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Abstract

Background/Aims: There is ample consensus that there is a neurophysiological basis for eating disorders (ED). Traits of personality translate into behavioral traits, purging being a well-defined transversal example. The direct implication of steroid hormones on ED has seldom been studied, despite their effects on behavior. ***Methods:*** After psychological in- terview analysis, 57 ED female patients (31 purgative and 26 nonpurgative) and 17 female controls were studied. Met- abolic parameters and analysis of androgen, estrogen and glucocorticoid hormones were determined in parallel to the psychopathological profile (EDI-2 and SCL-90-R) and anth- ropometric measurements. ***Results:*** Psychometric tests showed clear differences between ED and controls, but there were few hormonal-metabolic significant differences. In purgative ED there were repeated (significant) positive correla- tions with corticosteroid-binding globulin (CBG) and nega- tive correlations with sex hormone-binding globulin (SHBG) versus eating and general psychopathology. In nonpurging ED there were positive correlations for deoxycortisol, free fat- ty acids and albumin and negative for aspartate aminotrans- ferase and psychopathological traits. ***Conclusion:*** The data suggest that CBG/corticosteroids and sexual hormones/ SHBG are involved in purging behavior and its psychopathol- ogy and severity scores. Correlations of selected psychomet- ric data and the CBG/SHBG levels in purging may eventually result in clinical markers. This approach may provide addi- tional clues for understanding the pathogenesis of ED.

Key Words: Eating disorders · Anorexia · Bulimia · Corticosteroid-binding globulin · Sex hormone-binding globulin · Estrogens · Androgens · Glucocorticoids

Introduction

Hormonal and metabolic changes in eating disorders (ED) have widely been described and studied in the litera- ture [1, 2] . Their metabolic causes, however, have been seldom analyzed, mainly because of the limited availability of data and the wide complexity of the populations studied [3] . This is in part a consequence of the fact that the diag- nostic of ED is in itself a fairly complex issue [4] and part- ly due to the intrinsic variability of most metabolic and hormonal parameters in human populations that are oth- erwise 'normal'. Nevertheless, this relationship may run deeper than usually assumed: the common occurrence of amenorrhea in deeply affected anorectic individuals sug- gests that at least the hypothalamus-pituitary-gonadal axis is affected and their biological implications known.

Biological Vulnerability in ED

Although genetic predisposition to ED has received considerable attention [5, 6] , it is difficult to arrive at clear conclusions because of the variability in the manifesta- tions, intensity and symptom-focusing of these disorders [7] . Most of these studies only hint at increased frequency (or predisposition) because of the presence of certain al- leles in a number of genes related with control of energy, appetite, behavior or other pathways [8, 9] , but there is not a clear-cut direct relationship with the ED [10, 11] . The intrinsic variability that characterizes any group of humans (height, weight, metabolic parameters, hormon- al cycles), even if limited to one sex and a fairly narrow age limit, makes it very difficult to find well-defined group differences in parameters that otherwise are subjected to homoeostatic control and tend to remain stable in spite of powerful manipulation. This problem is compounded by the intrinsic variability added by the analytical meth- ods (in fact of any analytical method).

The markedly individual or personal nature of human psychological makeup is a key factor adding variability to any group-based analysis of metabolic-psychological rela- tionships. The complexity of the etiology and even manifes- tations of eating diseases can be simplified by ascribing each patient to a particular category of the ATP-III, but the con- tinuum of individual patient characteristics will no doubt affect not only psychological reactions but also hormonal correlates inducing metabolic consequences, thus increas- ing the 'gray zone' between specific diagnostic groups. The obvious consequence is the relative lack of studies showing clear metabolic changes attributable to specific manifesta- tions of ED [12, 13] . There are a few studies showing the tip of the iceberg [14] , and it is generally acknowledged that metabolic correlates of eating diseases can be first-order el- ements both for their diagnostic and as key

elements for understanding their pathogenic mechanisms [15] .

Hormonal Correlates and ED

There are a number of studies linking metabolic and hormonal changes with ED, both in human and animal models [16] , but changes induced by ED within the main hormonal and metabolic parameters have only been sparsely studied. Steroidal hormones, a case in point, are seldom analyzed in blocks, including a number of differ- ent molecular species, as a way to better understand the changes of their patterns in disease. The rapid intercon- version of a number of corticosteroids [17] and especial- ly androgen and estrogen hormones and their precursors are a key characteristic of their function and a powerful means for their control. Although hormonal profiles and influence in ED have been widely studied, e.g. estrogens [3, 18, 19] , androgens [20] , altered hypothalamic-pitu- itary-adrenal [21] and hypothalamic-pituitary-gonadal axes functions [15] , their relationships with specific phe- notypical characteristics of ED have seldom been de- scribed. Although specific clinical traits such as purging behavior have frequently been associated with higher psychopathology and poorer prognosis [21–24] , their po- tential association with hormonal functioning has rarely been investigated.

The division of ED along the purging/nonpurging line is based on its clear association with medical risk [25] and follows previous studies in which this subtyping has been widely used [26] on the basis of medical consequences and empirical phenotyping [27] .

Aims of the Study

Given the current gaps in the literature, the goal of the present study was to overcome the limitations of the pre- vious studies by comparing ED individuals and healthy- eating controls across a broad range of hormonal com- ponents (online suppl. fig. 1; for all online suppl. mate- rial, see www.karger.com/doi/10.1159/000350473), i.e. the key steroidal hormones and the transporting globu- lins, sex hormone-binding globulin (SHBG) [28] and corticosteroid-binding globulin (CBG) [29] , together with phenotypical characteristics (purging behavior, clinical symptoms and general psychopathology).

Our specific goals were 3-fold: (1) to explore the dis- tribution of hormonal parameters in a sample of ED individuals and to analyze whether they are different when compared with healthy-eating controls, (2) to compare whether hormonal parameters differ between purging and nonpurging ED as a way to determine the eventual implication of steroid hormones in the mani- festation of this marker symptom and (3) to assess the relationship of differential hormonal features with oth- er phenotypical traits in ED (clinical and psychopatho- logical variables).

We hypothesized that hormonal function may be as- sociated not only with ED categories but with some spe- cific ED clinical features associated with severity (ED se- verity and general psychopathology). This approach opens a new avenue for the study of the pathogenicity of ED and its metabolic correlates in populations otherwise diverse, and allows us to distinguish a specific metabolic- hormonal pattern in ED.

Materials and Methods

Participants

The final sample included 57 female ED patients [12 anorexia nervosa and subthreshold anorexia nervosa (21.0%), 31 bulimia nervosa and subthreshold bulimia nervosa (54.4%), and 14 with ED not otherwise specified, (24.6%), including 5 binge ED (8.8%)]. In total there were 35 purgative and 22 nonpurgative ED patients con- secutively admitted to the Eating Disorders Unit in the Department of Psychiatry at the University Hospital at Bellvitge (Barcelona, Spain). All participants were diagnosed according to DSM-IV crite- ria, using a semistructured clinical interview (SCID-I) [30] conduct- ed by experienced psychologists or psychiatrists. A total of 17 healthy-eating women, the comparison group (CG), were volun- teers recruited from the staff of our centers. The exclusion criteria were: current treatment with hormones (including anovulatory combinations), diabetes and other metabolic diseases (including polycystic ovary syndrome) and drug consumption (including to- bacco and alcohol), as well as other infectious, hormonal or meta- bolic diseases and lifetime ED in the case of CG individuals. The Ethics Committee of the University Hospital at Bellvitge approved this study, and informed consent was obtained from all participants.

Psychometric Measures

Eating Disorders Inventory 2 (EDI-2) The EDI-2 [31] is a reliable and validated 91-item multidimensional self-report questionnaire that assesses different cognitive and behavioral characteristics which are typical for ED. The ques- tions are answered on a 6-point Likert scale. This instrument was validated in a population of Spaniards [32] and had a mean inter- nal consistency of 0.63 (coefficient α). Interrater reliability ranged from good to excellent (0.77–0.96).

Symptom Checklist – Revised (SCL-90-R)

We used the SCL-90-R [33] to assess a broad range of psychopathological symptoms. This test contains 90 items and helps to measure 9 primary symptom dimensions. In addition, it includes 3 global indices: (1) a global severity index (GSI), designed to mea- sure overall psychological distress, (2) a positive symptom distress index, designed to measure the intensity of symptoms and (3) a positive symptom total. The GSI can be used as a summary of the test. This scale has been validated in a population of Spaniards [34] and had a mean internal consistency of 0.75 (coefficient α). Inter- rater reliability ranged from good to excellent with values between 0.70 and 0.90.

Procedure

Experienced psychologists and psychiatrists with master or doctoral degrees (all extensively trained in the use of the instru- ments) completed the clinical assessment during two structured face-to face interviews before any psychological or pharmacologi- cal treatment was initiated. The first interview included questions about the regularity of their menses and the mean duration and time of their ovulation cycle at the moment of the analyses. In ad- dition to the clinical interview, demographic information was ob- tained through self-report questionnaires.

In this session, basic anthropological measurements were car- ried out. Body weight and height were measured using standard pr- ocedures and were used to calculate the body mass index (BMI). The percentage of body fat was estimated with a bioimpedance system (Body Mass Analyzer BC-418MA; Tanita Corp., Tokyo, Japan).

Hormonal and Metabolic Measurements

Venous blood samples were taken in the morning after an overnight fast; serum was separated and stored at –80 ° C; later it was used for the analysis of glucose, total cholesterol, triacylglycerols, bilirubin, albumin, total serum protein, urea, alanine and aspartate aminotransferases, lactate dehydrogenase and ketone bodies using dry chemistry strips (Spotchem Strips; Menarini, Firenze, Italy); free fatty acids were measured with a kit (NEFA kit; Wako, Osaka, Japan). Steroid hormones (except hormone sulfates) were mea- sured by HPLC-MS/MS following the procedure described in on- line supplementary Methods.

Specific radioimmunoanalysis/ELISA kits were used for the measurement of insulin (RIA HI-14K; Millipore, Billerica, Mass., USA), SHBG (IRMA KP32CT; RADIM, Rome, Italy), CBG (RIA KIP1809; BioSource Europe, Nivelles, Belgium), estrone sulfate (RIA DSL-5400; Diagnostic Systems Laboratories, Webster, Tex., USA) and dehydroepiandrosterone (DHEA) sulfate (RIA DSL- 3500; Diagnostic Systems Laboratories). The Homeostasis Model Assessment (HOMA) value was calculated from insulin and glu- cose data [35] .

Statistical Analyses

The statistical analysis was carried out with PASW17 statistics (SPSS system), t test procedures (and the nonparametrical Mann- Whitney test for data with high asymmetries) explored differences in clinical and psychological measures between groups (purging vs. nonpurging and ED vs. CG).

Heterotypical association between hormones and metabolic measures (considered as predictors) with psychometric scores (considered as outcomes) was valued through multiple lineal re- gressions. One independent model was defined for each psycho- metric outcome, simultaneously entering the set of hormones or metabolic incomes (ENTER procedure). Beta coefficients ob- tained with these models valued the specific contribution of each predictor in the criteria, adjusted to the presence of the other vari- ables considered of the same set; the R 2 coefficient valued the total predictive accuracy of the model.

Homotypical association between variables pertaining to the same group (hormones – metabolic and psychometric) was valued with partial correlations. These coefficients measures the degree of association between pairs of variables controlling (adjusting) the effect of other covariates. In this study, one independent partial r coefficient was obtained for each pair of variables, considering as covariates the rest of the variables of the same group different from zero. Paired correlations were considered relevant only when sta- tistical significance emerged ($p < 0.05$) and effect sizes of R coef- ficients were good ($|r| > 0.35$).

Results

Clinical, General Psychopathology, Anthropometric and Metabolic Description among the Groups

The mean values obtained among the ED groups (purging vs. nonpurging) for all anthropometric values are shown in online supplementary table 1. There were no significant differences between groups except for higher body fat in nonpurging than in CG. Table 1 pres- ents the comparison of the EDI-2 and SCL-90-R test scores between the three experimental groups. There were significant differences for all items between ED as a whole and both purging and nonpurging women. How- ever, no differences were observed between both ED

groups. The results for SCL-90-R test were fully compa- rable to those obtained with the EDI-2 test: there were significant differences versus CG for all ED and the sub- groups purging and nonpurging, but there were no dif- ferences between these two subgroups.

Table 2 shows the serum steroid hormone-related pa- rameters in CG, ED and the two subgroups of purging and nonpurging ED women. The differences observed were sparse. When considering the whole of ED versus CG, es- trone sulfate and cortisone levels were lower in ED and androstenedione was higher. Comparison of CG and non- purging was coincident with all ED in estrone sulfate and androstenedione, but not in cortisone; however, the dif- ferences versus CG were significant for β-estradiol. SHBG levels were higher in purging women than in CG. There were significant differences between purging and non-purging groups for androstenedione and DHEA sulfate, with levels higher in both cases in nonpurging women.

Online supplementary table 2 depicts the serum me- tabolite data for ED and CG. There were no statistically significant differences between groups for any of the pa- rameters studied.

Interaction between Hormonal-Metabolic Parameters and ED and General Psychopathology between Purging and Nonpurging ED

The analysis of paired correlation data applied to the EDI-2 psychometric aspects showed a considerable num- ber of significantly interrelated parameters (table 3). Thus, in ED nonpurging women, BMI, body weight and body fat were positively correlated with body dissatisfac- tion and bulimia. Deoxycortisol was correlated with in- terpersonal distrust, ineffectiveness, impulse regulation, ascetism and social insecurity. Free fatty acids were cor- related with ineffectiveness, impulse regulation, ascetism and social insecurity. Other correlations were limited to one or two factors: pregnenolone to interpersonal dis- trust, progesterone to impulse regulation, androstenedi- one to ascetism, alanine aminotransferase to bulimia, al- bumin to perfectionism and both urea and plasma pro- teins to EDI total.

The pattern of negative correlations for ED nonpurg- ing women was more limited. Aspartate aminotransfer- ase was negatively correlated with interoceptive aware- ness, interpersonal distrust, ineffectiveness, impulse regulation, social insecurity and EDI total, and cortisol was negatively correlated with interpersonal distrust.

ED purging women showed positive correlations be- tween CBG and interoceptive awareness, bulimia, ineffec- tiveness, ascetism and EDI total; aspartate aminotransfer- ase was positively correlated with interpersonal distrust, ineffectiveness and perfectionism, urea with interoceptive awareness, lactic dehydrogenase with perfectionism, uric acid with body dissatisfaction, glucose and alanine amino-transferase with ineffectiveness, and deoxycortisol with interpersonal distrust and social insecurity.

Negative correlations for purging ED women were centered on SHBG, which correlated with interoceptive awareness, bulimia, ineffectiveness, maturity fears, im- pulse regulation, ascetism, social insecurity and EDI total. Other negative correlations were pregnenolone with drive for thinness, aldosterone with body

dissatisfaction, height with maturity fears and albumin with ascetism.

CG showed negative correlations for deoxycortisol with drive for thinness, body dissatisfaction, bulimia and impulse regulation; BMI was negatively correlated with drive for thinness, body dissatisfaction and perfectionism, body fat with drive for thinness and perfectionism, HOMA with ineffectiveness, maturity fears and social in- security, glucose with maturity fears, social insecurity and EDI total, plasma proteins with maturity fears, CBG with impulse regulation, and bilirubin with EDI total.

Negative correlations for control women were cortisol and cortisone with body dissatisfaction, and estrone sul- fate with drive for thinness.

In table 3 only the GSI of the SCL-90-R test is shown. ED nonpurging women showed correlations for total protein and albumin, and negative correlation for alanine aminotransferase. In purging women, the correlation was positive for CBG and negative for SHBG. The CG showed only positive correlations for both glucose and bilirubin.

Discussion

The present study aimed to explore whether a spe- cific ED cluster of patients (purging vs. nonpurging) are differentiated on hormonal-metabolic parameters when compared with healthy-eating controls and to analyze whether there is an interaction between the hormonal- metabolic functioning and phenotypical features (purg- ing behavior, eating and general psychopathology) in ED patients. Our observations indicate that potentially meaningful correlations do exist between eating severity and general psychopathology and specific hormonal and metabolic functioning, and that purging and non- purging subjects respond in a different hormonal-met- abolic way.

When comparing the absolute mean values of the items analyzed between the three experimental groups we observed only small differences if any. The limited num- ber of significant differences between purgative and non- purgative groups (and between these and the CG) suggest that most of the psychometric hormonal and metabolic data presented fall well within the limits of ‘normalcy’. There were no marked differences due to purging behav- ior, nor were there marked differences (considering only the metabolic and hormonal parameters) between con- trols and patients with a clinically defined eating disease. This was also expected, since most of the subjects had normal weight and there were no deviations from the range of normalcy as those observed in deeply altered hormonal states. These results are comparable to a num- ber of similar studies in which there were no marked ef- fects of ED on most metabolic indicators other than those expected by altered food intake [36] . Nevertheless, genet- ic studies have shown a number of allele distributions

closely related with ED [37, 38] and, evidently, gene ex- pression ultimately translates into metabolic effects.

The application of a deeper-layer analysis of possible correlations between the data, i.e. determining the pos- sible differences in relationships between different pa- rameters, showed distinct patterns between both psy- chometric and metabolic factors in a way that clearly dif- ferentiated the three groups. The statistically defined association of parameters helps explain the basic pat- terns of change, often obliterated in direct comparisons by the ‘noise’ of human variability, individual specificity of the ED and the variability inherent to the analytical techniques.

Purging behavior is a key diagnostic element for the classification of ED and is a distinct qualitative and qual- ifying trait [22, 24] . The application of the statistical cor- relation analysis to a sample of eating-disordered women on the basis of purging behavior resulted in two well- marked behavioral patterns that transcend the simple sharing of ED diagnostic categories. However, the most important finding is that these different patterns associ- ated with purging behavior are also closely correlated with a number of hormonal and metabolic parameters in a well-differentiated pattern.

We centered a large part of the efforts for this study on the analysis of a large number of steroid hormones because of their relationship with behavior [39, 40] and their alterations under stress [41] , depression-like con- ditions [42, 43] , sexual drive, cycles [44] and role-relat- ed behavior [45] . In the obese, estrone levels are a cor- relate of body fat [46] . Estradiol facilitates fat mobiliza- tion [47] and controls gonadotropin

synthesis in the brain [48] . Testosterone is an important controller of sexual behavior in women [49] and competes with es- tradiol for binding to SHBG [50] . Unfortunately, most values for testosterone were below the limit of detection of the methodology used, which at least allows us to prove that the analyzed women had normal or lower than normal levels of testosterone, whereas those of es- tradiol were within the normal range [51] . Glucocorti- coids are affected by rhythms [52] , control energy me- tabolism [53] and the immune response to inflamma- tion [54] . Cortisol is carried in blood mainly by CBG [55] , which also helps modulate the corticosteroid re- sponse [56, 57] .

Purging is clearly associated with hormone function, as shown by the positive correlation of ED psychopathol- ogy and general psychopathology with CBG levels and their negative relationship with SHBG, traits not ob- served in the CG of ED nonpurging. The levels of estradiol were lower in nonpurging than in CG, but unaffected in ED purging, which also showed higher levels of SHBG than either group. A trend to increase SHBG levels like that observed in purging women may result in lower availability of free sex hormones and is in line with the SHBG increase under conditions of malnutrition and an- orexia [58, 59] . Estradiol is probably the SHBG main binding hormone, since testosterone levels were very low in all cases, but its levels did not show significant differ- ences between groups. These findings confirm a marked reversed interrelationship between purging and SHBG. However, it is unclear how SHBG may help define the metabolic profile of purging women.

The case for CBG mirrors that of SHBG, but now the correlations of CBG with purging and of deoxycortisol in nonpurging ED patients were positive.

The inactive/active corticosteroid (cortisone/corti- sol) concentration ratio was 17.5 for nonpurging, 19.9 for purging and 24.1 for CG ($p < 0.01$ for ED and non- purging and $p < 0.05$ for purging). This difference points to an overall increased reconversion of inactive cortisone into active cortisol via 11β-hydroxysteroid de- hydrogenase [17, 41] in the ED patients, irrespective of the purgative factor analyzed here. This may represent a mechanism of homoeostatic preservation or increased hormone turnover rather than a direct increase in hor- mone activity, since cortisol levels were normal in all three groups. The high correlations of purging ED with CBG and the unchanged ratio of CBG versus cortisol in all three groups suggests that in purging women there may be relatively maintained (but tighter) activity of glucocorticoids compared with CG. The correlations of corticosteroid activity, including CBG, suggest that they play a role in the particular behavioral act of purging, in parallel to their implication in stress and in most re- actions to harm, external interaction and depression [60, 61] .

The positive correlations of BMI, body weight, body fat, albumin and other indicators of possible tendency to excess of nutrients were in part shared by CG, and clearly reflect both the trend to increase food intake (repeated correlations with BMI, free fatty acids and albumin in nonpurging and BMI, glucose and uric acid in CG), and concerns with eating and weight. However, the remark- able and repeated negative correlation with aspartate aminotransferase, an index of liver failure [62] , may sug- gest that there is not an excessive ‘excess’ of nutrients driving to a complicated situation such as liver steatosis, obesity or other metabolic syndrome components. In nonpurging women, metabolic control seems tighter

than in CG, and the negative correlations with amino- transferases contrast with the positive correlations found in purging women.

Positive correlations in the purging women show a disturbing assortment of markers of liver dysfunction (serum aminotransferases, urea, uric acid, lactic dehy- drogenase). None of these parameters is outside of the normalcy range, but their association suggests that the purging behavior is a harbinger of possible future he- patic alterations. Evidently, the loss of electrolyte and the upper gastrointestinal tract damage induced by forced vomiting [63] can elicit protracted negative consequenc- es, but the possible implication for the liver has not yet been established. The data presented here suggest a need for the control of liver well-being in ED associated with purging.

The ED components of the purging women may be translated into a deep preoccupation with their image, bulimia and the ability to act against its consequences, i.e. the decision to vomit. This second active part is probably where the relative lowering of estrogenic func- tion may help favor a more action-prone brain setting [64] . Bulimic behavior is again negatively associated with SHBG levels (unpublished data), reinforcing the notion that there is an inverse relationship between the impulse to act and SHBG levels,

i.e. higher free circulat- ing sex hormones. The lack of correlation with param- eters more directly related with body weight and shape suggests that purging behavior is not a simple compo- nent of the drive to eliminate excess energy intake, but is rooted in sex hormone/glucocorticoid functional re- lationships.

In the nonpurging group the ED substrate is the same (body dissatisfaction, bulimia), but the fear of the conse- quences was greater than the drive for action. There was no correlation with sex hormones or their transporting globulin and no metabolic correlations with liver func- tion indexes, but there were a number of positive correla- tions with BMI, body fat and free fatty acids. This reflects a more 'normal' approach to the problem of bulimia, and a lot more passiveness on the part of the patient with re- spect to the eventual consequences. The image problem, however, persists because no 'actions' are taken, and as a consequence the metabolic derangements associated with these actions did not appear, or at least not more than in the CG, where EDI-2 responses were also fairly well correlated with BMI, HOMA and body fat. Since the BMI of nonpurging women was higher than that of CG (probably, at least in part, as a consequence of the com- bination of bulimia and not purging) but within the limit of normalcy and overweight no significant alteration in the insulin-glucose handling (HOMA) can be appreci- ated. Controls, however, showed deeper correlations for these parameters in the absence of both overweight and bulimia, which suggests that other factors may help pro- tect the nonpurging women from the unbalancing of glycemia/insulinemia.

The differential degrees of interaction between psy- chopathology (both eating and general) and hormonal functioning, when considering purging and nonpurging women, suggest that both disorders have not only pheno- typical and symptomatological differences, but also may have some differential underlying biological functioning.

Psychopathology, and indirectly degree of severity in ED, and reproductive steroid hormones may interact and reinforce each other. This finding is in concordance with previous studies where sex hormones not only played a role in brain development but were also associ- ated with general psychopathology and mental disorders [65, 66] .

In sum, the data presented show that correlations of selected eating and general psychopathological symp-

toms with BMI in nonpurging and the CBG and SHBG correlations in purging may eventually result in possible markers of this aspect of the disorder. The application of this approach may provide additional clues for under- standing the pathogenesis and development of eating dis- eases. The recommendation for long-term control of liv- er function in purging women is also a conclusion that can be drawn from this study.

Metabolic correlates, therefore, provide a physiologi- cal substrate to the psychological findings and may help unravel the mechanisms that define these behavioral traits despite the interference of variability, personality factors and complexity of the task.

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Table 1

Parameter	ED nonpurging	ED purging	CG	Statistical significance			
				C-ED	C-NP	C-P	P-NP
EDI-2 test							
Drive for thinness	15.4±1.2 (18)	16.06±1.02 (33)	2.70±1.31 (10)	***	***	***	
Body dissatisfaction	18.2±1.8 (18)	17.82±1.43 (33)	7.7±3.5 (10)	***	**	**	
Interoceptive awareness	13.9±1.5 (18)	13.12±1.19 (33)	2.10±0.64 (10)	***	***	***	
Bulimia	5.39±1.36 (18)	8.70±0.99 (33)	0.50±0.34 (10)	***	*	***	
Interpersonal distrust	7.78±1.48 (18)	5.06±0.96 (33)	2.00±0.75 (10)	*	**		
Ineffectiveness	12.72±1.95 (18)	11.33±1.13 (33)	3.50±1.05 (10)	***	**	***	
Maturity fears	9.56±1.27 (18)	7.76±0.93 (33)	3.70±1.36 (10)	**	**	*	
Perfectionism	7.22±1.16 (18)	5.70±0.74 (33)	2.00±0.92 (10)	**	**	*	
Impulse regulation	8.33±1.76 (18)	7.91±1.34 (33)	0.30±0.21 (10)	**	**	**	
Ascetism	8.72±0.98 (18)	8.18±0.76 (33)	3.10±0.59 (10)	***	***	***	
Social insecurity	8.78±1.46 (18)	7.48±0.79 (33)	3.40±0.95 (10)	**	*	*	
EDI total	116±11 (18)	109±8 (33)	31.0±6.9 (10)	***	***	***	
SCL-90-R test							
GSI	1.96±0.20 (18)	2.06±0.12 (31)	0.56±0.12 (10)	***	***	***	
Positive symptom index	69±4 (18)	72±2 (31)	33.4±5.69 (10)	***	***	***	
Positive symptom distress index	2.48±0.16 (18)	2.54±0.09 (31)	1.46±0.10 (10)	***	***	***	

Table 2

Parameter	Units	ED nonpurging	ED purging	CG	Statistical significance			
					C-ED	C-NP	C-P	P-NP
Estrone	pM	0.24±0.02 (19)	0.25±0.03 (34)	0.35±0.07 (18)				
Estrone sulfate	nM	6.02±0.63 (18)	6.74±0.78 (33)	8.80±0.90 (17)	*	*		
β-estradiol	pM	0.27±0.04 (20)	0.47±0.10 (34)	0.45±0.06 (18)		*		
Estriol[a]	pM	0.06±0.03 (3/16)	0.01±0.01 (4/*30*)	0.01±0.00 (2/*16*)				
Cortisone	nM	56.8±4.4 (20)	56.1±2.6 (33)	66.3±5.0 (17)	*			
Cortisol	nM	325±30 (20)	282±19 (33)	275±32 (17)				
Deoxycortisol	pM	5.41±2.92 (16/3)	2.84±0.65 (23/11)	3.90±1.30 (8/*8*)				
Androstenedione	pM	9.62±1.51 (11/*8*)	4.88±0.43 (19/15)	3.69±0.69 (10/*7*)	*	**		***
DHEA-sulfate	μM	6.37±0.66 (21)	4.80±0.44 (35)	5.56±0.37 (17)				*
Testosterone[a]	pM	<0.6 (0/*21*)	<0.6 (0/*35*)	1.82 (1/*17*)				
17OH-progesterone[a]	pM	<6.0 (0/*21*)	11.3±2.7 (5/*29*)	19.5±7.6 (2/*16*)				
Progesterone	pM	17.7±6.2 (4/*15*)	23.0±5.5 (15/*19*)	25.9±5.5 (8/*10*)				
Pregnenolone[a]	pM	26.4±7.0 (6/*13*)	62.2±26.8 (7/*27*)	14.6 (1/*17*)				
SHBG	nM	46.2±5.8 (21)	56.0±5.2 (35)	39.0±4.1 (18)			*	
CBG	nM	1,202±66 (21)	1,181±49 (35)	1,083±39 (18)				

Table 3

	Acronym	ED nonpurging (n = 24–26)		ED purging (n = 33–36)		Controls (n = 17–18)	
		+correlation	–correlation	+correlation	–correlation	+correlation	–correlation
Drive for thinness	DT				pregnenolone (9)	*BMI* deoxycortisol (8) body fat	estrone-sulfate
Body dissatisfaction	BD	*BMI* *body weight* body fat		uric acid	aldosterone (19)	BMI deoxycortisol (8)	cortisol cortisone
Interoceptive awareness	IA		*AspT*	CBG urea	SHBG		
Bulimia	B	*BMI* *body weight* *AlaT* *body fat* *insulin* *HOMA*		CBG	*SHBG*	deoxycortisol (8)	
Interpersonal distrust	ID	deoxycortisol pregnenolone	*AspT* cortisol	deoxycortisol AspT			
Ineffectiveness	I	*free fatty acids* deoxycortisol	*AspT*	*CBG* glucose HOMA *AspT* AlaT	SHBG	HOMA	
Maturity fears	MF				SHBG height	glucose HOMA plasma-proteins	
Perfectionism	P	albumin		*AspT* LDH		BMI body fat	
Impulse regulation	IR	deoxycortisol progesterone (8) *free fatty acids*	*AspT*		*SHBG*	uric acid CBG deoxycortisol (8)	
Ascetism	A	deoxycortisol androstenedione free fatty acids		CBG	SHBG albumin		
Social insecurity	SI	deoxycortisol *free fatty acids*	AspT	deoxycortisol	SHBG	glucose HOMA	
EDI-2 total scores	EDI	urea plasma proteins albumin	*AspT*	CBG	SHBG	glucose bilirubin	
SCL-90-R GSI	GSI	total protein albumin urea	AspT	CBG	SHBG	glucose bilirubin	-