

**INTERNATIONAL JOURNAL OF FOOD AND
NUTRITIONAL SCIENCES**

IMPACT FACTOR ~ 1.021



Official Journal of IIFANS

Research Paper

Open Access

DIET AND NUTRITION MANAGEMENT IN POLYCYSTIC OVARY SYNDROME

Mohini Paliwal^{1*}, Vandana Bharti² and Kirti Tiwari³

*Corresponding Author: Mohini Paliwal, ✉ mohini_pali@yahoo.in

Received on: 19th April 2016

Accepted on: 1st June 2016

PCOS patients are not always marked overweight but PCOS is strongly associated with abdominal obesity and insulin resistance. Effective approaches to nutrition and exercise improve endocrine features, reproductive function and cardio metabolic risk factors. Recent studies allow us to make recommendations on macronutrients intake. High intake of low GI carbohydrate contributes to dyslipidaemia and weight gain, also stimulates hunger and craving. Protein should be high biological value that improves hormonal function. Fat should be restricted $\leq 30\%$ of total calories with low proportion of saturated fat. Diet and exercise need to be tailored to the individual's need and preferences. Calorie intake should be distributed between several meals per day. The benefit of weight management through lifestyle change—all women suffering from PCOS benefit from dietary therapy and exercise; in fact dietary and lifestyle interventions are considered among the first line treatment for PCOS.

Keywords: Exercise, Lifestyle modification, Nutrition, Polycystic ovary syndrome

INTRODUCTION

Polycystic ovary syndrome is one of the most common endocrine disorders in reproduction age women and its prevalence varies broadly from 6-15 % in general population depending on ethnicity studied and the criteria utilized (Kumarapeli *et al.*, 2008; and Mehrabian *et al.*, 2011). It is characterized by the presence of oligo or amenorrhoea, polycystic ovaries, hirsutism, raised LH: FSH ratio, insulin resistance and compensatory hyperinsulinemia (The Rotterdam ESHRE/ASRM – Sponsored Consensus Workshop Group, 2004). Abdominal over weight and obesity also important components of PCOS that affects 30-70% of the PCOS population (Pasquali *et al.*, 2006; and Vrbikova *et al.*, 2009). Insulin resistance is present in women with PCOS independent of body mass. However obesity in PCOS is associated with greater insulin resistance, and a higher

incidence of dyslipidaemia, hypertension and diabetes type 2 (Perciaccante *et al.*, 2006). Obesity has significant effects on the clinical manifestations of PCOS, menstrual/ovulatory disturbances tend to be more marked in the obese; androgen levels are higher contributing to hirsutism and acanthosis nigricans (Mor *et al.*, 2004). Fertility is decreased and the rate of spontaneous abortion increased (Wang *et al.*, 2001). This paper reviews our understanding of nutritional aspects of PCOS, and proposes an approach to diet management and nutritional therapy in patients with PCOS.

Calorie Requirement and Restriction

Many studies in overweight and obese subjects shown beneficial effects of even modest ($\leq 5\%$) weight loss on well being, insulin sensitivity, and cardiovascular risk profile. There is every reason to believe that these benefits extend

¹ Dietician, Department of Dietetics, AIIM & Dr. Shefali Jain Test Tube Baby Centre, Indore, Madhya Pradesh, India.

² Assitant Professor of Food Science and Nutrition, Department of Home Science, M.L.B.G.D. Collage, Indore.

³ Professor & HOD, Department of Home Science, M.L.B.G.D. Collage, Indore.

to women with PCOS (Marsh and Brand – Miller *et al.*, 2005). Studies in patients with PCOS confirm that modest weight loss improves glucose tolerance, cardiovascular risk profile and reproductive function (Norman *et al.*, 2004; and Douglas *et al.*, 2006). In approaching dietary management it is important to reduce total calories consumed to standard levels for age and activity. Calories requests are higher for women with higher BMI and increase in relation to activity. It is often useful to initially focus on the eating pattern and the macronutrient content of the diet rather than try to promote both healthy eating and weight loss too quickly (Farschi *et al.*, 2007). Energy consumption can be reached by limiting nutrient or by increasing calories expenditure.

A daily calories deficit of 200 kcal/day will prevent weight gain; a deficit of 500 kcal/day is needed for the average person to lose 0.5 kg/week, while a 1000 kcal deficit is needed for 1 kg weight lose/week (Farschi *et al.*, 2007). It is important to recognize that improved abdominal obesity and insulin sensitivity may occur without an overall change in body weight. In particular, body composition of patients who exercise regularly may change with increased lean body muscle and decreased fat mass, but no overall change in weight. Increased body muscle increases resting energy expenditure and may help in improve hormonal and metabolic parameters in women with PCOS (Moran *et al.*, 2004). Short term meal replacement followed by dietary macronutrient restriction enhances weight loss in polycystic ovary syndrome (Moran *et al.*, 2006).

Dietary Carbohydrates

A period of relatively strict carbohydrate restriction helps at the beginning of the diet; a recent study demonstrated that a reduced carbohydrates diet results in lower measure of β cell responsiveness and circulating insulin (27% reduction in fasting insulin) when compared with a standard higher – carbohydrates diet (Gower *et al.*, 2013). Other studies have reported improvement in LDL cholesterol particle size, LDL concentration, and post prandial blood lipid profile (Parker *et al.*, 2002; Sharman *et al.*, 2004). On the other hand, low carbohydrates diets have been associated with deleterious effects on lipid profile when used long term (Kwitero vich *et al.*, 2003) and so severe carbohydrates restriction should use as a short term measure to achieve weight loss (Farshchi *et al.*, 2007).

Glycemic Index (GI)

It has been shown that eating foods with a low GI improves glucose control in women with PCOS and diabetes. The

Table 1: Glycemic Index Cutoffs

Glycemic Index Cutoffs	Range
High	?70
Moderate	50-70
Low	<50

Table 2: Glycemic Load Cutoffs

Glycemic Load Cutoffs	Range
High	?20
Intermediate	11-19
Low	<10

glycemic index indicates the rate in which glycemic increases after taking a quantity of “X” food containing 50 gm of carbohydrates. Foods with carbohydrates that break down quickly during digestion and release glucose rapidly into the blood stream tend to have a high GI; foods with carbohydrates that break down more slowly, emitting glucose more gradually into the bloodstream, tend to have a low GI (Stansbury *et al.*, 2012). GI cuts offs are listed in Table 1.

Glycemic Load (GL)

Glycemic load accounts for how much carbohydrate are in the food and how much each gram of carbohydrates in the food raises blood glucose levels. GL is a GI – weighted measure of carbohydrates content. GL cutoffs are listed in Table 2.

A high GI diet, on the other hand, has been shown to worsen post prandial insulin resistance (Brynes *et al.*, 2003) in fact a recent study showed that a low GI diet improves insulin sensitivity and menstrual regularity more than a conventional healthy (Marsh *et al.*, 2010).

Dietary Protein

Diets those are either low in fat or low in carbohydrates almost inevitably deliver an increased proportion of calorie intake as protein. Adequate protein intake is important to protect lean body mass and to increase muscle in response to exercise (Farshchi *et al.*, 2007). Actually there is little evidence to suggest benefits of high protein diet on insulin resistance and a number of studies in women with PCOS have failed to show significant long-term benefits of a high

protein diet on weight loss or insulin sensitivity (Parker *et al.*, 2002; and Stern *et al.*, 2004). There are also concerns about the safety of high protein, low carbohydrates diets including the effect of kidney function and bone mineral density (Marsh *et al.*, 2005).

It was demonstrated that proteins consumed at breakfast (compared with lunch and dinner) lead to a greater initial and sustained feeling of fullness, increased satiety, and reduced concentration of the appetite – regulating hormone ghrelin (Leidy *et al.*, 2009; and Leidy *et al.*, 2010). General advice is that the diet should deliver 20-25% of its calories as protein, this may increase at the expense of the other dietary components for short term diets designed to help the patient lose weight or improve glucose tolerance.

Dietary Fat

Fat is the most energy rich macro nutrient component of the diet containing 9 Kcal/gm, compared with only 4 Kcal/gm for carbohydrates and protein. Increased consumption of unsaturated fatty acids has been reported to improve insulin sensitivity in healthy (Vessby *et al.*, 2001), obese and type 2 diabetic subjects (Vessby *et al.*, 2003). The longer chain PUFAs, eicosapentaenoic acid and docosahexaenoic acid which are found in fish oil have beneficial effects on metabolic parameters in patients with diabetes, but specific evidence relating to PCOS is not available at this stage (Kasim-Karakas *et al.*, 2004). While the Mediterranean diet rich in mono saturated fatty acids (MUFA), has been widely accepted as a gold standard for healthy diets, its potential benefits in patients with PCOS have not been documented, although decreased features of obesity and insulin resistance have been noted in patient with PCOS (Carmina *et al.*, 2006). Consumption of Trans fat has been linked with increased risk of anovulatory infertility (Chavarro *et al.*, 2007). Over all, dietary fat should account for no more than 30% of the calorie content of the diet, with $\leq 7\%$ of calories coming from saturated fat. The remainder of the fat content should be as a balanced mixture of unsaturated fat including cooking oils and spreads.

Antioxidants

Polycystic ovary syndrome is also associated with decreased antioxidant concentrations and it is considered an oxidative state (Palacio *et al.*, 2006). Oxidative stress and inflammation promotes hyperandrogenism, which augments the inflammatory load (Gonzalez *et al.*, 2006). Oxidative stress promotes its effects causing damage to follicular proteins by marking of free thiol groups (Diamanti-Kandarakis *et al.*,

2006; and O'Connor *et al.*, 2010). Furthermore Reactive Oxygen Species (ROS) has been considered to play a critical role in the success of different IVF techniques. ROS are produced with the follicle, especially during the ovulatory process (Sugino, 2005) and it is believed that oxidative stress may be a cause of poor oocyte quality (Sugino, 2007).

Therapeutic strategy to reduce the oxidative stress includes diet rich in fruits and vegetables, weight reduction, physical exercise, smoking cessation, alcohol consumption reduction and adequate number of sleeping hours.

Vitamin D

Hypovitaminosis D was found in about 80% of PCOS women (Elimoglu *et al.*, 2010; and Firouzabadi *et al.*, 2012). Calcium has an important role in follicle development and both calcium and vitamin D deficiencies are considered as potential risk factors for insulin resistance and obesity (Zemel, 2004; and Firouzabadi *et al.*, 2012). Supplementation of vitamin D (50,000 IU/week) and calcium (1 gm/day) seems to support the positive effect of metformin therapy, with greater results in restoring normal menstrual regularity and improving hyperandrogenism symptoms, weight loss and follicle maturation compared to metformin treatment alone (Firouzabadi *et al.*, 2012).

Eating Patterns

The frequency and regularity of eating pattern are important, even if there are small data in the literature. In a study of nearly 16000 adults (Kerner *et al.*, 2006), meal and snack pattern were good markers for overall nutrient intake. Those who ate frequently during the day had higher intakes of carbohydrates, fibers and a range of micronutrients, while those who ate less frequently had higher intakes of fat, cholesterol, protein and sodium. Other studies showed that a regular meal frequency leads to higher post prandial energy expenditure, lower energy intake and improved impaired insulin sensitivity compared with irregular eating in 2 week interventions (Farshchi *et al.*, 2004). In further study, breakfast consumption was associated with lower energy intake and improved insulin sensitivity compared with breakfast omission (Farshchi *et al.*, 2005). The skipping of breakfast impacted overweight positively while eating habits vegetarian or non vegetarian (Goyal *et al.*, 2014). Lower micronutrients intake was associated with skipping breakfast (Kerver *et al.*, 2006). High calorie intake at breakfast with reduced intake at dinner is suggested, because it leads to rescued over all insulin levels (Jakubowics *et al.*, 2013).

Exercise and PCOS

Exercise reduces insulin resistance by two mechanisms. It induces a reduction in visceral fat even if it results in moderate weight loss and BMI reduction (Palomba *et al.*, 2008). Visceral fat is more metabolically active than subcutaneous fat and central adiposity is more closely related to insulin resistance (Panidis *et al.*, 2013). Exercise, besides increases muscle cell metabolism: it modulates the expression or the activity of proteins mediating insulin signaling in the skeletal muscles (Hawley *et al.*, 2004; and Palomba *et al.*, 2008). It has been shown that exercise improves menstrual abnormalities and restores ovulation in obese patients with PCOS (Farrell *et al.*, 2010) and its benefit on reproductive function is greater than the benefit of low-calories diet only (Giallauria *et al.*, 2008). Exercise exerts its beneficial effects on body composition with a 45% greater reduction in fat free mass (Thomson *et al.*, 2008). In fact, it is important to clarify that improved abdominal obesity and insulin sensitivity may occur without a total change in body weight: body composition of patients who exercise regularly may change with increased lean body mass and decreased fat mass, but no overall change in weight.

Insulin-Sensitizing Agents and Statins

According to the ASRM committee of 2008, insulin-sensitizing agents should be considered in patients with impaired glucose tolerance and PCOS. Particularly, in 2010 AE – PCOS society consensus treatment emphasized that metformin should be used in women with PCOS who have already started lifestyle treatment (diet and exercise) and do not have improvement in IGT or in those who have normal weight but still having impaired glucose tolerance. When administered to insulin-resistant patients, these drugs act to increase target tissue responsiveness in order to reduce hyperinsulinemia. Moreover, statins have also been used to improve lipid profile in PCOS women.

CONCLUSION

PCOS is a complex disorder due, in part but not exclusively to, insulin resistance and overweight. All women suffering from PCOS benefit from dietary therapy and exercise; in fact dietary and lifestyle interventions are considered among the first line treatments for PCOS. Based on published information summarized in this review, certain recommendations can be made about diet and exercise in patient with PCOS. Dietary approach may be divided as follows:

1. Carbohydrates should count for 50%-55% of the diet initially. Keep intake of refined carbohydrate down. Concentrate on low Glycemic Index (GI) foods, those high in fiber.
2. Diet of higher protein (25% of daily energy) content may improve satiety and insulin sensitivity.
3. Eat no more the 30% of daily calories as fat; restricting saturated fat to $\leq 7\%$ total calories.
4. Avoid red meat. Eat only fish at least once per week to supply long chain essential fatty acids like omega-3.
5. Eat at least five portions of fruit or vegetables per day. This promotes satiety, supplies fiber and maintains the micronutrients content of the diet.
6. Eat regularly and focus on food intake on three to four meals per day. Breakfast is an important meal. An approach which deals with the fundamental problem in PCOS will help to improve the multiple facts of the disease and to protect the patients from the long term consequence including, type 2 diabetes and cardiovascular disease. A rational approach to lifestyle management in PCOS will help the practitioner engage with the patient, and allow both practitioner and patient to approach this complex disorder in rational manner.

REFERENCES

- Brynes A E, Edwards M C and Ghatei MA (2003), "A Randomized Four Intervention Crossover Study Investigating the Effect of Carbohydrates on Daytime Profile of Insulin, Glucose, Non-esterified Fatty Acids and Triacylglycerols in Middle Aged Men", *Br. J. Nutr.*, Vol. 89, pp. 207-218.
- Carmina E (2006), "Metabolic Syndrome in Polycystic Ovary Syndrome", *Minerva Ginecologica*, Vol. 58, pp. 109-114.
- Chavarro J E, Rich-Edwards J W, Rosner B A and Willett W C (2007), "Dietary Fatty Acids Intake and Risk of Ovulatory Infertility", *American Journal of Clinical Nutrition*, Vol. 85, pp. 231-237.
- De Leo V, Musacchio M C, Morgante G, Piomboni P and Petraglia F (2006), "Metformin Treatment is Effective in Obese Teenage Girls with PCOS", *Human Reproduction*, Vol. 21, pp. 2252-2256.

- Diamanti-Kandarakis E and Economou F (2006), “Stress in Women: Metabolic Syndrome and PCOS”, *Annals of the New York Academy of Science*, Vol. 1083, pp. 54-62.
- Douglas C C, Gower B A, Darnell B E, Ovalle F, Oster R S and Azziz R (2006), “Role of Diet in the Treatment of PCOS”, *Fertility and Sterility*, Vol. 85, pp. 679-688.
- Elimoglu H, Duran C and Kiyici S (2010), “The Effect of Vitamin D Replacement Therapy on Insulin Resistance and Androgen Levels in Women with PCOS”, *J. Endocrinol Invest.*, Vol. 33, No. 4, pp. 234-238.
- ESHRE/ASRM (2004), “Revised 2003 Consensus on Diagnostic Criteria and Long Term Health Risks Related to PCOS”, *Fertil Steril*, Vol. 81, pp. 19-25.
- Farshchi H, Taylor M and Macdonald I (2004), “Regular Meal Frequency Creates More Appropriate Insulin Sensitivity and Lipid Profiles Compared with Irregular Meal Frequency in Healthy Lean Women”, *Eur. J. Clin. Nutr.*, Vol. 58, pp. 1071-1077.
- Farshchi H, Taylor M and Macdonald I (2005), “Deleterious Effects of Omitting Breakfast on Insulin Sensitivity and Fasting Lipid Profile in Healthy Lean Women”, *Am. J. Clin. Nutr.*, Vol. 81, pp. 388-396.
- Farshchi H, Rane A, Love A and Kennedy R L (2007), “Diet and Nutrition in Polycystic Ovary Syndrome (PCOS): Pointers for Nutritional Management”, *J. Obstet Gynaecol*, Vol. 27, pp. 762-773.
- Farrell K and Antoni M H (2010), “Insulin Resistance, Obesity, Inflammation, and Depression in Polycystic Ovary Syndrome: Biobehavioral Mechanisms and Interventions”, *Fertil Steril*, Vol. 94, pp. 1565-1574.
- Firouzabadi R, Aflatoonian A and Modarresi S (2012), “Therapeutic Effects of Calcium & Vitamin D Supplementation in Women with PCOS”, *Complement Ther. Clin. Pract.*, Vol. 18, pp. 85-88.
- Gonazalez F, Rote N S, Mnum J and Kirwan J P (2006), “Reactive Oxygen Species-Induced Oxidative Stress in the Development of Insulin Resistance and Hyperandrogenism in Polycystic Ovary Syndrome”, *J. Clin. Endocrinol. Metab.*, Vol. 91, pp. 336-340.
- Gower B A, Chandler-Laney P and Ovalle F (2013), “Favorable Metabolic Effects of a Eucaloric Lower – Carbohydrate Diet in Women with PCOS”, *Clin. Endocrinol (oxf)*, Vol. 79, No. 4, pp. 550-557.
- Glycemic Load Definds, Glycemic Research Institute, Retrieved February 8, 2013.
- Giallauria F, Palomba L, Maresca L *et al.* (2008), “Exercise Training Improves Autonomic Function and Inflammatory Pattern in Women with PCOS”, *Clin Endocrinol (Oxf)*, Vol. 69, pp. 792-798.
- Goyal R and Julka S (2014), “Impact of Breakfast Skipping on the Health Status of the Population”, *Indian J. Endocrinol Metab.*, Vol. 18, No. 5, pp. 683-687.
- Hawley J A (2004), “Exercise as a Therapeutic Intervention for the Prevention and Treatment of Insulin Resistance”, *Diabetes Metab Res. Rev.*, Vol. 20, pp. 383-393.
- Jakubowicz D, Barnea M, Wainstein J and Froy O (2013), “Effects of Caloric Intake Timing on Insulin Resistance and Hyperandrogenism in Lean Women with Polycystic Ovary Syndrome”, *Clin. Sci.*, Vol. 125, pp. 423-432.
- Kasim – Karakes S, Almario R U, Gregory L *et al.* (2004), “Metabolic and Endocrine Effects of a Polyunsaturated Fatty Acids-Rich Diet in Polycystic Ovary Syndrome”, *J. Clin Endocrinol Metab*, Vol. 89, No. 2, pp. 615-620.
- Kerver J M, Yang E J, Obayashi S *et al.* (2006), “Meal and Snack Patterns are Associated with Dietary Intake of Energy and Nutrients in US Adults”, *J. Am. Diet Assoc.*, Vol. 106, pp. 46-53.
- Kumarapeli V, Seneviratne Rde A, Wijeyaratne C N, Yapa R M and Dodampahala S H (2008), “A Simple Screening Approach for Assessing Community Prevalence and Phenotype of PCOS in a Semi Urban Population in Sri Lanka”, *Am. J. Epidemiol.*, Vol. 168, pp. 321-328.
- Kwiterovich P O, Vining E P G *et al.* (2003), “Effect of High Fat Ketogenic Diet on Plasma Levels of Lipids, Lipoproteins, and Apolipoproteins in Children”, *JAMA*, Vol. 190, pp. 912-920.
- Leidy H J, Bossingham M J, Mattes R D and Campbell W (2009), “Increased Dietary Protein Consumed at Breakfast Leads to an Initial and Sustained Feeling of Fullness During Energy Restriction Compared to Other Meal Times”, *Br. J. Nutr.*, Vol. 101, pp. 798-803.
- Leidy H J and Racki E M (2010), “The Addition of a Protein-Rich Breakfast and its Effects on Acute Appetite Control and Food Intake in Breakfast Skipping Adolescent”, *Int. J. Obes.*, Vol. 34, pp. 1125-1133.

- Marsh K and Brand-Miller J (2005), “The Optimal Diet for Women with Polycystic Ovary Syndrome”, *Br. J. Nutr.*, Vol. 94, pp. 154-165.
- Marsh K A, Steinbeck K S, Atkinson F S *et al.* (2010), “Effect of a Low Glycemic Index Compared with a Conventional Healthy Diet on Polycystic Ovary Syndrome”, *Am. J. Clin. Nutr.*, Vol. 92, pp. 83-92.
- Mehrabian F, Khani B, Kelishadi R and Ghanbari E (2011), “The Prevalence of PCOS in Iranian Women Based on Different Diagnostic Criteria”, *Endokrynol Pol.*, Vol. 62, pp. 238-242.
- Mor E, Zograbyan A, Saadat P, Bayrak A, Tourgeman D E, Zhang C *et al.* (2004), “The Insulin Resistant Subphenotype of PCOS, Clinical Parameters and Pathogenesis”, *American Journal of Obstetrics and Gynecology*, Vol. 190, pp. 1654-1660.
- Moron L J, Noakes M, Clifton P M *et al.* (2003), “Dietary Composition in Restoring Reproductive and Metabolic Physiology in Overweight Women with Polycystic Ovary Syndrome”, *J. Clin. Endocrinol. Metab.*, Vol. 88, pp. 812-819.
- Moran L J, Noakes M, Clifton P M, Wittert G A, Williams G and Norman R J (2006), “Short Term Meal Replacements Followed by Dietary Macronutrients Restriction Enhance Weight Loss in PCOS”, *American Journal of Clinical Nutrition*, Vol. 84, pp. 77-87.
- Norman R J, Noakes M, Wu R, Davies M J Moran and Wang J X (2004), “Improving Reproductive Performance in Overweight/Obese Women with Effective Weight Management”, *Human Reproduction Update*, Vol. 10, pp. 267-280.
- O’Connor A, Gibney J and Roche H M (2010), “Metabolic and Hormonal Aspects of Polycystic Ovary Syndrome: The Impact of Diet”, *Proc. Nutr. Soc.*, Vol. 69, pp. 628-635.
- Palacio J R, Iborra A, Ulcova – Gallova Z *et al.* (2006), “The Presence of Antibodies to Oxidative Modified Proteins in Serum from Polycystic Ovary Syndrome Patients”, *Clin. Exp. Immunol.*, Vol. 144, pp. 217-222.
- Palomba S, Giallauria F, Falbo A *et al.* (2008), “Structured Exercise Training Programme versus Hypo Caloric Hyperproteic Diet in Obese Polycystic Ovary Syndrome Patients with Anovulatory Infertility: A 24 Week Pilot Study”, *Hum. Reprod.*, Vol. 23, pp. 642-650.
- Panidis D, Tziomalos K *et al.* (2013), “Lifestyle Intervention and Anti Obesity Therapies in the Polycystic Ovary Syndrome: Impact on Metabolism and Fertility”, *Endocrine*, Vol. 44, pp. 583-593.
- Parker B, Noakes M, Luscombe N and Clifton P (2002), “Effect of a High Protein, High Monounsaturated Fat Weight Loss Diet on Glycemic Control and Lipid Levels in Type 2 Diabetes”, *Diabetes Care*, Vol. 25, pp. 425-430.
- Pasquali R, Gambineri A, Biscotti D, Vicennati V, Gagliardi L and Colitta D (2000), “Effect of Long Term Treatment with Metformin Added to Hypocaloric Diet on Body Composition, Fat Distribution, and Androgen and Insulin Levels in Abdominally Obese Women with and Without the PCOS”, *Journal of Clinical Endocrinology and Metabolism*, Vol. 85, pp. 2767-2774.
- Perciaccante A, Fiorentini A, Paris A, Serra P and Tubani L (2006), “Circadian Rhythm of the Autonomic Nervous System in Insulin Resistant Subjects with Normo-Glycemia, Impaired Fasting Glycemia, Impaired Glucose Tolerance Type 2 Diabetes Mellitus”, *BMC Cardiovasc Disord*, Vol. 6, p. 19.
- “Practice Committee of the American Society for Reproductive Medicine, Use of Insulin Sensitizing Agents in the Treatment of PCOS”, *Fertil Steril*, 2008, Vol. 90, pp. S69-S73.
- Sharman M J, Gomez A L, Kraemer W J and Volek J S (2004), “Very Low-Carbohydrate and Low-Fat Diets Affects Fasting Lipids and Post Prandial Lipemia Differently in Overweight Men”, *J. Nutr.*, Vol. 134, pp. 880-885.
- Stansbury J (2012), “The PCOS Health & Nutrition Guide: Includes 125 Recipes for Managing Polycystic Ovarian Syndrome”, *Robert Rose*, ISBN: 9780778804055.
- Stern L, Iqbal N *et al.* (2004), “The Effects of Low-Carbohydrate versus Conventional Weight Loss Diets in Severely Obese Adults: One-Year Follow-Up of a Randomized Trial”, *Ann. Intern. Med.*, Vol. 140, pp. 778-785.
- Sugino N (2005), “Reactive Oxygen Species in Ovarian Physiology”, *Reprod. Med. Biol.*, Vol. 4, pp. 31-44.
- Sugino N (2007), “Roles of Reactive Oxygen Species in the Corpus Luteum”, *Anim. Sci. J.*, Vol. 77, pp. 556-565.

- Thomson R L, Buckley J D, Noakes M *et al.* (2008), “The Effect of a Hypocaloric Diet with and Without Exercise Training on Body Composition, Cardio Metabolic Risk Profile, and Reproductive Function in Overweight and Obese Women with PCOS”, *J. Clin. Endocrinol. Metab.*, Vol. 93, pp. 3373-3380.
- Vessby B, Uusitupa M, Hermansen K, Riccardi G, Rivellese AA, Tapsell L C *et al.* (2001), “Substituting Dietary Saturated for Monounsaturated Fat Impairs Insulin Sensitivity in Healthy Men and Women: The KANWU Study”, *Diabetologia*, Vol. 44, pp. 312-319.
- Vessby B (2003), “Dietary Fat, Fatty Acid Composition in Plasma and the Metabolic Syndrome”, *Current Opinion in Lipidology*, Vol. 40, pp. 119-123.
- Vrbikova J, Dvorakova K, Hill M and Starka L (2006), “Weight Change and Androgen Levels During Contraceptive Treatment of Women Affected by Polycystic Ovary”, *Endocrine Regulations*, Vol. 40, pp. 119-123.
- Wang J X, Davies M J and Norman R J (2001), “Polycystic Ovarian Syndrome and Risk of Spontaneous Abortion Following Assisted Reproductive Technology Treatment”, *Human Reproduction*, Vol. 16, pp. 2606-2609.
- Wild R A, Carmina E, Diamanti – Kandarakis E *et al.* (2010), “Assessment of Cardiovascular Risk and Prevention of Cardiovascular Disease in Women with PCOS: A Consensus Statement by the Androgen Excess and Polycystic Ovary Syndrome (AE-PCOS) Society”, *J. Clin. Endocrinol. Metab.*, Vol. 95, pp. 2038-2049.
- Zemel M B (2004), “Role of Calcium and Dairy Products in Energy Partitioning and Weight Management”, *Am. J. Clin. Nutr.*, Vol. 79, pp. 907-912.

