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.

Keywords: Binge Eating Disorder, Polycystic Ovarian Syndrome, Eating Disorders, Menstruation, Body Dissatisfaction, Menstrual irregularities.

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 Eating 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, bidirectional links). Hence, this review aspires to shed light on the coexistence 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
Polycystic, BED Polycystic, binge eating PCOS, binge eating pol, Binge Eating Disorders, Bulimia Nervosa Pol
plied to detect relevant sources: Polycystic Ovarian Syndrome Ea
ScienceDirect, PubMed, Google Scholar, Utas Library, University of adopted [29]. A computer research has bee
Ovarian Syndrome (PCOS), the PRISMA guidelines have been
the broader context of eating disorder behaviors, and Polycystic
2. METHOD
the theoretical model, which attempts to explain the simultaneously
both PCOS and binge ea
shared metabolic, hormonal and psychological factors between
and PCOS seems to exist simultaneously, this review aims to h
bated by dieting.
It is interesting to note that weighting loss has been identified as
a key treatment for PCOS, even though, PCOS women seem to be
emotions are a key predi
PCOS co
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 im
balance [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
eclucidated [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].
Since there is an inadequate understanding of why binge eating
and PCOS seems to exist simultaneously, this review aims to hy
thesize 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, Utas Library, University of
Melbourne Library, and the following identifying terms were ap
plied to detect relevant sources: Polycystic Ovarian Syndrome Eat
ing, 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 in
volved human participants. Studies have been selected in ac
dance 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 popul
ation, (iii) contain empirical data, (iv) following the criteria of diag
nosing 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 anovula
tion, clinical and/or biochemical hyperandrogenism, and polycystic
ovaries on ultrasound [12]. A total of 21 studies were deemed eligi
ble 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 find
ings 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 sa
tisfaction [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 popu
lations with binge eating behaviors [14] suggests a potential rela
ship 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 pre
sence 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, ap
proximately 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 pres
ence of the two conditions, concluding that scores for dieting and
overall ED symptoms in the polycystic ovary group were not sig
ificantly higher than those for women with normal ovaries [19].
Counter intuitively, when examining the presence of PCOS symp
ptomatology 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 dys
function 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 inter
relation between the two conditions (PCOS and binge eating) is
Table 1. Prevalence of PCOS in Eating Disorder populations.

<table>
<thead>
<tr>
<th>Study</th>
<th>Sample size</th>
<th>ED’s type</th>
<th>Criteria of diagnosis</th>
<th>Prevalence rate of PCOS in EDs (%)</th>
<th>Phenotype</th>
</tr>
</thead>
<tbody>
<tr>
<td>Jahanfar et al., 2005</td>
<td>154</td>
<td>SEB</td>
<td>Clinical, biochemical and ultrasound tools for PCOS; BITE questionnaire</td>
<td>8 on the total sample</td>
<td>Oligomenorrhea, PCO</td>
</tr>
<tr>
<td>Morgan et al., 2002</td>
<td>8</td>
<td>BN</td>
<td>Ultrasonography; PCOS Rotterdam criteria; DMS IV for BN.</td>
<td>75 of the sample had PCOS</td>
<td>PCO</td>
</tr>
<tr>
<td>Naessen et al., 2007</td>
<td>21 BN</td>
<td>BN</td>
<td>PCOS Rotterdam criteria-revised; PSR scale for BN.</td>
<td>28.5 in BN</td>
<td>Oligomenorrhea, hyperandrogenism</td>
</tr>
<tr>
<td>Naessen et al., 2006</td>
<td>46 BN</td>
<td>BN</td>
<td>PCOS Rotterdam criteria-revised; Transvaginal ultrasound.</td>
<td>30.7 in BN/EDNOS</td>
<td>Oligomenorrhea, hyperandrogenism</td>
</tr>
<tr>
<td>Pinhas-Hamiel et al., 2006</td>
<td>11 AN+PCOS</td>
<td>AN</td>
<td>DSM-IV for AN; PCOS Rotterdam criteria-revised; Pelvic sonogram.</td>
<td>28.9 on the total sample</td>
<td>Oligomenorrhea, PCO</td>
</tr>
<tr>
<td>Resch et al., 2004</td>
<td>6 BN</td>
<td>BN</td>
<td>BITE; PCOS Rotterdam criteria-revised.</td>
<td>30.5 in BN/EDNOS</td>
<td>Oligomenorrhea, PCO</td>
</tr>
<tr>
<td>McCluskey et al., 1992</td>
<td>34 BN</td>
<td>BN</td>
<td>DSM-IIIR for BN; Pelvic ultrasound.</td>
<td>76% of the total</td>
<td>PCO</td>
</tr>
</tbody>
</table>

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.

<table>
<thead>
<tr>
<th>Study</th>
<th>Sample size</th>
<th>ED’s type</th>
<th>Criteria of diagnosis</th>
<th>Prevalence rate of EDs in PCOS (%)</th>
<th>Phenotype</th>
</tr>
</thead>
<tbody>
<tr>
<td>Annagur et al., 2015</td>
<td>88 PCOS women</td>
<td>BED</td>
<td>PCOS Rotterdam criteria; SCID.</td>
<td>6.8 on the total sample</td>
<td>Oligomenorrhea, hyperandrogenism, PCO</td>
</tr>
<tr>
<td>Batcheller et al., 2013</td>
<td>6 obese PCOS</td>
<td>BED</td>
<td>PCOS Rotterdam criteria; SCID.</td>
<td>50% subclinical BED for obese PCOS</td>
<td>Obesity, oligomenorrhea, hyperandrogenism, PCO</td>
</tr>
<tr>
<td></td>
<td>5 lean PCOS</td>
<td></td>
<td></td>
<td>0 for lean PCOS</td>
<td></td>
</tr>
<tr>
<td></td>
<td>10 control</td>
<td></td>
<td></td>
<td>0 for controls</td>
<td></td>
</tr>
<tr>
<td>Berenson et al., 2014</td>
<td>24 overweight and obese with PCOS</td>
<td>BED</td>
<td>PCOS Questionnaire; BES.</td>
<td>50 of the participants had moderate/severe BED</td>
<td>Obesity, oligomenorrhea, hyperandrogenism, PCO</td>
</tr>
<tr>
<td>Barry et al., 2011</td>
<td>24 women with PCOS</td>
<td>Subclinical EDs</td>
<td>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’.</td>
<td>58% of the PCOS group reported binge and/or comfort eating compared to 32% of control women</td>
<td>Oligomenorrhea, hyperandrogenism, PCO</td>
</tr>
</tbody>
</table>

(Table 2) Contd....
<table>
<thead>
<tr>
<th>Study</th>
<th>Sample size</th>
<th>ED’s type</th>
<th>Criteria of diagnosis</th>
<th>Prevalence rate of EDs in PCOS (%)</th>
<th>Phenotype</th>
</tr>
</thead>
<tbody>
<tr>
<td>Jahanfar et al., 1995</td>
<td>52 normal ovaries; 42 PCOS</td>
<td>BN</td>
<td>Transabdominal ultrasound examination; BITE.</td>
<td>73 of PCOS women had abnormal BITE</td>
<td>PCO</td>
</tr>
<tr>
<td>Jensterle et al., 2014</td>
<td>36 obese PCOS</td>
<td>Subclinical EDs</td>
<td>TFEQ-R18.</td>
<td>High scoring in Three-Factor Eating Questionnaire (TFEQ-R18) in all the sample (37 PCOS women)</td>
<td>Obesity, PCO, oligomenorrhea, hyperandrogenism</td>
</tr>
<tr>
<td>Kerchner et al., 2009</td>
<td>60 PCOS women</td>
<td>BED</td>
<td>PCOS Rotterdam criteria; Polycystic Ovary Syndrome Survey; PHQ; BDI-II; BAI.</td>
<td>23.3% on the total sample</td>
<td>PCO, oligomenorrhea, hyperandrogenism</td>
</tr>
<tr>
<td>Larson et al., 2015</td>
<td>72 PCOS women; 30 controls</td>
<td>Eating behavior</td>
<td>PCOS Rotterdam criteria; TFEQ-R21; EAT; DMS V Questionnaire.</td>
<td>EAT&gt; 29: 8% PCOS women; 3% controls EAT</td>
<td>Weight gain, PCO, oligomenorrhea, hyperandrogenism</td>
</tr>
<tr>
<td>McCluskey et al., 1991</td>
<td>153 PCOS women; 150 controls</td>
<td>BN</td>
<td>BITE.</td>
<td>6% of PCOS women; 1% of endocrinopathic women</td>
<td>PCO, oligomenorrhea, hyperandrogenism</td>
</tr>
<tr>
<td>Michelmore et al., 2001</td>
<td>74 PCOS women; 150 controls</td>
<td>Eating behavior</td>
<td>EDE; transabdominal ultrasound scan.</td>
<td>Binge eating: 4% in PCOS; 4% in controls; Overeating: 27% in PCOS; 28% in controls</td>
<td>PCO, oligomenorrhea, hyperandrogenism</td>
</tr>
<tr>
<td>Morgan et al., 2008</td>
<td>80 PCOS women</td>
<td>EDs</td>
<td>SCID; EDE; RSES; SAS -M; GHQ.</td>
<td>12.6% BN; 22.5% EDNOS; 1.3% AN</td>
<td>Hyperandrogenism, oligoestradiol</td>
</tr>
<tr>
<td>Sharangi et al., 2008</td>
<td>81 infertile couples (5 with PCOS)</td>
<td>BED</td>
<td>SCID.</td>
<td>18 % in infertile couple (15% in PCOS subgroup); 0% controls</td>
<td>Infertility, PCO, oligoestradiol</td>
</tr>
<tr>
<td>Wylie et al., 2009</td>
<td>131 PCOS women</td>
<td>Eating Behavior</td>
<td>EMA.</td>
<td>Significantly more sweet snacks compared to savoury snacks</td>
<td>PCO, oligomenorrhea, hyperandrogenism</td>
</tr>
<tr>
<td>Barr et al., 2011</td>
<td>210 PCOS women (53% obese)</td>
<td>Eating behavior</td>
<td>EMA.</td>
<td>Fat consumption was significantly higher in women with PCOS; Mean dietary GI (54.6) was substantially higher in PCOS obese than PCOS lean women.</td>
<td>Oligomenorrhea, hyperandrogenism, infertility</td>
</tr>
</tbody>
</table>

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 to 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 Anagaur (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 physiological consequences of PCOS, such as hirsutism, acne and weight gain, females with PCOS tend to experience feelings of deviance from idealized cultural norms, in which in turn influences self-esteem and cultivate feelings of body dissatisfaction [76], that 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.
Table 3. Shared factors between PCOS and binge eating behavior.

<table>
<thead>
<tr>
<th>Shared features</th>
<th>Eating disorder (binge-type)</th>
<th>PCOS</th>
</tr>
</thead>
<tbody>
<tr>
<td>Binge eating behavior</td>
<td>✓</td>
<td>✓</td>
</tr>
<tr>
<td>Overweight and obesity</td>
<td>✓</td>
<td>✓</td>
</tr>
<tr>
<td>Menstrual imbalance</td>
<td>✓</td>
<td>✓</td>
</tr>
<tr>
<td>Hyperandrogenism</td>
<td>✓</td>
<td>✓</td>
</tr>
<tr>
<td>Anovulation and ovarian cysts</td>
<td>✓</td>
<td>✓</td>
</tr>
<tr>
<td>Hirsutism</td>
<td>✓</td>
<td>✓</td>
</tr>
<tr>
<td>Insulin resistance</td>
<td>✓</td>
<td>✓</td>
</tr>
<tr>
<td>Body dissatisfaction and negative body image</td>
<td>✓</td>
<td>✓</td>
</tr>
</tbody>
</table>

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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