Habitual dietary intake, eating pattern and physical activity of Women with Polycystic Ovary Syndrome

Suzanne Barr PhD[1], Kathryn Hart PhD[2], Sue Reeves PhD[1], Kay Sharp PhD[1] and Yvonne Margaret Jeanes PhD[1]

[1] Health Sciences Research Centre, Roehampton University, London, UK
[2] Faculty of Health and Medical Sciences, University of Surrey, Surrey, UK

Corresponding author:
Dr Yvonne M Jeanes
Health Sciences Research Centre
Department of Life Sciences
Roehampton University
London, UK
SW15 4JD
Tel. +44 (0)2083923189
Fax. +44(0)2083923160
y.jeanes@roehampton.ac.uk

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Abstract 250 words:

Background/ Objective

Diet and lifestyle modifications may be of benefit in the management of polycystic ovary syndrome (PCOS) but there is a paucity of data on these behaviours in women with PCOS. This study aims to address this through a comprehensive investigation of the habitual diet and activity patterns of UK women with PCOS and their alignment with dietary recommendations for health.

Subjects/ Methods

A 7-day estimated food and activity diary and questionnaire was completed by 210 women with PCOS for calculation of activity levels, energy and nutrient intakes and dietary glycaemic index.

Results

Mean (SD) BMI was 27.4 (7.3) kgm^{-2} (n=183) with 53% of women with PCOS having a BMI > 25 kgm^{-2}. Of the overweight women approximately half were not achieving sufficient physical activity to promote weight loss. More frequent eating episodes and a lower BMI were weakly associated (r=-0.158, p=0.034). Mean percentage energy from fat was 38 (7)% (12% energy from saturated fat) with 68% of women with PCOS consuming > 35% energy from fat. Mean dietary glycaemic index (GI) was higher in obese women with PCOS compared with healthy weight women with PCOS (55.7 (3.4) and 53.8 (4.0) respectively; p=0.043).

Conclusion

Many women with PCOS are not achieving dietary intakes and levels of physical activity that optimise symptom management and disease prevention. Advice should focus on fat quality and quantity and carbohydrate modification. There is a need for further robust research into the role of dietary GI in the PCOS population.

Key words (upto 6): Diet, Polycystic Ovary Syndrome, feeding behaviour, motor activity

Introduction:
Polycystic ovary syndrome (PCOS) is the most common endocrine disorder in women of reproductive age, affecting up to 10% of women (Franks, 1995; Lindholm *et al.,* 2008). The presentation of PCOS is heterogeneous in nature, including menstrual irregularity and fertility problems, hirsutism and acne (Diamanti-Kandarakis, 2008). Women with PCOS are also more likely to be overweight and have an increased risk of metabolic syndrome, type 2 diabetes and cardiovascular disease (Dokras, 2008; Ehrmann *et al.,* 1999). The pathogenesis of PCOS is multifactorial; a key component is the association between insulin resistance, compensatory hyperinsulinaemia and hyperandrogenism (Balen, 2004; Carmina, 2006).

Weight loss through dietary restriction and increased physical activity are key management strategies for overweight and obese women with PCOS (Balen *et al.,* 2006). Weight losses of as little as 5% have been shown to reduce insulin levels, improve ovulatory function and reduce serum testosterone (Moran *et al.,* 2003; Stamets *et al.,* 2004; Qublan *et al.,* 2007). Reducing dietary glycaemic index (GI) may be advantageous with demonstrated benefits of low GI diets in non-PCOS insulin resistant populations (McMillian-Price *et al.,* 2006; Barclay *et al.,* 2008). Low GI diets are popular with women with PCOS (Jeanes *et al.,* 2009), yet there is a paucity of data describing the habitual diet and lifestyle of women with PCOS, with just two studies reporting dietary intake of women with PCOS in the United States and one comparison of US and Italian women with PCOS (Wright *et al.,* 2004; Douglas *et al.,* 2006; Carmina *et al.,* 2003). There are no publications describing the habitual diet or snacking habits of UK women with PCOS.

The referral rate to UK dietitians is also surprisingly low, with only 15% of women with PCOS having seen a dietitian (Jeanes *et al.,* 2009; Sharma *et al.,* 2010). Key sources of dietary information for women with PCOS have been reported as the internet and books (Avery *et al.,* 2007; Humphreys and Costarelli, 2008; Jeanes *et al.,* 2009). It is of concern that many of these sources are unregulated, there are currently no official UK dietary guidelines available for healthcare professionals advising women with PCOS.

Whilst increasing physical activity levels have been shown to improved glucose metabolism, insulin sensitivity (Kiddy *et al.,* 1992; Vigorito *et al.,* 2007) and reduce abdominal adiposity independent of weight loss (Ross *et al.,* 2004), evidence from studies reporting the habitual physical activity levels of women with PCOS is relatively scarce.

This study aims to comprehensively investigate the habitual dietary intake and activity levels of women with PCOS in the UK and assess whether dietary and activity recommendations for health are being met. Given the heterogeneity of women with PCOS this information is essential in order to accurately characterise their behaviours and hence identify the most relevant targets for lifestyle intervention.

Methods:

Women with PCOS were recruited through the UK charity Verity via email. The investigators aimed to recruit the maximum number of participants within a six month period. Eligibility criteria required participants to be pre-menopausal, aged over 18 years and to provide a self reported diagnosis of PCOS with date and means of diagnosis. Exclusion criteria included those who were pregnant or breastfeeding (currently or within the last 6 months), those suffering from any medical condition known to independently influence weight, body composition or biochemistry, those receiving treatment or currently suffering from an untreated eating disorder and those taking medication for weight loss (currently or within last 6 months). Ethical approval for the study was granted by Roehampton University Ethics Board and Verity gave approval to contact their members.

Participants completed a questionnaire and a 7-day estimated food and activity diary (previously used in published studies (Truby *et al.,* 2006)). The questionnaire was designed specifically for this study and included questions relating to diagnosis, self reported symptoms, weight and height and any PCOS related nutritional advice received (Jeanes et al. 2009). Food diary data were entered into the dietary analysis software package Dietplan 6.3 (Forestfield software, UK) by a registered dietitian. Energy, macro and micronutrient intakes were calculated. National Diet and Nutrition Survey (NDNS) nutrient intakes (Bates *et al.,* 2010) for women aged 19-64 years were used as reference values for comparison. Dietary GI and glycaemic load (GL) were determined using a previously established method (Frost & Dornhurst, 2000; Barclay *et al.,* 2007; Aston *et al.,* 2008). GI values for foods containing carbohydrate were obtained from published values (Foster-Powell *et al.,* 2002; Atkinson *et al.,* 2008; Aston *et al.,* 2008). Those foods with less than 1% of total energy content from carbohydrate were excluded from GI analysis. Mean dietary GI and GL were classified into high (above 70 and 20 respectively), moderate (56-69 and 10-19.9 respectively) or low (less than 55 and 10 respectively) according to previously established cut-offs (Brand-Miller et al, 1998).

Eating frequency (EF) was defined as the total number of eating and drinking episodes per day (Drummond *et al.,* 1998). The timing of eating episodes was categorised into either; morning (05:01-11.59), afternoon (12.00-19.00), evening (19.01-05.00), or all-day according to previously defined methods (Hampl, 2003). Foods were categorised into one of 26 categories and subcategories based on NDNS data and previous studies (Drummond *et al.,* 1998).

Average daily physical activity levels were calculated from the self reported diaries with activities categorised into metabolic equivalents of energy (METS) (Ainsworth *et al.,* 2000) and time spent at different levels of activity intensity (low, moderate and vigorous).

Frequencies and descriptive statistics were generated using SPSS version 16.0. Data was tested for normality using the one-way Kolmogorov-Smirnov test. T tests were used to compare subcategories of data. A one sample t test was used to compare nutrient intakes with the NDNS (2008/9) data for women aged 19-64 years. Relationships were

determined using Pearson correlation. Significance was assumed at P <0.05. All data are presented as mean (standard deviation) unless otherwise stated.

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Results:
Of the 1138 women with PCOS contacted, 210 women completed the study between May and November 2006, a response rate of 18%.

Study population characteristics
The mean (SD) self reported age of the group was 32.6 (6.3) years (n=189), with 97% of participants reporting their ethnicity as British Caucasian (21 did not report their age and two participants did not report their ethnicity). The mean (SD) BMI was 27.4 (7.3) kgm^{-2} (n=183). Forty-four percent were within the healthy range for BMI (18.5-24.9 kgm^{-2}), 53% were overweight or obese (BMI >25 kgm^{-2}) and 3% were considered underweight (BMI<18.5 kgm^{-2}). There were fewer overweight women with PCOS but a greater proportion of obese women with PCOS, 22% and 31% respectively). The majority of women with PCOS reported a combination of the classic PCOS symptoms of; weight issues (overall weight issues or abdominal adiposity in lean women with PCOS), hirsutism, acne or irregular menses, with 69% of the women with PCOS reporting three or more symptoms. Weight issues was the most common symptom reported by those who were overweight or obese and hirsutism and irregular menses were the two most commonly reported symptoms in all women. Those who reported four or more symptoms had significantly greater BMI (29.1(7.5) kgm-$^{-2}$) than those with less than four symptoms (26.1(6.7) kgm^{-2}) (p=0.006).

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Physical activity
The majority of women (74.2%, n=147) reported achieving the recommendation for health of at least 30 minutes of moderate intensity activity per day (Department of Health (DH), 2004). Women within the healthy BMI range reported spending significantly more time in moderate intensity activity (78 (62) minutes) compared with obese women (57(49) minutes) (p=0.041). Forty eight percent of overweight or obese women reported at least 60 minutes of moderate intensity activity per day; sufficient activity to promote weight loss (DH 2004).

Dietary intakes
Total energy and nutrient intakes reported by women with PCOS were significantly higher when compared with women in the NDNS (Bates *et al.*, 2010) (p<0.01) as shown in table 1. In women with PCOS the percentage energy from fat was higher and percentage energy from carbohydrates was slightly lower (NS) compared with the NDNS. Sixty eight percent of women with PCOS in this study had a total fat intake greater than 35% contribution to total energy, with saturated fatty acid intake accounting for 12% of total energy, substantially exceeding the RNI (<10% energy). Using Goldberg cut-offs, an EI:BMR ratio of less than 1.1 is indicative of under-reporting of dietary intake (Goldberg, 1991). Using this cut-off, 17% of participants were considered to be under-reporting, which reduced to 15% when those reporting decreasing weight were excluded.

Total sugar intake was accounted for 19% of total energy intake (44% of all carbohydrate consumed). Non-milk extrinsic sugar intake was 10.5% of total energy, exceeding the maximum recommended intakes (<10% of total energy). Non starch polysaccharide (NSP) (16.5g) was below the RNI of 18 grams per day (DH, 1991), yet significantly higher than NDNS values for adult women (13g, p<0.001).

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The mean dietary GI for the women with PCOS was 54.6 (4.2), categorised as low GI (less than 55), yet only two participants achieved a mean GI of less than 45 as recommended by Barclay *et al.,* (2008). Over half (54.6%) (n=109) of women with PCOS had a mean dietary GI in the low GI category, 44.9% (n=89) were in the medium GI category and 0.5% (n=1) in the high GI category. Mean dietary GL was 10.9 (2.4) with 38% of the women considered to have a low dietary GL, 62% medium and none found to have high mean dietary GL. Thirteen percent (n=26) of women were both reporting and following a low GI diet, an additional 16% (n=32) reported following a low GI diet but had mean GI levels greater than 55.

Eating pattern

Mean eating frequency (EF) including drinks was 8.7 (1.9) episodes per day, and excluding drinks was 5.0 (1.3) episodes per day. Intake of sweet snacks (1.6 (1.0) episodes per day) was significantly higher than savoury snacks (0.75 (0.6) episodes per day) (p<0.001). Afternoon eaters consumed more sweet foods (1.9 (1.0)) compared with evening eaters (0.9 (0.5)) (p<0.001).

Relationships between dietary intake, eating pattern and BMI

A significant difference in dietary GI between healthy weight women with PCOS and obese women with PCOS was found, with the former reporting a lower dietary GI (53.8 (4.0) versus 55.7 (3.4), p=0.043). There was a positive relationship between BMI and dietary GI (r=0.217, p=0.003) for all women with PCOS, although no relationship was observed between dietary GI and energy intake.

There was a significant negative relationship between BMI and EF (r=-0.158, p=0.034) and a trend towards a negative relationship between energy intake and EF for all women with PCOS (r=-0.141, P=0.054). Significant negative correlations were identified between dietary GI and EF (r=-0.142, P=0.05) and also dietary GL and EF (r=-0.204, p=0.005).

Discussion:
This study is the first to comprehensively investigate the habitual dietary intake and activity levels of women with PCOS in the UK and assess whether dietary recommendations for health are being met. There are several key findings from the study:

- Half of overweight or obese women with PCOS were not achieving sufficient activity to promote weight loss (60 minutes per day). However, the majority of all women with PCOS (74%) were achieving the recommendations for health of at least 30 minutes of moderate intensity activity per day.
- Percentage energy contribution from fat was significantly higher in women with PCOS compared with recommended intakes and previously reported intakes of UK women (NDNS values).
- Mean dietary GI (54.6) was substantially higher than the recommendation of 45 or less purported to reduce long-term disease risk (Barclay *et al.,* 2008), however it is in line with an average dietary GI of 56.5 reported for women in the general UK population (van Bakel *et al.,* 2009).
- Lean women with PCOS reported a significantly lower mean dietary GI compared with obese women with PCOS.
- More frequent eating episodes was weakly associated with a lower energy intake and lower BMI.

The association between higher body mass index and greater number of reported symptoms seen in this study confirms the importance of recommending and supporting overweight women with PCOS to achieve even moderate weight loss in order to confer significant improvements to symptom presentation (Kiddy *et al.,* 1992; Stamets *et al.,* 2004; Qublan *et al.,* 2007). The current study suggests that women with PCOS may be more active than previously reported with 74% self reporting that they did at least 30 minutes of moderate intensity activity per day compared to Humphreys and Costarelli (2008) who reported that only 41% of women with PCOS reported undertaking moderate intensity exercise at least once per week. Although the Department of Health (2004) report that only 24% of women in the general population are sufficiently active to gain any health benefit, the higher rate in this group of women with PCOS may be explained by women with PCOS have reported benefits of physical activity improving some of their PCOS symptoms (Jeanes *et al.,* 2009). However of concern, 52% of overweight or obese women with PCOS were not achieving sufficient activity of 60 minutes per day to promote weight loss.

The high total and saturated fat intakes of the current sample are of concern given that fatty acid intake is shown to influence glucose metabolism through the altering of insulin signalling and cell membrane function, with a diet high in SFA associated with a decrease in insulin sensitivity when compared to a high MUFA diet (Galgani *et al.,* 2008). Furthermore, a review by Risérus (2008) concluded that saturated and trans fatty acids should be replaced with PUFAs and MUFAs to confer benefits in terms of improving insulin sensitivity and preventing type 2 Diabetes Mellitus. Riccardi *et al.,* (2004) further demonstrated a high MUFA diet significantly improved insulin sensitivity

compared to a high saturated fat diet. However these benefits were not demonstrated when total fat intake exceeded 38% of total energy (Riccardi *et al.,* 2004), as was the case in 50% of the women with PCOS. Therefore in this population, any benefits from increased MUFA intake may be lost as a result of a high total fat intake. As total dietary fat intake for women with PCOS in the current study was above recommended levels it is clear that a reduction of total fat intake should focus on lowering SFA intake concurrently with encouragement of the maintenance of MUFA and PUFA in women with PCOS.

Despite a relatively low percentage of total energy from carbohydrate intake (43%), the high total sugar intake in this population was a cause for concern. This may in part be explained by their more frequent consumption of sweet snacks (1.6 per day) compared with savoury snacks (0.75 per day). Mean dietary GI reported by women with PCOS was similar to the average dietary GI reported by women in the general UK population (54.6 and 56.5 respectively) (van Bakel *et al.,* 2009) higher than Barclay *et al.,*'s (2008) recommendation of 45 or less for the reduction of long-term disease risk. Achieving this recommendation would mean a reduction of approximately 10 units for the average participant in the current study, with only two women already reporting mean GI levels below 45. In addition the mis-match between women's perceptions and actual intakes in terms of GI is of note and may indicate a key area for education. Advice provided by dietitians focuses on a reduction in energy intake (78%) and dietary glycaemic index (77%), often in combination, although relatively few women with PCOS receive dietary advice from a registered dietitian, which may explain the problems with implementing this type of regime (Jeanes *et al.,* 2009). Despite the lack of studies investigating the effects of low GI diets in women with PCOS specifically, given the potential benefits for glycaemic control it seems prudent for women to incorporate low GI foods into everyday meals and snacks, whilst also aiming to remain in line with current dietary guidelines for health.

There is some debate regarding the role of low GI diets in weight reduction, yet the majority of evidence suggests following an *ad libitum* low GI diet is not an effective means of achieving weight reduction independently (Aston, 2006); although this may help with weight maintenance (Thomas *et al.,* 2007). In the current study a weak relationship was found between BMI and dietary GI, with significant lower dietary GI reported by healthy weight women compared with obese women, consistent with findings from a recent systematic review (Thomas *et al.,* 2007). Whilst altered GI diets remain popular for PCOS management well controlled studies are needed to confirm the effectiveness of these approaches in both lean and overweight women with PCOS.

Previous studies in the general population have demonstrated that increased eating frequency may contribute to increased energy intake in women (Hampl *et al.,* 2003; Drummond *et al.,* 1998); indicating women who eat more frequently may be at greater risk of weight gain. However other researchers have concluded that regular eating episodes can actually help with weight management and improve insulin sensitivity in obese women (Farshchi *et al.,* 2005) and propose that the same would also be true for women with PCOS. Drummond *et al.,* (1998), using a similar methodology to the current study, reported that women in the general population had a mean of 4.4 eating episodes

per day (excluding drinks), lower than the eating frequencies for women with PCOS reported here (five eating episodes per day (excluding drinks)). women with PCOS frequently report food cravings and difficulty losing weight which may be linked to eating pattern and eating behaviour (Hirschberg, 2004; Herriot *et al.,* 2008) perhaps evidenced by the significant negative relationship between BMI and EF and the weak negative trend between energy intake and EF.

Study participants were recruited via the charity Verity, which may have lead to a non-representative sample of women with PCOS as these were women more likely to be better informed. The use of a 7 day food and activity diary has enabled comprehensive dietary analysis, however, the limitations of self reported intake and activity are well established (Gibson 2006).The mean age of the women was also relatively young, and therefore more likely to be physically active (DH, 2004) and any complications of PCOS may not have presented yet. The majority (96%) of women who took part in the study were Caucasian, an over-representation of this ethnic group when compared to the general population (92% Caucasian, Office for National Statistics, 2010). This is particularly important as previous literature has indicated a high prevalence of PCOS in South Asian and Black populations (Wijeyaratne *et al.,* 2002; Azziz *et al.,* 2006) indicating the need to target these ethnic groups in future research.

This research has shown that, even in a self-selected and therefore potentially motivated sample of women with PCOS, many of whom were not overweight, dietary intakes and eating patterns may not be optimal for management of their symptoms and reduction of future disease risks. The importance of focusing lifestyle interventions to promote weight management through physical activity and dietary advice on quality and quantity of fat, as well as carbohydrate modification, has been highlighted alongside the need for further robust research into the role of dietary GI and GL and eating patterns in the PCOS population, specifically in order to inform the development effective lifestyle guidelines.

Conflict of interest:
The authors declare no conflict of interest.

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Table 1. Mean [SD] dietary intake of women with PCOS (n=198) compared with females from the NDNS (2008/9) and Reference Nutrient Intake (RNI) values

Nutrient	women with PCOS (18-54 yrs)	NDNS 2008/9 (19-64 yrs)	RNI (19-50 yrs)
Energy (kJ)	8390 [1861]*	6920 [2010]	8100 (EAR)
Protein (g) % Energy from protein	78 [18]* 16 [4]	66.3 [18.6] 16.6 [3.9]	45
Fat (g) % Energy from Fat	85 [27]* 38 [7]	61.1 [23.4] 33.0 [6.9]	70
SFA (g) % Energy from SFA	26.5 [9.1]* 12	22.2 [9.4] 12 [3.3]	<21 <10
MUFA (g)	29.7 [10.7]*	21.7 [8.9]	28
PUFA (g)	16.2 [8.3]*	12.6[#]	14
CHO (g) % Energy from CHO	229 [59]* 43 [7]	198 [66] 45.5 [7.7]	250
Total sugar(g)	102 [35]*	87.4 [45.8]	n/a
Estimate≠ NMES(g)	56 [23]	51.7 [41.7]	51
Fibre (NSP) (g)	16.5 [5.8]*	13.0 [4.8]	18
Glycaemic Index	54.6 [4.2]		
Glycaemic Load	10.9 [2.4]		

* Significant difference according to one sample t-test between women with PCOS and NDNS ($p<0.05$). NDNS; National Diet and Nutrition Survey (2008/9), RNI; reference nutrient intake, EAR; estimated average requirement, SFA; saturated fatty acid, MUFA; monounsaturated fatty acid, PUFA; polyunsaturated fatty acid, NDNS PUFA calculated by the addition of reported n-3 and n-6 PUFA. NMES; non milk extrinsic sugar (≠NMES estimated by: glucose + sucrose (g), differing method to NDNS), NSP; non-starch polysaccharide.