

1 **Binge eating behaviours and food cravings in women with Polycystic Ovary**
2 **Syndrome**

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20 **Abstract:**

21 Polycystic Ovary Syndrome (PCOS), the most common endocrine condition in women, is
22 often anecdotally associated with binge eating behaviours and food cravings; however there
23 is a paucity of research. This study aimed to report the prevalence of binge eating and food
24 cravings and their relation to obesity risk in women with PCOS. Participants completed an
25 online survey including the Bulimia Investigatory Test, Edinburgh, Food Cravings-Trait
26 Questionnaire and the Three Factor Eating Questionnaire revised-18. The study included
27 obese (n=340), overweight (n=70) and lean (n=45) women with PCOS and lean healthy
28 women (n=40). Sixty percent of obese women with PCOS were categorised with binge-
29 eating behaviour, with 39% presenting with clinically significant behaviour. Obese women
30 with PCOS presented with high mean food cravings-trait scores (131.6±28.9) that were
31 significantly greater compared with lean (114.0±34.9) and overweight women with PCOS
32 (120.1±29.5; p<0.001). Multiple regression exploring relations between eating styles and
33 adiposity explained 59% of the variance in binge eating symptom scores in women with
34 PCOS (F =173.8; p<0.001, n=463): significant predictors were food cravings total score
35 (beta =0.52; p<0.001), emotional eating score (beta =0.16; p<0.001), BMI (beta= 0.13;
36 p<0.001) and uncontrolled eating score (beta =0.10; p<0.01). Compared with lean healthy
37 women, lean women with PCOS exhibited significantly higher binge eating symptom scores
38 (10.9±7.8 versus 7.4±6.0; p<0.05), though similar total food craving scores (114.0±34.9
39 versus 105.6±26.6: NS). This study is the largest, to date, to robustly report that a high
40 proportion of women with PCOS exhibit binge eating behaviours. We recommend screening
41 women with PCOS for binge eating behaviours to help inform the choice of weight
42 management approach for this clinical population.

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44

45 **Key words: Polycystic ovary syndrome, Obesity, Binge eating, Food cravings, eating**
46 **disorders**

47

48 **Abbreviations:**

49 **PCOS: Polycystic ovary syndrome**

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52 **Introduction**

53

54 Polycystic ovary syndrome (PCOS) is the most common endocrine condition in women,
55 affecting up to 18% of women (1) and is characterised by a heterogeneous presentation of
56 hyperandrogenism and ovulatory dysfunction. Women with PCOS have a greater insulin
57 resistance, risk of developing type 2 diabetes (2), and a greater risk of being overweight and
58 obese compared with healthy controls (BMI >30 RR 2.77 (95% CI 1.88 to 4.10) (3). Obesity
59 significantly worsens all metabolic and reproductive outcomes for women with PCOS (4),
60 though importantly as little as 5% weight loss has been shown to improve reproductive,
61 metabolic and clinical markers (5, 6). Weight management through lifestyle modification is
62 the first line treatment within international guidelines for the management of PCOS (7-11),
63 although the effectiveness of such treatments is limited.

64

65 Binge eating has been shown to predict excess weight gain (12), obesity onset (13), weight
66 regain after dieting (14) and failed weight loss (15). Binge eating behaviour is characterized
67 by: (i) eating, in a discrete period of time, an amount of food that is definitely larger than
68 most people would eat in a similar period of time under similar circumstances; and (ii) a
69 sense of lack of control over eating (16). There is a paucity of studies exploring disordered
70 eating behaviours in women with PCOS; small studies have indicated a higher prevalence of
71 PCOS in patients with eating disorders (17, 18). There are also reports suggesting both that
72 disordered eating and bulimia nervosa are more common among women with PCOS (19-
73 21), though others have reported no difference (22). Furthermore, a meta-analysis showed
74 an increased prevalence of depression and anxiety associated with PCOS compared with
75 controls (23, 24), and it is known that negative emotions are a key predictor of binge eating
76 (25, 26). Binge eating is positively associated with hyperandrogenism (27) and amenorrhea
77 (28), with hyperandrogenism implicated within the pathogenesis of anovulation and
78 menstrual irregularities (29, 30). The role of circulating testosterone concentrations in the
79 aetiology of eating disorders has yet to be fully elucidated (31). Elevated testosterone
80 concentrations may promote bulimic behaviours by influencing food cravings and impulse
81 control (31, 32). A suggestion supported by the observation that anti androgenic treatment
82 reduces bulimic behaviour (33). An alternative hypothesis is that recurrent binge eating may
83 increase insulin levels, which, via decreased concentrations of sex hormone binding
84 globulin, increase free circulating testosterone(34), ultimately negatively impacting upon
85 follicular maturation and ovulation (28).

86

87 Food cravings and obesity are positively correlated (35, 36) with evidence that individuals
88 who are obese have higher frequencies of food cravings than healthy weight individuals (37).
89 Food cravings may also discriminate between successful and unsuccessful dieters (38, 39).
90 Recently, it has been reported that food craving was identified as a significant partial
91 mediator in the relationships between elevated BMI and binge eating episodes (40). A food
92 craving has been defined as an intense desire directed at a specific food or drink that is hard
93 to resist (41). Craved and binged foods usually have a high energy density and fat content
94 (42, 43) and previous studies have reported strong associations between cravings and
95 intake of high-fat foods, sweets, and fast-food (44, 45). Food cravings are often anecdotally
96 reported by women with PCOS (46); and a pilot study indicated women with PCOS had
97 significantly higher Food Cravings-Trait scores compared with healthy women (47).
98 Raised androgens and menstrual disturbances have been associated with greater food
99 cravings in women without PCOS (48). The underlying mechanism for the relationship is
100 unclear; although circulating testosterone has been shown to stimulate appetite (49) and is
101 associated with impaired impulse control, irritability and depression (32, 50). Accordingly, it
102 has been proposed that elevated levels of androgens may promote food cravings (51).

103

104 There is an inadequate understanding of eating behaviours in women with PCOS. If binge
105 eating and food cravings are common in this group, this needs to be highlighted to help
106 clinicians focus on appropriate interventions and strategies to promote weight loss. Weight
107 loss has already been identified as a key treatment for reproductive and metabolic outcomes
108 for women with PCOS, but one which women report difficulty achieving. This study aims to
109 report the prevalence of binge eating and food cravings and their relation to obesity risk in
110 women with PCOS. It is hypothesised that a high proportion of binge eating and food craving
111 behaviours will be identified.

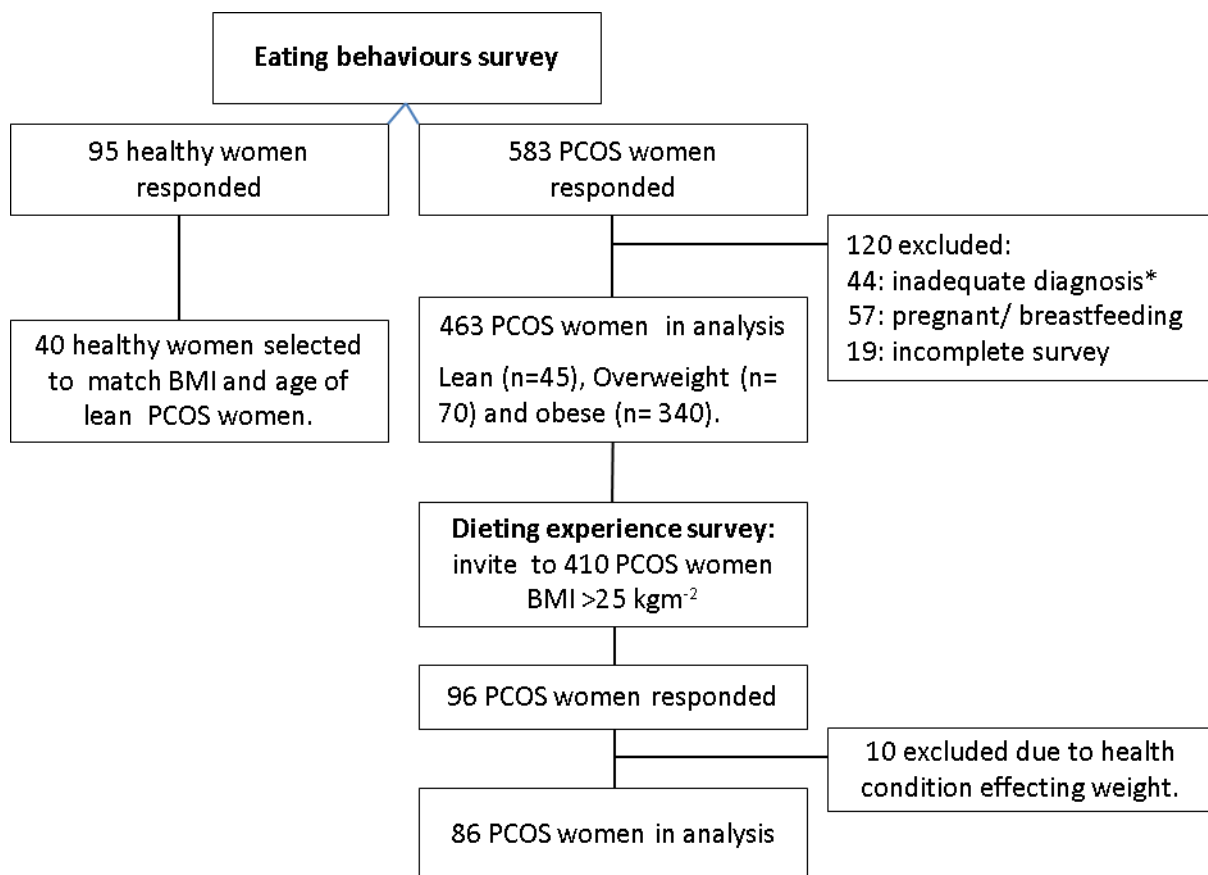
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113 **2. Methods**

114 **2.1 Participants**

115 The study recruited 583 women with PCOS and 95 women without PCOS (Figure 1).
116 Healthy lean women were matched for weight, age and ethnicity to lean women with PCOS.
117 Recruitment of study participants utilised social media sites and email advertisements at the
118 University of Surrey. Participant eligibility was determined by a screening questionnaire. All
119 women were at least 18 years of age. Participants were excluded if they were pregnant or
120 breastfeeding. For women with PCOS, a diagnosis of PCOS by a healthcare professional
121 was required. All overweight and obese women with PCOS were invited to participate in the
122 'Dieting experience' survey. Ethical approval was granted by the procedures of the

123 University of Roehampton and University of Surrey. The studies were carried out in
 124 accordance with The Code of Ethics within the Declaration of Helsinki.
 125



126
 127 Figure 1. Recruitment of participants
 128 * Inadequate diagnosis was a diagnosis by someone other than a healthcare professional. Data for
 129 the Dieting experience survey was collected anonymously.
 130

131 **2.2 Assessments and measurements**

132 The online survey was presented on the Bristol Online Survey and SurveyMonkey®
 133 platforms. Informed consent procedures were embedded into the survey. Participants were
 134 asked questions relating to PCOS diagnosis, other medical conditions, self-reported PCOS
 135 symptoms, weight, height and dieting history similar to a previous study (52). Amenorrhea
 136 was considered present if participants provided a negative response to “have you had a
 137 period in the previous 12 months?”

138
 139 The following validated questionnaires were used:

- 140 i) The Bulimia Investigatory Test, Edinburgh, (BITE) (53); recognised for its validity and
 141 reliability (54), is a 33-item self-report measure designed to identify individuals with
 142 symptoms of bulimia or binge eating. It consists of a symptom scale and a severity scale,

143 which provides an index of the severity of bingeing and purging behaviour as defined by their
144 frequency.

145 ii) The Food Cravings Questionnaire–Trait (FCQ–T), a 39-item self-report questionnaire
146 whereby participants indicate how frequently each statement ‘would be true for you in
147 general’ using a 6-point scale [range: 1 (‘never or not applicable’) to 6 (‘always’)]. Nine trait
148 craving domains (Table 2) have been reported in healthy participants (55), those with eating
149 disorders (56) and obese populations (57).

150 iii) The Three Factor Eating Questionnaire- Revised 18 (TFEQ-R18 version 2)(58), was
151 selected to establish cognitive restraint, uncontrolled and emotional eating in the
152 participants. It consisted of 18 statements, which participants indicate their agreement on a
153 Likert like scale. The results are calculated into scores from 1 to 4, with higher values
154 indicating more of the behaviour.

155 The dieting experience survey for overweight and obese women with PCOS included items
156 assessing dieting circumstances and perception of dieting strategies through an online
157 questionnaire previously published by (59, 60).

158

159 **2.3 Data analysis**

160 Frequencies and descriptive statistics were generated using IBM® Statistical Package for
161 the Social Sciences® (SPSS®) version 21. Data are presented as means \pm SD or number
162 and percent. Normality of data was assessed; independent t tests were used to compare
163 variables between healthy women and women with PCOS; Mann-Whitney was used for non-
164 parametric data. Cohen’s d values and eta squared were calculated to establish size of
165 effect. One-way or two-way ANOVA with Bonferroni post-hoc correction was chosen to
166 compare variables between weight categories for women with PCOS. Partial correlations
167 were used to control for body mass index (BMI). Multiple regression analysis with predictor
168 values entered simultaneously was used to explore variance of binge eating behaviours, as
169 measured by BITE symptom score; independent variables were total food cravings trait
170 score, BMI, uncontrolled eating and emotional eating scores from TFEQ-R18.

171

172 **3. Results**

173 **3.1 Population characteristics**

174 The majority of women with PCOS were obese (73.4%; n=340), 15.1% (n=70) were
175 overweight and 9.7 % (n=45) were lean. Women with PCOS had a mean \pm SD weight of
176 98.6 ± 27.4 kg (n=460) and BMI of 36.0 ± 9.1 kgm⁻² (n=458). The majority of participants were
177 Caucasian (84.7%), with 3.9% mixed race, 2.6% Black, 2.2% Asian and 6.7% classified as
178 ‘other’. Responses were from North America (n=303), Europe (n=107), Australasia (n=36)
179 and other continents (n=17).

180

181 Diagnosis of PCOS was by a hospital or specialist doctor (60%), general practitioner (38%)
182 or nurse (2%). Prevalence of PCOS symptoms included hirsutism 85% (n=392); acne 56%
183 (n=257) and irregular menstruation 55% (n=255). Thirty one women reported a diagnosis of
184 type 2 diabetes, 32 reported having depression and 11 reported a diagnosis of an eating
185 disorder (table 1).

186

187 Table 1. Age, BMI and self-reported symptoms of women with PCOS

	Lean n=45	Overweight n=70	Obese n=340
Age (years)	31.3 (5.6)	31.4 (7.6)	32.63 (7.3)
BMI (kgm-2)	22.5 (1.8)	27.3 (1.4)	39.7 (7.3)
Response to the question: Do you have...			
Hirsutism	71%	81%	87% ^a
Acne	62%	46%	57%
Irregular menses	51%	53%	56%
Amenorrhoea	2%	9%	14% ^a
Positive response to the question: Do you have any other medical conditions?			
Type 2 diabetes	2%	6%	8%
Depression	11%	14%	5% ^a
An eating disorder	2%	1%	2%
Weight management			
Dieting to lose weight	27%	40%	47% ^a
Agree with the statement 'I am a yo-yo dieter'	35%	33%	57%

188 No significant difference between BMI groups in age (p=0.23, One way ANOVA). ^aSignificant
189 difference between BMI groups in prevalence hirsutism (χ^2 p=0.012; Cramer V=0.14), amenorrhoea (χ^2
190 p=0.044; Cramer V=0.12), depression (χ^2 p=0.012; Cramer V=0.14) and dieting to lose weight (χ^2
191 p<0.001; Cramer V=0.24).

192

193 3.2 Food cravings in women with PCOS

194 Nearly all of the women with PCOS self-reported craving foods (99%); these included
195 savoury and sweet, energy dense, high carbohydrate and high fat foods. BMI groups differed
196 in FCQ-T scores (one-way ANOVA group effect, F(2, 452) = 10.0 p <0.001); multiple
197 comparisons between groups (Bonferroni-adjusted) confirmed that obese women had
198 significantly higher trait food craving scores than either lean (p=0.001) or overweight
199 (p=0.01) women with PCOS (Table 2); specifically greater scores on the sub scales: '*Having*
200 *intentions and plans to consume food*', '*Lack of control over eating*', '*Emotions that may be*
201 *experienced before or during food cravings or eating*' and '*Guilt from cravings/for giving into*
202 *cravings*' compared with lean women with PCOS (all p<0.01) (table 2). Total food cravings
203 and BMI were weakly correlated (r = 0.21; p<0.01).

204 Higher FCQ-T scores were observed in women with PCOS with acne (n=257) compared to
205 those without acne (n=206)(130±3 versus 124±3; p=0.02, Cohen's d =0.22). Hirsutism in
206 women with PCOS did not significantly affect their reported food cravings whether assessed
207 by BMI sub-group or with all weight categories combined (hirsute PCOS: n=392, FCQ-T

208 score 127±30; non-hirsute PCOS: n=71, FCQ-T= 127±32; p=0.8). Similarly neither
 209 depression nor irregular menses were found to significantly impact on FCQ-T within the
 210 PCOS cohort. When FCQ-T scores were compared between sub-groups of PCOS women
 211 with and without specific symptoms, only amenorrhea (n=55) was associated with greater
 212 food cravings (139±32 versus 126.2±30 for all other women; p=0.03, Cohen's d =0.42).
 213 Obese women with PCOS who reported being on a diet to lose weight had similar FCQ-T
 214 scores compared with obese women with PCOS not dieting (132±27 n=159; versus 133±31
 215 n=132, p=0.77). However, one subscale did differ by dieting status, i.e. those on a diet to
 216 lose weight had a higher score for '*Guilt from cravings and/or for giving into them*' compared
 217 to those not dieting (12.1±2.4 versus 11.5±3.0 respectively; p=0.049, Cohen's d =0.22).

218

219 Table 2. Food craving scores* for women with PCOS (mean (SD)).

	Lean n=45	Overweight n=70	Obese n=340
Total food cravings score (FCQ-T)	114.0 (34.9)	120.1(29.5)	131.6 (28.9)^{ac}
<i>Subscales:</i>			
Having intentions and plans to consume food	9.1 (3.2)	9.8 (2.8)	10.9 (2.6) ^{ac}
Anticipation of positive reinforcement that may result from eating	14.7 (4.3)	14.2 (4.2)	15.7 (4.4) ^d
Anticipation of relief from negative states and feelings as a result of eating	8.0 (3.4)	7.9 (3.1)	8.9 (2.9) ^d
Lack of control over eating	16.3 (7.2)	18.4 (6.1)	20.4 (5.6) ^{ad}
Thoughts or preoccupation with food	18.1(7.8)	18.6 (7.3)	20.8 (7.0) ^b
Craving as a physiological state	13.1 (3.0)	13.3 (3.0)	14.1 (3.1)
Emotions that may be experienced before or during food cravings or eating	11.9 (5.1)	13.6 (4.5)	14.5 (4.1) ^a
Cues that may trigger food cravings	13.1 (4.3)	13.3 (4.0)	14.6 (3.7) ^d
Guilt from cravings and/or for giving into them	9.6 (3.7)	11.0 (3.4)	11.8 (2.7) ^a

220

221 ^ap<0.01, ^bp<0.05: significantly different between lean and obese women with PCOS;

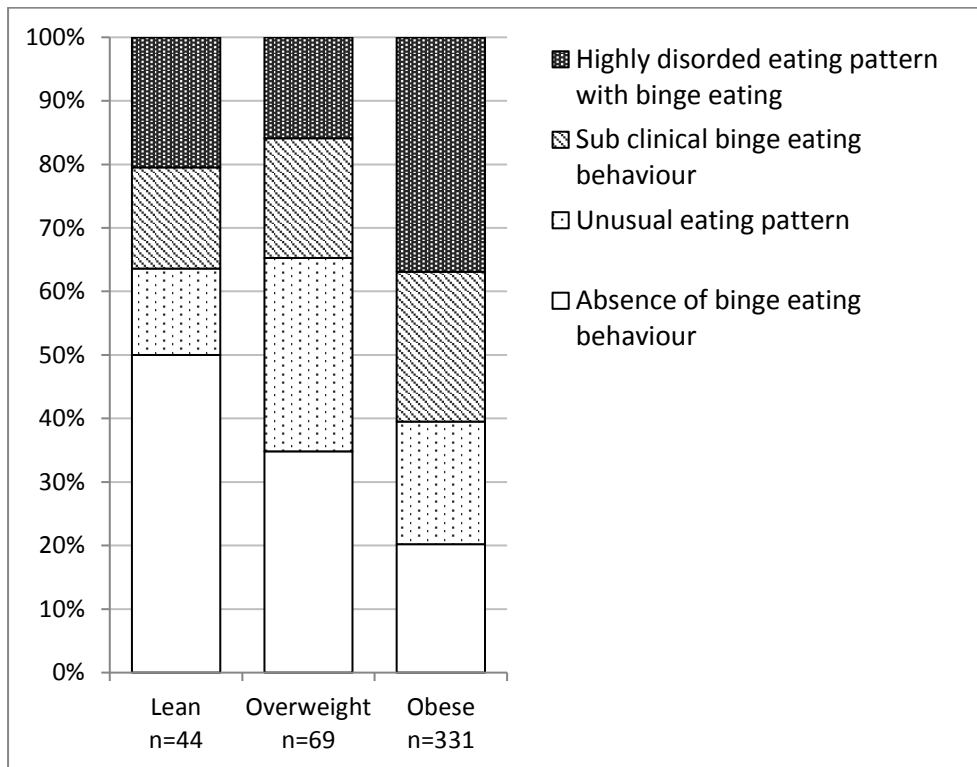
222 ^cp<0.01, ^dp<0.05: significantly different between overweight and obese women with PCOS; one-way
 223 ANOVA with Bonferroni post-hoc adjustment.

224 *Possible ranges for the scale scores: Total score, 39-234; Having intentions and plans to consume
 225 food, 3-18; Anticipation of positive reinforcement that may result from eating, 5-30; Anticipation of
 226 relief from negative states and feelings as a result of eating, 3-18; Lack of control over eating, 6-36;
 227 Thoughts or preoccupation with food, 7-42; Craving as a physiological state, 4-24; Emotions that may
 228 be experienced before or during food cravings or eating, 4-24; Cues that may trigger food cravings, 4-
 229 24; Guilt from cravings and/or for giving into them, 3-18.

230

231 3.3 Binge eating behaviours in women with PCOS

232 Only 20% of obese women with PCOS were free of both compulsive eating and binge-eating
 233 (Figure 2). Sixty percent of obese women with PCOS (n =200) presented scores that
 234 indicated binge eating behaviour; 39% presented with clinically significant or high degree of
 235 severity (n=130) (table 3), but only 2% of obese women with PCOS reported a diagnosed
 236 eating disorder (table 1). A significantly greater proportion of obese women with PCOS
 237 exhibited binge eating behaviours compared with overweight and lean women with PCOS
 238 (Figure 2).



240

241

Figure 2. Proportion of women with PCOS exhibiting binge eating behaviour.

242

Significant difference in proportion of binge eating symptoms between BMI groups (χ^2 $p < 0.001$,

243

Cramer's $V = 0.25$).

244

245

Similar to the results for reported food-cravings, sub-groups created according to the

246

presence or absence of specific symptoms (hirsutism, depression or irregular menses) did

247

not show different binge eating symptom scores. However once again, women who reported

248

acne ($n = 257$) had higher binge eating symptom scores (16.0 ± 7 versus 13.6 ± 7 ; $p = 0.01$,

249

Cohen's $d = 0.32$) than those without ($n = 206$), likewise those who reported amenorrhea

250

($n = 55$) when compared with women who reported having menses in the previous 12 months

251

($n = 408$; 17.0 ± 7.0 versus 14.7 ± 7.1 ; $p = 0.02$, Cohen's $d = 0.33$). Obese women with PCOS

252

who reported being on a diet to lose weight had similar binge eating symptom scores

253

compared with obese women with PCOS not dieting (16.5 ± 6.3 , $n = 159$; versus 16.0 ± 7.1 ,

254

$n = 132$, $p = 0.36$).

255

256

Table 3. Binge eating scores from women with PCOS.

	Lean n=44	Overweight n=69	Obese n=331
Binge eating symptom score*; Mean (SD)	10.9 (7.8)	12.4 (6.8)	15.9 (6.8)^{ab}
<i>Subscales:</i>			
Absence of both compulsive eating and binge-eating.	50% n=22	34.8% n=24	20.2% n=67
Unusual eating pattern might be a compulsive	13.6% n=6	30.4% n=21	19.3% n=64

eater who eats excessively but does not binge-eat.			
Subclinical group of binge-eaters, either in the initial stages of the disorder or recovered bulimics.	15.9% n=7	18.8% n=13	23.6% n=78
Highly disordered eating pattern and the presence of binge-eating.	20.5% n=9	15.9% n=11	36.9% n=122
Binge eating severity score*^a; Mean (SD)	2.8 (2.1)	3.6 (3.3)	4.3 (3.2)^a
Normal	86.4% n=38	76.8% n=53	60.7% n=201
Clinically significant behaviour	13.6% n=6	14.5% n=10	32.3% n=107
High degree of severity	0% n=0	8.7% n=6	6.9% n=23

257 ^ap<0.01: significantly different between lean and obese women with PCOS;

258 ^bp<0.01: significantly different between overweight and obese women with PCOS; analysis by one-
259 way ANOVA with Bonferroni post-hoc adjustment. * Possible range for binge eating symptom score, 0-
260 30; binge eating severity score, 2-39.

261

262 **3.4 Emotional eating, cognitive restraint and uncontrolled eating scores in women** 263 **with PCOS**

264 Emotional eating scores were higher in obese compared with lean women with PCOS
265 (obese 2.7±0.8, overweight 2.5±0.8 and lean 2.3±0.9; p=0.006, eta squared =0.021, post
266 hoc obese versus lean p=0.013; score ranges from 1-4). Emotional eating scores were
267 positively associated with total food craving score (r=0.74; p<0.001) and binge eating
268 symptom score (r=0.64, p<0.001). These strong correlations remained when controlled for
269 BMI. Conversely, cognitive restraint scores were lower in obese compared with lean women
270 with PCOS (obese 2.5±0.7, overweight 2.7±0.8 and lean 2.8±0.8; p=0.001, eta squared
271 =0.027, post hoc obese versus lean p=0.004). Weak negative associations were observed
272 between cognitive restraint scores and total food craving score (r=-0.23, p<0.001) and binge
273 eating symptom score (r=-0.15, p=0.01), although when controlled for the influence of BMI
274 only the weak correlation with food cravings remained (r=-0.2, p<0.001). There was a trend
275 towards greater uncontrolled eating scores in obese women with PCOS (obese 2.6±0.4,
276 overweight; 2.5±0.4 and lean 2.5±0.5; p=0.053). Uncontrolled eating scores were positively
277 associated with total food craving score (r=0.67; p<0.001) and binge eating symptom score
278 (r=0.56, p<0.001). These strong correlations remained when controlled for BMI.

279

280 **3.5 Association between binge eating and food cravings in women with PCOS**

281 Binge eating symptom score and food cravings total scores were strongly correlated
282 (r=0.745; p<0.001, n=463 women with PCOS. **Multiple regression analysis to predict**
283 **contribution to binge eating symptom score included BMI, total food cravings score,**
284 **uncontrolled, emotional and cognitive restraint eating scores as predictor variables. The**
285 **model explained 57% of the variance in binge eating symptom scores (F(df1, df2)=130.4;**
286 **p<0.001): food cravings total score (beta =0.53; p<0.001), emotional eating score (beta**
287 **=0.18; p<0.001), BMI (beta= 0.11; p<0.001) and uncontrolled eating score (beta =0.09**

288 $p=0.02$) independently contributed to this explained variance, whereas cognitive restraint
 289 was not an independent predictor (beta 0.03; $p=0.28$).

290

291 **3.6 Comparisons between lean healthy women and lean women with PCOS**

292 Lean healthy women ($n=40$) and lean women with PCOS ($n=45$) were similar in ethnicity
 293 (both $>95\%$ Caucasian), age (28.3 ± 8.5 years and 31.3 ± 5.6 years; $p=0.07$) and BMI
 294 ($21.8\pm 1.6\text{kgm}^{-2}$ and $22.5\pm 1.8\text{kgm}^{-2}$; $p=0.09$). They returned similar total food craving scores,
 295 although, women with PCOS reported significantly higher scores on the food craving sub-
 296 scale ‘*Anticipation of Positive Reinforcement That May Result From Eating*’ ($p=0.017$,
 297 Cohen’s $d = 0.52$) and ‘*Anticipation of Relief From Negative States and Feelings as a Result*
 298 *of Eating*’ ($p=0.009$, Cohen’s $d = 0.56$) compared with lean healthy women (table 4).
 299 Significantly higher mean binge eating score was observed in lean women with PCOS
 300 compared with lean healthy women (10.9 ± 7.8 versus 7.4 ± 6.0 , $p=0.024$; Cohen’s $d = 0.50$
 301 (table 4). Lean women with PCOS had a significantly higher proportion of subclinical/ highly
 302 disordered eating (36%, $n=16$) compared with lean healthy women (12%, $n=5$; $\chi^2 p=0.02$ phi
 303 $=0.28$). Multiple regression analysis to predict contribution to binge eating symptom score
 304 included PCOS diagnosis, BMI, uncontrolled eating score, emotional eating score and total
 305 food cravings score as predictor variables. The model explained 68% of the variance in
 306 binge eating symptom scores ($F(df1, df2)=31.2$; $p<0.001$); food cravings total score (beta
 307 $=0.72$; $p<0.001$), PCOS status (beta 0.14; $p=0.042$), independently contributed to this
 308 explained variance, however emotional eating score (beta $=0.07$; $p=0.9$), uncontrolled eating
 309 score (beta $=0.107$; $p=0.23$) and BMI (beta $= 0.008$; $p=0.91$) did not.

310

311 Table 4. Food craving and binge eating scores from lean healthy women and lean women
 312 with PCOS.

	Healthy n=40	PCOS n=45
Total food cravings score* ; Mean (SD)	105.6 (26.6)	114.0 (34.9)
<i>Subscales:</i>		
Having intentions and plans to consume food	8.6 (2.4)	9.1 (3.2)
Anticipation of positive reinforcement that may result from eating	12.6 (3.8) ^a	14.7 (4.3) ^a
Anticipation of relief from negative states and feelings as a result of eating	6.4 (2.2) ^a	8.0 (3.4) ^a
Lack of control over eating	14.5 (5.4)	16.3 (7.2)
Thoughts or preoccupation with food	17.3 (6.2)	18.1(7.8)
Craving as a physiological state	12.3 (3.1)	13.1 (3.0)
Emotions that may be experienced before or during food cravings or eating	11.2 (4.2)	11.9 (5.1)
Cues that may trigger food cravings	14.0 (4.2)	13.1(4.3)
Guilt from cravings and/or for giving into them	8.8 (3.6)	9.6 (3.7)
Binge eating symptom score* ; Mean (SD)	7.4 (6.0)	10.9 (7.8)^a

Absence of both compulsive eating and binge-eating.	65% n=26	50% n=22
Unusual eating pattern might be a compulsive eater who eats excessively but does not binge-eat.	17.5% n=7	13.6% n=6
Subclinical group of binge-eaters, either in the initial stages of the disorder or recovered bulimics.	5.0% n=2	15.9% n=7
Highly disordered eating pattern and the presence of binge-eating	7.5% n=3	20.5% n=9
Binge eating severity score^a; Mean (SD)	2.0 (2.2)	2.8 (2.1)
Normal	89.5% n=34	86.4% n=38
Clinically significant behaviour	7.9% n=3	13.6% n=6
High degree of severity	2.6% n=1	0% n=0

313

314 ^ap<0.01: Significant difference between healthy and PCOS women; independent t test.

315 *See Tables 2 and 3 for notes on possible scale score ranges.

316

317 **3.7 Dieting experience in women with PCOS**

318 The eating behaviours study indicated a high proportion of overweight and obese women
319 with PCOS expressed an interest in losing weight (96% and 99% respectively). Despite
320 these intentions only 47% of obese women with PCOS reported to be modifying their diet to
321 promote weight loss and a further 11% were modifying their diet to avoid weight gain (40%
322 and 11% comparatively for overweight women with PCOS). This was explored further in the
323 Dieting Experience Survey completed by 86 overweight or obese women with PCOS; mean
324 BMI 37.4±7.1kgm⁻² (6 participants had incomplete data for their BMI). Most of the
325 respondents were of Caucasian ethnicity 86% (n=74). Nearly all (93%) of the women
326 reported to have been on diets previously to lose weight, though only 13% reported
327 stopping the diet as they had attained their goal of weight loss or duration. Hunger and
328 frustration were the most common reason for abandoning a dietary change (57%) followed
329 by perceived ineffectiveness of the diet (40%) and expense (35%). Barriers reported to
330 'often' or 'routinely' impact on achieving their goal of staying healthy were; *'too tired'* (71%),
331 *'interferes with other responsibilities'* (57%), *'lack of time'* (55%), *'embarrassment about my*
332 *appearance'* (46%), *'feeling what I do does not help'* (46%), *'lack of money'* (40%), and *'lack*
333 *of help from healthcare professionals'* (24%).

334

335 **4. Discussion**

336

337 **4.1 Binge eating behaviour**

338 The current study has reported binge eating behaviour in the majority of obese women with
339 PCOS, and more than a third of overweight and healthy weight women with PCOS. This is
340 the first time binge eating has been reported with a validated tool in a large cohort of women
341 with PCOS. Regression analysis demonstrated the interrelationship between binge eating

342 behaviours and food cravings in the women with PCOS, similar to previous studies in obese
343 and overweight non PCOS participants (61, 62).

344

345 Direct comparisons with published studies of non PCOS populations need to take into
346 account different methods for assessing binge eating behaviour. The prevalence of clinically
347 significant binge eating behaviour in our cohort of obese women with PCOS (39%) is greater
348 than reports in non PCOS obese women within a large Italian study whereby 24-32% of
349 obese women were classified as exhibiting binge eating behaviour as defined by a score ≥ 18
350 on the Binge Eating scale (63), similarly, in the United States, 27% of overweight/obese
351 women had some bingeing or probable binge eating disorder (64). Larrison *et al.* (2015) also
352 recently reported women with PCOS (n=72) had a higher Eating Attitudes Test score,
353 reflecting disordered eating, compared with controls (n=30), though women with PCOS had
354 a significantly higher BMI (19). Our cohort of lean women with PCOS had significantly higher
355 binge eating symptom scores compared with lean healthy women in agreement with the
356 findings of Hart *et al.* (2012)(47).

357 Women with PCOS who reported amenorrhea had significantly higher binge eating symptom
358 scores compared with those with menses, this agrees with the association between binge
359 eating and menstrual dysfunction in women without PCOS observed by Algars *et al.*
360 (2014)(28). The pathogenesis is believed to involve elevated testosterone (31), we did
361 observe higher binge eating symptom scores in PCOS women with acne compared to those
362 without acne, however, scores were similar in hirsute and non-hirsute women with PCOS,
363 although it should be noted that the study was not powered to detect differences between
364 symptom sub-groups and so these results should be viewed with caution. We suggest future
365 studies explore menstrual dysfunction and hyperandrogenism in relation to eating
366 behaviours in women with PCOS including investigation of hormonal influencers in binge
367 eating (65) which was beyond the scope of this study.

368

369 Binge eating has a complex and incompletely understood aetiology. Contributing factors
370 include anxiety, depression and negative body image (66-68), all frequently observed in
371 women with PCOS (23, 24, 69). Rodino *et al.* (2016) recently reported that infertile obese
372 women, including a small cohort of obese women with PCOS experienced lower self-
373 esteem, body shape concerns and binge eating behaviours (70). Our study was not powered
374 to report a difference in binge eating symptoms and depression and there is a gap in the
375 literature exploring this potential relationship in PCOS especially given the high prevalence
376 of depression in women with PCOS (24). Further research into the causes and possible long
377 term consequences of binge eating behaviours in lean women with PCOS is needed to
378 investigate whether bingeing contributes to future weight gain in this syndrome.

379

380 **4.2 Food craving**

381 Food cravings are often anecdotally reported by women with PCOS (46), though there is a
382 paucity of research and the current study is the first to report food cravings in a large cohort
383 of women with PCOS using a validated tool. Our cohort reported food craving questionnaire-
384 Trait (FCQ-T) scores in the obese women with PCOS (131.6 ± 28.9) that were higher than
385 published values for non PCOS populations, e.g. 111.5 ± 36.8 in an Italian cohort of 411
386 overweight and obese women, and 86 obese men (71) and 119.2 ± 31.4 for 109 overweight
387 and obese in the United States (57). Direct comparisons are limited by the fact that these
388 studies include males and overweight participants; further studies are needed to compare
389 food cravings in obese women with and without PCOS. Of interest, food craving scores for
390 obese women with PCOS are more similar to the scores reported by Jarosz *et al.* (2007) in
391 obese women with binge eating disorder or bulimia (137.6 ± 40.2 $n=7$) or night eating
392 syndrome (122.5 ± 19.0 $n=16$) (72) and normal-weight university students with food addiction
393 (147.1 ± 34.5 , $n = 48$) (38), although some of those scores were based on very small
394 numbers. The current study revealed lean women with PCOS and lean healthy women had
395 similar total FCQ-T scores; however, women with PCOS did have greater 'anticipation of
396 positive reinforcement that may result from eating' and 'anticipation of relief from negative
397 states and feelings as a result of eating'. These both address feelings of satisfaction from
398 eating and the clinical relevance of these aspects needs to be explored in more detail. Of
399 note, although food cravings are strongly correlated to binge eating, which is highly prevalent
400 in women with PCOS, the facets of food cravings that distinguished PCOS from healthy
401 women are those concerning anticipation of reinforcement and relief from negative emotions
402 and these may be crucial for the development of binge eating (73). Women with PCOS who
403 reported amenorrhea had significantly higher FCQ-T scores compared with those with
404 menses; this agrees with the association reported between menstrual dysfunction and fast
405 food cravings in overweight/ obese women (48). However, like binge eating symptom
406 scores, FCQ-T scores were higher in PCOS women with acne compared to those without
407 acne, though scores were similar in hirsute and non-hirsute women with PCOS; whereas
408 Lim *et al.* (2009) observed greater high fat food cravings in women with hyperandrogenism
409 (48). This is an area for further study that requires more robust measurements of menstrual
410 function and androgen excess in women with PCOS.

411 Another factor that may influence food cravings is dieting status, i.e. restricting energy intake
412 to lose weight: repeatedly eating palatable energy-rich food such as chocolate when hungry
413 has been shown to exacerbate craving in established chocolate cravers and induce craving
414 in previously non-cravers (43). Therefore, we examined whether trait craving or binge eating
415 scores differed by dieting status in obese women with PCOS; by and large, there were no

416 differences, with the exception that dieting women reported slightly more guilt at having
417 cravings or giving in to them, presumably because such behaviour was contrary to their
418 attempts to limit energy intake. In agreement with this, when controlled for BMI, there was
419 no correlation between cognitive restraint eating and food craving scores.

420

421 **4.3 Weight management**

422 A large proportion of the overweight and obese women with PCOS were not following dietary
423 modifications to prevent weight gain or promote weight loss, although the majority of women
424 had tried to lose weight in the past. Similarly a high dropout rate has been reported in a
425 meta-analysis of 10 lifestyle intervention program studies in infertile overweight or obese
426 women (74). In our study only 13% of overweight and obese women with PCOS reported
427 attaining their goal of weight or duration as their reason for stopping the diet emphasising the
428 difficulty associated with weight loss and weight maintenance in this population. Barriers to
429 successful weight loss included feeling frustrated and hungry, interference with other
430 responsibilities, adherence difficulty, lack of time and tiredness, are in line with people
431 wanting to lose weight (59, 75). The hunger reported by women could allude to the lower
432 meal stimulated ghrelin levels measured in women with PCOS (76), additionally studies
433 have shown that testosterone stimulates food intake (49). Given that weight management is
434 the primary treatment for women with PCOS understanding the barriers and reasons for
435 non-compliance is crucial.

436

437 **4.4 Clinical Implications**

438 Binge eating behaviours may be a contributor to the difficulties associated with weight
439 management reported amongst women with PCOS. It is important that the high prevalence
440 of binge eating behaviours in women with PCOS is included within clinical guidelines, with
441 suggested screening for disordered eating to help towards appropriate strategies to help
442 women with binge eating behaviours (77). In particular in lean women with PCOS, often
443 overlooked in the clinical and research setting, strategies to help with binge eating
444 behaviours could be an effective intervention to prevent future weight gain. To strengthen
445 the evidence it is important that the high prevalence of binge eating behaviours in obese
446 women with PCOS reported in this study is explored in a large case control study. The
447 prevalence of food cravings in PCOS is less clear. Cognitive behavioural therapy (78) and
448 mindfulness (79) within interventions to help individuals reduce their food cravings has been
449 successful, though further study in this area is needed before clinical interventions are
450 recommended (36). In addition to the limitations of the present study highlighted above, the
451 self-report nature of the PCOS diagnosis should be noted, with limited information on
452 hyperandrogenism and menstrual function collected. Information on menstrual cycle was not

453 collected, which would have been valuable given the variations in food cravings through the
454 menstrual cycle shown previously (80); however this should not have affected between
455 group comparisons.

456

457 **4.5 Conclusion**

458 This study is the largest, to date, to robustly report binge eating and food cravings in women
459 with PCOS, contributing significantly to the existing anecdotal evidence and small scale
460 studies. Such disordered eating behaviours may be a contributor to and/ or a function of the
461 difficulties with weight management reported amongst women with PCOS. Clinician
462 awareness of binge eating in individual women with PCOS should influence the choice of
463 weight management approaches: thus screening of overweight and obese women with
464 PCOS for binge eating is recommended. To further our understanding of disordered eating
465 behaviours in women with PCOS we suggest, BMI matched case-control, studies to assess
466 the influence of medication, hormonal and psychological contributors to binge eating
467 behaviours in women with PCOS.

468

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472

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