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An Investigation into Carbohydrate Cravings and BMI in Women with Polycystic Ovary Syndrome

Agnes J Morrell*

Department of Life Sciences, University of Roehampton, United Kingdom

***Corresponding Author:** Agnes J Morrell, Department of Life Sciences, University of Roehampton, United Kingdom.

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Abstract

Background: Polycystic ovary syndrome is a common endocrine disease among females, with up to 10% of women suffering in the UK. Genes and environment both contribute to the onset of PCOS, but symptoms can be worsened by obesity and a poor diet. Food cravings have been linked to weight gain in women with PCOS, and there has been minimal research into carbohydrate consumption and eating behaviours, however they may be linked.

Aim: The purpose of this study was to understand the issues regarding eating behaviours and food cravings and whether they could be related to weight gain and increased carbohydrate consumption in women with PCOS. Two hypotheses have been investigated; hypothesis 1: women with PCOS have differing levels of food craving which is positively associated with BMI, hypothesis 2: women with PCOS who have higher TFEQ scores, representing disturbed eating behaviours, have higher carbohydrate consumption levels compared to those with lower TFEQ scores.

Method: An online survey was constructed including the Three Factor Eating Questionnaire, the Food Craving Questionnaire and the Food Frequency Questionnaire, along with questions regarding diagnosis, anthropometric measurements and basic subject characteristics. Volunteers were recruited through posters and Verity, an online PCOS charity and ethical approval was granted by the University of Roehampton ethics committee.

Results: 70 participants completed the survey and 68 participants gave anthropometric data, (n = 19 lean and n = 49 overweight). There was a significantly greater prevalence of food cravings in the obese women compared with the lean women, ($P < 0.05$). The uncontrolled eating subscale of the TFEQ was not associated with carbohydrate intake ($P > 0.05$), however, uncontrolled eating was positively associated with BMI ($P < 0.05$). Emotional eating and cognitive restraint were not correlated with either carbohydrate intake or BMI ($P > 0.05$).

Conclusion: These finding back previous studies in regards to links found between food cravings and BMI. The results also provide an important insight into the links between uncontrolled eating and carbohydrate craving as there is minimal research in this area.

Keywords: *BMI; Obesity; Carbohydrate; Food Craving; PCOS; TFEQ; Emotional Eating; Weight Gain*

Abbreviations: BMI: Body Mass Index; TFEQ: Three Factor Eating Questionnaire; PCOS: Polycystic Ovary Syndrome; FCQ: Food Craving Questionnaire; FFQ: Food Frequency Questionnaire; St. Dev: Standard Deviation; Sig: Significance; FCI: Food Craving Inventory; SPSS: Statistical Package for the Social Sciences; N: Number; Kg: Kilograms; M: Metre;

Introduction

Polycystic Ovary Syndrome; Prevalence and Obesity

Polycystic ovary syndrome is a common endocrine disease among females, with an estimated prevalence in the UK of up to 10%. Genes and environment both contribute to the development of PCOS, but symptoms can be worsened by obesity and a poor diet [1]. PCOS can considerably influence the quality of life of women throughout their reproductive years and can affect the hormone levels and the menstrual cycle. It is associated with subfertility, acne, obesity and hirsutism, and is linked with a higher mortality when compared with unaffected women [2]. Women with PCOS are also at a higher risk of long-term health issues such as type 2 diabetes, cardiovascular disease, endometrial cancer and breast cancer [3].

Approximately 50% of women with PCOS are overweight or obese, and obesity may have a pathogenetic role in the development of the syndrome in susceptible individuals [4]. A number of studies [5,6] demonstrate that varying diets can have a beneficial effect on the symptoms of PCOS; however, the composition of the optimal diet for PCOS sufferers is still to be determined. Recent findings [7] suggest that women with PCOS suffer from increased carbohydrate cravings, which may have an effect on insulin resistance and weight gain.

Carbohydrate Intake, Craving and Measurement

The symptoms of PCOS vary greatly between women; however, the most prevalent characteristics associated with the syndrome are hyperandrogenism and chronic oligo-anovulation [4].

It has been reported that women with PCOS may find relief from symptoms by following a low carbohydrate diet as a result of the associations with insulin resistance and diabetes. Increased insulin availability may favour excess androgen synthesis at the level of ovarian tissue. Obesity may be partially responsible for insulin resistance and subsequent hyperinsulinaemia in women with PCOS. Consequently, obesity-induced hyperinsulinaemia may be a key factor in the onset of hyperandrogenism in women with PCOS [4].

Research into the possible beneficial effects of a carbohydrate restrictive diet has been carried out to investigate whether there is any relief in symptoms of PCOS [8]. Eleven overweight and obese women with PCOS restricted their carbohydrate intake to 20 grams or less for a 24 week period while consuming unlimited animal foods (meat, chicken fish etc.) prepared and fresh cheeses (up to 2 and 4 ounces per day, respectively), unlimited eggs, salad vegetables (2 cups per day) and low carbohydrate vegetables (1 cup per day). Participants returned every 2 weeks for measurements and dietary instruction. Results from the study found significant improvements in weight loss (-12%), free testosterone (-22%), luteinizing hormone/follicle stimulating hormone ratio (-36%) and fasting insulin (-54%). Although the sample used for this study was relatively small, there were some clear and significant improvements in the symptoms of PCOS in the participants during the 24 week low carbohydrate diet, indicating that carbohydrate consumption may play a large role in the association of obesity with PCOS, and could be a key parameter to investigate with regards to weight loss and to alleviating symptoms.

The findings from this study which suggested a beneficial effect of restricted carbohydrate in women with PCOS, imply that it would be appropriate to explore further the potential causes of increased carbohydrate consumption in order to gain a better understanding of the specific eating behaviours which may lead to increased carbohydrate consumption. Carbohydrate craving is a factor that should be taken into consideration due to the subsequent increased carbohydrate consumption that may occur due to cravings.

Carbohydrate craving can be defined as a disorder of disturbed appetite, with a perceived desire to consume sweet or starchy food [9], although there is controversy in literature over the correct definition of food cravings [10]. The most commonly used definitions used in literature are behavioural and subjective descriptions of cravings [11]; however, to describe a craving as behaviour does not differentiate craving from hunger and discounts the cognitive nature of craving. Temporary mood improvement often follows carbohydrate consumption in the carbohydrate craver, whereas those who do not crave carbohydrates can feel fatigued after consumption [12]. The improvement in mood after carbohydrate consumption is due to an increase in serotonin levels [13]. Serotonin release is also involved

with other functions such as, sensitivity to pain, sleep onset and mood control; individuals therefore learn to overeat carbohydrates in order to improve their mood (predominantly snack foods which are high in carbohydrate and fat such as chocolate and crisps) [14]. This learned behaviour leads to weight gain as individuals use these foods to comfort themselves when psychologically stressed.

Cholecystokinin (CCK) is a hormone that enables regulation of food intake as it slows down the digestive process and signals satiety to prevent overeating. CCK is secreted in the gastrointestinal tract when food is consumed; however it has been suggested [15] that some women with PCOS have reduced CCK secretion leading to disturbed appetite regulation. Recent research has been carried out in order to gain a better understanding of these carbohydrate cravings amongst women with PCOS [16]. The study involved an overnight fast of 16 pairs of women with PCOS and matched controls, after which blood samples were taken during a meal. Results from the blood samples showed that women with PCOS had a significantly lower CCK response ($P < 0.05$), and results from a self-rated scale to measure appetite revealed higher ratings of cravings for sweets as an indicator of carbohydrate craving, among women with PCOS ($P < 0.07$). However, no correlation with insulin was established. Interestingly, the craving for sweets rating was inversely related to testosterone and the CCK response was positively correlated with levels of free testosterone. The results from this study suggest that women with PCOS have reduced CCK secretion compared with healthy women, and the sweet craving results suggests that women with PCOS also suffer from abnormal appetite regulation which is related to the increased levels of testosterone found. These findings are of interest with regard to the potential effect on symptoms of PCOS, as symptoms can be worsened when testosterone levels are increased.

There are multiple craving scales that can be used to measure carbohydrate craving. Food craving scales, which have been developed and used in studies, May not show an accurate representation of craving level due to misperception over the classification of cravings and inconsistencies in measurement scales between studies. There have been multiple scales used in literature [17,18], some of which interpret cravings as behaviours. This makes it difficult for the participants to differentiate between craving and hunger. Studies mostly rely on the participant's subjective perception of a craving in order to interpret when they are craving certain foods, which can cause confusion in the differentiation of hunger and cravings between participants [19].

Carbohydrate cravings can also be measured using Trait and State Food Craving Questionnaires (FCQ-T and FCQ-S) which are both reliable and valid measures of general trait-like and state-dependent food craving [20].

Food Cravings and Body Mass Index

Food cravings have been found to have an adverse relationship with BMI, not only in women with PCOS, but also within the general population. A recent study [21] investigated the association between psychological characteristics and BMI. The study included 75 participants; 50 obese patients and 25 normal-weight volunteers, each of whom completed a number of questionnaires regarding differing psychological characteristics, including food cravings measured with the food craving questionnaire-trait. The results showed that the obese participants had higher levels of food cravings compared with the normal-weight controls. This suggests that food cravings may play a key role in weight gain and increased BMI. These findings are backed by further research into the links between food cravings and BMI [22], which found a positive correlation between the two factors.

Current research has showed that food cravings have also been linked to factors that could directly affect BMI, such as associations with binge eating behaviour and unsuccessful dieting. A recent study [23] has investigated the links between food cravings and dieting success, which could have an impact on weight gain and BMI. An online survey was carried out by 616 participants to test the role of food cravings and perceived dieting success. The results showed a significant inverse relationship between food cravings and dieting success, which suggests that there may be an association between food cravings and unsuccessful dieting. This link gives an insight into the potential mechanisms that can influence dieting success. Further research carried out by Meule *et al*. [24] has also revealed that food cravings have been strongly associated with triggering food consumption and binge eating behaviours, which in turn can also have a direct impact on BMI.

The Food Craving Index (FCI) was developed to measure specific food cravings using two subscales: subjective cravings and consumption of particular foods. Carbohydrate craving has been frequently studied using the Food Craving Index and has been found to be a reliable and valid measure of food cravings [25]. An alternative method for measuring food cravings is the Food Acceptance and Awareness Questionnaire (FAAQ), which is an effective self-reported measurement of urges and cravings. Items are rated on a seven-point scale ranging from never true to always true on two scales: ability to regulate eating urges and cravings, and desire to maintain internal control over eating thoughts. Although the FAAQ is a sufficient craving measurement tool, it only uses 10 items of food for measurement, which may not be enough to illustrate the differences in cravings between food groups [26].

Given the known associations from recent research linking binge eating, unsuccessful dieting and increased BMI with PCOS [27], it is necessary to explore further the relationship between food cravings and BMI within the PCOS population. Further research into food cravings and BMI are necessary to gain a further understanding into the relationship between the two factors.

Hyperinsulinaemia and Insulin Resistance

A retrospective audit [28] was carried out on women with PCOS to determine anthropometrics, biochemistry, symptoms, and to evaluate the effects of dietary interventions on symptoms. Data was collected from 88 participants over a two year period from medical records from dietetic consultations. Low GI diets had been prescribed to the participants during their consultations, and reduced energy intake was advised for individuals who were overweight. The follow-up data was obtainable from 59 participants. The results from the study found that over two thirds of participants reported one or more of the following symptoms: carbohydrate craving, tiredness, hunger and hypoglycaemia. In the overweight participants, there was a significant decrease in waist circumference and BMI in the follow up appointment ($P < 0.05$). There was also a reduction from 70% to 13% in self-reported hypoglycaemia in participants from the initial consultation to the follow-up consultation. The findings of this study led to the conclusion that a low-glycaemic diet may improve symptoms in PCOS.

Although this is a significant result, in the intention to treat analysis, 32.96% of participants did not have data from the follow up appointment. It is a possibility that this group of participants did not return for the follow up consultation, as they may not have adhered to the low-glycaemic dietary plan that had been prescribed. Higher levels of adherence to this study would enable improved validity of results.

The majority of research, which explores cravings in women with PCOS, focuses on the association and effects of hyperinsulinaemia and insulin secretion [29]. Hyperinsulinaemia has been suggested as a potential cause of carbohydrate craving and general hunger which leads to reduced blood glucose, resulting in a perceived need to ingest carbohydrates, with more recent research into the association between hyperinsulinaemia and carbohydrate cravings explored in the investigation by Hischberg [16]. This subsequent craving for carbohydrates caused by possibly reduced blood glucose levels may then lead to weight gain and obesity, which increases the likelihood of insulin resistance occurring [28].

Many individuals suffering with PCOS are obese women with hyperinsulinaemia. An initial review of research [30] carried out to investigate the disturbances of insulin secretion and sensitivity in women with PCOS has explored various explanations of the causes of insulin resistance. A study has investigated the possibility that an increase in truncal-abdominal fat mass and consequently increased free fatty acid levels induce insulin resistance in women with PCOS. This is not necessarily the only explanation of why insulin resistance occurs in women with PCOS, as contrasting research [31] has supported the suggestion of genetic target cell defects as a cause of insulin resistance, which is generally considered to be due to multiple post binding factors. When considering the insulin-resistant individuals with unimpaired glucose tolerance, the majority of the hyperinsulinaemia may be due both to secondarily increased insulin secretion and to decreased insulin degradation [31]. It is worth noting that insulin sensitivity was not reversed after weight loss, contradicting current findings in insulin resistance [32], which found insulin sensitivity was restored with weight loss. It is not fully understood why this increase in insulin release occurs but is has been postulated that it may be associated with the hormonal imbalances

which occur as a result of menstrual irregularities. In accordance with previous literature, this review also suggests that there are links between carbohydrate craving and insulin release, which may ultimately lead to insulin resistance, obesity and diabetes. The enhanced insulin secretion observed in PCOS may potentially be associated with the perturbed steroid balance associated with anovulation. Overall, extensive links in the androgen-insulin association have been identified, and the review of literature suggests that there are various mechanisms which can have an effect on this. However, the effects of this may vary between individual women with PCOS.

In depth research into the effect on food cravings of both hyperandrogenaemia and menstrual disturbances in overweight and obese women has identified significant links [33]. A study involving 198 women aged 28 ± 0.3 years recorded their food cravings and explored the relationship between psychological distress and reproductive health. The results from the study showed there was a significant correlation between menstrual disturbances and food cravings *(P* < 0.05) and that there was also a significant correlation between hyperandrogenaemia and food cravings (*P* < 0.01). Psychological stress has previously been linked to increased food cravings within the Three Factor Eating Questionnaire among women with PCOS [34]; in contrast, however, the findings from a recent study [33] showed no statistically significant correlation between psychological stress and food cravings. This research suggests that hyperandrogenaemia and menstrual disturbances are associated with greater food cravings, and that food cravings may be due to physiological imbalances in the body as opposed to psychological issues. To explore this further, it may be helpful to compare overweight and lean women with PCOS in order to understand whether there are varying levels of cravings causing weight gain and increased PCOS symptoms, as opposed to lack of willpower when experiencing cravings.

It has been widely reported that a high proportion of women with PCOS are either overweight or obese, and in most cases obesity has a detrimental effect on the symptoms suffered as a result of PCOS. The main issue surrounding obesity when associated with PCOS is that the increase in insulin resistance as a result of obesity may further promote excessive production of ovarian and adrenal androgens and unbound testosterone. Due to the increased adverse outcomes of individuals with both PCOS and obesity, weight loss treatment is a vital factor in reducing the severity of symptoms in obese women suffering with PCOS, although this proves challenging due to impaired lipolysis and insulin resistance [35].

As it is widely accepted that there is an improvement in symptoms following weight loss in obese women with PCOS, it is important to identify the factors which can influence weight loss, such as food cravings. Factors affecting BMI in women with PCOS would be a useful topic for further study.

Eating Behaviour Relationships and Measurement

At present, there has been minimal research on links between the Three Factor Eating Questionnaire score (TFEQ), which measures uncontrolled eating, restrained eating and emotional eating behaviours, and food cravings within the PCOS population. There has, however, been a limited amount of research carried out to investigate the relationships between TFEQ score and BMI in women with PCOS. A recent study [36] carried out on 24 pre-menopausal women with PCOS investigating the links between BMI and TFEQ score found that there was a significantly positive correlation between BMI and both the emotional eating score (P = 0.01) and the uncontrolled eating score (= 0.04). It is worth noting that when obese and overweight women were compared with lean women, there was a trend towards a significantly greater emotional and uncontrolled eating score in the overweight and obese women. From the results of this study, it would seem helpful to explore whether and how BMI is associated with the TFEQ scores in women with PCOS. Although there are significant findings in this study, the results may not be valid due to the limited number of participants used. Replication of this work using a larger sample size may improve validity.

These findings are backed by further research [27], which involved 25 PCOS women and 24 healthy, BMI-matched women, each of whom completed a pre-coded food diary to measure dietary intake and a TFEQ to asses eating behaviours. Results from this study showed that eating behaviours from the TFEQ did not differ significantly between the groups, although this may be due to validity

issues concerning pre-coded diaries. Research into the validity of pre-coded food diaries [37] suggests that participants are only moderately correct when using pre-coded food diaries to assess food and nutrient intakes. Alternative forms of measuring food intake may produce more accurate results, although they can be time consuming.

Due to the various forms of disordered eating which require accurate monitoring there is a need for a valid and effective form of measuring eating behaviours. The Three Factor Eating Questionnaire is one of the most popular scales used to measure disordered eating in recent research. The original questionnaire was developed by Stunkard and Messick [38] and contains 51 items to which the individual responds in a self-assessment format. Research into the revised TFEQ-R18 [39,40] has found it to be an effective method of analyzing eating behaviours across varying populations, and is therefore an appropriate tool for the measurement of eating behaviours within the PCOS population.

The Current Proposed Study

Hypotheses

Hypothesis 1: Women with PCOS have differing levels of food craving which are positively associated with BMI.

Hypothesis 2: Women with PCOS who have a higher TFEQ score, representing disturbed eating behaviours, have higher carbohydrate consumption levels than those with a lower TFEQ score.

Aim

The aim of this study is to identify whether there is a relationship between food cravings and BMI in women with PCOS.

Objectives

Due to significant findings to date that suggest increased food cravings in women with PCOS, it would be beneficial to compare the food craving severity of women suffering with PCOS with BMI, in order to investigate whether there is a significant correlation between craving severity and increased BMI. Furthermore, as there is minimal conclusive research to date, it would be useful to investigate the links between eating behaviours and carbohydrate consumption. If this can be established, then a better understanding of eating behaviours and factors influencing energy intake in women with PCOS may be established.

Materials and Methods

Study Design

This was an observational study investigating varying food craving severity levels in women with PCOS and the relationship that craving levels have with BMI. An observational study was the most appropriate design to establish if there was a relationship between the food cravings and BMI, it was also appropriate given the length and cost limitations of the study. When comparing food craving and BMI, the data obtained for BMI was calculated from the weight and height of each participant, each participant was then grouped according to their BMI status of either 'lean or underweight' or 'overweight or obese'. Further data collected included a food frequency questionnaire, food craving severity using the food craving index and the Three Factor Eating Questionnaire to measure eating behaviours. General information was also collected including age, previous dietary guidance, date of diagnosis and type of symptoms.

Protocol

Participants

The initial sample used in this study was 76 pre-menopausal women with PCOS. This sample size was chosen to represent the population of women with PCOS because a similar cross-sectional observational study [41] investigating women with PCOS found this to be a sufficient sample size to give an accurate representation of the PCOS population. The study carried out by Barr *et al*. [41] consisted of 37 women with PCOS and matched pairs, each of whom completed a 7 day food diary and completed anthropometric

data collection. As there has been minimal research in this field, no further similar studies currently exist. This sample number was an achievable figure in terms of recruitment for this study. The eligibility criteria required the participants to be over 18 years of age, to be of reproductive age (not yet to have been through menopause), and with self-reported PCOS. The exclusion criteria for participants included those who are currently pregnant or have been pregnant in the last 6 months, those who are breastfeeding, or those who are on very restrictive diets or who are currently suffering with an eating disorder.

Materials

Anthropometric measurements in this study were self-reported and therefore the equipment used for measurement was unknown. Questionnaires included an introductory questionnaire, a food craving inventory questionnaire to report the severity of carbohydrate craving, a food frequency questionnaire to establish consumption levels, and a Three Factor Eating Questionnaire (-18), to gain information on eating behaviours. The Three Factor Eating Questionnaire is a common scale used to measure disordered eating in recent research. The original questionnaire contained 51 questions which covered three scales; disinhibition, hunger and cognitive restraint. A study was carried out by Karlsson and Karlsson [42] after concerns were raised over the validity and format of the 51-item Three Factor Eating Questionnaire. The sample of the study involved 377 middle aged obese women and men, who underwent psychometric analysis, the results of which showed discrepancies when compared to the Three Factor Eating Questionnaire. Along with additional research supporting the concerns of the Three Factor Eating Questionnaire [43], a revised questionnaire was compiled which was comprised of three more appropriate categories including cognitive restraint, emotional eating and uncontrolled eating. This revised version of the Three Factor Eating Questionnaire, the TFEQ-R18, comprised of 18 questions, the most effective items from the original set of 51 questions were used to increase the legitimacy of the questionnaire. Participants were instructed to contact the investigator for guidance if they wanted further clarification.

Procedure

The data collection process was carried out from July until December 2011. The majority of the participants were recruited via Verity, a charity and self-help organization for women with PCOS, which has approximately 1000 members. Participants were also recruited through email and poster advertisements to staff and pupils at Roehampton University. The proposal, which was released on Verity for recruitment of participants included a brief description of the project explaining that many women with PCOS have difficulty managing their weight and that this study was investigating the factors which influence what you eat and why.

There was a description of what would be expected from the participants' involvement, explaining that they would be requested to complete an online questionnaire. The potential participants were informed that any information obtained would be kept confidential and that each participant would have a code which would be used to identify any information provided. The initial collection method included an online questionnaire created using Survey Monkey (USA), an online questionnaire generating tool. Participant data was collected from questions requesting information including self-reported anthropometry measurements (height and weight measurements), relevant medical diagnoses and prescribed medication, food frequency and habits questionnaires including a food craving inventory and a Three Factor Eating Questionnaire.

The link to the electronic survey and full details of information on the study were initially posted on the Verity website and discussion board. Participants were reassured that they could be in close consultation with the project supervisor from Roehampton University and further assistance would be provided by the Verity support staff. Along with all Verity members being notified of the study through the posting on their website, as an additional stage of participant recruitment, a random selection of 200 Verity members were emailed an outline of the survey details via verity support staff, and an electronic link to the surveys was provided. This generated substantial further interest in the study and additional participants were recruited. Participants were offered the option of receiving feedback from a dietician from the dietary information they had given, including an indication of whether they were meeting the intake requirements for a wide variety of nutrients.

The details of the completed questionnaires were then entered into an excel data spread sheet with corresponding numbers for each participant to ensure confidentiality. Specific data was then analysed in SPSS to establish the necessary differences and correlations within the data.

Ethics

The main ethical issue which was to be considered during the study was to respect the confidentiality of the volunteers. Each volunteer was assigned a number and their name only appeared on the consent form and not associated with the data collected regarding the individual. The proposal was sent to the University of Roehampton Ethics Committee for approval, and general approval from Verity was obtained to recruit women from their charity. A risk assessment was carried out for the study and potential risks were managed and minimized. The potential risks that were covered in the risk assessment were; emotional distress, which was to be controlled and minimized by providing details of what to do if suffering emotional distress in the participant consent form and the participants were informed that they could withdraw at any time. The risk of having an inexperienced investigator carry out the investigation was controlled by ensuring the investigator had fully researched the topic to be as aware as possible for any situations that could have occurred. As with many studies of this nature, incorrect reporting of food intake is often an issue; producing specific guidelines for the participants to follow reduced inconsistencies. Roehampton University Ethics Board granted ethical approval for the study and Verity gave approval to contact their members.

Data Analysis

Frequencies and descriptive statistics were generated using SPSS version 16.0. A 95% confidence level ($P = \leq 0.05$) was assumed for statistically significant results throughout and continuous data was presented as mean standard deviation.

Data was tested for normality using the one-way Kolmogorov-Smirnov test. T-tests and anova tests were used to compare subcategories of data and relationships were determined using a Pearson's correlation. A bonferri Post hoc analysis was used to determine where the significance occurred in the 'lack of willpower' analysis. Data from the food craving questionnaire was analysed and categorized for both trait and state measures for each of the behaviour characteristics within the food craving questionnaire and data from the TFEQ was analysed for each of the subscales; uncontrolled eating, cognitive restraint and emotional eating. The BMI data was split into two groups for analysis: BMI 18-24.9 kg/m_2 (underweight and lean) and BMI ≥ 25 kg/m_2 (overweight and obese).

Results and Discussion

Results

Study Population Characteristics

There were 76 participants who had PCOS, with 92.06% (*n* = 70) of participants reporting their ethnicity as White, 3.96% (*n* = 3) as Asian or Asian British, 1.32% (*n* = 1) as Black or Black British and 2.66% (*n* = 2) of the participants not stating any ethnicity. Nine of the participants were excluded from the findings due to incomplete data entries. One participant was excluded from the findings regarding carbohydrate consumption due to excessively high results given for weekly carbohydrate consumption; the participant was included in findings that did not include carbohydrate consumption, as the remaining data collected was satisfactory. Of the 68 participants who gave anthropometric data, 27.9% (*n* = 19) were allocated in the lean group (BMI < 25 kg/m_2) and 72.1% (*n* = 49) were allocated in the overweight group (BMI > 25 kg/m_2).

The table below (Table 1) displays the ranges and means of the data collected; the mean BMI for the sample population was 30.02 kg/m_2, the mean carbohydrate consumption was 37 portions per week and the mean age was 31.49 years.

Food Craving Questionnaire

The data for trait measures have been analysed in table 2 and state measures have been analysed in table 3.

	Minimum	Maximum	Mean	Std. Dev.
BMI (kg/m_2)	17.4	47.4	30.02	6.61
Food Craving Score	51	194	126.85	35.19
Carbohydrate portions consumed per week	6	114	37	18.37
TFEQ score	22	61	42.13	17.99
Age (years)	19	45	31.49	6.03

Table 1: *Descriptive statistics of basic data collected including BMI, food craving, carbohydrate consumption and TFEQ score. Food craving score was assessed using the Food Craving Inventory and carbohydrate consumption was assessed using the Food Frequency Questionnaire.*

Trait Measure	Minimum	Maximum	Mean	St. dev.
Intent	3	17	8.96	3.18
Anticipation of positive reinforcement	6	26	18.43	4.69
Anticipation of negative reinforcement	4	18	11.58	3.23
Control	6	33	20.03	7.3
Thoughts	7	39	24.77	8.45
Hunger/physiological	4	19	12.8	4
Emotions/negative affect	4	24	10.77	5.29
Cues/environment	4	22	11.74	4.51
Guilt	3	16	7.96	3.76

Table 2: *Descriptive statistics for trait measures of the FCQ.*

State Measure	Minimum	Maximum	Mean	St. dev
Desire	3	16	9.22	3.37
Anticipation of positive reinforcement	3	15	8.16	3.13
Anticipation of negative reinforcement	3	16	9.06	3.48
Lack of control	3	16	10.3	3.14
Hunger/physiological	3	16	10.35	2.96

Table 3: *Descriptive statistics for state measures of the FCQ.*

Food Cravings and BMI

The findings in table 2 show the results of the *t*-test, the significant *P* Value shows that for overweight women, food cravings scores were significantly higher than lean women. The bar graph in figure 1 shows the differences in food craving inventory score in lean and overweight/obese women.

BMI Group	N	Mean Food Craving Score	Std. Dev.	Sig. (2-tailed)
Overweight	19	150.73	34.33	*P = 0.04*
Lean	48	131.26	33.87	

Table 4: *Independent t-test used to test hypothesis, result: P = 0.04. A significant result and therefore supports the hypothesis.*

The findings in the table below show the results of a Pearson's correlation used to determine if there is a correlation between the (trait) control subscale of the FCQ and BMI. The significant *P* value shows that when there is a higher level of lack of control, BMI is also higher.

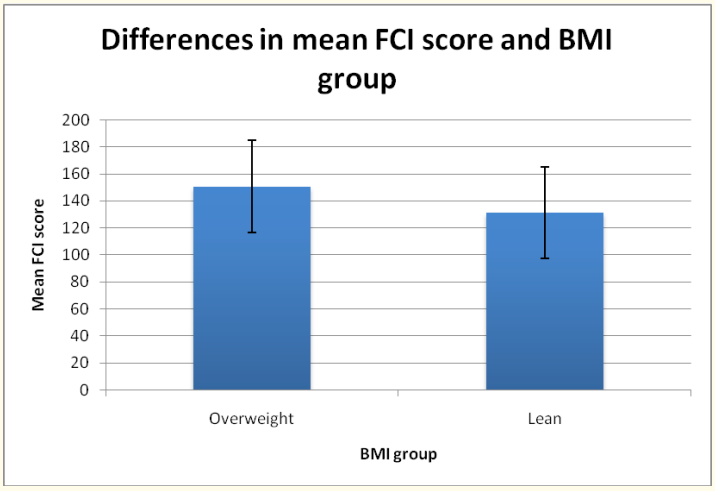

Figure 1: *Significant differences in mean FCI score between lean and overweight groups with standard deviation error bars, n = 67.*

Pearson's Correlation	N	Correlation Coefficient	Sig. (two-tailed)
Trait lack of control and BMI	67	0.274	*P = 0.025*

Table 5: *Pearson's correlation used to test relationship between trait lack of control and BMI, result: P < 0.05. The correlation coefficient shows that there is a positive linear correlation between the two factors.*
It was revealed in an additional Pearson's correlation test that there was no significant correlation between (state) lack of control and BMI, (P > 0.05).

It was revealed in an additional Pearson's correlation test that there was no significant correlation between (state) lack of control and BMI, (*P* > 0.05). The findings in table 3 show the statistically significant results from an anova test carried out on food cravings and BMI. The 6 groups have been categorized by the answer given by each participant for the following question; 'I have no willpower to resist my food cravings'. A bar chart displayed in figure 2 is used to show the differences between the mean BMI between the 6 groups, with error bars to demonstrate the standard deviation for each group.

Answer Group	N	Mean BMI (kg/m_2)	Std. Dev.	Sig. (2-tailed)
Always	7	35.2	6.58	*P = 0.044*
Usually	10	31.17	6.96	
Often	13	28.18	5.6	
Sometimes	24	30.98	5.75	
Rarely	12	25.67	7.18	
Never	2	30.8	10.47	

Table 6: *Anova test used to test differences in mean BMI between the 6 answer groups. The 6 answer categories: 1 = always, 2 = usually, 3 = often, 4 = sometimes, 5 = rarely and 6 = never, result: P = 0.044, therefore the result is significant. A bonferroni post hoc analysis shows the significant difference lies between the 'always' and 'rarely' group.*

The numbers of total participants in each group show that the group with the lowest number of participants and a minority of individuals, 2.94%, responded 'Never' to the statement, 'I have no willpower to resist my food cravings'. This result gives a clear indication that the majority of participants report having some degree of food cravings of which they have no willpower to resist. There does not appear to be a pattern with BMI and the bonferroni post hoc analysis shows that there is a significant difference between the 'always' group and the 'rarely' group only (see appendices).

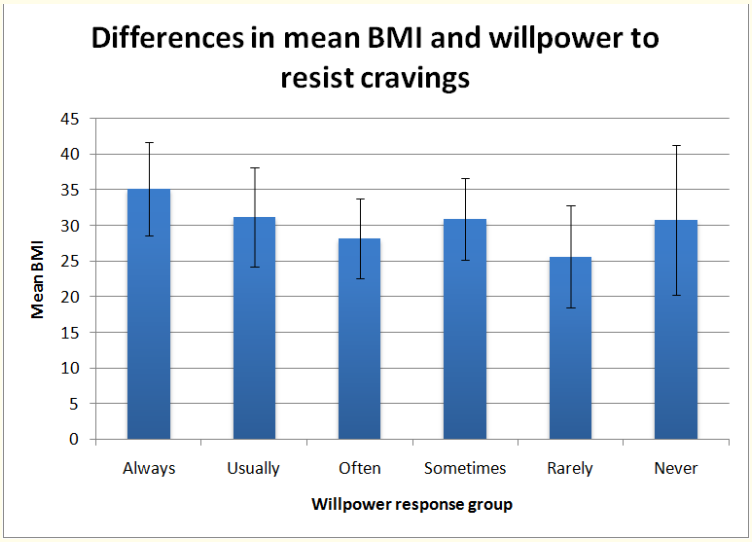

Figure 2: *Significant differences in mean BMI between the answer groups to the question, 'I have no willpower to resist my food cravings', with standard deviation error bars, n = 68.*

BMI and Specific Food Craving Groups

The findings in table 7 show the results of an anova test used to determine if there is a difference in BMI between and type of foods craved which were grouped as either sweet carbohydrate (such as chocolate, biscuits etc.), savoury carbohydrate (such as potatoes, bread etc.) and non-carbohydrate (such as cheese, meat etc.). The majority of participants craved sweet carbohydrates, with 50.7% of the sample, the most common craving of which was chocolate with 74.1% of the participants in the sweet carbohydrate craving group selecting chocolate as the food which they crave the most often.

The P value shows that there was not a significant difference in mean BMI between the 3 groups.

Craving Group	N	Mean BMI (Kg/m_2)	Std. Dev.	Sig. (2-tailed)
Sweet carbohydrate	35	29.03	6.7	*P = 0.426*
Savoury Carbohydrate	26	31.27	5.89	
Non-carbohydrate	8	29.4	8.9	

Table 7: *Anova used to test differences in mean BMI between 3 craving groups; sweet carbohydrate, savoury carbohydrate or non-carbohydrate, result: P = 0.426. The result is not significant which shows that there is no difference between craving groups and means BMI.*

There is minimal difference in the mean BMI for each of these groups; with a total range of 1.24, which is somewhat unexpected given the total BMI, range for the sample is 30 kg/m_2.

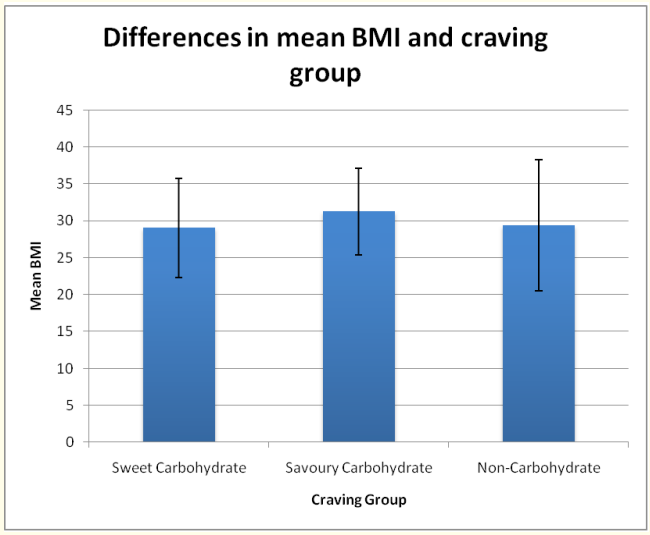

Figure 3: *No significant differences in mean BMI score between craving groups with standard deviation error bars, n = 69.*

Food cravings and carbohydrate consumption

The findings in the table below show the results of a Pearson's correlation used to determine if there is a correlation between FCQ score and carbohydrate consumption. The *P* value > 0.05 and therefore no relationship were found between FCQ score and carbohydrate consumption.

Pearson's Correlation	N	Correlation Coefficient	Sig. (two-tailed)
FCQ score and carbohydrate portions consumed per week	68	0.175	*P = 0.153*

Table 8: *Pearson's correlation used to test correlation between FCQ score and carbohydrate consumption, result P > 0.05, and therefore not significant.*

This was explored further by a Pearson's correlation test carried out on the (trait) lack of control subscale of the FCQ and carbohydrate consumption shows that there is no significant correlation between the 2 factors, (*P* > 0.05). There was also no significant correlation found between the (state) lack of control subscale and carbohydrate consumption, (*P* > 0.05).

Three Factor Eating Questionnaire

The table below shows the data from the TFEQ. The data from the participants has been analysed for each behaviour; emotional eating, restrained eating and uncontrolled eating. The number of participants in each eating behaviour group has been totaled to demonstrate the distribution of participants across the groups, (high (80-100%), average (50-80%), or low (0-50%) for each eating behaviour). The mean score for cognitive restraint was 52.8 (st.dev 19.8), uncontrolled eating score 55.2 (st. dev. 22.6), emotional eating score 54.8 (st. dev. 23.37).

Eating Behaviours and Carbohydrate Consumption

The findings in table 4 display the result of the Pearson's correlation, which shows that there was no significant correlation between carbohydrate consumption and TFEQ score. This result therefore supports the null hypothesis 2, as participants with a higher TFEQ score were not found to have higher carbohydrate consumption levels.

	Cognitive Restraint	Uncontrolled Eating	Emotional Eating
High levels of eating behavior	5 (6.75%)	10 (14.5%)	6 (8.7%)
Average levels of eating behavior	40 (58.35%)	31 (44.9%)	31 (44.9%)
Low levels of eating behavior	24 (34.9)	28 (40.6%)	32 (46.4%)

Table 9: *Descriptive statistics of the three eating behavior categories within the TFEQ.*

Pearson's Correlation	N	Correlation Coefficient	Sig. (two-tailed)
TFEQ score and carbohydrate consumption	68	-1.44	0.241

Table 10: *Pearson's Correlation used to test correlation between the Three Factor Eating Questionnaire score and carbohydrate consumption, P > 0.05. The result is not significant and therefore does not support the hypothesis.*

An additional Pearson's correlation also showed that there was no correlation found between any of the eating behaviour groups (emotional eating $P > 0.05$, cognitive restraint $P > 0.05$and uncontrolled eating $P > 0.05$) and carbohydrate consumption.

Eating Behaviours and BMI

Table 5 show the results of an additional independent *t*-test, which highlights a significantly greater TFEQ score in lean women compared with overweight women. The *P* value shows a significant difference between BMI and TFEQ score. The bar chart in figure 4 shows the differences in mean TFEQ score between the BMI groups, with error bars to demonstrate the standard deviation for each BMI group.

BMI Group	N	Mean TFEQ Score	Std. Dev.	Sig. (2-tailed)
Lean	18	43.61	6.14	0.024
Overweight	48	49.33	9.75	

Table 11: *Independent t-test used to test differences in TFEQ between lean and overweight BMI groups, result: P = 0.024. The result is significant which shows there is a difference in TFEQ score and between lean and overweight participants.*

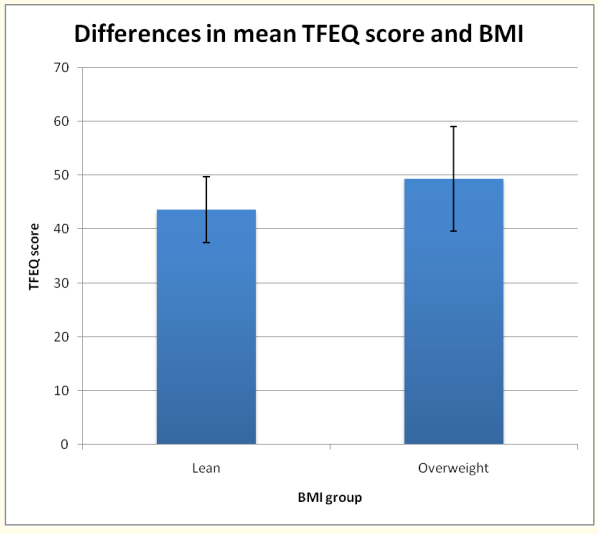

Figure 4: *Significant differences in mean TFEQ score between BMI groups with standard deviation error bars, n = 66.*

When explored in further detail, results from t-tests carried out on each TFEQ subscale showed that there was no significant differences in BMI between either emotional eating $P > 0.05$ or cognitive restraint $P > 0.05$, there was however a significant difference in the uncontrolled eating score between lean and overweight individuals ($P < 0.05$), displayed in the findings in table 12.

BMI group	N	Mean uncontrolled Eating Score	Std. Dev.	Sig. (2-tailed)
Overweight	48	59.65	20.52	*P = 0.04*
Lean	19	48.73	15.38	

Table 12: *Independent t-test used to test differences in uncontrolled eating score between lean and overweight BMI groups, results: P = 0.04. The result is significant which shows that there is a difference in uncontrolled eating score between lean and overweight participants.*

Sugar-free Drink Consumption and BMI

The findings in table 8 show the results of an anova test used to test the differences in mean BMI and sugar free drink consumption. The answers given by the participants were grouped in three consumption categories; once a week or less, 2-7 portions per week and 2+ portions per day.

The statistically significant result shows that the participants who consumed more sugar-free drinks had a higher BMI than those who consumed less. A bar chart has been used in figure 7 to show the mean BMI for each group with error bars to show the standard deviation for each group.

Drink frequency	N	Mean BMI (Kg/m_2)	Std. Dev.	Sig. (2-tailed)
Once a week or less	30	28.02	7.04	*P = 0.039*
2-7 portions per week	19	30.11	5.34	
2+ per day	18	33.1	6.69	

Table 13: *Anova used to test differences in mean BMI between 3 sugar-free drink frequency groups; once a week or less, 2-7 portions per week and 2 + portions per day, result: P = 0.039. The result is statistically significant which shows that there is a difference in mean BMI between drink frequency groups.*

A previous test carried out to investigate differences in mean BMI and high sugar drinks such as Coca-Cola, high sugar squash etc. showed that there was no significant difference in mean BMI and high sugar drink consumption ($P > 0.05$). Although this result was not statistically significant, it is worth observing that the P value was 0.054 and therefore the anova test showed a trend towards significance.

Discussion

Key findings

There were several key findings from the results:

a. Overweight women had a significantly greater food craving score compared with lean women with PCOS, ($P < 0.05$).

b. No significant correlation was found between food craving score and carbohydrate consumption, ($P > 0.05$)

c. There was no significant correlation found in carbohydrate consumption between either of the TFEQ subscales; emotional eating score, uncontrolled eating score or cognitive restraint score, ($P > 0.05$).

d. Overweight women had a significantly greater mean TFEQ score than lean women, and overweight women had a significantly greater uncontrolled eating subscale score ($P < 0.05$); however, no significant difference was found between overweight and lean women in the emotional eating subscale or the cognitive restraint subscale, ($P > 0.05$).

e. The majority of participants stated that they craved carbohydrate based food (88.4%) compared to with non-carbohydrate based foods (11.6%), however there was no significant correlation found between food type craved and BMI, ($P > 0.05$).

f. There was a significant positive correlation found between sugar-free drink consumption and BMI, ($P < 0.05$), but no significant correlation was found between high-sugar drinks and BMI ($P > 0.05$).

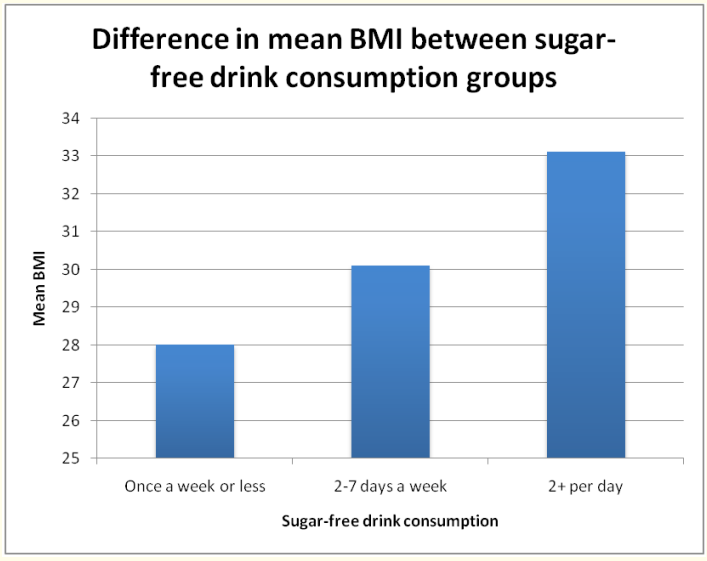

Figure 5: *Significant differences in mean BMI score between snack groups with standard deviation error bars, n = 67.*

The first hypothesis was supported by the results, which indicated that overweight women have more severe food cravings than lean women with PCOS. This result gives further insight into the first main aim of the study, which was to investigate the relationship between food cravings and BMI in women with PCOS.

The second hypothesis was rejected as the results showed that no correlation between eating behaviours and carbohydrate consumption was found. This result gives a further understanding of the second main aim of the study, to explore the relationship between TFEQ score and carbohydrate consumption levels in order to clarify if there are any links between eating behaviours and carbohydrate consumption.

Data characteristics

The study population characteristics showed that there were considerably more overweight and obese participants than lean participants in the study, with 27.9% lean participants and 72.1% overweight and obese participants. The descriptive statistics of the participants in table 1 show the mean BMI of the total sample was 30.02. The World Health Organisation defines class I obesity as BMI 20-25 (WHO, 2000). This suggests that women who are suffering from PCOS may be more likely to be obese than the average female, which has been found in previous studies, [4,44] although this may be due to the more obese women with PCOS than lean women with PCOS volunteering to be involved with the study.

Food Cravings and Body Mass Index Findings

The findings regarding the significantly greater food cravings established in overweight women compared with lean women were explored further by investigating the relationship between the trait lack of control subscale of the FCQ and BMI, in order to gain a better

understanding of the 'control' aspect of eating behaviours. The result from the Pearson's correlation was statistically significant and therefore the results suggest that there is a relationship between trait control and BMI.

The data analysis in this study is the first to assess this as there is currently no published studies in this field, however, when compared to the non-PCOS population, recent research [45] did not find an association between food craving scores and BMI. The study investigated 234 healthy participants each of whom completed a UK-specific version of the Food Craving Inventory. These findings may indicate that overweight and obese women with PCOS are likely to engage in disordered eating behaviour such as binge eating, [46], which in turn could contribute to weight gain.

Interestingly, when investigating the relationship between the state control subscale of the FCQ and BMI, the result was not found to be statistically significant. The insignificant result suggests that when there is a temporary change in an individual's eating behaviour such as food bingeing following a trigger such as stress, fear or anger etc., no impact on BMI occurs. The results also suggest that, although state control has no significant correlation with BMI, trait control does, and therefore more permanent characteristics of an individual's personality in regards to eating control, such as consistent dietary behaviour, have a stronger relationship with BMI. This conflicts with findings investigating non-PCOS women, where binge eating behaviours were found to be positively associated with BMI [47].

The hypothesis of abnormal appetite regulation in women with PCOS, which is suggested by research carried out by Hischberg [16], could explain the differences in food cravings between the lean group and the overweight or obese group in this study. The research carried out by Hischberg [16], states that abnormal appetite regulation may lead to increased risk of weight gain as a result of women with PCOS having reduced postprandial CCK secretion. It has been suggested that impaired CCK secretion may be a factor contributing to the phenomenon of binge eating and obesity in women with PCOS.

These findings suggest that women with PCOS who are overweight suffer from cravings more severely or frequently than lean women with PCOS. It may therefore be inferred that, in this sample, lean women with PCOS do not necessarily have more willpower when dealing with a craving; they may simply not be experiencing cravings as frequently or severely as those felt by the overweight women.

The first hypothesis is further supported by the findings which explored the relationship between BMI and will-power by using a willpower-focused question which was lifted from the food craving inventory questionnaire carried out by the individuals. The result was significant ($P < 0.05$) although a post hoc analysis revealed the significance was only between the 'rarely' and the 'always' groups. The numbers of total participants in each group show that the group with the lowest number of participants and a minority of individuals, 2.94%, responded 'Never' to the statement 'I have no willpower to resist my food cravings'. This result gives a clear indication that the majority of participants have some degree of food cravings which they felt unable to resist. Research investigating the lack of willpower in non-PCOS women has found it to be a dominant factor in weight gain [48]. Investigating the willpower question specifically and testing for differences in BMI was necessary in order to understand the relationship between BMI and willpower exclusively, because although the FCQ is a valid food craving measurement tool, there is a broad spectrum of questions incorporated in the questionnaire, some of which are not necessarily associated with this research question. This is because the FCQ is often used as a tool to assess eating disorders such as bulimia. Therefore, by taking the most specific area to the topic being investigated in the first hypothesis from the FCQ, the result reveals that not only is there a significant difference between BMI and FCQ as a whole, but also between BMI and willpower specifically, which was one of the main research aims of this study.

The results from the specific foods craved data and BMI show that the majority of participants craved sweet carbohydrates 50.7%, followed by savoury carbohydrates 37.7%, and the minority of participants stated that they either crave non-carbohydrate based food or do not crave foods at all 11.6%. Specific food cravings were explored in figure 3, which showed that 88.4% of participants craved either sweet or savoury carbohydrates, however there was no correlation found between food craving and BMI. Recent research supports these findings, as a study found that sweet carbohydrates were the food group craved by the majority of women with hyperandrogenaemia [33]. The specific sweet food that was craved most by the majority of people in the research carried out by Lim [33] was chocolate. This finding was replicated in this research, with 74.1% of participants within the sweet carbohydrates category reporting chocolate as the most craved food. As there was no significant difference found in the mean BMI between the 3 groups, a relationship between the food craving groups and BMI could not be identified. Interestingly, there was only a minimal difference in the mean BMI for each of these groups, with a total range of 1.24. This was unexpected given that the total BMI range for the sample was 30, however research investigating the non-PCOS population has also found that various food craving groups have a positive relationship with BMI and do not differentiate greatly between groups [49]. This may be an indication that the type of foods craved may not be a leading cause of weight gain and therefore increased BMI in the sample used.

Carbohydrate Consumption Findings

The findings regarding the links between TFEQ score and carbohydrate consumption were explored further by assessing the relationship between carbohydrate consumption levels and the trait and state control subscale of the FCQ, and the results also failed to show any significant correlation between either state or trait control and BMI. This was unexpected; however, recent research into food craving and carbohydrate consumption also found no significant links between the two factors [33]. The research carried out by Lim [33] which investigated the links between hyperandrogenaemia, psychological distress and food cravings in 198 young women, found that although food cravings were significantly associated with psychological distress, there were no significant links between psychological distress and energy intake. There was no correlation found between foods craved and energy intake and therefore it could not be concluded that there were any links between food cravings and food consumption, which was also found in this investigation. Although the results from this study were backed by findings in the research carried out by Lim [33], there has been research reporting contrasting findings suggesting significant links between food craving and carbohydrate consumption. The research carried out by Martin investigated the links between food craving and food intake, using the FCQ specifically to measure cravings for sweets, fats, carbohydrates and fast food fats. Participants then took part in a taste test consisting of four foods; jelly beans, M&Ms, regular crisps and low-fat baked crisps, and were in an environment where could eat as much or as little of each food as they chose. The results showed that there was a significant correlation between the specific food craving groups and consumption of the corresponding food. This conflicts with the findings from this investigation, possibly as a result of discrepancies surrounding self-reported carbohydrate consumption which may have been eliminated by the use of a taste test method implemented in the research carried out by Martin.

The findings from the Pearson's correlation test results investigating the relationship between carbohydrate consumption and TFEQ score found no statistically significant correlation, ($P > 0.05$), and therefore supports the null hypothesis2. When the TFEQ subscales were analysed individually, neither the emotional eating, cognitive restraint nor uncontrolled eating subscales were significantly correlated with carbohydrate consumption levels ($P > 0.05$). Although there has been minimal research carried out to date regarding the links between TFEQ score and eating behaviours within PCOS, a recent study (Chambers, 2011) [] consisting of healthy participants has investigated the carbohydrate and fat intake levels of 64 women who were preselected for high and low TFEQ scores for the cognitive restraint and uncontrolled eating subscales. The results of the study showed that women who had high scores in the uncontrolled eating subscale of the TFEQ were found to consume more than the women who had low scores in the uncontrolled eating subscale. There was, however, no significant correlation found between the cognitive restraint subscale score and energy consumption.

The findings in the research carried out by Chambers with regards to the cognitive restraint subscale of the TFEQ concur with the findings of this study; however, the results regarding the uncontrolled eating subscale conflict with the findings as no correlation with carbohydrate consumption was found, although this may be due to the study consisting of healthy participants with a normal BMI. Although the study was carried out with healthy participants and therefore might not produce the same results for PCOS women, it does give a good indication of the links between eating behaviours and carbohydrate consumption, as the study size was similar to the one used in this research and the participants were also all female.

There has been minimal research directly comparing the differences in carbohydrate craving in lean and overweight women with PCOS; however, the comparisons in previous literature gives an accurate indication of the differences between the two groups within the PCOS population. The findings of the differences in TFEQ score between the two groups in this study could lead to further understanding of findings in previous research, such as the investigation carried out by Wylie [34], which suggested that carbohydrate craving in women with PCOS may cause them to eat more frequently. The results also supported initial research carried out by Heller and Heller [29], which indicated reduced blood glucose and the subsequent urge to replace energy as the main cause for carbohydrate craving in women with PCOS. If a craving is satisfied by over-consuming carbohydrates then weight gain may occur, which in turn increases the likelihood of insulin resistance.

Eating Behaviours and Body Mass Index findings

The second hypothesis was investigated by exploring the differences in TFEQ score and BMI, which, in contrast with the previous insignificant finding in carbohydrate consumption and TFEQ, was significant ($P = 0.024$). This suggests that there is a relationship between BMI and TFEQ score.

When explored in further detail, results from t-tests carried out on each TFEQ subscale showed that there was no significant difference in BMI between either emotional eating $P > 0.05$ or cognitive restraint $P > 0.05$; there was, however, a significant difference in the uncontrolled eating score between lean and overweight individuals, ($P < 0.05$).

The findings regarding the significant correlation in uncontrolled eating subscale and BMI were replicated in research carried out by Jeanes [36], which also demonstrated a significant positive correlation with BMI and the uncontrolled eating subscale of the TFEQ ($P < 0.05$). By contrast, the research carried out by Jeanes [36], also found there to be a significant correlation between emotional eating and BMI; this was not found to be significant in this study. This study was similar with regards to data collection although a larger sample size of 131 PCOS women was used.

Although there was no significance found between TFEQ and carbohydrate consumption, there was a significant correlation between BMI and TFEQ score. This may indicate either that carbohydrate consumption was not a predominant factor in weight gain in the sample used, or that discrepancies in the self-reported food questionnaire may have caused the TFEQ and carbohydrate consumption result to be insignificant. Previous research into eating behaviour characteristics carried out on 154 overweight non-PCOS women suggested that specific eating behaviours may be associated with weight gain through increased food intake [50], which backs the findings in this research regarding the significant relationship found between uncontrolled eating and BMI.

Research into the relationship between the eating behaviours and BMI remains unclear and further studies are needed fully to understand the relationship between the two factors.

Sugar-free Drinks and Body Mass Index Findings

An anova test was carried out on BMI measurements and both sugar-free and high sugar drink consumption, ($P = 0.054$, $P = 0.039$) respectively. The results showed a significant correlation between BMI and sugar-free drink consumption, but not with high sugar drinks. This result is unexpected given the extensive research suggesting that high sugar drinks can be a key cause of weight gain [51]

and therefore may be an indication that sugar-free soft drinks have as much of an adverse effect on weight gain as high-sugar drinks. Although these results conflict with current literature [51,52] regarding the links between high sugar drinks and obesity within the non-PCOS population, this may be due to inconsistencies in the TFEQ.

Limitations

Matched pairs

The main element of this study which differs from most of the current research carried out on women suffering with PCOS is that most research includes two groups of women which are then compared, usually PCOS and matched controls for weight, height, age etc. The matched paired method is an effective approach to comparing the PCOS population with the healthy population as it reduces the risk of an alternative factor having an effect on the results. Although there are issues which arise with the PCOS matching method, and there is possibility for improvement to increase the likelihood of accurate results, it is more of an effective system than comparing a group of PCOS individuals as a whole with a group of healthy individuals as whole, which is the sample used in the majority of studies which do not adopt the PCOS-healthy matching method. By not matching PCOS and healthy individuals, this method greatly increases the chances of alternative factors having an effect on the results, decreasing the validity of any findings. This method is often adopted to generate studies with high numbers of participants, as it is difficult to find appropriate age and BMI matches for high numbers of PCOS participants.

This study differs from both these methods as only a PCOS population is being investigated and therefore there will be no comparisons with a healthy population or healthy matched pairs. The study will be exploring the variances within the PCOS population only, with lean participants being compared with overweight and obese participants. By carrying out the study in this format it enables a greater understanding of the variances of cravings and other factors which may cause some women with PCOS to become overweight or obese while other women are able to remain lean. As healthy participants are not included in this study, the risk of invalid results is reduced due to the exclusion of comparison of the healthy and PCOS groups and therefore a reduced risk of factors which are not being accounted for affecting results.

Issues Surrounding Self-Reported Food Intake

The use of self-report food intake is a common method used in epidemiological studies to measure food intake. The use of self-monitoring in food consumption has been consistently found to be an effective method concerning adherence to diets [53]; however, extensive research has found the accuracy of self-reported food intake to be poor. Research has been carried out to investigate the validity of self-reported food intake, primarily concerning under-reporting in actual food intake compared to the corresponding reported intake [54]. The study carried out by Goris [54] to investigate the validity of self-reported measures for food intake consisted of 30 obese men. Underreporting was measured by calculating the difference in energy expenditure, measured using the doubly labeled water technique, and energy intake from the reported intake. Body weight was measured at the beginning and the end of the same week in which the food intake was recorded, and 1 week following the recording week to determine the energy balance of the individuals. The results of the study showed that energy intake was under reported by 12% and that participants were under eating by 26%, recorded by weight loss in the observation week. This study, along with other well controlled clinical trials measuring self-reported food intake against doubly labeled water results, found this inconsistency to be replicated [55,56]. These results highlight concerns that there is underreporting in self-reported food intake and changes of behaviour for the duration of the period of observation, resulting in inaccurate findings in studies using self-reported food measures such as this study. The results also found that the obese men were specifically underreporting fat intake from their diets, which raises concerns over whether underreporting in fat intake of obese individuals is a common trend in research.

Due to the findings regarding underreporting specific food groups amongst obese men, it should be considered that underreporting may have occurred in carbohydrate consumption levels, which could have affected the validity of the results in this study, given the issues surrounding the sample used. Concerns over the validity of self-reported food measures are heightened in this study, as overweight individuals are more likely to underreport their food intakes than are normal-weight individuals [57] and the majority of the sample used in this study were overweight. Women were found to be more likely to underreport than men [58] which increases the chance even more given that that the sample used in this study was all female.

Missing Data

Limitations occurred in this study as a number of participants left sections of the questionnaires blank. Of the 76 participants who were initially recruited, 68 sets of data were obtained. In some cases, the partial data could be used in analyses which did not include the missing data; in other cases where the data was essential, the participant was removed from the analysis. One particular individual was removed from the carbohydrate consumption analysis because although they had filled out the questionnaire, an unlikely quantity of food consumption had been recorded (over 30 portions of carbohydrate per day). This resulted in a varying number of participants being analysed for each test. The highest number of participants used for analysis was 70, and the lowest number used was 67. This was not unexpected in a study of this subject area, and adherence rates for completion of data collection was relatively high when compared to other PCOS research, with 93.4% completion of the FFQ in this study compared to 75% completion rate of diet diaries in a study carried out by Egan *et al*. [59].

The inconsistencies in completion of the questionnaires may have been due to participants feeling uncomfortable in answering questions on particular topics. Participants may not have wanted to answer questions which touched on topics about which they felt sensitive, such as food intake, despite assurances of anonymity. Steps were taken to ensure high adherence rates, such as providing a strong support system of Verity workers and the project coordinator. Furthermore, all the questionnaires were provided at the same time to eliminate drop-out rates which can occur when information is given in multiple intervals, and participants were not required to attend any testing at the university as information was provided on domiciliary self-measurement of anthropometric data.

Although this may have increased adherence rates in the study, limitations then arose due to inaccuracies in measurements. This method of data collection also eliminated the possibility of measuring the body fat percentage of the individuals, as they would have had to travel to the university to attend a data collection day. Body fat measurements would have enabled a more accurate health status to be obtained than BMI alone, therefore increasing the validity of results.

Anthropometric Measurements

Limitations arose in the accuracy of the representation of the PCOS population in regards to proportions of overweight and lean participants. Research shows that up to 50% of women with PCOS are overweight or obese [4]; however, the descriptive statistics in the results show that 72.1% of participants were overweight or obese and 27.9% were lean. A study carried out in the United States [60] to determine whether the degree of obesity of PCOS women has increased, paralleling the rise in obesity in the population has found that the risk of PCOS only minimally increases with obesity, although the scale of obesity within the PCOS population has increased, similar to that observed in the general population and reflecting the increase in BMI of the surrounding population. The findings from this study highlight issues surrounding the increasing prevalence of obesity and the consequent associations with PCOS, which are also a concern in the UK due to increasing obesity rates.

This could have affected the results, as food craving and carbohydrate consumption are more prevalent in the overweight group, and therefore these results caused the overall PCOS sample to have apparently high levels of food craving and carbohydrate consumption. It would be helpful to have equal numbers of lean and overweight participants; however, it may be more difficult to recruit lean participants as they may be less motivated to seek a further understanding of weight management surrounding PCOS if they are not

suffering from weight-related or other symptoms. Overweight participants may be easier to recruit, as they may perceive a gain in participation through potential weight loss advice and information on their nutrient intake. Future studies could ensure this by focusing on the beneficial factors of participation on factors other than weight loss, such as clearer skin or reduced hirsutism.

Another potential limitation was the division of participants into 2 categories of BMI, either lean and underweight, or overweight and obese. Results may have been more accurate if the participants had been grouped into 4 categories; underweight, lean, overweight and obese, but as the sample size was 68, the number of participants in the categories would be relatively low, especially the underweight group which would have had a total of 2 participants. The results would not have been an accurate representation of the PCOS population if 2 participants had represented the underweight category. Using 2 groups for BMI categorization was a legitimate way to split the data as the same 2 categories have been used in a similar study [28] however future research could benefit from splitting the overweight participants into varying degrees of obesity.

Further discrepancies in portion size when calculating carbohydrate consumption levels may have affected results. This effect of this was minimized by the wording of the questions; however, varying portion sizes between different participants is inevitable. This could have an effect on the results as individuals may be consuming significantly differing portion sizes. This limitation could be eliminated through adopting a different study design; the study coordinator could control participants' portion sizes; however, this would not be a time or cost effective procedure and may reduce adherence rates, as it would rely on greater participation from subjects.

Conclusion

The results from this research suggest that overweight and obese women with PCOS suffer from craving more severely or frequently than lean women with PCOS, and therefore it can be concluded that lean women with PCOS do not necessarily have more willpower than overweight women when they suffer a craving as they do not suffer cravings as severely as overweight women with PCOS.

The findings from the TFEQ results suggest that there is no relationship between carbohydrate consumption and emotional eating, uncontrolled eating or cognitive restraint. These findings suggest that differences in eating behaviours between women may not play a key role in the amount of carbohydrate consumed and therefore other factors may be responsible for carbohydrate intake. This is an important finding as there is currently minimal research into the links between eating behaviours and carbohydrate intake. However, there was a correlation found between eating behaviours and BMI, specifically the uncontrolled eating subscale which suggests that there is a link between uncontrolled eating behaviours and BMI. The increased BMI which occurs with increased uncontrolled eating behaviours appears to conflict with the previous findings regarding uncontrolled eating and carbohydrate intake. The results indicate that the BMI increases with more uncontrolled eating behaviour but carbohydrate consumption does not, which suggests that the weight gain observed from the increased BMI may be due increased intake of fats as opposed to carbohydrates. Although this is a possibility, common discrepancies in self-reported food questionnaires may have been the cause of no significant correlation being found between uncontrolled eating and carbohydrate consumption.

Further research carried out in carbohydrate consumption could benefit from exploring alternative methods of food intake data collection, such as providing food for each participant so that energy intake can be pre-determined for the duration of the study, as there have been many issues surrounding the validity of self-reported food intake measures. Further research into the links between carbohydrate intake and the TFEQ subscales; emotional eating, uncontrolled eating and cognitive restraint, is essential in order to gain a clearer understanding of the links between eating behaviours and carbohydrate intake because, although there are tangible relationships in recent research through BMI and carbohydrate consumption, there has been minimal research into TFEQ scores and carbohydrate consumption. Future studies could focus on the differences in carbohydrate consumption of PCOS and non-PCOS women in a monitored environment as opposed to self-reported carbohydrate intake and explore the links with the TFEQ subscale scores between the 2 groups.

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