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REVIEW

Medical comorbidity of binge eating disorder

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Abstract
Purpose To gain further understanding of the general medical comorbidity of binge eating disorder (BED) beyond its association with obesity.
Method We reviewed studies of general medical comorbidity in people with BED or clinically significant binge eating behavior beyond obesity. We also reviewed studies of BED in specific medical conditions.
Results Three broad study categories of medical comorbidity in BED were found: cross-sectional studies of medical conditions in BED; prospective studies of medical conditions in BED; and studies of BED in specific medical conditions. Cross-sectional epidemiologic data suggest that BED is associated with medical conditions related to obesity, including diabetes, hypertension, dyslipidemias, sleep problems/disorders, and pain conditions, and that BED may be related to these conditions independent of obesity and co-occurring psychiatric disorders. Prospective data suggest that BED may be associated with type 2 diabetes and metabolic syndrome. BED or binge eating behavior is also associated with asthma and gastrointestinal symptoms and disorders, and among women, menstrual dysfunction, pregnancy complications, intracranial hypertension, and polycystic ovary syndrome.
Conclusions BED is associated with substantial medical comorbidity beyond obesity. Further study of the general medical comorbidity of BED and its relationship to obesity and co-occurring psychiatric disorders is greatly needed.

Keywords Binge eating · Medical comorbidity · Obesity · Diabetes · Metabolic syndrome

Introduction

Binge eating disorder (BED) is a newly recognized eating disorder characterized by recurrent, distressing episodes of binge eating without the inappropriate compensatory behaviors of bulimia nervosa (BN) (e.g., self-induced vomiting or laxative abuse) [1]. BED is more common than other eating disorders, with an estimated worldwide lifetime prevalence of 1.9 % [2, 3]. It is associated with psychiatric comorbidity, psychological distress, reduced quality of life, and functional impairment.

In addition to substantial psychiatric and psychological morbidity, growing research indicates that BED, as well as binge eating behavior in general, is also associated with obesity [2, 3]. Moreover, a growing number of prospective studies show that BED or binge eating behavior is associated with the development of obesity [4–6]. Finally, BED appears to be associated with greater health dissatisfaction [7], increased health service utilization and costs [8–11], and enhanced mortality [12].

Less is known, however, about the specific medical conditions associated with BED beyond obesity, and the relationship of these medical conditions to co-occurring obesity and psychiatric disorders. Moreover, while there

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are a number of authoritative reviews on the medical conditions associated with BN and AN [13–15], there have only been a few reviews of the medical comorbidity of BED [16–18].

In light of the increasing awareness of BED, we reviewed studies of the medical comorbidity of BED, focusing on medical conditions beyond obesity. We also attempted to assess the contribution of obesity and psychiatric comorbidity to the general medical morbidity of BED.

Methods

We searched PubMed and the Cochrane Library for all English-, Spanish-, and French-language articles published from database inception through March 2016 using the key terms binge eating and medical comorbidity, which revealed 216 articles. We evaluated only studies of BED or potential variants of BED, including non-purging BN and/or clinically significant binge eating behavior. We did not include studies of anorexia nervosa (AN), BN, or EDNOS unless rates of BED or clinically significant binge eating behavior were specified. We also evaluated only studies that assessed general medical conditions beyond obesity. From the 216 articles, 17 were appropriate for review. Based on these articles, we then conducted searches of the term binge eating disorder with the specific medical terms diabetes, cardiovascular, heart disease, metabolic syndrome, gastrointestinal, arthritis, asthma, and narcolepsy, which yielded 54 more suitable reports. The search was supplemented with a manual review of the reference lists of relevant articles.

Results

We found three broad categories of studies: cross-sectional studies of medical conditions in BED; prospective studies of medical conditions in BED; and studies of BED in specific medical conditions. These studies are summarized in Tables 1, 2, 3 and described below.

Cross-sectional studies of medical conditions in BED

In epidemiological samples, BED was associated with diabetes, hypertension, arthritis, chronic back/neck pain, other pain disorders (including chronic headaches and fibromyalgia), gastrointestinal conditions (gastrointestinal symptoms, ulcer, and irritable bowel syndrome), sleep problems, and asthma [3, 19–25]. Among women, BED was also associated with early menarche, menstrual dysfunction, delivery of higher birth weight babies, and long duration of the first and second stages of labor [23, 26–28]. Associations of BED with fibromyalgia, pain, irritable bowel syndrome, gastrointestinal symptoms, sleep problems, and early menarche persisted after controlling for obesity or body mass index (BMI) [20, 22, 25, 28]. Associations of BED with diabetes, hypertension, chronic back/neck pain, chronic headaches, other chronic pain, and asthma, but not with arthritis or ulcer persisted after controlling for psychiatric comorbidity [3, 19, 21, 24].

Several studies explored the temporal relationship between onset of BED and onset of co-occurring medical conditions. For example, in the World Health Organization (WHO), World Mental Health Surveys, over 24,000 respondents from 14 countries were evaluated with the WHO Composite International Diagnostic Interview and a checklist assessing 15 lifetime chronic physical conditions [3]. Survival analysis found temporally primary BED predicted subsequent arthritis, chronic back/neck pain, chronic headaches, other chronic pain, diabetes, hypertension, and ulcer. In addition, reciprocal survival models found generally insignificant associations between temporally primary physical conditions and subsequent onset of BED. In subsequent analyses of data from the WHO World Mental health Surveys, temporally primary BED was associated with the development of diabetes [21], hypertension [24], and adult-onset asthma [19]. These findings remained significant when analyses were adjusted for lifetime mental disorder comorbidity.

Two epidemiology studies found BED was not associated with subsequent heart attack and stroke [3] or with heart disease [23]. In another epidemiologic sample, binge eating behavior was not associated with heart disease [7]. In addition, BED was not associated with cancer or renal disease [23].

At least four studies evaluated diabetes in groups of patients with BED [23, 29–31] with rates ranging from 2 % [29] to 26 % [31]. Studies with non-BED comparison groups found higher [23, 30] or comparable [31] rates of diabetes in the BED group.

A number of studies assessed metabolic syndrome (or metabolic syndrome components) in groups of patients with BED, with rates of metabolic syndrome ranging from 24 % [32] to 60 % [33]. Some rates may be falsely low, as several studies excluded patients with medical conditions, including hypertension or diabetes [32, 34–36]. Three studies found metabolic syndrome to be more common in men with BED than women with BED [33, 37, 38], but this was not found in two other studies [29, 36]. Succurro et al. [39] compared obese patients with and without BED and found that BED patients had higher hemoglobin A1C and fasting insulin levels, lower HDL levels, and greater inflammatory markers. However, BED patients had a higher BMI than non-BED patients. In a study of 2225

Table 1 Cross-sectional studies of medical conditions in individuals with BED

Study	Participants	Design	Findings
Johnson et al. [23]	4651 female patients (age 18–99 years) from 8 primary care and 7 obstetric gynecology clinics in the US	Participants evaluated with the Patient Health Questionnaire and General Health Survey	Patients with BED were significantly more likely than patients without EDs to have diabetes (6 vs. 2.7 %; OR = 1.3, CI 1.3–4.0). BED also associated with increased prevalence of limb or joint pain, headaches, gastrointestinal problems, menstrual problems, shortness of breath, and chest pain. BED not associated with prevalence of arthritis, cancer, hypertension, or with cardiac, hepatic, pulmonary, or renal disease
Bulik et al. [7]	166 Caucasian female twins who were obese without BE ($N = 107$) or obese with BE ($N = 59$)	Participants evaluated with a symptom checklist	BE not associated with hypertension, visual impairment, asthma/respiratory illness, DM, cardiac problems, osteoarthritis, or any major medical disorder. However, BE group had higher prevalence for all 6 individual conditions ($P = .015$)
Reichborn-Kjennerud et al. [28]	8045 same-sex and opposite-sex twins, aged 19–31 years	Participants assessed with questionnaire which included health characteristics	Among women, BED associated with early menarche, sleep problems, and IBS. Early menarche and sleep problems remained after controlling for BMI. Among males, BED associated with neck–shoulder pain, low back pain, and chronic muscular pain; all associations remained after controlling for BMI
Takimoto et al. [76]	23 patients with non-purging BN, 63 with BN, 78 with AN, and 52 healthy women	Electrocardiograms of patients were compared to those of healthy women	QT interval and QT dispersion were significantly longer in all ED subtypes than in the control group
Guerdjikova et al. [29]	44 obese males with BED and 44 age- and race-matched obese females with BED seeking obesity treatment	Participants' charts evaluated for type 2 DM and MetS by NCEP ATP III criteria	2 % had type 2 DM and 32 % had MetS; males and females had similar rate of MetS
Javaras et al. [22]	285 participants with lifetime BED, 54 with subthreshold BED, and 849 without BED or subthreshold BED; all participants recruited from the community	Participants evaluated with SCID-IV, which included sections for IBS, fibromyalgia, CFS, and migraine	For full BED, rates of IBS, fibromyalgia, CFS, and migraine were 20.4, 8.8, 2.8, and 9.1 %. For subthreshold BED, rates were 18.5, 5.6, 0, and 2.8 %. For no BED, rates were 8.2, 1.6, 0.6, and 9.1 %. Results were unaffected when BMI was adjusted for
Lourenço et al. [42]	128 children and adolescents seeking treatment for obesity with (39.1 %) or without (60.9 %) BE, defined as BES scores ≥18	Participants assessed for blood pressure, and glucose, insulin, and lipid profiles	Participants with BE had similar HOMA-IR, insulin, glucose, TGs, HDL, LDL, VLDL, and systolic and diastolic blood pressure to those without BE
Roehrig et al. [33]	93 obese individuals with BED recruited by advertisement for treatment studies of BED	Evaluation of MetS by NCEP ATP III	56 (60 %) met criteria for MetS
Cremonini et al. [20]	4096 community residents	Participants completed a self-report questionnaire measuring gastrointestinal symptoms	After adjusting for BMI, age, gender, race, diabetes, SES, and physical activity level, BED (present in 6 % of sample) was significantly associated with acid regurgitation, heart burn, dysphagia, bloating, upper abdominal pain, diarrhea, urgency, constipation, and feeling of anal blockage
Barnes et al. [38]	81 consecutive treatment-seeking obese patients with BED	Patients assessed for MetS by NCEP ATP III criteria	43 % met criteria for MetS. MetS was more common in men (66 %) than women (35 %) ($P = .01$)

Table 1 continued

Study	Participants	Design	Findings
Webb et al. [31]	154 consecutive patients with obesity and BED and 334 obese patients without BED seeking bariatric surgery	Patients assessed with the QWEP and for type 2 DM	26 % of BED patients and 30 % of non-BED patients had type 2 DM
Blomquist et al. [36]	148 consecutive treatment-seeking obese men and women with BED	Patients assessed for MetS by NCEP criteria ATP III	Patients with MetS (44 %) did not differ from those without MetS on demographic or disordered eating variables, but did have later age of onset and shorter duration of BED
Trace et al. [25]	Population-based sample of 3790 female Swedish twins	Participants assessed with a questionnaire about sleep habits and problems	Lifetime BE was significantly associated with not getting enough sleep, sleeping poorly, problems falling asleep, feeling sleepy during work or free time, and disturbed sleep. Though also associated with obesity, the associations between BE and sleep remained after accounting for obesity
Higgins et al. [30]	45,477 overweight or obese veterans; 78 % with clinically significant BE (≥2 BE episodes/week)	Participants evaluated with a survey that assessed psychiatric and medical comorbidities	Prevalence of BE was higher among veterans with type 2 DM, hypertension, CAD, hyperlipidemia, and arthritis/joint pain
Kessler et al. [3]	24,124 community respondents (age 18 and older) from 14 mostly upper middle and high income countries	Respondents assessed with WHO Composite International Diagnostic Interview and a checklist for 15 lifetime a chronic conditions based on the US National Health Interview Survey	Compared to respondents with no eating disorder, lifetime BED significantly associated with higher BMI, higher rates of obesity (41.7 vs. 15.8 %) in the past 12 months, and higher rates of class III obesity (7.6 vs. 1.3 %) in the past 12 months. Odds ratios predicted subsequent onset of arthritis, chronic back/neck pain, chronic headaches, other chronic pain, diabetes, hypertension, and ulcer. Findings were similar for BN, except BN was associated with subsequent heart attack and stroke, while BED was not
Santonicola et al. [43]	128 bariatric surgery candidates and 100 healthy controls	Participants administered questionnaires on FGIDs and the DSM-IV SCID	The prevalence of FGIDs was similar in those with obesity and healthy controls. Obese patients with BE had a higher prevalence postprandial distress syndrome
Algars et al. [26]	11,503 Swedish female twins	Patients evaluated for amenorrhea and lifetime oligomenorrhea	BE, but not BED, was significantly associated with amenorrhea and lifetime oligomenorrhea after controlling for compensatory behaviors, BMI, PCOS, and age. Numerically greater proportion of women with BED reported amenorrhea (17 %) or oligomenorrhea (51 %) than women without BED
Alonso et al. [19]	52,095 community respondents; 1860 with adult-onset asthma	Assessment of self-reported physician diagnosis of asthma	BED significantly associated with subsequent development of adult-onset asthma, including after adjustment for comorbid mental disorders (OR = 1.8; 95 % CI 1.2–2.9)
de Jonge et al. [21]	52,095 community respondents, 2580 with adult-onset DM	Assessment of self-reported physician diagnosis of DM	BED significantly associated with subsequent development of DM, including after adjustment for comorbid mental disorders
Stein et al. [24]	52,095 community respondents	Assessment of self-reported physician diagnosis of hypertension	BED significantly associated with subsequent development of hypertension, including after adjustment for comorbid mental disorders (OR = 2.6; 95 % CI 1.7, 4.0)

Table 1 continued

Study	Participants	Design	Findings
Lelli et al. [44]	32 patients with BED, 33 patients with BN, and 43 patients with AN	Measure of liver function levels	In BED patients, AST and ALT levels directly associated with BMI
Linna et al. [27]	2257 female patients with EDs; 52 with BED	Review of register-based information on pregnancy, obstetric, and perinatal health	Women with BED had babies with higher birth weight. Maternal BED was associated with hypertension and long duration of first and second stages of labor
Udo et al. [37]	347 adults with BED and obesity	Evaluation of MetS by NCEP ATP III criteria	39 % met criteria for MetS
Barber et al. [32]	102 adults participating in a weight loss study; 38 % had DSM-5 BED	Evaluation of MetS by NCEP ATP III criteria	24 % of BED patients and 34 % of non-BED patients had MetS
Lelli et al. [79]	40 ED patients (13 with BED, 13 with BN, and 14 with AN) and 23 healthy women	Participants evaluated with conventional transthoracic two-dimensional echocardiography	BED patients showed a significantly lower LvEDV, stroke volume, and cardiac output compared with normal controls. After normalization for body surface area, BED patients had significantly lower LvEDV and LvESV than controls, AN patients, and BN patients
Mitchell et al. [40]	2225 bariatric surgery candidates; 350 with BED	Patients evaluated with the QEWP and for 15 medical comorbidities	After adjusting for age, sex, education, and BMI, BED status was independently associated with impaired glucose levels, high triglycerides, and urinary incontinence
Succurro et al. [39]	115 obese patients, 30 with BED	Patients evaluated for BED with the BES and for metabolic and inflammatory variables	Compared with non-BED patients, BED patients had higher BMI, waist circumference, fat mass, A1C, fasting insulin, insulin resistance, uric acid, ESR, CRP, and WBC counts; and lower HDL. All differences remained significant after adjusting for BMI
Rosenbaum et al. [41]	484 women veteran primary care patients	BED assessed with the Patient Health Questionnaire; Medical conditions obtained from medical record review	Compared with non-BED women, women with BED (7.4 %) had higher rates of chronic pain (86 vs. 77 %), lipid disorders (56 vs. 43.5 %), hypertension (50 vs. 42 %), and sleep disorders (42 vs. 22 %)

ATP III adult Treatment Panel III, *ALT* alanine aminotransferase, *AST* aspartate aminotransferase, *BE* binge eating behavior, *BED* binge eating disorder, *BES* Binge Eating Scale, *BMI* body mass index, *CAD* coronary heart disease, *CFS* chronic fatigue syndrome, *CI* confidence interval, *CRP* C-reactive protein, *DM* diabetes, *ED* eating disorder, *ESR* erythrocyte sedimentation rate, *A1c* glycoslytated hemoglobin, *FGIDs* functional gastrointestinal disorders, *HOMA-IR* homeostasis model assessment-insulin resistance, *HDL* high-density lipoprotein cholesterol, *IBS* irritable bowel syndrome, *LDL* low density lipoprotein cholesterol, *LvEDV* left ventricular end-diastolic volume, *LvESV* left ventricular end-systolic volume, *MetS* metabolic syndrome, *NCEP* national cholesterol education program, *OR* odds ratio, *PCOS* polycystic ovary syndrome, *QWEP* questionnaire on eating and weight patterns, *SCID-IV* structured clinical interview for DSM-IV, *SES* socioeconomic status, *SF-20* medical outcomes study short-form general health survey, *TGs* triglycerides, *VLDL* very low-density lipoprotein cholesterol, *WBC* white blood cell, *WHO* world health organization

Table 2 Prospective studies of medical conditions in BED

Study	Participants	Design	Findings
Hudson et al. [47]	134 people with BED and 134 with no ED history from the community	Individuals with and without BED evaluated at 2.5 and 5 years for development of 3 components of MetS: dyslipidemia, hypertension, and diabetes	Controlling for age, sex, baseline BMI, and interval BMI changes, hazard ratios (95 % CI) for new MetS components were: 2.2 (1.2, 4.2; $P = .023$) for dyslipidemia, 1.6 (.77, 3.9; $P = .29$) for type 2 DM, 1.5 (.76, 2.9; $P = .33$) for hypertension, 1.7 (1.1, 2.6; $P = .023$) for any component, and 2.4 (1.1, 5.7; $P = .038$) for ≥ 2 components
Tanofsky-Kraff et al. [48]	180 children at risk for adult obesity, aged 5–12 years	Children completed a questionnaire for BE at baseline and had MetS components measured at baseline and 5-year follow up	Baseline self-reported BE was associated with a 5.33 greater odds of MetS at follow up (CI 1.47–19.27, $P = 0.01$)
Raevuori et al. [88]	2342 Finnish patients with EDs treated over 16 years (171 with BED) and 9368 matched general population controls	EDs (including BED) diagnosed by ICD-10	Before treatment, 15 % of patients with BED had type 2 DM vs. 2 % of controls. At study end, 34 % of BED patients vs. 4 % controls had type 2 DM. 41 % of female patients with BED developed type 2 DM vs. 54.5 % of male patients

BED binge eating disorder, *BMI* body mass index, *BN* bulimia nervosa, *CI* confidence interval, *ED* eating disorder, *ICD-10* international classification of disease, 10th revision, *OR* odds ratio, *PD* purging disorder, *MetS* metabolic syndrome

bariatric surgery candidates, after adjusting for age, sex, education, and BMI, BED was associated with impaired glucose and triglyceride levels [40]. Similarly, Rosenbaum et al. [41] found women veteran primary care patients with BED had higher rates of lipid disorders and hypertension than those without BED. In contrast, in a study of 128 children seeking obesity treatment, those with clinically significant binge eating had similar glucose and lipid levels and systolic and diastolic blood pressures to those without binge eating [42]. In addition, Barber et al. [32] found comparable rates of MetS among overweight or obese patients with and without DSM-5 BED. Of note, the factor structure of metabolic syndrome in obese individuals with BED was similar to those in normative population studies [37].

Two studies assessed gastrointestinal disorders in patients with BED. In a comparison of 100 bariatric surgery candidates with 100 healthy controls evaluated for functional gastrointestinal disorders (FGIDs) according to Rome III criteria and for binge eating behavior, the prevalence of FGIDs was the same in the two groups [43]. However, patients who also had binge eating behavior had elevated rates of postprandial distress syndrome. In a study of liver function tests in a group of patients with eating disorders, levels of aspartate aminotransferase and alanine aminotransferase were directly associated with BMI in those with BED [44]. Of note, gastric dilation with or without rupture has been described in patients with BN and those with AN [45, 46]. However, we were unable to find a description of gastric dilation in an individual with clearly documented BED.

Prospective studies of medical conditions of BED

We found three prospective studies of medical conditions beyond obesity in individuals with BED (summarized in Table 2). In one study, overweight or obese adults with BED were more likely than those without BED to receive new diagnoses of dyslipidemia, hypertension, or diabetes over a 5-year period [47]. Individuals with BED were statistically significantly more likely to receive a new diagnosis of dyslipidemia, at least one of these diagnoses, as well as two or more of these diagnoses. As analyses were adjusted for baseline BMI and interval BMI change, the authors concluded that BED may confer a risk of the development of components of the metabolic syndrome over and above the risk attributable to obesity alone.

In a study of 180 children aged 5–12 years at risk for adult obesity conducted from 1996 to 2010, the presence of self-reported binge eating was associated with a 5.33 greater odds of metabolic syndrome at follow up [48]. In a recent Finnish study of 2342 eating disorder patients followed for 16 years and 9368 matched community controls [49], a substantially increased risk of type 2 diabetes was reported among individuals with BED at treatment onset. By the end of the study, every third BED patient had type 2 diabetes, and the risk was even higher in males. In contrast, 4.4 % of those with BN had type 2 diabetes.

Studies of BED in medical samples

We found 28 studies evaluating BED or binge eating behavior in groups of patients with a particular medical

Table 3 Studies of BED in specific medical conditions

Study	Participants	Design	Findings
Kenardy et al. [56]	50 newly diagnosed patients with type 2 DM and 50 matched controls	Patients and controls assessed with the QEWP	14 % of patients with type 2 DM had BE compared with 4 % of participants without type 2 DM ($P < .10$), but there was no difference in rate of BED between those with and without type 2 DM (6 % vs. 0)
Herpertz et al. [64]	663 patients with DM (341 type 1 and 322 type 2), age range 18–65 years	Patients evaluated with EDI and SIAB	Lifetime DSM-IV BED present in 2.6–3.5 % of type 1 patients and 5.9–8.1 % of type 2 patients. 89 % of type 2 patients developed ED before DM compared with 30 % of type 1 DM patients
Takii et al. [67]	33 female patients (ages 16–36 years) with type 1 DM and BE (11 had BED and 22 had BN) and 32 controls with DM but no ED	Patients with BED compared to those with BN and a control group	Patients with BED had a significantly higher BMI and A1C levels than controls. Patients with BN had earlier age of onset of DM and poorer glycemic control (higher A1C levels) than patients with BED. Poorer glycemic control was associated with insulin omission
Herpertz et al. [54]	322 patients with type 2 DM	Patients evaluated with the SIAB	6 % had lifetime BED vs. 2 % with lifetime BN
Crow et al. [52]	43 patients with type 2 DM	Patients assessed with SCID-IV	26 % of patients met criteria for DSM-IV BED
Kenardy et al. [55]	215 women with type 2 DM	Patients evaluated with the EDE	21 % reported regular BE and 13.5 % had DSM-IV BED. BE predicted blood glucose control after controlling for BMI and exercise level
Mannucci et al. [58]	156 overweight or obese patients with type 2 DM, 192 obese non-diabetic patients, and 48 obese individuals	Participants evaluated with the EDE	Prevalence of BED was <5 % in all 3 samples
Bankier et al. [73]	100 patients with stable coronary heart disease	Patients evaluated with the SCID-IV	10 % had current BED
Colton et al. [62]	101 girls with type 1 DM, ages 9–14 years, and 303 age-matched, female non-diabetic controls	Case–controlled study; participants evaluated with EDE	Binge eating was more common in diabetic girls (3 %) than controls (.3 %, $P = 0.05$)
Kotagal et al. [57]	31 children with narcolepsy	Retrospective chart review	16 % had a history of BE
Papelbaum et al. [60]	70 patients with type 2 DM	Patients evaluated with the SCID-IV and BES	10 % had BED and 10 % had other EDs
Meneghini et al. [59]	140 patients with type 2 DM	Patients assessed with the QEWP and BES	40 % had abnormal eating, defined as ≥1 positive answers on the QEWP. Patients with BE had a higher BMI and higher A1C than those without BE. BES scores were significantly positively correlated with A1C ($P = .021$), BMI, ($P = .001$) and diastolic blood pressure ($P = .018$)
Allison et al. [50]	845 patients with type 2 DM	Patients evaluated with the EDE-Q for screening and the EDE for diagnostic confirmation.	1.4 % had BED by EDE, though 7 EDE-Q positive patients not assessed
Hollinrake et al. [84]	103 women with PCOS	Patients were assessed with the PRIME-MD PHQ	13 % of PCOS patients had BED compared with 2 % of controls ($P < .01$)
Dahmen et al. [71]	116 patients with narcolepsy (95 % also with cataplexy) and 80 controls	Participants evaluated with the SIAB to diagnosis EDs over past 3 months	3, 5, and 2 % of narcoleptic patients had BED, BN, binge subtype, or BN compared with 1, 1, and 0 % of controls. 13 % of narcoleptic patients and 18 % of controls had "any hyperphagic diagnosis." EDs not more common in narcoleptics than controls
Fortuyn et al. [69]	30 patients with narcolepsy without cataplexy and 15 patients with narcolepsy and cataplexy from tertiary sleep centers, 120 healthy controls, and 32 BMI-matched controls	Case–control study of eating symptoms and disorders using the SCAN 2.1	25 % of patients reported BE ≥2 times per week compared with none of controls. Significant increase in BE persisted among narcolepsy patients when compared to BMI-matched controls

Table 3 continued

Study	Participants	Design	Findings
Gorin et al. [53]	5145 overweight or obese adults with type 2 DM	BE in the past 6 months without any compensating behaviors assessed with a self-report questionnaire based on the QEWP	12 % of patients had BE; only 2 % met DSM-IV criteria for BED
Smith et al. [66]	40 females age 11–19 years with Type I DM, 76 with scoliosis, and 76 controls	Participants evaluated with the EDE-Q	27.5 % of diabetes group had BED (12.5 %) or BN (15 %) compared with 10.5 % of controls (5 % with BED and 5 % with BN) ($P = .05$). No scoliosis patient had BED or BN
Takii et al. [65]	109 female patients with type 1 diabetes and an ED	Patients evaluated with the DSM-IV SCID	26 % had BED, 64 % had BN, and 6 % had AN. Duration of insulin omission was significantly associated with retinopathy and nephropathy
Fan et al. [83]	400 patients with PD receiving anti-parkinsonian drugs	Patients assessed with self-report screening questionnaire for ICD behaviors	0.3 % had BE
Dimitrova et al. [70]	45 participants with narcolepsy (15 also with cataplexy) and 32 controls	Participants evaluated with the BES	Participants with narcolepsy and cataplexy had higher BES scores than controls and those with narcolepsy alone; 23 % had moderate to severe binge eating compared with none of the controls and 3 % of those with narcolepsy alone
The TODAY study group [61]	678 youth with type 2 DM participating in a clinical trial	Participants classified as non-overeaters, overeaters, subclinical binge eaters, or clinical binge eaters based on their response to the YEDE-Q	6 % were clinical binge eaters and 20 % were subclinical binge eaters. Youth with clinical and subclinical BE had more obesity, global ED and depressive symptoms, and impaired quality of life
D'Emden et al. [63]	124 adolescents with type 1 DM	Participants evaluated with YEDE-Q and EDI-3RC	BE was the most common disturbed eating behavior, present in 17 % of participants
Passananti et al. [72]	100 patients with celiac disease and 100 healthy controls	Participants evaluated with the BES	Percentage of pathological BES scores was similar in patients (6 %) and controls (0 %)
Senna et al. [80]	131 patients with fibromyalgia	Patients evaluated with the EDE	Obese patients had higher rates of binge days (9.5 %) than non-obese patients (6.8 %, $P = .005$)
Celik et al. [51]	152 patients with type 2 DM	Patients evaluated with the DSM-IV SCID	5 % of patients had DSM-IV BED. Patients with and without BED had similar A1C levels
Kolstad et al. [82]	706 pregnant women with epilepsy and 106,511 pregnant women without epilepsy	Participants evaluated for DSM-IV EDs	Pregnant women with epilepsy were significantly more likely to have BED (6.5 %) than pregnant women without epilepsy (4.7 %), $P < .05$
Raggi et al. [81]	33 patients with idiopathic intracranial hypertension	DSM-5 diagnosis of BED	15 % of patients had BED and obesity

A1C hemoglobin A1C, *AN* anorexia nervosa, *BE* binge eating behavior, *BED* binge eating disorder, *BES* binge eating scale, *BN* bulimia nervosa, *BMI* body mass index, *CIDI 2* composite international diagnostic interview, *DM* diabetes mellitus, *ED* eating disorder, *EDE* eating disorders examination, *EDE-Q* eating disorder examination-questionnaire, *EDI* eating disorder inventory, *FGID* functional gastrointestinal disorders, *ICD* impulse control disorder, *ICD-10* international classification of disease 10th revision, *PCOS* polycystic ovary syndrome, *PD* parkinson's disease, *PRIME-MD-PHQ* primary care evaluation of mental disorders patient health questionnaire, *QEWP* questionnaire on eating and weight patterns, *SCID* structured clinical interview, *SIAB* structured interview for anorexic and bulimic disorders, *WHO* world health organization, *YEDE-Q* youth eating disorder examination questionnaire

disorder (see Table 3). We review these studies below according to medical disorder.

Diabetes

We found 12 studies that evaluated BED or binge eating behavior in patients with type 2 diabetes [50–61], with rates of BED by DSM-IV criteria ranging from 1.4 % [50] to 26 % [52]. In the two studies that employed healthy control groups, there were no differences in BED prevalence rates between diabetes patients and controls [56, 58], but one study found a higher rate of binge eating behavior among diabetic patients than controls [56]. Five studies evaluated BED or binge eating behavior in patients with type 1 diabetes [62–66] with rates of binge eating behavior ranging from 3 % [62] to 17 % [63]. In the only study that had a control group, 12.5 % of females with type 1 diabetes had DSM-IV BED compared with 5.3 % of control females [66]. In a study that compared type 1 diabetic patients with and without BED, BED patients had a higher BMI and greater HgA1C levels [67].

Sleep problems/disorders

Questionnaire data from 72,435 women found that BED symptoms were associated with sleep problems during the first 18 weeks of pregnancy and greater dissatisfaction with sleep 18 months after childbirth [68].

High rates of binge eating have also been found in individuals with narcolepsy [57, 69]. One study found higher rates of binge eating in people with narcolepsy and cataplexy than narcolepsy alone [70]. However, in a study of 116 patients with narcolepsy and 80 controls, eating disorders, including BED, were not more common in patients with narcolepsy [71].

Gastrointestinal disorders

One study assessed eating psychopathology in 100 adults with newly diagnosed celiac disease and 100 controls and found the two groups had similar rates of clinically significant binge eating behavior (defined as a Binge Eating Scale score $\geq$17) [72]. However, these results are limited by the fact that people with eating disorder diagnoses were specifically excluded from participation.

Heart/cardiovascular disease

Bankier et al. [73] found that 10 % of a sample of patients with stable coronary heart disease had current BED. Interestingly, two studies have found reductions in high-frequency heart rate variability in response to mental stress (a marker of reduced cardiac parasympathetic activity) in obese people with BED as compared to similarly obese people without BED [74, 75]. Another study found non-purging BN to be associated with longer QT intervals and increased QT dispersion [76]. Decreases in high-frequency heart rate variability are associated with an increased risk of coronary heart disease [77], while prolonged QT interval dispersion is predictors of cardiovascular mortality [78]. Finally, in an echocardiography study of 40 eating disorder patients, BED patients had lower left ventricular end-diastolic stroke volume (LvEDV) and cardiac output compared with normal controls [79]. After normalization for body surface area, BED patients had significantly lower LvEDV and left ventricular end-systolic volume than controls, AN patients, and BN patients.

Pain

In a study of 131 patients with fibromyalgia, obese patients had more binge days than non-obese patients [80].

Neurological disease

Raggi et al. [81] found that 15 % of 33 patients with idiopathic intracranial hypertension had BED and obesity [81]. In a large epidemiological sample, Kolstad et al. [82] found that pregnant women with epilepsy had a significantly higher rate of BED compared with pregnant women without epilepsy (6.5 vs. 4.7 %, respectively). In contrast, in a study of 400 patients with Parkinson's disease, only 3 % had binge eating behavior [83].

Endocrine disease (other than diabetes)

Hollinrake et al. [84] evaluated 103 women with polycystic ovary syndrome, and found 13 % had BED compared with 2 % of controls.

Treatment of medical comorbidity in BED

We found no randomized-controlled treatment trials of patients with BED with medical comorbidity beyond obesity. Of note, in a double-blind, randomized trial in BED, chromium picolinate at two different doses (600 mcg and 900 mcg/day) significantly reduced fasting glucose without significantly reducing binge eating frequency or body weight [85].

Discussion

Growing research suggests BED is associated with a range of medical conditions in addition to obesity (see Table 4). Many of these conditions are related to obesity, including

Table 4 Main medical comorbidities of BED (beyond obesity)

Type 2 diabetes	Asthma
Hypertension	Menstrual dysfunction (women)
Dyslipidemias	Pregnancy complications (women)
Sleep problems/disorders	Intracranial hypertension
Pain conditions	Polycystic ovary syndrome (women)
Functional gastrointestinal symptoms/disorders	

type 2 diabetes, hypertension, and dyslipidemia [86]. Several studies suggest that BED or BE behavior may increase the risk of these conditions, and of metabolic syndrome, above that of obesity or psychiatric comorbidity, but this needs further study. BED or binge eating behavior may also be associated with asthma, gastrointestinal symptoms and disorders (especially functional disorders), sleep disorders and problems, pain disorders, and among women, menstrual dysfunction, pregnancy complications, intracranial hypertension, and polycystic ovary syndrome.

Though preliminary, these findings indicate patients with BED should receive comprehensive medical evaluations with particular focus on diabetes, hypertension, dyslipidemias, pain, sleep disorders, functional gastrointestinal disorders, and asthma. Women should additionally receive evaluation of reproductive function and for polycystic ovary syndrome. Conversely, patients with diabetes, hypertension, dyslipidemias, pain, and sleep disturbances should be evaluated for binge eating behavior despite their BMI, since BED could be an independent risk factor for some of these medical conditions.

The major limitation of this review is the paucity of epidemiologic and prospective studies of medical conditions in persons with BED. Also, the majority of studies of BED used DSM-IV criteria [87], and it is unknown if their findings would generalize to BED as defined by DSM-5 criteria. Another limitation is that most studies did not evaluate the relationship of medical comorbidity in BED with obesity, co-occurring psychiatric disorders, or degree of psychological distress. Thus, though BED is associated with substantial medical comorbidity, it remains unknown if this is due to BED itself, obesity, and/or the associated psychiatric comorbidity of BED. In addition, due to the lack of prospective studies, the chronological relationship of BED with its comorbid medical disorders is largely unknown. Yet, another limitation is the paucity of studies exploring the treatment of medical disorders in persons with BED. It is, therefore, unknown if diabetes, hypertension, dyslipidemias, pain, or sleep disturbances need to be differentially managed in individuals with BED. It is also unknown to what degree successful treatment of BED symptomatology is associated with resolution of medical comorbidity.

Further studies of medical comorbidity in BED are greatly needed. These include prospective studies of development of medical conditions in persons with BED, and the relationship of these conditions to eating disorder psychopathology, other forms of co-occurring psychopathology, and to baseline weight, weight change, and other measures of adiposity. A major priority for future research is to conduct longitudinal studies to determine if the development of BED predicts subsequent obesity-related conditions independent of the development of obesity. It is unknown whether BED affects treatment response of comorbid medical conditions, including diabetes, hypertension, or dyslipidemia. Conversely, the effects of BED in response to treatments for dyslipidemia, hypertension, diabetes, and pain are largely unknown. Prospective, randomized-controlled trials of treatment of medical comorbidities in persons with BED are, therefore, also needed.

Compliance with ethical standards

Funding This study received no funding.

Conflict of interest Drs. Olguin, Fuentes and Gabler have no conflicts of interest to disclose. Dr. McElroy is a consultant to or member of the scientific advisory boards of Bracket, F. Hoffmann-La Roche Ltd., MedAvante, Myriad, Naurex, Novo Nordisk, Shire, and Sunovion. She is a principal or co-investigator on studies sponsored by the Alkermes, Forest, Marriott Foundation, National Institute of Mental Health, Naurex, Orexigen Therapeutics, Inc., Shire, Sunovion, and Takeda Pharmaceutical Company Ltd. She is also an inventor on United States Patent No. 6,323,236 B2, Use of Sulfamate Derivatives for Treating Impulse Control Disorders, and along with the patent's assignee, the University of Cincinnati, Cincinnati, Ohio, has received payments from Johnson & Johnson, which has exclusive rights under the patent. Dr. Keck is employed by the University of Cincinnati College of Medicine and the University of Cincinnati Physicians. Dr. Keck is presently or has been in the past year a principal or co-investigator on research studies sponsored by: Cephalon, Marriott Foundation, National Institute of Mental Health (NIMH), Shire. Dr. Keck has been reimbursed for consulting to: 2014: Shire, Supernus, Otsuka, ProPhase, Merck. Dr. Paul E. Keck, Jr. is a co-inventor on United States Patent No. 6,387,956: Shapira NA, Goldsmith TD, Keck, PE Jr. (University of Cincinnati) Methods of treating obsessive–compulsive spectrum disorder comprises the step of

administering an effective amount of tramadol to an individual. Filed March 25, 1999; approved May 14, 2002. Dr. Keck has received no financial gain from this patent. Dr. Guerdjikova is employed by the University of Cincinnati College of Medicine and is a consultant for Bracket.
This is a review article. No animals were involved.
This is a review article. To the best of our knowledge, all procedures performed in studies described in the review, involving human participants, were in accordance with the ethical standards of the institutional and/or national research committee and with the 1964 Helsinki declaration and its later amendments or comparable ethical standards.

Ethical approval This article does not contain any studies with human participants or animals performed by any of the authors.

Informed consent Informed consent was obtained from all participants.

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