

REVIEW ARTICLE

The Overlap Between Binge Eating Behaviors and Polycystic Ovarian Syndrome: An Etiological Integrative Model

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Abstract: Studies indicate that Polycystic Ovarian Syndrome (PCOS) features (*e.g.* insulin instability, food cravings, overproduction of androgens and menstrual irregularities) are associated with increased appetite, impaired impulse control and feelings of body dissatisfaction. Counter intuitively, binge eating behaviors have been shown to reinforce PCOS symptomatology, precipitating concurrently body dissatisfaction, weight gain, insulin instability and overproduction of androgens. The present systematic literature review aspires to investigate the relationship between binge eating, in the broader context of eating disorder behaviors, and Polycystic Ovarian Syndrome (PCOS), taking into account shared characteristics between EDs (Eating Disorders) and PCOS. To address this aim, the PRISMA guidelines are adopted. A total of 21 studies, which investigated the presence of binge eating in PCOS population and the presence of PCOS in EDs population, were synthesized. Findings suggested that an increased prevalence of binge eating has been reported in women with Polycystic Ovarian Syndrome (PCOS); and that women suffering from BN (Bulimia Nervosa) and BED (Binge Eating Disorder) are more likely to display polycystic ovaries. Further research on their shared liability is required in order to inform more efficient prevention and treatment initiatives for populations presenting with comorbid features.

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1. INTRODUCTION

Binge eating is characterized by consuming an excessively large amount of food in a short period of time and experiencing a loss of control when these episodes occur. Binge eating constitutes a shared feature among various eating disorders (EDs) diagnoses, including Binge Eating Disorder (BED), Bulimia Nervosa (BN) and Otherwise not Specified Feeding and Eating Disorders (OSFED) [1-2]. Binge eating has been envisaged as a debilitating [3] and a continuously expanding pathological behavior, with an estimated prevalence of 4.5% in women and 2.5% in men over the life course [4-6]. Interestingly, although individuals binge eating manifestations can be of normal weight, they are more likely to be overweight, and at a proportion of about 30% obese [7, 8].

On the other hand, polycystic ovary syndrome (PCOS) is considered a rather common endocrine condition in women, being interwoven with high levels of androgens (the testosterone level may be greater than 150 ng/dL and the DHEA-S level may be above 800 mcg/dL) [9] and ovulatory dysfunctions. Specifically, more than 18% of women appears to be affected by PCOS, presenting concurrently with higher insulin resistance [10], and a greater risk of being overweight and obese compared with healthy controls (BMI >30 RR 2.77; 95% CI 1.88 to 4.10) [11]. The Rotterdam and AE-PCOS Society criteria recognize at least 3 unique clinical phenotypes: (1) Frank PCOS (oligomenorrhea, hyperandrogenism, and PCO), (2) Ovulatory PCOS (hyperandrogenism, PCO, and regular menstrual cycles), and (3) Non-PCO PCOS (oligomenorrhea, hyperandrogenism, and normal ovaries) [12].

Women with PCOS are more likely to have a diagnosis of diabetes (odds ratio [OR], 4.35; 95% confidence interval [CI], 3.63-5.21), dyslipidemia (OR, 3.56; 95% CI, 3.04-4.19), dysmetabolic

syndrome (OR, 23.46; 95% CI, 13.64-40.36), glucose intolerance (OR, 5.46; 95% CI, 3.10-9.60), hypertension (OR, 2.76; 95% CI, 2.41-3.18), obesity (OR, 5.79; 95% CI, 5.07-6.62), infertility (OR, 23.42; 95% CI, 10.63-51.61), obstructive sleep apnea (OR, 6.47; 95% CI, 3.62-11.55), anxiety (OR, 1.76; 95% CI, 1.53-2.04), bipolar disorders (OR, 1.94; 95% CI, 1.55-2.44), and depression (OR, 2.22; 95% CI, 1.94-2.54) than did controls [13].

Several studies examined eating disorder behaviors among women with PCOS. Not surprisingly, findings revealed a higher prevalence of PCOS in patients with eating disorders [14, 15], especially for disordered eating and bulimia nervosa [16-18]. Nevertheless, relevant research presents inconsistent with some studies reporting insignificant findings [19]. In addition, an increased prevalence of depression and anxiety has been associated with PCOS compared to healthy controls [20, 21]. This appears important, given the contribution of negative emotions as a key predictor of binge eating behaviors [22, 23]. Furthermore, binge eating has been positively associated with hyperandrogenism (bulimia sufferers had higher serum levels of free testosterone than age-matched controls (6.0 ± 0.7 vs. 3.9 ± 0.8 pmol/l; p = 0.03) [22, 24] and amenorrhea, which have both been in turn linked with PCOS related dysfunctions [25].

Despite the comorbidity between binge eating and PCOS being acknowledged by relevant findings, the extant literature appears (to the best of the authors knowledge) insufficient considering the interpretation of their association (*e.g.* direction of causality, bi-directional links). Hence, this review aspires to shed light on the co-existence of binge eating behaviors and PCOS. To achieve this goal (*e.g.* to summarize and expand the available evidence regarding the inter-relationship between binge eating and PCOS, taking into consideration the shared factors between the two conditions), the present work adopts an integrative theoretical conceptualization that embraces principles from metabolic, hormonal and psychological models (which have never before been combined, so as to provide a more holistic spectrum of understanding the interrelation between

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binge eating and PCOS presentations). In the context of this hybrid theoretical framework, the current literature review aims to: 1.) critically review the studies that have assessed the overlap between these two conditions; 2.) illustrate/ identify the strongest etiological links between PCOS and binge eating behaviors, through the lenses of metabolic, hormonal and psychological factors shared between the two conditions and 3.) integrate and synthesize the available findings to inform a more comprehensive etiological model explaining the overlap between PCOS and binge eating behaviors, that could in turn pave future avenues for more targeted and effective research and clinical efforts in the field.

1.1. Conceptual Framework

In the present study, the relationship between binge eating and PCOS is investigated using an integrative approach that blends three different factors: metabolic, hormonal and psychological. Specifically, metabolic factors analyze the role of insulin; hormonal factors focus on the level of androgens and menstrual irregularities; psychological factors are related to the feeling of body dissatisfaction and negative emotions. Usually these factors have been investigated separately, but the purpose of this review was to combine them for the first time in order to create the lens through which the current review approaches the empirical research of PCOS and binge eating.

In accordance with metabolic factors, women with PCOS have greater insulin resistance and a greater risk of being overweight compared with healthy controls [11]. Similarity, binge eating has been shown to predict excess weight, obesity onset and insulin imbalance [26].

In accordance with hormonal factors, both binge eating and PCOS are positively associated with hyperandrogenism (bulimia sufferers showed higher serum levels of free testosterone than age-matched controls (6.0 ± 0.7 vs. 3.9 ± 0.8 pmol/l; $P= 0.03$)) [24] and amenorrhea [25], with hyperandrogenism implicated within the pathogenesis of anovulation and menstrual irregularities [27]. In spite of this, the role of circulating testosterone concentrations in the etiology of binge eating behaviors and PCOS has yet to be fully elucidated [28].

In accordance with psychological factors, research showed an increased prevalence of depression and anxiety associated with PCOS compared with controls [21], and it is known that negative emotions are a key predictor of binge eating [23].

It is interesting to note that weight loss has been identified as a key treatment for PCOS, even though, PCOS women seem to be prone to develop a binge eating behaviors, which can be exacerbated by dieting.

Since there is an inadequate understanding of why binge eating and PCOS seems to exist simultaneously, this review aims to hypothesize a possible answer approaching this topic analyzing the shared metabolic, hormonal and psychological factors between PCOS and binge eating. For the purpose of this review, these three components have been considered complementary in exacerbating both PCOS and binge eating and they have been combined in a new theoretical model, which attempts to explain the simultaneously presence of these two conditions.

2. METHOD

In order to investigate the relationship between binge eating, in the broader context of eating disorder behaviors, and Polycystic Ovarian Syndrome (PCOS), the PRISMA guidelines have been adopted [29]. A computer research has been conducted on ScienceDirect, PubMed, Google Scholar, Uta Library, University of Melbourne Library, and the following identifying terms were applied to detect relevant sources: Polycystic Ovarian Syndrome Eating, Binge Eating Disorders, Bulimia Nervosa Polycystic, Anorexia Polycystic, BED Polycystic, binge eating PCOS, binge eating poly-

cystic. All searches were limited to full text, peer reviewed articles, available in English, published between 1991 and 2016, which involved human participants. Studies have been selected in accordance with the following inclusion criteria (see relevant guidelines for identification and screening; [1, 12]): (i) studying PCOS in ED population, (ii) studying EDs/disordered eating in PCOS population, (iii) contain empirical data, (iv) following the criteria of diagnosing PCOS (presenting polycystic ovaries, Rotterdam Criteria). Rotterdam Criteria proposed that a PCOS diagnosis has to contain at least two of the following three criteria: oligo- and/or anovulation, clinical and/or biochemical hyperandrogenism, and polycystic ovaries on ultrasound [12]. A total of 21 studies were deemed eligible for this review on the basis of concurrently addressing all the above criteria.

3. RESULT

Tables 1 and 2 provide a summary of the 21 studies reviewed in this paper, including demographic information and the major findings reported in each study.

Results revealed that PCOS is associated with a higher number of psychological symptoms, including depression, anxiety, body image dissatisfaction, eating and sexual disorders, and low life satisfaction [30-34]. In line with this, women with PCOS are known to have disturbed appetite regulation [35], which has been therefore argued to explain their increased risk of developing binge eating behaviors [36].

The frequent observation of PCOS features, such as obesity, menstrual imbalance, hyperandrogenism and anovulation, in populations with binge eating behaviors [14] suggests a potential relationship between binge eating and PCOS. In that context, studies that have focused on the co-existence of binge eating and PCOS are presented in Table 1, while studies that have focused on the presence of PCOS in EDs population are presented in Table 2.

Considering Table 1, a total of 14 studies have assessed eating behaviors in PCOS populations, highlighting an increased incidence of binge eating among women with PCOS [19]. Specifically, approximately 50% of women with PCOS seem to struggle with binge and comfort eating manifestations, compared to 32% of controls [37]; with a survey of 60 women with PCOS resulting to a binge eating prevalence of 23% [38]. In consensus with the above, 30% to 50% of women with PCOS appear prone to display overeating, emotional eating, eating without feeling of hunger and/or EDs [39, 40]. In addition, women with PCOS appear more likely to have hyperinsulinemia and to obtain higher scores on the Binge Eating Scale (BES), which however tend to improve with a controlled diet [41, 42]. Nevertheless, one study did not confirm the mutual presence of the two conditions, concluding that scores for dieting and overall ED symptoms in the polycystic ovary group were not significantly higher than those for women with normal ovaries [19].

Counter intuitively, when examining the presence of PCOS symptomatology in EDs population, 7 studies revealed an increased incidence of polycystic ovaries among women with EDs (Table 2), with approximately 30% of the ED samples inclining to display PCOS related dysfunctions [15, 43-44]. In line with this, further studies have shown that bulimic women have higher relevant dysfunction scores among PCOS subjects; Jahanfar (2005) showed that women with subclinical bulimia had significantly higher BMI and acne compared to the normal eating group, along with amenorrhea, anovulation and polycystic ovaries [45].

McCluskey (1992) concluded that 76% of bulimic women (based on the study sample, $N=34$) presented with polycystic or multifollicular ovaries [46]. On that basis, one could argue that a significant proportion of the extant literature advocates the overlap between EDs and PCOS (especially binge eating related behaviors) [39, 47-49]. However, a clearer understanding about the interrelation between the two conditions (PCOS and binge eating) is

Table 1. Prevalence of PCOS in Eating Disorder populations.

Study	Sample size	ED's type	Criteria of diagnosis	Prevalence rate of PCOS in EDs (%)	Phenotype
Jahanfar <i>et al.</i> , 2005	154	SEB	Clinical, biochemical and ultrasound tools for PCOS; BITE questionnaire	8 on the total sample	Oligomenorrhea, PCO
Morgan <i>et al.</i> , 2002	8	BN	Ultrasonography; PCOS Rotterdam criteria; DMS IV for BN.	75 of the sample had PCOS	PCO
Naessen <i>et al.</i> , 2007	21 BN 17 controls	BN	PCOS Rotterdam criteria-revised; PSR scale for BN.	28.5 in BN 0 in controls	Oligomenorrhea, hyperandrogenism, PCO
Naessen <i>et al.</i> , 2006	46 BN 31 EDNOS 59 controls	BN EDNOS	DIAB; PCOS Rotterdam criteria-revised; Transvaginal ultrasound.	30.7 in BN/EDNOS 8.5 in controls	Oligomenorrhea, hyperandrogenism
Pinhas-Hamiel <i>et al.</i> , 2006	11 AN+PCOS 14 AN 13 PCOS	AN	DSM-IV for AN; PCOS Rotterdam criteria-revised; Pelvic sonogram.	28.9 on the total sample	Oligomenorrhea, PCO
Resch <i>et al.</i> , 2004	6 BN 8 subclin BN 22 EDNOS 22 controls	BN EDNOS	BITE; PCOS Rotterdam criteria-revised.	30.5 in BN/EDNOS 0 in controls	Oligomenorrhea, PCO
McCluskey <i>et al.</i> , 1992	34 BN	BN	DSM-III-R for BN; Pelvic ultrasound.	76% of the total	PCO

Note. Note. Psychiatric Status Scale (PSR); Subclinical Eating Behavior (SEB); Diagnostic Interview for Anorexia and Bulimia (DIAB); Structured Clinical Interview for DSM (SCID); Bulimia investigation test (Edinburgh) (BITE); Polycystic Ovaries (PCO).

Table 2. Prevalence of Eating Disorders in PCOS populations.

Study	Sample size	ED's type	Criteria of diagnosis	Prevalence rate of EDs in PCOS (%)	Phenotype
Annagur <i>et al.</i> , 2015	88 PCOS women	BED	PCOS Rotterdam criteria; SCID.	6.8 on the total sample	Oligomenorrhea, hyperandrogenism, PCO
Batcheller <i>et al.</i> , 2013	6 obese PCOS 5 lean PCOS 10 control	BED	PCOS Rotterdam criteria; SCID.	50% subclinical BED for obese PCOS 0 for lean PCOS 0 for controls	Obesity, oligomenorrhea, hyperandrogenism, PCO
Berenson <i>et al.</i> , 2014	24 overweight and obese with PCOS	BED	PCOS Questionnaire; BES.	50 of the participants had moderate/severe BED	Obesity, oligomenorrhea, hyperandrogenism, PCO
Barry <i>et al.</i> , 2011	24 women with PCOS 299 healthy control women 47 with possibly undiagnosed PCOS 92 men	Subclinical EDs	MACL; HSC-7; Eating behavior assessed by asking (a) kind of diet and (b) to classifying eating behavior in: healthy eating, unhealthy, binge and/or comfort eating, or 'other'.	58% of the PCOS group reported binge and/or comfort eating compared to 32% of control women	Oligomenorrhea, hyperandrogenism, PCO

(Table 2) Contd....

Study	Sample size	ED's type	Criteria of diagnosis	Prevalence rate of EDs in PCOS (%)	Phenotype
Jahanfar <i>et al.</i> , 1995	52 normal ovaries 42 PCOS	BN	Transabdominal ultrasound examination; BITE.	73 of PCOS women had abnormal BITE	PCO
Jensterle <i>et al.</i> , 2014	36 obese PCOS	Subclinical EDs	TFEQ-R18.	High scoring in Three-Factor Eating Questionnaire (TFEQ-R18) in all the sample (37 PCOS women)	Obesity, PCO, oligomenorrhea, hyperandrogenism
Kerchner <i>et al.</i> , 2009	60 PCOS women	BED	PCOS Rotterdam criteria; Polycystic Ovary Syndrome Survey; PHQ; BDI-II; BAI.	23.3% on the total sample	PCO, oligomenorrhea, hyperandrogenism
Larsson <i>et al.</i> , 2015	72 PCOS women 30 controls	Eating behavior	PCOS Rotterdam criteria; TFEQ-R21; EAT; DMS V Questionnaire.	EAT > 29: 8% PCOS women 3% controls EAT	Weight gain, PCO, oligomenorrhea, hyperandrogenism
McCluskey <i>et al.</i> , 1991	153 PCOS women 109 women with endocrinopathy	BN	BITE.	6% of PCOS women 1% of endocrinopathic women	PCO, oligomenorrhea, hyperandrogenism
Michelmores <i>et al.</i> , 2001	74 PCOS women 150 controls	Eating behavior	EDE; transabdominal ultrasound scan.	Binge eating: 4% in PCOS 4% in controls; Overeating: 27% in PCOS 28% in controls	PCO, oligomenorrhea, hyperandrogenism
Morgan <i>et al.</i> , 2008	80 PCOS women	EDs	SCID; EDE; RSES; SAS -M; GHQ.	12.6% BN; 22.5% EDNOS; 1.3% AN	Hyperandrogenism, oligomenorrhea
Sbaragli <i>et al.</i> , 2008	81 infertile couples (5 with PCOS) 70 fertile controls	BED	SCID.	18 % in infertile couple (15% in PCOS subgroup); 0% controls	Infertility, PCO, oligomenorrhea
Wylie <i>et al.</i> , 2009	131 PCOS women	Eating Behavior	EMA.	Significantly more sweet snacks compared to savoury snacks	PCO, oligomenorrhea, hyperandrogenism
Barr <i>et al.</i> , 2011	210 PCOS women (53% obese)	Eating behavior	EMA.	Fat consumption was significantly higher in women with PCOS; Mean dietary GI (54.6) was substantially higher in PCOS obese than PCOS lean women.	Oligomenorrhea, hyperandrogenism, infertility

Note. Psychiatric Status Scale (PSR); Diagnostic Interview for Anorexia and Bulimia (DIAB); Structured Clinical Interview for DSM (SCID); Binge Eating Scale (BES); The UWIST Mood Adjective Check List (MACL); The Hypoglycemia Symptom Checklist-7 items (HSC-7); Bulimia investigation test (Edinburgh) (BITE); Three-Factor Eating Questionnaire (TFEQ); Eating Attitudes Test (EAT); Patient Health Questionnaire (PHQ); Beck Depression Inventory-II (BDI-II); Beck Anxiety Inventory (BAI); Eating disorder examination (EDE); Rosenberg's Self Esteem Scale (RSES); Modified Social Adjustment Scale (SAS-M); General Health Questionnaire (GHQ); Polycystic Ovaries (PCO).

recommended to inform future research and clinical work in the field.

4. DISCUSSION

4.1. An Etiological Link Between PCOS and Binge Eating Behavior

Research reviewed here, has revealed that, metabolic [50], hormonal [51] and psychological [52] factors are relevant to both binge eating and PCOS, and could therefore be implicated in the shared etiology between the two conditions.

Considering common metabolic factors, previous literature confirms that women with PCOS are more likely to suffer from insulin resistance compared to healthy women of a similar body mass index (BMI) [53]; with insulin resistance having been described as one of the “subtle symptoms” of PCOS [54]. Insulin resistance tendencies impedes body cells to be stimulated by insulin, thus constituting them unable to respond to it as effectively, that in turn precipitates blood sugar spikes [55]. Because of this, a significant proportion of women with PCOS are prone to experience increased cravings and desires to eat a particular food, usually high in carbohydrates [56]. In that context, researchers have postulated that food cravings play an important role in the development and maintenance of binge eating due to a combination of psychological and physiological effects [57, 58]. Specifically, high carbohydrate meals are responsible for boosting blood sugar levels, prompting the pancreas to produce more insulin to handle the excess glucose [59], being responsible for raising serotonin levels, which causes fluctuations considering one’s sense of wellbeing [60]. On the other hand, the subsequent abrupt drop of blood sugar and serotonin levels (after the utilization/consumption of glucose) precipitates sudden feelings of hunger and craving behaviors [61], as well as the potential return of a state of anxiety [62], by inducing brain mitochondrial and dopaminergic dysfunctions [63].

The mood state typical of insulin-resistant individuals has been described as “tense-tiredness” [36]. Accordingly, the likelihood of experiencing food cravings and mood swings is elevated among women with PCOS compared to healthy controls [64]. Moreover, given that binge eating involves the ingestion of large quantities of carbohydrate and fat food during the episodes, a vicious cycle of mutual exacerbation of cravings, insulin resistance and binge eating could be induced [65].

Considering hormonal factors, a high androgenic predisposition/ biological inclination could additionally explain the shared ground between PCOS and binge eating behaviors. Androgens are well known for accounting differences in food intake and body weight between males and females [50]. In particular, testosterone seems to be responsible for increasing food intake in males [66]. In line with this, to highlight how that appetite might be affected by hormone profile abnormalities, studies showed that testosterone replacement could increase meal frequency in male rodents [67], whereas anti-androgenic drug therapy was found to reduce meal-related hunger in women with bulimia [42].

Considering the above mentioned details, androgens in females appear to play an important role in regulating insulin: in conditions of extreme insulin resistance, such as mutations of the insulin receptor and in PCOS, high insulin levels seem to stimulate theca cells in ovaries to produce more androgens [68]. Therefore, androgen excess might contribute to insulin resistance in women with PCOS, potentially setting up a vicious cycle whereby hyperinsulinemia might promote the production of androgens, which in turn contributes to insulin resistance [69]. Due to high androgen levels being responsible for increasing appetite, in conjunction with insulin resistance and the subsequent frequent cravings, women with PCOS could be more susceptible to develop a binge eating pattern [70].

Overall, research and clinical management of PCOS have primarily been focused on the physiological consequences of the disorder [71]. However, as a result of the numerous physical and metabolic changes, women with PCOS may also be at a high risk for psychological problems, such as depression, decreased satisfaction with life and EDs [72, 73].

In that context, and considering potential significant psychological factors that could explain the PCOS and binge eating overlap, a considerable number of women with PCOS present with a psychiatric disorder during their lifetime; with preliminary work undertaken by Annagur (2015) estimating the prevalence of comorbidity between PCOS and psychiatric disorders to approach 50% (based on a clinical sample of 44 women suffering from PCOS) [74]. Similarly, other work (based on a sample of 60 women with PCOS) showed an overall prevalence rate of 40% for depression, 57% for mood disorders, 12% for anxiety syndromes and 23% for BED [35] with 60% of women with PCOS reporting painful emotions and high sense of insecurity, confusion and ambivalence, low self-esteem and anxiety. In addition, these women presented less able to tolerate frustration, often behaving impulsively [75]. In line with these, one could assume that due to common physical consequences of PCOS, such as hirsutism, acne and weight gain, females with PCOS tend to experience feelings of deviance from idealized cultural norms, which in turn influences self-esteem and cultivate feelings of body dissatisfaction [76], that could in turn precipitate and perpetuate psychopathological manifestations. Interestingly, body dissatisfaction and the feeling of shame towards the body might prompt dieting in order to improve physical appearance. Due to high levels of impulsivity in PCOS women, dieting could result in the development of a binge eating behaviors that further exacerbates feelings of shame and body dissatisfaction, increasing the attempts to lose weight with intensified dieting, which in turn worsens binge eating behaviors [77].

4.2. An Integrative Conceptual Model of Binge Eating and PCOS

As previously demonstrated, PCOS and binge eating show shared characteristics. Hence, the aim of the current paragraph is the integration of the outlined perspectives in a model that provides a novel context for the mutual relationship between PCOS and binge eating behaviors. Fig. (1) outlines this integrative model, showing the possible link between these two conditions.

Overweight and obesity may result to insulin resistance. This leads to high blood sugar levels, which in turn are addressed by increasing the pancreatic insulin production. Moreover, high levels of insulin are responsible for boosting androgen levels. Androgens promote insulin resistance and the development of cysts on ovaries, which excretes more androgens [78]. Due to the high level of androgens, women with PCOS may experience hirsutism and weight gain and subsequent feelings of body dissatisfaction. On the other hand, androgens increase appetite and impulsivity, making women with PCOS more vulnerable to experiencing cravings [66]. Cravings could further be intensified by dieting behaviors often adopted to improve body image and reduce feelings of body dissatisfaction [79]. The cycle of dieting-cravings (suggested here) promotes binge eating behaviors, which, besides reinforcing weight gain and feelings of body dissatisfaction [80], may generate insulin spikes and sudden drops that intensify insulin resistance, androgens production and PCOS symptomatology, in a cycle of mutual reinforcement (e.g. bi-directionality). These factors seem to cause an exacerbation of PCOS and binge eating at the same time, making PCOS women more susceptible to engaging and maintaining a binge eating pattern compared to their healthy counterparts. Therefore, binge eating and PCOS presentations among women appear to share similar characteristics (Table 3) that could imply/ highlight the potential overlap between the generating mechanisms of two conditions.

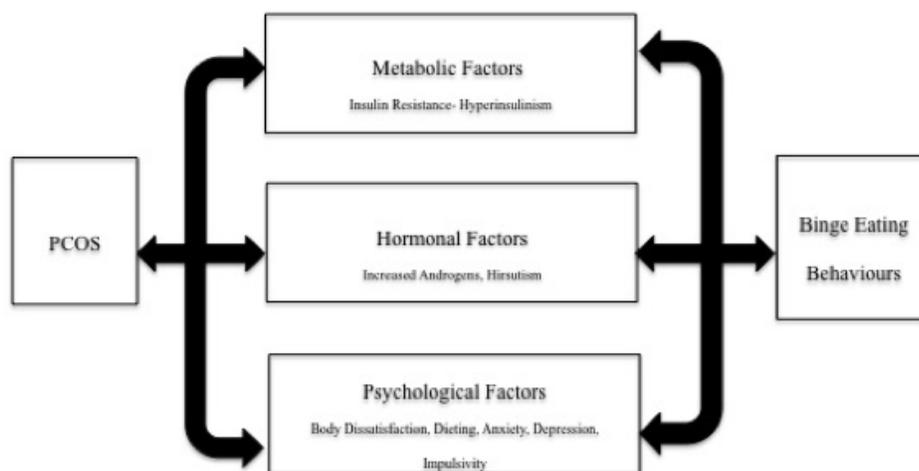


Fig. (1). An integrative model of PCOS and binge eating behavior. Potential association between PCOS and binge eating behavior.

Table 3. Shared factors between PCOS and binge eating behavior.

Shared features	Eating disorder (binge-ing-type)	PCOS
Binge eating behavior	✓	✓
Overweight and obesity	✓	✓
Menstrual imbalance	✓	✓
Hyperandrogenism	✓	✓
Anovulation and ovarian cysts	✓	✓
Hirsutism	✓	✓
Insulin resistance	✓	✓
Body dissatisfaction and negative body image	✓	✓

4.3. Treatment Implications

Provided that PCOS appears to have a significant negative impact on women's eating behaviors, especially in relation to binge eating, early and effective management of PCOS, concurrently with emerging or established eating patterns, could be deemed as necessary to improve quality of life in adolescence and adulthood [81]. For this reason, screening for mental health-related issues in patients with PCOS, as well as screening for PCOS in ED sufferers (especially those with binge eating behavior), should constitute an inherent part of the initial evaluation.

Subsequently, a proactive approach to the treatment of psychological co-morbidity should be preferred, since psychological treatments in women with PCOS are considered to have a positive effect on binge eating patterns, weight management, insulin resistance and hormonal imbalances [82, 83]. In that context, it has been suggested that the best approach combines psychological and pharmacological interventions [34], with the psychological treatments aimed at improving eating, body image and comorbid psychopathology, and the pharmacological and hormonal interventions decreasing androgen levels and reducing PCOS symptomatology [84].

For example, the endocrine disorders present in PCOS could benefit by specific strategies employing sequential or combined pharmacological treatment. Low-dose of combined oral contraceptives and antiandrogenic progestins helps to decrease androgens and regulate menstrual cycle.

Another therapeutic approach aimed to establish ovulatory cycles involves the administration of Insulin-Sensitizing Drugs (metformin) in order to reduce the hyperandrogenemia, restore of ovulatory function and increase of pregnancy rates [85, 86].

On the other hand, it should be emphasized to assess not only the clinical aspects of PCOS but also the clinical symptoms of eating disorders, anxiety or depression that could be effectively treated through psychological therapy, especially cognitive-behavioral therapy. In addition, it is a chance to address concerns that are not necessarily associated with a psychiatric condition or a psychiatric diagnosis (marital, family, social issues, low level of quality of life, sexual dysfunction, low self-esteem) that often could be PCOS associated [87].

CONCLUSION

The present PRISMA systematic literature review reinforces the notion that binge eating behaviors and PCOS should not always be considered as distinct disorders; given their shared metabolic, hormonal and psychological risk factors. Therefore, further investigations on the links between PCOS and binge eating behaviors, as well as their mechanisms of mutual reinforcement could be beneficial, leading to more effective treatment modalities for both conditions. Given the seriousness of BED symptoms in women with PCOS, further study of epidemiology, clinical features, neurobiology, disability, quality of life, and treatment in different settings and countries is needed to better understand this association.

CONSENT FOR PUBLICATION

Not applicable.

CONFLICT OF INTEREST

The authors declare no conflict of interest, financial or otherwise.

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REFERENCES

- [1] APA. Diagnostic and statistical manual of mental disorders, ed. t. ed. 2013, Arlington: American Psychiatric Publishing.
- [2] Obadina S. An overview of anorexia nervosa, bulimia and binge eating disorder. *BJSN* 2014; 9(9): 441-6.
- [3] Mitchell, J.E., Medical comorbidity and medical complications associated with binge-eating disorder. *International Journal of Eating Disorders*, 2015.
- [4] Hoek HW, Van Hoeken D. Review of the prevalence and incidence of eating disorders. *Int J Eat Disord* 2003; 34(4): 383-96.
- [5] Kessler RC, Berglund PA, Chiu WT, *et al.* The prevalence and correlates of binge eating disorder in the World Health Organization World Mental Health Surveys. *Biol Psychiatry* 2013; 73(9): 904-14.
- [6] Reslan S, Saules KK. Assessing the prevalence of and factors associated with overweight, obesity, and binge eating as a function of ethnicity. *Eat Weight Disord* 2013; 18(2): 209-19.
- [7] De Lenclave MBD, Florequin C, Bailly D. Obesity, alexithymia, psychopathological disorders and binge eating: a comparative study between 40 obese subjects and 32 controls. *Encephale* 2001; 27(4): 343-50.
- [8] Smink FR, Van Hoeken D, Hoek HW. Epidemiology of eating disorders: incidence, prevalence and mortality rates. *Curr Psychiatry Rep* 2012; 14(4): 406-14.
- [9] American College of Obstetricians and Gynecologists. Polycystic ovary syndrome. Washington, DC; 2009. ACOG practice bulletin; no. 108.
- [10] Moran LJ, Misso ML, Wild RA, Norman RJ. Impaired glucose tolerance, type 2 diabetes and metabolic syndrome in polycystic ovary syndrome: a systematic review and meta-analysis. *Hum Reprod Update* 2010; 16(4): 347-63.
- [11] Lim SS, Davies MJ, Norman RJ, Moran LJ. Overweight, obesity and central obesity in women with polycystic ovary syndrome: a systematic review and meta-analysis. *Hum Reprod Update* 2012; 18(6): 618-37.
- [12] The Rotterdam ESHRE/ASRM-sponsored PCOS consensus workshop group. Revised 2003 consensus on diagnostic criteria and long-term health risks related to polycystic ovary syndrome (PCOS). *Hum Reprod* 2004; 19(1): 41-7.
- [13] Sirmans SM, Parish RC, Blake S, Wang X. Epidemiology and comorbidities of polycystic ovary syndrome in an indigent population. *J Investig Med* 2014; 62(6): 868-74.
- [14] Morgan J, Scholtz S, Lacey H, Conway G. The prevalence of eating disorders in women with facial hirsutism: An epidemiological cohort study. *Int J Eat Disord* 2008; 41(5): 427-31.
- [15] Naessén S, Carlström K, Garoff L, Glant R, Hirschberg AL. Polycystic ovary syndrome in bulimic women - an evaluation based on the new diagnostic criteria. *Gynecol Endocrinol* 2006; 22(7): 388-94.
- [16] Hollinrake E, Abreu A, Maifeld M, Van Voorhis BJ, Dokras A. Increased risk of depressive disorders in women with polycystic ovary syndrome. *Fertil Steril* 2007; 87(6): 1369-76.
- [17] Larsson I, Hulthén L, Landén M, Pålsson E, Janson P, Stener-Victorin E. Dietary intake, resting energy expenditure, and eating behavior in women with and without polycystic ovary syndrome. *Clin Nutr* 2016; 35(1): 213-8.
- [18] McCluskey S, Evan C, Lacey JH, Pearce JM, Jacobs. Polycystic ovary syndrome and bulimia. *Fertil Steril* 1991; 55(2): 287-91.
- [19] Michelmore KF, Balen AH, Dunger DB. Polycystic ovaries and eating disorders: are they related? *Hum Reprod* 2001; 16(4): 765-9.
- [20] Dokras A, Clifton S, Futterweit W, Wild R. Increased risk for abnormal depression scores in women with polycystic ovary syndrome: a systematic review and meta-analysis. *Obstet Gynecol* 2011; 117(1): 145-52.
- [21] Dokras A, Clifton S, Futterweit W, Wild R. Increased prevalence of anxiety symptoms in women with polycystic ovary syndrome: systematic review and meta-analysis. *Fertil Steril* 2012; 97(1): 225-30 e2.
- [22] Goldfield GS, Adamo KB, Rutherford J, Legg C. Stress and the relative reinforcing value of food in female binge eaters. *Physiol Behav* 2008; 93(3): 579-87.
- [23] Mason TB, Heron KE, Braitman AL, Lewis RJ. A daily diary study of perceived social isolation, dietary restraint, and negative affect in binge eating. *Appetite* 2016; 97: 94-100.
- [24] Sundblad C, Bergman L, Eriksson E. High levels of free testosterone in women with bulimia nervosa. *Acta Psychiatr Scand* 1994; 90(5): 397-8.
- [25] Algars M, Huang L, Von Holle AF, *et al.* Binge eating and menstrual dysfunction. *J Psychosom Res* 2014; 76(1): 19-22.
- [26] Neumark-Sztainer D, Wall M, Haines J, Story M, Eisenberg ME. Why does dieting predict weight gain in adolescents? Findings from project EAT-II: a 5-year longitudinal study. *J Am Diet Assoc* 2007; 107(3): 448-55.
- [27] Van Anders, S.M. and Watson, N.V., Social neuroendocrinology : Effects of social contexts and behaviors on sex steroids in humans. *Hum Nat*, 2006. 17(2): p. 212-37.
- [28] Baker JH, Girdler SS, Bulik CM. The role of reproductive hormones in the development and maintenance of eating disorders. *Expert Rev Obstet Gynecol* 2012; 7(6): 573-83.
- [29] Moher D, Liberati A, Tetzlaff J, Altman DG; PRISMA Group. Preferred reporting items for systematic reviews and meta-analyses: the PRISMA statement. *J Clin Epidemiol* 2009; 62(10): 1006-12.
- [30] Bishop SC, Basch S, Futterweit W. Polycystic Ovary Syndrome, Depression and Affective Disorders. *Endocr Pract* 2009, 15(5): 475-82.
- [31] Farkas J, Rigo A, Demetrovics Z. Psychological aspects of the polycystic ovary syndrome. *Gynecol Endocrinol* 2014; 30(2): 95-9.
- [32] Krępuła K, Bidzińska-Speichert B, Lenarcik A, Tworowska-Bardzińska U. Psychiatric disorders related to polycystic ovary syndrome. *Endokrynol Pol* 2012; 63(6): 488-91.
- [33] Moran LJ, Ko H, Misso M, *et al.* Dietary composition in the treatment of polycystic ovary syndrome: a systematic review to inform evidence-based guidelines. *Hum Reprod Update* 2013, 19(5): 432.
- [34] Morgan JF. Bulimic eating patterns should be stabilised in polycystic ovarian syndrome. *BMJ* 1999; 318(7179): 328.
- [35] Moran L, Norman RJ. Understanding and managing disturbances in insulin metabolism and body weight in women with polycystic ovary syndrome. *Best Pract Res Clin Obstet Gynaecol* 2004, 18(5): 719-36.
- [36] Hirschberg AL, Naessén S, Stridsberg M, Byström B, Holtet J. Impaired cholecystokinin secretion and disturbed appetite regulation in women with polycystic ovary syndrome. *Gynecol Endocrinol* 2004; 19(2): 79-87.
- [37] Barry JA, Bouloux P, Hardiman PJ. The impact of eating behavior on psychological symptoms typical of reactive hypoglycemia. A pilot study comparing women with polycystic ovary syndrome to controls. *Appetite* 2011; 57(1): 73-6.
- [38] Kerchner A, Lester W, Stuart SP, Dokras A. Risk of depression and other mental health disorders in women with polycystic ovary syndrome: a longitudinal study. *Fertil Steril* 2009; 91(1): 207-12.
- [39] Batcheller AE, Ressler IB, Sroga JM, Martinez AM, Thomas MA, DiPaola KB. Binge Eating Disorder in the Infertile Polycystic Ovary Syndrome Patient. *Fertil Steril* 2013; 100(3): S413.
- [40] Wylie J, Barr S, Jeanes Y. Eating frequency and snacking habits in women with polycystic ovary syndrome. *J Hum Nutr Diet* 2009(22): 56-75.
- [41] Berenson, A., *et al.*, A Low Insulinemic Diet Improves Binge Eating and Quality-of-Life in Women with PCOS. *Journal of Womens Health* 2014; 23(4): 16.
- [42] Jensterle M, Kocjan T, Kravos NA, Pfeifer M, Janez A. Short-term intervention with liraglutide improved eating behavior in obese women with polycystic ovary syndrome. *Endocr Res* 2014; 1-6.
- [43] Naessén S, Carlström K, Byström B, Pierre Y, Hirschberg AL. Effects of an antiandrogenic oral contraceptive on appetite and eating behavior in bulimic women. *Psychoneuroendocrinology* 2007; 32(5): 548-54.
- [44] Pinhas-Hamiel O, Pilpel N, Carel C, Singer S. Clinical and laboratory characteristics of adolescents with both polycystic ovary disease and anorexia nervosa. *Fertil Steril* 2006; 85(6): 1849-51.
- [45] Resch M, Szendei G, Haasz P. Bulimia from a gynecological view: hormonal changes. *J Obstet Gynaecol* 2004; 24(8): 907-10.
- [46] Jahanfar S, Maleki H, Mosavi AR. Subclinical eating disorder, polycystic ovary syndrome- is there any connection between these two conditions through leptin- a twin study. *Med J Malaysia* 2005; 60(4): 441-6.
- [47] McCluskey SE, Lacey JH, Pearce JM. Binge-Eating and Polycystic Ovaries. *Lancet* 1992; 340(8821): 723.

- [48] Morgan JF, McCluskey SE, Brunton JN, Hubert Lacey J. Polycystic ovarian morphology and bulimia nervosa: a 9-year follow-up study. *Fertil Steril* 2002; 77(5): 928-31.
- [49] Jahanfar S, Eden JA, Nguyent TV. Bulimia nervosa and polycystic ovary syndrome. *Gynecol Endocrinol* 1995; 9(2): 113-7.
- [50] Sbaragli C, Morgante G, Goracci A, Hofkens T, De Leo V, Castrogiovanni P. Infertility and psychiatric morbidity. *Fertil Steril* 2008; 90(6): 2107-11.
- [51] Culbert KM, Breedlove SM, Sisk CL, Burt SA, Klump KL. The emergence of sex differences in risk for disordered eating attitudes during puberty: a role for prenatal testosterone exposure. *J Abnorm Psychol* 2013; 122(2): 420-32.
- [52] Lawrenz B, Neunhoeffer E. Polycystic Ovaries Syndrome (PCOS), insulin resistance and sterility in obese women. *Geburtshilfe Und Frauenheilkunde* 2008; 68(11): 1106-8.
- [53] Karacan E, Caglar GS, Gürsoy AY, Yilmaz MB. Body satisfaction and eating attitudes among girls and young women with and without polycystic ovary syndrome. *J Pediatr Adolesc Gynecol* 2014; 27(2): 72-7.
- [54] Diamanti-Kandarakis E, Papavassiliou AG. Molecular mechanisms of insulin resistance in polycystic ovary syndrome. *Trends Mol Med*, 2006; 12(7): 324-32.
- [55] Brand-Miller J, Farid N. *The low GI guide to managing PCOS*, ed. H. Stoughton 2004; London.
- [56] Mahraj S. Polycystic ovary syndrome: a review. *JEMDSA* 2009; 14(2): 86-95.
- [57] Yu JH, Shin MS, Kim DJ, et al. Enhanced carbohydrate craving in patients with poorly controlled Type2 diabetes mellitus. *Diabet Med* 2013; 30(9): 1080-6.
- [58] Hormes JM, Orloff NC, Timko CA. Chocolate craving and disordered eating. Beyond the gender divide? *Appetite* 2014; 83: 185-93.
- [59] Moreno-Domínguez S, Rodríguez-Ruiz S, Fernández-Santaella MC, Ortega-Roldán B, Cepeda-Benito A. Impact of Fasting on Food Craving, Mood and Consumption in Bulimia Nervosa and Healthy Women Participants. *Eur Eat Disord Rev* 2012; 20(6): 461-7.
- [60] Sacks FM, Carey VJ, Anderson CA, et al. Effects of high vs. low glycemic index of dietary carbohydrate on cardiovascular disease risk factors and insulin sensitivity: the OmniCarb randomized clinical trial. *JAMA* 2014; 312(23): 2531-41.
- [61] Rouch C, Meile MJ, Orosco M. Extracellular hypothalamic serotonin and plasma amino acids in response to sequential carbohydrate and protein meals. *Nutr Neurosci* 2003; 6(2): 117-24.
- [62] Young H, Benton D. The nature of the control of blood glucose in those with poorer glucose tolerance influences mood and cognition. *Metabolic Brain Disease* 2014; 29(3): 721-8.
- [63] Robinson OJ, Overstreet C, Allen PS, Pine DS, Grillon C. Acute Tryptophan Depletion Increases Translational Indices of Anxiety but not Fear: Serotonergic Modulation of the Bed Nucleus of the Stria Terminalis? *Neuropsychopharmacology* 2012; 37(8): 1963-71.
- [64] Kleinridders A, Cai W, Cappellucci L, et al. Insulin resistance in brain alters dopamine turnover and causes behavioral disorders. *Proc Natl Acad Sci USA* 2015; 112(11): 3463-8.
- [65] Balıkcı A, Erdem M, Keskin U. Depression, Anxiety, and Anger in Patients with Polycystic Ovary Syndrome. *Noro Psikiyatir Ars* 2014; 51(4): 328-33.
- [66] Barr S, Hart K, Reeves S, Sharp K, Jeanes YM. Habitual dietary intake, eating pattern and physical activity of women with polycystic ovary syndrome. *Eur J Clin Nutr* 2011; 65(10): 1126-32.
- [67] Marcondes RR, Carvalho KC, Duarte DC, et al. Differences in neonatal exposure to estradiol or testosterone on ovarian function and hormonal levels. *Gen Comp Endocrinol* 2015; 212: 28-33.
- [68] Chai JK, Blaha V, Meguid MM, Laviano A, Yang ZJ, Varma M. Use of orchietomy and testosterone replacement to explore meal number-to-meal size relationship in male rats. *Am J Physiol* 1999; 276(5): R1366-73.
- [69] Diamanti-Kandarakis E, Dunaif A. Insulin Resistance and the Polycystic Ovary Syndrome Revisited: An Update on Mechanisms and Implications. *Endocr Rev* 2012; 33(6): 981-1030.
- [70] Corbould A. Effects of androgens on insulin action in women: is androgen excess a component of female metabolic syndrome? *Diabetes Metab Res Rev* 2008; 24(7): 520-32.
- [71] Hirschberg AL. Sex hormones, appetite and eating behaviour in women. *Maturitas* 2012; 71(3): 248-56.
- [72] Hirschberg AL. Polycystic ovary syndrome, obesity and reproductive implications. *Womens Health (Lond)* 2009; 5(5): 529-40; quiz 541-2.
- [73] Cipkala-Gaffin J, Talbott EO, Song MK, Bromberger J, Wilson J. Associations Between Psychologic Symptoms and Life Satisfaction in Women with Polycystic Ovary Syndrome. *J Womens Health (Larchmt)* 2012; 21(2): 179-87.
- [74] Hollinrake E, Abreu A, Maifeld M, Van Voorhis BJ, Dokras A. Increased risk of depressive disorders in women with polycystic ovary syndrome. *Fertil Steril* 2007; 87(6): 1369-76.
- [75] Annagür BB, Kerimoglu ÖS, Tazegül A, Gündüz Ş, Gençoglu BB. Psychiatric comorbidity in women with polycystic ovary syndrome. *J Obstet Gynaecol Res* 2015; 41(8): 1229-33.
- [76] Scaruffi E, Gambineri A, Cattaneo S, Turra J, Vettor R, Mioni R. Personality and psychiatric disorders in women affected by polycystic ovary syndrome. *Front Endocrinol (Lausanne)* 2014; 5: 185.
- [77] Goldschmidt AB, Hilbert A, Manwaring JL, et al. The significance of overvaluation of shape and weight in binge eating disorder (vol 48, pg 187, 2010). *Behav Res Ther* 2010; 48(11): 1160.
- [78] Albohn-Kuhne C, Rief W. Shame, Guilt and Social Anxiety in Obesity with Binge-Eating Disorder. *Psychother Psychosom Med Psychol* 2011; 61(9-10): 412-7.
- [79] Nader S. Hyperandrogenism during puberty in the development of polycystic ovary syndrome. *Fertil Steril* 2013; 100(1): 39-42.
- [80] Liechty JM, Lee MJ. Longitudinal predictors of dieting and disordered eating among young adults in the U.S. *Int J Eat Disord* 2013; 46(8): 790-800.
- [81] Goldschmidt AB, Wall M, Loth KA, Le Grange D, Neumark-Sztainer D. Which Dieters Are at Risk for the Onset of Binge Eating? A Prospective Study of Adolescents and Young Adults. *J Adolesc Health* 2012; 51(1): 86-92.
- [82] Dilbaz B, Cinar M, Ozkaya E, Tonyalı NV, Dilbaz S. Health related quality of life among different PCOS phenotypes of infertile women. *J Turk Ger Gynecol Assoc* 2012; 13(4): 247-52.
- [83] Correa JB, Sperry SL, Darkes J. A case report demonstrating the efficacy of a comprehensive cognitive-behavioral therapy approach for treating anxiety, depression, and problematic eating in polycystic ovarian syndrome. *Arch Womens Ment Health* 2015; 18(4): 649-54.
- [84] Roessler KK, Glinthorg D, Ravn P, Birkebaek C, Andersen M. Supportive relationships--psychological effects of group counseling in women with polycystic ovary syndrome (PCOS). *Commun Med* 2012; 9(2): 125-31.
- [85] Setji TL, Brown AJ. Polycystic ovary syndrome: update on diagnosis and treatment. *Am J Med* 2014; 127(10): 912-9.
- [86] Legro RS, Arslanian SA, Ehrmann DA, et al. Diagnosis and treatment of polycystic ovary syndrome: an Endocrine Society clinical practice guideline. *J Clin Endocrinol Metab* 2013; 98(12): 4565-92.
- [87] Tang T, Lord JM, Norman RJ, Yasmin E, Balen AH. Insulin-sensitising drugs (metformin, rosiglitazone, pioglitazone, D-chioorinositol) for women with polycystic ovary syndrome, oligo-amenorrhoea and subfertility. *Cochrane Database Syst Rev* 2012; 5: CD003053.
- [88] Blay SL, Aguiar JV, Passos IC. Polycystic ovary syndrome and mental disorders: a systematic review and exploratory meta-analysis. *Neuropsychiatr Dis Treat* 2016; 12: 2895-903.