

**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 word count: 202

Word count: 4113

Number of figures: 1

Number of tables: 4

Acknowledgements

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

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

1 Abstract

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

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

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

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

21

22 *Keywords: bariatric surgery, temperament, impulsivity, emotion regulation, eating disorder*
23 *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/m²) and grade II (35.0 kg/m² \leq BMI < 40.0 kg/m²) 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

1 nervosa,²¹ anorexia nervosa,^{22,23} and other non-normative eating behaviors.^{24,25} The
2 characterization of distinct subtypes in these samples allows to detect patients' specific
3 psychological pattern and may help to develop treatment programs tailored to individuals'
4 particular needs. Indeed, there is first evidence for the predictive value of empirically derived
5 personality subtypes for treatment outcome (e.g., objective binge-eating episodes and purging
6 frequency) in bulimia nervosa.²⁶ In pre-bariatric patients, LPA would be valuable for
7 identifying subgroups which are at risk for insufficient surgery outcome. However, a cluster
8 analytic approach has only been applied in two studies so far^{27,28} which subtyped patients
9 based on temperament traits.

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

1

2 *Measures for Cluster Identification*

3 *Reactive temperament – punishment and reward sensitivity.* To measure patients'
4 reactive temperament, total scores of the Behavioral Inhibition System (BIS) scale and the
5 Behavioral Activation System (BAS) scale³³ were used. The BIS scale (Cronbach's α in this
6 study's sample = .72) measures individual dispositional differences in punishment sensitivity,
7 whereas the BAS scale ($\alpha = .82$) assesses the dispositional sensitivity to reward.

8 *Regulative temperament – effortful control.* Regulative temperament was assessed by
9 computing the total score of the effortful control subscale of the Adult Temperament
10 Questionnaire-Short Form (ATQ-EC³⁴; $\alpha = .77$). Effortful control allows performing an act
11 even in the presence of strong avoidance tendencies and regulates the reactive temperament.

12 *Emotion dysregulation.* The total score of the Difficulties in Emotion Regulation Scale
13 (DERS³⁵; $\alpha = .94$) was used to assess deficits in recognizing and managing negative affect.

14 *Disinhibited eating behaviors.* Emotional eating (EE) and eating in the absence of
15 hunger (EAH) were assessed to determine disinhibited eating behaviors in patients. For EE,
16 the total score of the emotional eating subscale of the Dutch Eating Behavior Questionnaire
17 (DEBQ-EE³⁶; $\alpha = .95$; German version by Grunert³⁷) was computed. EAH (i.e., starting or
18 continuing eating due to negative affect, fatigue/boredom, or external cues) was assessed by
19 an adapted version ($\alpha = .88$) of the Eating in the Absence of Hunger scale (EAH³⁸; German
20 translation by AH – unpublished manuscript). Total scores were computed.

21

22 *Measures for Cluster Validation*

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

1 Mental Disorders (DSM-5).¹⁵ In addition, an EDE module for the night eating syndrome
2 (NES)¹⁶ was used to diagnose NES according to DSM-5.¹⁵ Based on previous
3 recommendations, NES was defined as having at least two excessive evening and/or night
4 eating episodes per week during the last three months.⁴⁰

5 *Eating disorder psychopathology.* Patients' concerns and behaviors related to eating
6 restraint, body shape, and weight were measured by the global score of the Eating Disorder
7 Examination-Questionnaire (EDE-Q⁴¹; $\alpha = .86$).

8 *Food addiction.* Addictive eating was measured by the Yale Food Addiction Scale
9 (YFAS⁴²; $\alpha = .90$), which assesses seven food addiction symptoms (e.g., tolerance,
10 withdrawal). Food addiction was diagnosed if patients fulfilled more than two symptoms and
11 reported clinically significant distress.

12 *Depression.* The total score of the Patient Health Questionnaire Depression Scale
13 (PHQ-9⁴³; $\alpha = .85$), which covers each of the nine DSM-5 criteria for depression,¹⁵ was
14 computed and a cut-off of 15 was applied to determine probable cases of depression.⁴⁴

15 *Quality of life.* The total score of the Impact of Weight on Quality of Life-Lite
16 (IWQoL-Lite⁴⁵; $\alpha = .94$) was used to assess individual's quality of life regarding physical
17 function, self-esteem, sexual life, public distress, and work.

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

22

23 *Data Analytic Plan*

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

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

7 LPA were carried out using Latent Gold Version 4.5.⁴⁶ Total scores of the indicator
8 variables were available for all patients. LPAs were performed with one to eight clusters and
9 the most parsimonious number of latent classes was determined by examining the Bayesian
10 information criterion (BIC).⁴⁷ BIC was chosen as primary fit index as it is more conservative
11 than the indices based on the Akaike information criterion (AIC), which tend to overestimate
12 the true number of clusters.⁴⁸ Additionally, the Akaike information criterion (AIC),⁴⁹ the
13 Akaike information criterion 3 (AIC3),⁵⁰ and entropy-values were reported. Lowest values of
14 the three information criteria are indicative for the best-fitting model and higher entropy
15 values indicate better classification accuracy. In addition to global measures of model fit,
16 bivariate residuals as local fit indices were examined. High bivariate residuals indicate
17 remaining correlations between two indicators within clusters that were not adequately
18 explained by the model. In this case, the conditional independence assumption is not met. In
19 the present study, direct effects, demonstrated by bivariate residuals larger than 3.84,⁴⁶ were
20 added to the model if this procedure resulted in a more parsimonious cluster solution. After
21 determining the number of clusters, participants were assigned to a cluster on the basis of
22 their highest probability.

23 Univariate analyses of variance (ANOVAs), χ^2 tests and, in terms of violation of
24 normality and homogeneity of variances, non-parametric tests were used to compare and
25 validate the clusters identified in Model 2. Post-hoc tests with Bonferroni correction were

1 applied to examine pair-wise differences if omnibus tests were significant. Significant
2 differences in explained variances R^2 between Model 1 and Model 2 were examined by z tests
3 for correlation coefficients with a two-tailed α of .05 using z -transformed R .⁵¹ All statistical
4 tests, carried out using SPSS Version 23.0 (IBM Corp. Released 2015. IBM SPSS Statistics
5 for Windows, Version 23.0. Armonk, NY: IBM Corp), were two-tailed and considered
6 significant when p values were $< .05$.

7 Results

8 *Sample Description*

9 Data from $N = 370$ pre-bariatric patients (68.1% women) with a mean age of $M =$
10 45.15 years ($SD = 11.10$) and a mean BMI of $M = 48.59$ kg/m² ($SD = 7.71$) were included in
11 the LPA. Obesity grade III was present in the majority of patients ($n = 316$; 85.4%), followed
12 by obesity grade II ($n = 24$; 6.5%) and obesity grade I ($n = 4$; 1.1%). For $n = 26$ patients
13 (7.0%), both measured and self-reported BMI was missing.

14

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

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

22 The clusters differed significantly in terms of BIS, BAS, and ATQ-EC. Compared to
23 Cluster 2 ($n = 142$), Cluster 1 ($n = 228$) showed significant lower levels of BIS, $F(1, 368) =$
24 164.56, $p < .001$, and higher levels of BAS, $F(1, 368) = 14.82$, $p < .001$, and ATQ-EC, $F(1,$

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

3

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

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

12

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

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

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

21 *Cluster 2* ($n = 109$; 29.5%) showed a similar profile as the ‘Resilient’ subtype, as both
22 clusters did not differ significantly in BIS, BAS, and DERS ($ps = .358 - .808$). However,
23 patients from this cluster, referred to as ‘Slightly reduced control (RC)’ subtype, reported
24 significantly lower levels of ATQ-EC ($p = .026$) and higher levels of EAH and DEBQ-EE (ps
25 $< .001$) compared to the ‘Resilient’ cluster.

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

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

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

20

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

22 As presented in Table 4, there were no differences among the subtypes with respect to
23 age, BMI, sex, and education ($ps = .081 - .664$). Descriptively, BED and NES were most
24 prevalent in the 'Severely RC' cluster ($n = 10$, 17.2% and $n = 9$, 15.5%, respectively),
25 followed by the 'Moderately' ($n = 3$, 2.9% and $n = 8$, 7.8%, respectively) and 'Slightly RC'

1 subtype ($n = 3, 3.0\%$ and $n = 5, 5.0\%$, respectively). No cases of BED and NES were reported
2 in the ‘Resilient’ and ‘Food-specifically RC’ subtype. In this regard, both subtypes differed
3 significantly from the ‘Severely RC’ cluster ($ps = .001 - .024$). Half of the ‘Severely RC’
4 patients ($n = 36, 52.9\%$) met criteria for food addiction. High rates of food addiction were
5 also found in the ‘Food-specifically RC’ ($n = 5, 35.7\%$) subtype, which did not differ
6 significantly in this respect from the ‘Severely RC’ ($p = .240$) and ‘Moderately RC’ group (n
7 $= 34, 30.1\%$; $p = .667$), whereas food addiction occurred significantly less in the ‘Resilient’ (n
8 $= 10, 9.3\%$) and ‘Slightly RC’ subtype ($n = 4, 6.2\%$; $ps = .001 - .005$). Accordingly, highest
9 levels of eating disorder psychopathology were reported by patients from the ‘Severely’ and
10 ‘Food-specifically RC’ subtype, which did not differ significantly from each other ($p = .480$),
11 while the ‘Resilient’ and ‘Slightly RC’ subtype reported the lowest values compared to the
12 other groups ($ps = .001 - .002$). Depression was most prevalent in the ‘Severely RC’ cluster (n
13 $= 30, 44.1\%$), followed by the ‘Moderately RC’ ($n = 14, 12.3\%$) and ‘Food-specifically RC’
14 subtypes ($n = 1, 7.1\%$), while both clusters did not differ significantly from each other in this
15 respect ($p = .573$). Little to no cases of depression were reported in the Slightly RC’ and
16 ‘Resilient’ group, which did not show any significant group differences ($p = .177$). With
17 regard to quality of life, lowest levels were found in patients of the ‘Severely RC’ subtype,
18 followed by the ‘Food-specifically’, ‘Moderately’, and ‘Slightly RC’ cluster, whereas the
19 ‘Resilient’ patients significantly reported the highest levels compared to the remaining
20 clusters ($ps = .001- .036$).

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Discussion

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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

1 heterogeneity in psychological profiles in this sample. Using LPA, five subtypes with distinct
2 psychological profiles were identified and associated with different prevalence rates of eating
3 disorder diagnoses and varying levels of eating and general psychopathology. Based on the
4 high accuracy and gain in explained variance by assigning pre-bariatric patients to one of five
5 psychological profiles, the present investigation showed more favorable results than previous
6 subtyping studies using temperament traits only.^{27,28}

7 Most patients were classified as ‘Moderately RC’ subtype, characterized by low levels
8 of effortful control and high levels of punishment sensitivity, emotion dysregulation, as well
9 as frequent disinhibited eating, including emotional eating and eating in the absence of
10 hunger. Patients belonging to the ‘Severely RC’ subtype showed psychological profiles
11 similar to the ‘Moderately RC’ subtype, although they were even higher in impairment. The
12 profiles of these two subtypes correspond to the ‘emotionally dysregulated/undercontrolled’
13 cluster of pre-bariatric patients derived from temperament-based models.^{27,28} Thus, the
14 present study provided a more precise picture of different levels of self-control and emotion
15 regulation in pre-bariatric patients by distinguishing the ‘Resilient’ and ‘Slightly RC’
16 subtypes at the healthier end of the spectrum from the ‘Moderately RC’, ‘Severely RC’, and
17 ‘Food-specifically RC’ subtypes at the more pathological, less controlled end. Most cases of
18 BED, NES, food addiction, and highest levels of eating disorder psychopathology were found
19 among patients of the ‘Severely RC’ subtype, followed by the ‘Moderately’ and ‘Slightly RC’
20 subtype. This is consistent with previous findings indicating that deficits in self-control and
21 emotion regulation in pre-bariatric patients are closely connected to a range of pathological
22 eating behaviors.^{16-18,53,54} Further, previous studies revealed that pre- and post-bariatric BED,
23 binge eating, loss of control eating,⁵⁵⁻⁵⁷ and emotional eating⁵⁸ are negative predictors for
24 post-bariatric weight loss outcome in the long term. Consequently, patients of the ‘Severely
25 RC’ subtype are expected to be at higher risk for unfavorable weight loss, disturbed eating

1 behaviors, and psychological impairments after surgery compared to the other subtypes. Thus,
2 longitudinal investigations are required to test the predictive value of the five subtypes in
3 terms of surgery outcome.

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

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

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

9 Major strengths of this study include the application of LPA as an empirically driven
10 approach to subtype pre-bariatric patients in a large multicenter sample. Well-established
11 instruments were used to assess eating disorder diagnoses and psychopathology, independent
12 from clinical routines related to surgery. As a limitation, the cross-sectional design of the
13 study does not allow for evaluating the predictive value of the identified subgroups on diverse
14 surgery outcomes (e.g., weight loss, quality of life). In addition, several factors which may
15 have an effect on the analyzed variables were not examined, such as medication intake and
16 somatic comorbidities. Finally, for $n = 26$ patients, BMI was calculated by using the self-
17 reported body weight and height. However, correlation analyses of objective and subjective
18 BMI data of $n = 164$ patients revealed high agreement between these two types of sources ($r =$
19 $.95$), thus preventing from strong measurement biases.

20 Overall, the present findings highlight that pre-bariatric patients show heterogeneous
21 psychological profiles in terms of temperament traits, emotion regulation, and disinhibited
22 eating behaviors. Future studies are needed to replicate the identified subtypes in other pre-
23 bariatric samples, including the rather small cluster of ‘Food-specifically RC’ patients. In
24 addition, more research is needed to longitudinally investigate trajectories of psychological
25 profiles after bariatric surgery, because it has been shown that the majority of bariatric

1 patients improve significantly in terms of depressive symptoms^{1,2} and disinhibited eating
2 behaviors⁶² already six months after surgery. Further, future studies should compare several
3 cluster solutions on different pre- and post-bariatric time points in order to detect the
4 subtyping model with the highest predictive value for post-bariatric excess weight loss
5 outcome and other psychological aspects (e.g., patients' adherence at follow-up) and,
6 accordingly, determining the optimal assessment point for psychological evaluation to detect
7 and treat high-risk patients as early as possible.

8 Several clinical implications derive from the present findings. Clinicians may be
9 advised to systematically assess temperament, emotion dysregulation, and disinhibited eating
10 behaviors during pre-operative psychological evaluation in order to detect pre-bariatric
11 patients showing profiles of potential vulnerability for post-bariatric maladaptive eating
12 behaviors, insufficient weight loss, and psychosocial impairment. For orientation, clinicians
13 may refer to cut-off scores of instruments assessing deficits in self- and emotion regulation
14 (e.g., ATQ-EC, DERS). In addition, patients showing a psychological profile congruent with
15 the 'Severely RC' and 'Moderately RC' subtypes, i.e., difficulties with self- and emotion
16 regulation as shown by similar mean scores of measures, should receive particular attention
17 from clinicians as these subgroups may be prone for post-bariatric complications. First
18 evidence indicated that cognitive-behavioral interventions in pre-bariatric patients hold
19 promise for reducing eating disorder psychopathology and depressive symptomatology⁶³ and
20 that post-bariatric behavioral interventions improve post-surgery weight loss.^{64,65} Although
21 psychological examinations should be standard for all pre-bariatric patients, it remains unclear
22 which patients are in need for additional psychosocial interventions to improve post-bariatric
23 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 (<i>n</i> = 65)	Slightly RC (<i>n</i> = 109)	Moderately RC (<i>n</i> = 114)	Severely RC (<i>n</i> = 68)	Food- specifically RC (<i>n</i> = 14)		
	<i>M</i> (<i>SD</i>)	<i>M</i> (<i>SD</i>)	<i>M</i> (<i>SD</i>)	<i>M</i> (<i>SD</i>)	<i>M</i> (<i>SD</i>)	<i>F</i> (4, 365)	η^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 η^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 (<i>n</i> = 65)	Slightly RC (<i>n</i> = 109)	Moderately RC (<i>n</i> = 114)	Severely RC (<i>n</i> = 68)	Food-specifically RC (<i>n</i> = 14)			
	<i>M</i> (<i>SD</i>)	<i>M</i> (<i>SD</i>)	<i>M</i> (<i>SD</i>)	<i>M</i> (<i>SD</i>)	<i>M</i> (<i>SD</i>)	<i>F</i>	<i>df</i>	η^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
	<i>n</i> (%)	<i>n</i> (%)	<i>n</i> (%)	<i>n</i> (%)	<i>n</i> (%)	χ^2	<i>df</i>	<i>V</i>
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 (<i>n</i> = 65)	Slightly RC (<i>n</i> = 109)	Moderately RC (<i>n</i> = 114)	Severely RC (<i>n</i> = 68)	Food-specifically RC (<i>n</i> = 14)			
	<i>n</i> (%)	<i>n</i> (%)	<i>n</i> (%)	<i>n</i> (%)	<i>n</i> (%)	χ^2	<i>df</i>	<i>V</i>
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 (<i>n</i> = 65)	Slightly RC (<i>n</i> = 109)	Moderately RC (<i>n</i> = 114)	Severely RC (<i>n</i> = 68)	Food-specifically RC (<i>n</i> = 14)			
	<i>M</i> (<i>SD</i>)	<i>M</i> (<i>SD</i>)	<i>M</i> (<i>SD</i>)	<i>M</i> (<i>SD</i>)	<i>M</i> (<i>SD</i>)	<i>F</i>	<i>df</i>	η^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 η^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.

