The factor structure of the metabolic syndrome in obese individuals with binge eating disorder

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ABSTRACT

Objective: Metabolic syndrome (MetS) is strongly linked with cardiovascular disease and type-II diabetes, but there has been debate over which metabolic measures constitute MetS. Obese individuals with binge eating disorder (BED) are one of the high risk populations for developing MetS due to their excess weight and maladaptive eating patterns, yet, the clustering patterns of metabolic measures have not been examined in this patient group.
Methods: 347 adults (71.8% women) were recruited for treatment studies for obese individuals with BED. We used the VARCLUS procedure in the Statistical Analysis System (SAS) to investigate the clustering pattern of metabolic risk measures.
Results: The analysis yielded four factors: obesity (body-mass-index [BMI] and waist circumference), lipids (HDL and triglycerides), blood pressure (systolic and diastolic blood pressure), and glucose regulation (fasting serum glucose and Hb1Ac). The four factors accounted for 84% of the total variances, and variances explained by each factor were not substantially different. There was no inter-correlation between the four factors. Subgroup analyses by sex and by race (Caucasian vs. African American) yielded the same four-factor structure.
Conclusion: The factor structure of MetS in obese individuals with BED is not different from those found in normative population studies. This factor structure may be applicable to the diverse population.

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Introduction

Metabolic syndrome (MetS) is a clustering of metabolic risk factors, including central adiposity, high blood pressure, low level of high-density-cholesterol (HDL), elevated level of triglyceride, and high fasting glucose level [1]. Clear evidence suggests that these metabolic risk factors are associated with both cardiovascular disease and type-II diabetes [2,3], and contribute to a growing health care cost in the U.S. [4]. Obesity, as defined by body-mass-index (BMI) > 30, is a strong risk factor for MetS. While the prevalence of MetS in the U.S. adult population is approximately 24% [5], the rates of MetS are roughly 50% in obese women and 60% in obese men [6].

Binge eating disorder (BED) is defined by recurrent excessive food intake with feeling loss of control in the absence of inappropriate compensatory weight-control behaviors [7]. BED has been strongly associated with the severity of obesity [8,9]. Obese binge eaters engage in maladaptive eating behaviors and patterns that may place them at greater risk for MetS, compared with non-binge eating obese individuals. For example, a gorging eating pattern has been linked with more liver fat and elevated lipids in severely obese men and women [10]. Eating meals irregularly [11] and meal skipping [12] have also been associated with

MetS. A longitudinal study indeed demonstrated that binge eaters were at greater risk for newly diagnosis of MetS components, compared with non-binge eaters [13]. Therefore, obese individuals with BED have been highlighted as an important subgroup with elevated risk for MetS [9].

Currently, there are several different definitions of MetS, which consist of similar metabolic risk factors. However, depending on the definitions, the prevalence of MetS varies even within samples, and the discrepancy could be substantial for some subgroups [14], highlighting the need for a unified MetS definition that reflects underlying pathophysiological mechanisms across different populations. Factor analysis has been used to identify a clustering pattern of metabolic risk factors that may represent the underlying pathophysiological processes. There has been some consensus on the three- to four-factor structure, with insulin and glucose measures, blood lipid measures, blood pressure measures, and obesity measures (BMI and waist/hip circumferences) each clustering together [15–24]. Different patterns of clustering of metabolic risk factors, however, have been found in those with dysregulated metabolic function, such as type-II diabetes [25,26]. Given that abnormal eating patterns appear to have unique impact on the metabolic function, obese individuals with BED may also show a distinctive factor structure of MetS.

Most studies have used principal component analysis (PCA) as a factor extraction method. However, the use of PCA has been criticized for its exploratory and subjective nature, especially the secondary

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application of rotation methods [15,16,24]. To extract independent, interpretable solutions, previous studies primarily applied orthogonal rotation (e.g., varimax), which forces factors to be statistically un-correlated. This may be particularly questionable given MetS is often thought to represent a single disease construct with related risk components [15]. Further, even after orthogonal rotation is applied, there is often overlapping of factor loading [17–20], precluding clear interpretation of the identified factor structure. Woolston et al. [16] recently suggested an application of the VARCLUS procedure in the Statistical Analysis System (SAS) (release 9.3, 2002–2010, SAS Institute, Cary, NC) [27] as an alternative method of factor extraction. The VARCLUS is a type of oblique component analysis, and aims to identify one-dimensional clusters of mutually correlated variables [16]. The study applied different factor extraction methods to the same data, and demonstrated that without increasing the complexity of the statistical procedure, the VARCLUS procedure produced non-overlapping factor components, which is a simpler model to interpret than the results of PCA with an oblique rotation where a few metabolic risk measures loaded on more than one factor.

To our knowledge, the factor analysis of metabolic risk factors in obese individuals with BED has not been studied. This is important to evaluate whether currently available definitions of MetS are suitable in diagnosis of metabolic abnormalities in obese individuals with BED. In addition, the relationships among factor components and contribution of each metabolic risk factor are also valuable to understand risk for MetS that is specific to this population. These research questions have significant clinical implications as they may inform ways to develop targeted screening and prevention strategies for cardiovascular diseases and type-II diabetes. Therefore, the present study aimed to explore the factor structure of MetS in obese individuals with BED who participated in treatment studies for BED, using the VARCLUS procedure.

Methods

Participants

Participants were 347 adults (249 women, 98 men; mean age = 46.4 ± 10.7 years old) who were interested in participating in treatment studies for obese individuals with BED. All participants were obese (BMI $\geq 30 \, \text{kg/m}^2$), and met or exceeded the BED criteria based on DSM-5. We used the duration criterion of 6 months from DSM-IV-TR (APA) because it is more stringent than the 3-month duration criterion of DSM-5. Exclusion criteria were: current anti-depressant therapy, severe psychiatric problems (lifetime bipolar disorders and schizophrenia, and current substance dependence), severe medical problems (e.g., cardiac and liver diseases), and uncontrolled hypertension, thyroid conditions, or diabetes. Ethnic composition of the sample was 62.4% Caucasian, 23.4% African American, 8.7% Hispanic, and 5.5% others. 94.8% of the sample reported that they completed high school education or greater. Written informed consent was obtained from all participants and the research protocol was approved by the Yale Human Investigation Committee for the Protection of Human Subjects Involved in Research.

Assessment and measures

Features of eating disorders

The Eating Disorder Examination (EDE) [28] interview assesses eating disorders and their features. The EDE focuses on the frequency of different forms of overeating in the past 28 days, including objective bulimic episodes (OBE; i.e., binge eating defined as unusually large quantities of food coupled with a subjective sense of loss of control), which corresponds to the DSM-based definition of binge eating. The EDE also comprises four subscales: Restraint, Eating Concern, Shape Concern, and Weight Concern. The items assessing these four scales are rated on a 7-point scale (0–6 range), with higher scores reflecting greater severity or frequency. An EDE global score was calculated as

the mean of the four scales. The EDE interview is a well-established measure [29] with good inter-rater and test–retest reliability in studies with BED [30].

Metabolic measures

Participants' weights were measured using a high-capacity digital scale. Height, waist circumference, heart rate, and blood pressure were measured by trained research staff. Fasting lipid profile (total cholesterol, HDL cholesterol, LDL cholesterol, and triglycerides), glucose levels, and glycated hemoglobin 1Ac (HbA1c) were obtained through serum samples and were analyzed by Quest Diagnostics (Madison, New Jersey).

Statistical analysis

We used the VARCLUS procedure in the Statistical Analysis System (SAS) (release 9.3, 2002–2010, SAS Institute, Cary, NC) [27]. The following metabolic risk factors were included: BMI, waist circum-ference, systolic and diastolic blood pressure, HDL cholesterol, triglycerides, fasting serum glucose levels, and HbA1c. To correct skewness and kurtosis, triglycerides, fasting glucose levels, and HbA1c were log-transformed. The VARCLUS procedure attempts to divide a set of variables into non-overlapping clusters (i.e., no variable loads on more than one factor) by identifying the first principle component, and then iteratively splits them into two separate clusters to maximize the sum across clusters of the variance accounted for by the cluster components [27]. Each variable is assigned to a cluster component with which it has the higher squared correlation. In the VARCLUS, the quality of each cluster is measured by the ratio between R^2 of the variables when regressed on the remaining variables in the cluster to which it is assigned (R^2own), and R^2 of the variable when regressed on any other cluster produced in the analysis (R^2nearest). A variable has a strong fit to the cluster which is assigned when it has high R^2own and low R^2nearest values, which results in a low R^2 ratio (i.e., $[1 - R^2\text{own}] / [1 - R^2\text{nearest}]$). Given the exploratory nature of this study, following Woolston et al. [16], we did not specify the number of clusters to extract (i.e., MAXCLUSTERS) or the proportion of variance explained by each cluster (i.e., PROPORTION). SAS also uses a maximum eigenvalue >1 by default to identify latent clusters. We again did not specify eigenvalue as it is the most commonly used threshold to determine the sufficiency of a single underlying factor dimension [31]. To explore the relationship between the features of BED and identified clusters, correlation coefficients between the cluster component scores and eating and weight-related characteristics were also calculated. Furthermore, the factor structure or the patterns of factor loadings could differ by sex and race [24,32]. Therefore, in addition, we completed the VARCLUS procedure separately for men and women, and for non-Hispanic Caucasian and African American. Except for comparison between races, the analyses included all participants.

Table 1
Eating/weight-related characteristics

	Mean (SD)
BED developmental variables	
Age of first time overweight	19.3 (11.1)
Age of binge eating onset	25.4 (13.0)
Age of dieting onset	22.8 (10.3)
Features of eating disorders	
Binge eating frequency (episodes in the past 28 days)	18.9 (14.9)
EDE global	2.60 (0.9)
EDE restraint	1.70 (1.3)
EDE eating concern	2.06 (1.3)
EDE shape concern	3.52 (1.2)
EDE weight concern	3.14 (1.1)

Notes. EDE = Eating Disorder Examination.