refer to cut-off scores of instruments assessing deficits in self- and emotion regulation (e.g., ATQ-EC, DERS). In addition, patients showing a psychological profile congruent with the 'Severely RC' and 'Moderately RC' subtypes, i.e., difficulties with self- and emotion regulation as shown by similar mean scores of measures, should receive particular attention from clinicians as these subgroups may be prone for post-bariatric complications. First evidence indicated that cognitive-behavioral interventions in pre-bariatric patients hold promise for reducing eating disorder psychopathology and depressive symptomatology[63] and that post-bariatric behavioral interventions improve post-surgery weight loss.[64,65] Although psychological examinations should be standard for all pre-bariatric patients, it remains unclear which patients are in need for additional psychosocial interventions to improve post-bariatric diet compliance, weight loss, and quality of life.

*Conflict of Interest Statement*

The authors declare no conflicts of interest with respect to the content of this manuscript.

*Statement of Human and Animal Rights*

All procedures performed in studies involving human participants were in accordance with the ethical standards of the institutional research committees and with the 1964 Helsinki declaration and its later amendments or comparable ethical standards.

*Statement of Informed Consent*

Informed consent was obtained from all individual participants included in the study.

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Table 1

*Fit indices for temperament-based latent profile analyses (Model 1)*

| No. of clusters | BIC | AIC | AIC3 | LL | Entropy | Largest bivariate residual |
|---|---|---|---|---|---|---|
| 1 | 7369.00 | 7345.52 | 7351.52 | -3666.76 | 1.00 | 43.06 |
| 2 | **7357.09** | 7306.21 | 7319.21 | -3640.11 | 0.46 | 3.54 |
| 3 | 7371.12 | 7292.85 | **7312.85** | -3626.42 | 0.57 | 2.03 |
| 4 | 7391.87 | **7286.21** | 7313.21 | -3616.10 | 0.61 | 1.54 |
| 5 | 7421.82 | 7288.76 | 7322.76 | -3610.38 | 0.62 | 1.60 |
| 6 | 7454.35 | 7293.89 | 7334.89 | -3605.95 | 0.61 | 0.84 |
| 7 | 7482.85 | 7295.00 | 7343.00 | -3599.50 | 0.66 | 0.86 |
| 8 | 7511.95 | 7296.71 | 7351.71 | -3593.36 | 0.64 | 0.72 |

*Notes.* Best-fitting models are depicted in bold. Higher entropy values indicate better classification accuracy. The largest bivariate residual checks for the conditional independence assumption. BIC = Bayesian information criterion; AIC = Akaike information criterion; AIC3 = Akaike information criterion 3; LL = Log-Likelihood.

Table 2

*Fit indices for extended latent profile analyses (Model 2)*

| No. of clusters | BIC | AIC | AIC3 | LL | Entropy | Largest bivariate residual |
|---|---|---|---|---|---|---|
| 1 | 15865.98 | 15819.02 | 15831.02 | -7897.51 | 1.00 | 250.87 |
| 2 | 15315.07 | 15217.24 | 15242.24 | -7583.62 | 0.85 | 86.80 |
| 3 | 15189.78 | 15051.07 | 15079.07 | -7482.53 | 0.84 | 32.57 |
| 4 | 15182.10 | 14982.51 | 15033.52 | -7440.25 | 0.79 | 19.09 |
| 5 | **15181.77** | 14931.31 | 14995.31 | -7401.65 | 0.82 | 13.80 |
| 6 | 15200.41 | 14899.07 | 14976.07 | -7372.54 | 0.82 | 6.77 |
| 7 | 15235.97 | 14883.75 | **14973.75** | -7351.88 | 0.83 | 5.03 |
| 8 | 15275.16 | **14872.07** | 14975. 07 | -7333.04 | 0.85 | 3.71 |

*Notes.* Best-fitting models are depicted in bold. Higher entropy values indicate better classification accuracy. The largest bivariate residual checks for the conditional independence assumption. BIC = Bayesian information criterion; AIC = Akaike information criterion; AIC3 = Akaike information criterion 3; LL = Log-Likelihood.

Table 3

*Characterization of pre-bariatric subtypes with regard to indicator variables (Model 2)*

| | Resilient (*n* = 65) | Slightly RC (*n* = 109) | Moderately RC (*n* = 114) | Severely RC (*n* = 68) | Food-specifically RC (*n* = 14) | | |
|---|---|---|---|---|---|---|---|
| | *M (SD)* | *M (SD)* | *M (SD)* | *M (SD)* | *M (SD)* | $F(4, 365)$ | $\eta^2$ |
| Temperament | | | | | | | |
| BIS | 17.89 (3.68)[a] | 18.39 (3.29)[a] | 20.33 (2.79)[b] | 23.53 (2.50)[c] | 18.43 (3.08)[ab] | 38.59*** | .30 |
| BAS | 41.73 (5.56)[a] | 41.28 (4.61)[ab] | 38.31 (4.87)[c] | 39.16 (5.74)[bc] | 42.14 (4.75)[ac] | 7.80*** | .08 |
| ATQ-EC | 100.75 (13.65)[a] | 96.17 (11.46)[b] | 83.73 (8.47)[c] | 72.56 (9.88)[d] | 106.36 (6.98)[a] | 88.83*** | .49 |
| Emotion dysregulation | | | | | | | |
| DERS | 60.92 (12.50)[a] | 60.51 (9.83)[a] | 85.05 (12.51)[b] | 105.14 (20.06)[c] | 62.74 (15.83)[a] | 147.39*** | .62 |
| Disinhibited eating | | | | | | | |
| EAH | 7.89 (0.81)[a] | 12.30 (3.29)[b] | 15.09 (4.15)[c] | 21.01 (4.45)[d] | 22.29 (6.75)[d] | 128.02*** | .58 |
| DEBQ-EE | 11.29 (1.38)[a] | 20.22 (5.69)[b] | 27.09 (7.16)[c] | 35.34 (7.54)[d] | 40.86 (7.50)[e] | 168.91*** | .65 |

*Notes.* Superscripts that differ display significant differences between subtypes after post-hoc comparisons with Bonferroni corrections. Effect size $\eta^2$ was interpreted according to Cohen (small effect: $.01 \leq \eta^2 < .06$; medium: $.06 \leq \eta^2 < .14$; large: $\eta^2 \geq .14$).[52] RC = reduced control; 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 (10-50*); DEBQ-EE = Emotional Eating of the Dutch Eating Behavior Questionnaire (7-35*).

*** $p < .001$

Table 4

*Validation of pre-bariatric subtypes (Model 2)*

| | Resilient ($n$ = 65) | Slightly RC ($n$ = 109) | Moderately RC ($n$ = 114) | Severely RC ($n$ = 68) | Food-specifically RC ($n$ = 14) | | | |
|---|---|---|---|---|---|---|---|---|
| | *M (SD)* | *M (SD)* | *M (SD)* | *M (SD)* | *M (SD)* | $F$ | $df$ | $\eta^2$ |
| Sociodemographics | | | | | | | | |
| Age (years) | 47.45 (12.56) | 45.26 (11.22) | 44.41 (10.31) | 43.31 (10.57) | 48.57 (10.73) | 1.64 | 4, 365 | .02 |
| BMI (kg/m$^2$) | 50.76 (8.21) | 49.11 (8.39) | 47.68 (7.19) | 47.61 (6.74) | 47.06 (7.06) | 1.67 | 4, 335 | .02 |
| | *n (%)* | *n (%)* | *n (%)* | *n (%)* | *n (%)* | $\chi^2$ | $df$ | $V$ |
| Sex (female) | 41 (63.1) | 68 (62.4) | 79 (69.3) | 51 (75.0) | 13 (92.9) | 7.91 | 4, 370 | .15 |
| Education (years) | | | | | | | | |
| ≤ 8 | 3 (4.6) | 4 (3.7) | 4 (3.5) | 2 (2.9) | 0 (0.0) | 5.85 | 8, 315 | .10 |
| 9-11 | 46 (70.8) | 67 (61.5) | 74 (64.9) | 47 (69.1) | 10 (71.4) | | | |
| ≥ 12 | 5 (7.7) | 17 (15.6) | 17 (14.9) | 15 (22.1) | 4 (28.6) | | | |

Table 4 continued.

| | Resilient ($n$ = 65) | Slightly RC ($n$ = 109) | Moderately RC ($n$ = 114) | Severely RC ($n$ = 68) | Food-specifically RC ($n$ = 14) | | | |
|---|---|---|---|---|---|---|---|---|
| | *n (%)* | *n (%)* | *n (%)* | *n (%)* | *n (%)* | $\chi^2$ | *df* | *V* |
| Eating disorder diagnoses | | | | | | | | |
| BED | 0 (0.0)[a] | 3 (3.0)[a] | 3 (2.9)[a] | 10 (17.2)[b] | 0 (0.0)[ab] | 25.25*** | 4, 337 | .27 |
| NES | 0 (0.0)[a] | 5 (5.0)[ab] | 8 (7.8)[bc] | 9 (15.5)[c] | 0 (0.0)[abc] | 13.69** | 4, 337 | .20 |
| Food addiction | | | | | | | | |
| YFAS | 4 (6.2)[a] | 10 (9.3)[a] | 34 (30.1)[b] | 36 (52.9)[c] | 5 (35.7)[bc] | 58.48*** | 4,368 | .40 |
| Depression | | | | | | | | |
| PHQ-9 | 0 (0.0)[a] | 3 (2.8)[ab] | 14 (12.3)[c] | 30 (44.1)[d] | 1 (7.1)[bc] | 78.67*** | 4, 370 | .46 |

Table 4 continued.

| | Resilient (*n* = 65) | Slightly RC (*n* = 109) | Moderately RC (*n* = 114) | Severely RC (*n* = 68) | Food-specifically RC (*n* = 14) | | | |
|---|---|---|---|---|---|---|---|---|
| | *M (SD)* | *M (SD)* | *M (SD)* | *M (SD)* | *M (SD)* | *F* | *df* | $\eta^2$ |
| Eating disorder psychopathology | | | | | | | | |
| EDE-Q global | 2.48 (0.90)[a] | 2.72 (0.80)[a] | 3.10 (0.90)[b] | 3.65 (0.97)[c] | 3.45 (1.00)[bc] | 18.59*** | 4, 365 | .17 |
| Quality of life | | | | | | | | |
| IWQoL-Lite | 83.65 (25.28)[a] | 91.92 (24.80)[b] | 102.63 (21.90)[c] | 118.12 (16.66)[d] | 103.14 (23.38)[bcd] | 23.08*** | 4, 364 | .20 |

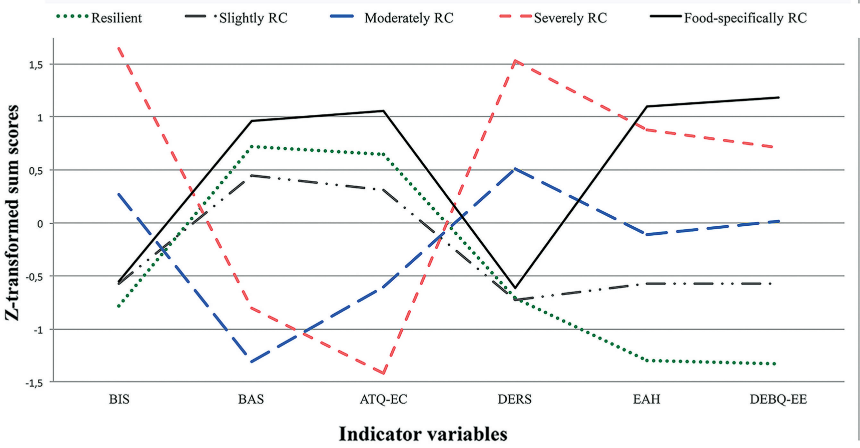
*Notes.* Superscripts that differ display significant differences between subtypes after post-hoc comparisons with Bonferroni corrections. Effect size $\eta^2$ and *Cramer's V* were interpreted according to Cohen (small effect: $.01 \leq \eta^2 < .06$, medium: $.06 \leq \eta^2 < .14$, large: $\eta^2 \geq .14$; small effect: $.10 \leq V < .30$, medium: $.30 \leq V < .50$, large: $V \geq .50$).[52] RC = reduced control; BED = binge-eating disorder; NES = night eating syndrome; YFAS = Yale Food Addiction Scale; PHQ-9 = Public Health Questionnaire-Depression; EDE-Q = Eating Disorder Examination-Questionnaire (0-6*, less favorable scores are asterisked); IWQoL-Lite = Impact of Weight on Quality of Life-Lite (31-155*).

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

Figure legend

*Figure 1.* Profile plots of the pre-bariatric subtypes.

*Notes.* The figure depicts the standardized scores of the six indicator variables for each of the five clusters of the extended latent profile analysis. 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.



Resilient
Slightly RC
Moderately RC
Severely RC
Food-specifically RC
Z-transformed sum scores
1,5
1
0,5
0
-0,5
-1
-1,5
BIS
BAS
ATQ-EC
DERS
EAH
DEBQ-EE
Indicator variables