Effect and comparison of the ketogenic, mediterranean and low glycemic index in the treatment of ovarian syndrome polycystic (PCOS)

Efecto y comparación de la dieta cetogénica, mediterranea y de bajo índice glucemico en el tratamiento del síndrome de ovario poliquístico (SOP)

Ana Albornos Antón

Universidad Internacional Iberoamericana, Spain (ana.albornos@alumnos.uneatlantico.es)(http://orcid.org/0009-0005-9148-0816)

ABSTRACT

Key words: Polycystic ovary syndrome (PCOS), Ketogenic diet (KD), Mediterranean diet (DM), Low glycemic index (GI) diet, PCOS treatment.	To analyze and compare the effect of ketogenic, mediterranean, and low glycemic index diets in the treatment of women with polycystic ovary syndrome (PCOS), evaluating the improvement of symptoms and evolution of the pathology. A bibliographic review based on the study of high-quality scientific articles found through databases was conducted for the complete preparation of this review. Studies indicate that any of the three dietary patterns can be an effective treatment for PCOS, depending on the aspects being treated. All low-calorie diets are effective for women with PCOS who are overweight and obese, improving associated symptoms. The ketogenic diet (KD) is beneficial in the short term for weight loss and glycemic control, although it is highly restrictive and difficult to maintain in the long term. The Mediterranean diet (MD), with less efficient in the short term, improves general health, has a high antioxidant capacity, and is evidenced to be more sustainable in the long term. The low glycemic index (GI) diet does not show conclusive results for PCOS but may improve the sex hormone profile and lipid profile parameters. A combined strategy of several dietary patterns can improve both short- and long-term results.: To provide a more specific treatment for PCOS, more studies with greater evidence and higher quality are necessary. However, it can be concluded that the dietary models studied, according to the symptoms and needs of the patients, possess the necessary characteristics to achieve improvements, constituting a vital part of the treatment of women with PCOS.

RESUMEN

Palabras clave:
Síndrome de ovario poliquístico (SOP), Dieta cetogénica (DC), Dieta mediterránea (DM), Dieta de bajo índice glucémico (IG), Tratamiento del SOP

Analizar y comparar el efecto de las dietas cetogénica, mediterránea, y de bajo índice glucémico como tratamiento en mujeres con síndrome de ovario poliquístico (SOP), evaluando la mejora de los síntomas y evolución de la patología. Revisión bibliográfica basada en el estudio de artículos científicos de la mayor calidad encontrada a través de bases de datos para la elaboración total de la revisión. Los estudios indican que los tres patrones dietéticos pueden ser un tratamiento efectivo para el SOP, dependiendo de los aspectos a tratar. Las dietas hipocalóricas resultan efectivas para mujeres con SOP que padecen sobrepeso y obesidad, mejorando los síntomas asociados. La dieta cetogénica (DC) es beneficiosa a corto plazo, aunque es restrictiva y difícil de mantener a largo plazo para lograr resultados sostenibles. La dieta mediterránea (DM), menos eficiente a corto plazo, mejora la salud general, tiene una alta capacidad antioxidante y evidencia de ser más sostenible a largo plazo. La dieta de bajo índice glucémico (IG) no muestra resultados concluyentes para el SOP, pero mejora el perfil hormonal y parámetros del perfil lipídico. Una estrategia combinada de varios patrones dietéticos puede mejorar los resultados tanto a corto como a largo plazo.

Para ofrecer un tratamiento más específico frente al SOP, son necesarios más estudios con mayor evidencia y calidad. Sin embargo, se puede concluir que los modelos dietéticos estudiados presentan, según la sintomatología y las necesidades, las características necesarias para lograr mejoras. Constituyendo una parte vital del tratamiento en mujeres con SOP

Introduction

Polycystic ovarian syndrome (PCOS) is a chronic disorder present in the main cause of this disease, which affects mainly the metabolic and endocrine system, has different short and long term impacts during the entire fertile life (1)the prevalence is 6 to 20% and is characterized by anovulation, hyperandrogenism and polycystic ovarian morphology (2). Usually diagnosed in adolescence during menarche, the first menstruation, with the use of gynecologic ultrasound as the primary diagnostic method (3).

It is considered a disease with heterogeneous symptomatology associated with metabolic and endocrine factors, which are related to other pathologies such as cardiovascular disease, type 2 diabetes mellitus (DM2) and insulin resistance (IR), as well as different long-term consequences (4).

Among the most prominent symptoms of PCOS, which significantly impact quality of life, are reproductive, metabolic and cardiovascular problems. Reproductive problems include cycle irregularity, infertility and complications during pregnancy. As for metabolic problems, DM2 is especially prevalent among women who are overweight or obese, affecting between 40% and 80% of women with PCOS (4) (4). In addition, a high incidence of cardiovascular disease and IR is observed. More recently, psychological problems, such as anxiety and depression, have been recognized as important components in PCOS (1,3) (1,3).

The main treatment for PCOS consists in the implementation of a healthier lifestyle, focused on improving the diet, with the aim of improving the quality of life of the patients (2). Diet is one of the most effective and beneficial treatments for both improving the symptomatology of PCOS and addressing associated conditions such as hyperinsulinemia and obesity (4). It is crucial that these dietary interventions be accompanied by appropriate medical and nutritional follow-up to tailor recommendations to the individual needs of each patient (3-5).

At the clinical level there is a need to determine a more concise treatment as there is a great deal of misinformation and confusion in the population about PCOS in general. It is a topic of personal relevance to me as I was diagnosed with PCOS a few years ago. In addition to the clinical symptoms that this syndrome presents and the complications that it can cause in the long term, experiencing it personally gives me a direct insight into the subject at hand.

Method

A bibliographic search was carried out in different databases for specific articles related to the topics to be addressed.
The databases used to begin the search were:

-PubMed: Establishing the present filters specific to the database: maximum publication date of 5 years. Using as keywords in your search *Polycystic ovary syndrome treatment, Chronic PCOS, Polycystic ovary syndrome epidemiology, Polycystic Ovary Syndrome AND Diet Ketogenic, Ketogenic diet treatment, Diet Mediterranean[Majr] AND Polycystic Ovary Syndrome, Polycystic ovary syndrome AND low glycemic index.*

134

- Google Scholar: This search engine was very useful for accessing the full text of various articles or for searching official web pages, as well as for accessing guides related to the topic to be covered. Using as keywords for your main search *Polycystic Ovary Syndrome*.

Inclusion criteria were experimental studies, clinical trials, case-control studies, cohort studies or observational studies or reviews in the case of providing demographic or theoretical data. With a population of women of childbearing age between 15 and 45 years, with a diagnosis of PCOS. Women with associated diseases or different BMIs were not excluded as part of the study was the relevance of environmental conditions in the predisposition and development of the syndrome. The articles used for the main discussion were published between 2019 and 2024, with the exception of the use of previously published articles that were highly relevant to provide a scientific basis.

Exclusion criteria were based on studies of little relevance to the study including systematic or literature reviews, in-vitro studies and expert experience. In addition, those studies developed in animals, specific to the male sex or with active treatments to treat other adjacent metabolic diseases.

Results

The nutritional approach to polycystic ovary syndrome (PCOS) is presented as a vital tool for the improvement of the pathology along with its associated factors and an improvement in the quality of life (6). We will begin by analyzing the studies related to the ketogenic diet and PCOS. These are supplemented by the information in Table 1. All the studies found were carried out in overweight and obese women, attributing most of the results to the benefits obtained, as they were hypocaloric diets, with weight reduction. In contrast to the study by Paoli et al. (4) results were not very conclusive as the small sample size and the short time to which the subjects were exposed were not considered sufficiently significant for the treatment of PCOS. While the study by Cincione et al. (7) used a greater amount of protein to preserve muscle mass. Improving symptomatology together with biochemical and anthropometric parameters, it is considered effective in a short period of time but highly hypocaloric and not recommended for long-term treatment as it is not clear whether it would continue to be beneficial. The final results were remarkable in the regulation of the menstrual cycle and an increase in fertility with improvements in all the women who completed the study.

The study by Magagnini et al. (8) obtained more significant results in the improvement of ovarian function and found a greater relationship with fertility, and also obtained improvements in both anthropometric and hormonal parameters, highlighting the improvement of progesterone. This study stands out for its greater adherence, since all subjects completed the study, being one of the longest follow-up periods compared to the other studies. While following the restrictive and hypocaloric pattern, nutrients were given prominence in the dietary guidelines. One of the values highlighted in the three studies (4,7,8) was the reduction in testosterone levels, although the lack of clinical improvement was highlighted as the time of action was not long enough to make such observations. Finally, the clinical study conducted by Yang et al. (9) stated that it was possible to conserve muscle mass by performing a hypocaloric CD, reducing visceral fat and lowering blood sugar levels. This was the study in which the least improvement in

analytical and anthropometric parameters was observed, in contrast to the previous studies, which could be due to a lower caloric restriction.

Table 1. Studies on ketogenic diet treatment in women with PCOS.

Author, year and reference	Type of study	Population	Features	Exclusion and inclusion criteria	Results
Paoli et al., 2020(4)	Uncontrolled trial	14 overweight and obese women with polycystic ovary syndrome	Duration of 12 weeks. Study of the ketogenic Mediterranean diet with phyoextracts. Evaluation of body weight, BMI, fat and lean body mass, visceral adipose tissue, lipid profile, insulin, glucose, HOMA-IR, and hormone profile. Place of origin: Italy	Inclusion criteria: diagnosis of PCOS through the Rotterdam criteria, age between 18 to 45 years, a BMI ≥ 25 kg/m2, desire to lose weight and not using contraceptives. Exclusion criteria: pregnancy or lactation, hormone therapy, insulin sensitivity, liver, kidney or heart disease.	No significant results were obtained in oligoamenorrhea or infertility. Androgen hormone levels decreased significantly. An average weight reduction of 9.43 kg was obtained along with a reduction in BMI, fat mass and visceral adipose tissue.
Cincione et al., 2021 (7)	Uncontrolled trial	17 overweight and obese women with polycystic ovary syndrome	Duration of 45 days. Study of the mixed ketogenic diet to establish ketosis while preserving lean mass. Evaluation of clinical and gynecological history, nutritional status, body composition and biochemical measurements. Place of origin: Italy	Inclusion criteria: BMI > 25, fertile age between 18 and 45 years, diagnosis of PCOS according to the Rotterdam Criteria, no contraceptive use and desire to lose weight. Exclusion criteria: pregnancy or breastfeeding, renal, hepatic or cardiac diseases, episodes of gout or hyperuricemia, estrogenic-progestagenic or insulinosensitizing pharmacological treatment in a period of less than one year.	Reduction of blood glucose, androgen and estrogen levels and improvement of insulin sensitivity. An average weight loss of 9.4% was obtained, together with a 3.6% reduction in BMI. Five of the seventeen patients with amenorrhea recovered their regular menstrual cycle, improved their cycles and five achieved a natural pregnancy after low fertility.
Magagnini et al., 2022 (8)	Uncontrolled trial	25 overweight and obese non-diabetic women with polycystic ovary syndrome and regular menstruation	Duration of 12 weeks. Very low calorie ketogenic diet (VLCKD) study Evaluation of anthropometric and blood parameters. Place of origin: Italy	Inclusion criteria: over 18 years of age, diagnosis of PCOS according to the Rotterdam Criteria, family history of DM2, regular menstrual cycle intervals and male couples with normozoospermia. Exclusion criteria: DM1, DM2, chronic renal failure, active or severe infections, cardiac arrhythmias, frailty,	Seventy-five percent of the patients reduced their weight. 96% improved serum AMH levels along with progesterone. 100% of the women improved in ovulatory dysfunction. 19 of the 25 patients went from obese to overweight BMI and the HOMA index normalized in 24 of the 25 patients.

				previous 48-h surgery, invasive procedures, psychiatric disorders, irregular menstrual cycles.	
Yang et al. 2022, (9)	Clinical trial	55 overweight and obese women with polycystic ovary syndrome	Duration of 12 weeks. Study of the effects of ketogenic diet on uric acid concentrations. Evaluation of weight, BMI, body fat percentage, fasting blood glucose, triglycerides, total cholesterol and uric acid. Place of origin: China	Inclusion criteria: BMI of ≥ 24 kg/m ^{2}, women of childbearing age between 20-40 years.	Maintenance of muscle mass along with reduction of total weight, BMI, total fat and hyperuricemia. The analytical and anthropometric values showed similar results at the beginning and end of the study.

To continue, studies related to the Mediterranean diet and PCOS will be discussed. These are detailed in **Table 2**.

Some of the studies (10-12) used the PREDIMED score as a method of evaluation, which is mostly used to determine adherence to DM, but it was observed that it does not provide absolute results and other parameters should be taken into account. The study by Barrea et al. (10) did not determine a direct relationship between DM with clinical improvement of PCOS due to certain limitations such as the relatively small sample size and the cross-sectional nature of the study, although it highlighted the formation of a homogeneous group for better comparison along with the inclusion of nutritional and cardiometabolic parameters, providing a better characterization of metabolic risk in PCOS. This study used PhA as a complementary marker to evaluate the clinical severity of the syndrome, although different inflammatory markers, which are quite relevant in PCOS, were not taken into account. We found an association between lower adherence to DM and worse metabolic and hormonal parameters in women with PCOS, emphasizing that better adherence to DM has benefits for body composition and reduces the severity of disease symptoms in women with PCOS. Mei et al. (13) highlighted the effectiveness of DM combined with a low-carbohydrate diet as a treatment for women with PCOS and overweight. Observing significant improvements in body composition, metabolic and hormonal markers, with notable benefits in the regulation of the menstrual cycle and the reduction of blood glucose and lipid parameters. Despite these findings, low continuity in dietary adherence by patients and cultural dietary constraints suggest that strategies are needed. In the study by Wang et al. (14) found a direct relationship between lower inflammation in women with PCOS and DM. DII was used to assess inflammation, observing improvements in inflammation and cardiovascular health, commonly compromised in the syndrome, associating DM as a protective factor against PCOS. Other studies, although they yielded less relevant results due to the methodologies used and the parameters measured, proved to be decisive in providing relevant information for the analysis of the Mediterranean diet.

The study by Mu L. et al. (15) did not find clear results on the direct relationship of DM with PCOS. Nutritional status and cardiometabolic indices were also not taken

137

into account, thus the study factors were incomplete. The study by Barrea et al. (12) developed a more complete evaluation, which was able to make a more direct comparison, with the presence of specific criteria. We observed what was predicted by previous studies, as MUO-SOP patients presented worse analytical values and lower adherence to the diet compared to MHO patients. Cutillas-Tollin et al. (11) did not find a clear association between DM and the presence of PCOS, which does not mean that there is no direct relationship, since the study also compared other dietary patterns. It showed a protective effect, highlighting the improvement of metabolic and hormonal indicators through DM, however these results were not very significant. The use of FFQ as a method of evaluation was not considered the most appropriate because of its greater biases and lack of precision.

Table 2. Mediterranean diet treatment studies in women with PCOS**.**

Author, year and reference	Type of study	Population	Features	Exclusion and inclusion criteria	Results
Barrea et al.2019, (10)	Observational cross-section al case-control study	224 women in total (112 women diagnosed with PCOS and 112 in the control group)	Study of adherence to the Mediterranean diet. Assessment of dietary adherence, dietary intake and body composition, clinical severity and testosterone levels. These were assessed through the PREDIMED study, BIA, PhA and the Ferriman-Gallwey hirsutism score scale. Place of origin: Italy	Inclusion criteria: premenopausal, overweight or obese, age between 18 and 40 years, no underlying metabolic or metabolic disease, diagnosis of PCOS. Exclusion criteria: Menopause, hyperandrogenism, systemic or psychiatric disease, use of drugs that affect metabolism, hypocaloric diet in the last three months, use of drugs that influence water balance, pacemakers or defibrillators.	Women with PCOS presented lower adherence together with a lower consumption of basic foods in DM (EVOO, legumes, fish or nuts).
Mu L. et al. 2019, (15)	Clinical trial	3551 women of reproductive age with PCOS	Study on the prevalence of PCOS in metabolically healthy obese (MHO) versus metabolically unhealthy obese (MHO) women. Assessment of the metabolic risk profile through a large epidemiological survey, physical examination (BMI, blood pressure,	Inclusion criteria: diagnosis of PCOS through the Rotterdam criteria, being of childbearing age. Exclusion criteria: Menopause	No significant differences in BMI were found between the two PCOS groups.

138

			glucose and lipid profile) and transvaginal ultrasound. Place of origin: China		
Barrea et al., 2021(12)	Cohort study	94 women with polycystic ovary syndrome and obesity	Differential study to determine metabolic health status in PCOS according to phenotypes metabolically healthy obese (MHO) and metabolically unhealthy obese (MUO). Assessment of endocrine-metabolic profile, inflammatory status, adherence to DM and body composition. Place of origin: Italy	Inclusion criteria: diagnosis of PCOS, BMI ≥30.0 kg/m ^{2}, fertile age between 18 to 30 years, same geographic area (Naples, Campania, Italy), no previous treatment. Exclusion criteria: BMI less than 30, menopause, lactation or pregnancy, psychiatric disease, treatment for metabolic activity, hypocaloric diet, dietary supplements, underlying metabolic disease, pacemakers or defibrillators, skin damage in the area of BIA application.	MUO patients presented higher CRP, testosterone and insulin levels, with lower adherence to DM and lower PhA. With a worse endocrine and metabolic profile compared to MHO patients.
Cutillas-Tollin et al., 2021(11)	Case-control study	121 women with polycystic ovary syndrome and 155 women as controls	Study on the associations between compliance with different dietary indices and the presence of polycystic ovary syndrome. Evaluation through anamnesis and semi-quantitative food frequency questionnaires (FFQ), physical examination, transvaginal ultrasound and blood collection, between days 2 to 5 of the menstrual cycle. Use of the PREDIMED test to assess adherence. Place of origin: Murcia (Spain)	Inclusion criteria: fertile age between 18 and 40 years, diagnosis by Rotterdam criteria. Exclusion criteria: pregnancy or breastfeeding, oncological treatment, hormonal medication during the three months prior to the study, genitourinary prolapse or endocrine disorders, medication that interferes with carbohydrate metabolism, hormonal contraceptives and thyroid hormones.	No clear association was found between the dietary indices studied together with PCOS and their phenotypes.
Wang et al., 2022(14)	Case-control study	527 women with polycystic ovary syndrome	Study on the association of PCOS-specific dietary patterns and quantification of possible inflammatory effects of diet. Evaluation of dietary		Inflammation was reduced by up to 4.79%, positively correlating diet with PCOS.

139

				Inclusion criteria	
Mei et al. 2022 (13)	Randomized controlled clinical trial	59 overweight women with polycystic ovary syndrome. 29 in the LF diet group and 30 in the MED/LC diet group	Duration of 12 weeks. Study on the therapeutic effect of a Mediterranean diet (MED) combined with a low-carbohydrate (LC) dietary model in women with PCOS and overweight to achieve long-term metabolic improvement by reducing the intake of foods with trans fatty acids. Evaluation of weight, BMI, waist circumference, waist-to-hip ratio, body fat percentage, insulin, fasting plasma glucose, cholesterol, triglycerides, total testosterone, luteinizing hormone, as anthropometric indicators, reproductive endocrine levels, degree of IR and lipid metabolism levels. Place of origin: China	Inclusion criteria: diagnosis of polycystic ovary syndrome according to Rotterdam criteria, age 16 to 45 years, BMI ≥24.0 kg/m2. Exclusion criteria: endocrine disorders, combination of cardiovascular and cerebrovascular diseases, hematological disorders, hepatic or renal failure, pregnancy or lactation period, absence of contraceptives during the intervention period, mental illness, cancer, hormonal drugs other than progesterone or insulin sensitizers.	No side effects were observed during the intervention throughout the study. No differences were observed between the two groups with respect to age, anthropometry, sex hormone levels and blood biochemistry. 72.4% (21/29) of the patients in the LF group returned to normal menstrual cycles and 86.7% (26/30) of the MED/LC patients returned to normal menstrual cycles, with no significant differences between the two groups. Both groups showed a significant decrease in fasting insulin levels (FINS), HOMA-IR index, QUICKI index and lipid parameters (TG, TC and LDL-C), while HDL-C levels did not change significantly. In the MED/LC group, the reduction in blood glucose was more significant, also had a greater decrease in FPG, FINS, HOMA-IR and QUICKI. It also showed greater reductions in TG, TC and LDL-C, but not in HDL-C. As for FSH and PRL levels, a slight change was observed in both groups.

Finally, the discussion of the studies related between low glycemic index diet and PCOS will be developed. These are detailed in Table 3. Some of the studies (16,17) were conducted as a focus on overweight and obese women, emphasizing hypocaloric diets.

140

Results were obtained in the reduction of body weight, BMI and improvements in the values associated with the lipid profile. Hoover et al. (16) presented results at the hormonal level, ghrelin and glucagon, which were not very significant. Although the changes defined were consistent throughout the study, they were not specific to the diet studied, with no notable differences in the analytical values. The lack of assessment of insulin and blood glucose, very relevant parameters in PCOS, is noteworthy. The study by Camerlingo et al. (17) showed similar analytical results without significant changes.

In the study developed by Shishehgar et al. (18) found relevant improvement in the population studied. Clinical reflected in cycle irregularity was improved in 80% of cases along with a reduction in IR, although both were associated with weight loss. The study showed a better adherence with a dropout rate of 15%, since it was determined to be one of the few studies that promoted healthy lifestyle habits beyond a hypocaloric diet. Although inflammatory markers and lipid profile, markers of great relevance in PCOS, were not evaluated. In contrast, the comparative study by Panjeshanin et al.(19) although it presented improvements in certain values, did not find a significant relationship between the low GI dietary pattern and PFS.

Szczuko et al. (20) identified the low-GI diet as a useful dietary strategy to improve the antioxidant profile in women with PCOS. Observing an increase in uric acid levels and antioxidant activity, which could improve antioxidant status and benefit parameters such as weight and reduction of oxidative stress in these women. It is important to carefully monitor these levels to avoid the risk of inflammation and other health problems.

Table 3. Studies on low glycemic index diet treatment in women with PCOS.

Author, year	Type of study	Study population	Features	Exclusion and inclusion criteria	Results
Shishehgar et al., 2019(18)	Intervention study	62 women in total (28 women with PCOS and 34 women as controls)	Duration of 24 weeks. Study of low glycemic index (LGI) diet and energy restriction to compare their effects on anthropometric variables and IR. Assessment at baseline, 12 weeks and at the end of the study of anthropometric, biochemical, hormonal and clinical measurements, evaluation of hirsutism through the modified Ferriman-Gallwey scoring method. Place of origin: Iran	Inclusion criteria: Diagnosis of PCOS through the Rotterdam criteria, fertile age between 18-40 years, BMI >20. Exclusion criteria: pregnant women, breastfeeding, use of insulin-sensitizing agents or lipid-lowering therapies, contraceptives in the previous 6 months, hypocaloric diets, antihypertensives, antipsychotics, hormonal drugs, mental or chronic illness, participation in	Weight loss values of 8%, with virtually no differentiation between PCOS and non-PCOS cases. RI was not reduced in any group. Women with PCOS had reduced levels of total testosterone and FAI. Along with an increase in SHBG. Cycle irregularities in PCOS improved by 80% with a reduction in acne occurrence of 32.1%.

141

					previous similar studies.	
Panjeshani n et al. 2020 (19)	Case-contr ol study	216 women in total (108 women with PCOS and 108 women as controls)	Duration of 14 months. Study of the relationship of major dietary patterns in Iranian women with PCOS. Evaluation of the percentage of total and visceral fat mass. Place of origin: Iran	Inclusion criteria: diagnosed PCOS according to Rotterdam criteria.		No direct relationship was found between the dietary patterns studied and the presence of PCOS. The low glycemic index diet showed an improvement in the analytical results but was not representative.
Hoover et al., 2021(16)	Randomize d crossover clinical study	30 women with polycystic ovary syndrome	Duration of 20 weeks. Study of a low glycemic load diet versus a high glycemic load diet. Evaluation of postprandial parameters of ghrelin, glucagon glucose, insulin and appetite. Oral glucose tolerance test to rule out diabetes.	Inclusion criteria: diagnosis of PCOS, fertile age between 21 to 50 years, BMI $\leq$ 45 kg/m^2, no weight fluctuations > 2.3 kg in the last 6 months. Exclusion criteria: intense exercise, diabetes, pregnancy, lactation, drugs affecting metabolism, food allergies.		The low glycemic load diet caused some reduction in postprandial glucagon and ghrelin in women with PCOS.
Camerlingo et al., 2022(17)	Randomize d clinical trial	40 overweight and obese women with polycystic ovary syndrome (21 of the women with hypocaloric diet and 19 of the women with hypocaloric diet together with Lactobacillus rhamnosus supplementatio n)	Duration of 20 weeks with monitoring every 4 weeks. Study of how intestinal bacterial abundance and lipid profile in a hypocaloric diet, with a 600 kcal deficit, affect changes in fecal short-chain fatty acid (SCFA) content. Evaluation of SCFA, selected intestinal bacteria (Akkermansia muciniphila, Bifidobacterium longum and Faecalibacterium prausnitzii), lipid profile and anthropometric parameters (body weight, waist circumference and fat mass), calculation of glycemic index values using the international glycemic index table and glycemic load.	Inclusion criteria: diagnosis of PCOS according to Rotterdam criteria, overweight/obese women, fertile age between 18 and 45 years, no previous ovarian surgeries. Exclusion criteria: pregnancy or breastfeeding, taking antibiotics or probiotics in the last 6 months, hormones that could affect the menstrual cycle in the last 3 months, drugs that affect carbohydrate metabolism, weight loss supplements, anti-inflammatory or nutraceutical drugs, thyroid		Body weight, BMI, fat mass, acetic and butyric acids were reduced and lipid profile (total cholesterol, low-density lipoprotein cholesterol and triglycerides) improved in both groups. No conclusive results were found with the use of supplementatio n or changes in SCFA levels in either group.

				disorders, hyperprolactinemia, Cushing's syndrome, liver, kidney, cardiovascular or digestive disease.	
Szczuko et al.2019 (20)	Intervention study	24 overweight and obese women with polycystic ovarian syndrome	Duration of 3 months. Study of low GI hypocaloric diet to determine which antioxidants increase their activity with exogenous antioxidant and essential fatty acid (EFA) supplementation to suppress inflammation. Evaluation of glutathione peroxidase (GPx3) activity, plasma iron-reducing capacity and uric acid concentration. Anthropometric measurements were assessed by BIA. Testosterone, insulin and SHBG were assessed by ECLIA (electrochemiluminescence immunoassay) and and androstenedione was analyzed by ELISA (Kobas Rosch E411). Glucose was analyzed by an enzymatic method with hexokinase. Place of origin: Poland	Inclusion criteria: diagnosis of PCOS according to Rotterdam criteria. Exclusion criteria: Women diagnosed with hyperprolactinemia, congenital adrenal hyperplasia, Cushing's syndrome, androgen-releasing tumor and acromegaly.	Increases in uric acid and GPx3 activity were observed, a significant correlation was observed between GPx3 and prolactin, fasting insulin and triglycerides. Antioxidant status did not change significantly. No significant correlation was observed between uric acid and FRAP. But if between uric acid level and increased PRL and fasting glucose, also in people with lower body mass, lower BMI and lower total body water.

Discussion and conclusions

At the end of the study on the three dietary patterns as a treatment for polycystic ovary syndrome (PCOS), the ketogenic diet, the Mediterranean diet and the low glycemic index diet, it is concluded that these can be beneficial depending on the aspects to be treated, observing as an important common factor a healthy lifestyle. Although there is still a large uninvestigated field, advances in recent years have given more relevance to the syndrome.

All the hypocaloric diets analyzed are effective for women with PCOS who are overweight and obese, thus improving the associated symptoms. .

The ketogenic diet is considered beneficial in the short term for weight loss, improving parameters that are directly associated with obesity and overweight. Considering in the same way that they present low adherence due to their highly restrictive nature.

143

The Mediterranean diet is considered less efficient in short-term studies against specific parameters, although it improves various aspects of general health. They present less restrictive characteristics, focused on quality of life and a healthy lifestyle. It is one of the diets with the highest long-term adherence, offering improvements in practically all levels compared.

The low glycemic index diet presents inconclusive results in terms of specific benefits for PCOS, in addition to being highly restrictive. Most of the studies are predominantly from Western countries, which influences the results mainly due to dietary cultural factors.

The combination of dietary patterns improves the quality of the treatment, according to the needs and symptomatology, adapting in the best way to the patient and offering different benefits.

These findings provide a balanced, evidence-based view of how different dietary patterns can be used in the treatment of PCOS. Concluding that the diets presented have great bearing on the treatment of PCOS, offering different approaches and benefits.

It is crucial to study more about the long-term repercussions of highly restrictive and hypocaloric diets in PCOS patients, as it is currently presented in a negative way but there is a lack of studies to support it.
More intervention studies are needed to directly relate the Mediterranean diet and PCOS, as there is not much evidence in this regard, as a dietary pattern with high therapeutic potential and not only as a habit improvement.

The efficacy of the dietary patterns analyzed in women with PCOS without overweight and obesity should be further studied. So far, there is little evidence that these diets work as a treatment for any woman diagnosed with PCOS.

Further studies are needed to determine whether the results found are sustained over time across all diets, as women with PCOS have a higher prevalence of weight gain along with associated long-term pathologies and symptoms, which could be prevented with appropriate dietary patterns.

References

1. Alesi S, Ee C, Moran LJ, Rao V, Mousa A. Nutritional Supplements and Complementary Therapies in Polycystic Ovary Syndrome. Adv Nutr [Internet]. July 2022 [cited Mar 24, 2024];13(4):1243-66. Retrieved from: https://linkinghub.elsevier.com/retrieve/pii/S2161831322000163
2. Recommendations from the 2023 international evidence-based guideline for the assessment and management of polycystic ovary syndrome [Internet]. [cited Mar 29, 2024]. Retrieved from: https://academic.oup.com/ejendo/article/189/2/G43/7242362
3. Tay CT, Garrad R, Mousa A, Bahri M, Joham A, Teede H. Polycystic ovary syndrome (PCOS): international collaboration to translate evidence and guide future research. J Endocrinol [Internet]. June 1, 2023 [cited March 29, 2024];257(3). Retrieved from: https://joe.bioscientifica.com/view/journals/joe/257/3/JOE-22-0232.xml

4.   Paoli A, Mancin L, Giacona MC, Bianco A, Caprio M. Effects of a ketogenic diet in overweight women with polycystic ovary syndrome. J Transl Med [Internet]. February 27, 2020 [cited March 29, 2024];18(1):104. Retrieved from: https://doi.org/10.1186/s12967-020-02277-0

5.   Vanhauwaert PS. Polycystic ovary syndrome and infertility. Rev Médica Clínica Las Condes [Internet]. March 1, 2021 [cited March 29, 2024];32(2):166-72. Retrieved from: https://www.sciencedirect.com/science/article/pii/S0716864021000195

6.   Liu J, Wu Q, Hao Y, Jiao M, Wang X, Jiang S, et al. Measuring the global disease burden of polycystic ovary syndrome in 194 countries: Global Burden of Disease Study 2017. Hum Reprod [Internet]. April 1, 2021 [cited March 29, 2024];36(4):1108-19. Retrieved from: https://doi.org/10.1093/humrep/deaa371

7.   Cincione RI, Losavio F, Ciolli F, Valenzano A, Cibelli G, Messina G, et al. Effects of Mixed of a Ketogenic Diet in Overweight and Obese Women with Polycystic Ovary Syndrome. Int J Environ Res Public Health [Internet]. January 2021 [cited April 29, 2024];18(23):12490. Retrieved from: https://www.mdpi.com/1660-4601/18/23/12490

8.   Magagnini MC, Condorelli RA, Cimino L, Cannarella R, Aversa A, Calogero AE, et al. Does the Ketogenic Diet Improve the Quality of Ovarian Function in Obese Women? Nutrients [Internet]. January 2022 [cited April 29, 2024];14(19):4147. Retrieved from: https://www.mdpi.com/2072-6643/14/19/4147

9.   Yang M, Bai W, Jiang B, Wang Z, Wang X, Sun Y, et al. Effects of a ketogenic diet in women with PCOS with different uric acid concentrations: a prospective cohort study. Reprod Biomed Online [Internet]. August 1, 2022 [cited April 29, 2024];45(2):391-400. Retrieved from: https://www.rbmojournal.com/article/S1472-6483(22)00219-X/abstract

10.   Barrea L, Arnone A, Annunziata G, Muscogiuri G, Laudisio D, Salzano C, et al. Adherence to the Mediterranean Diet, Dietary Patterns and Body Composition in Women with Polycystic Ovary Syndrome (PCOS). Nutrients [Internet]. October 2019 [cited April 7, 2024];11(10):2278. Retrieved from: https://www.mdpi.com/2072-6643/11/10/2278

11.   Cutillas-Tolín A, Arense-Gonzalo JJ, Mendiola J, Adoamnei E, Navarro-Lafuente F, Sánchez-Ferrer ML, et al. Are Dietary Indices Associated with Polycystic Ovary Syndrome and Its Phenotypes? A Preliminary Study. Nutrients [Internet]. February 2021 [cited April 29, 2024];13(2):313. Retrieved from: https://www.mdpi.com/2072-6643/13/2/313

12.   Barrea L, Muscogiuri G, Pugliese G, de Alteriis G, Colao A, Savastano S. Metabolically Healthy Obesity (MHO) vs. Metabolically Unhealthy Obesity (MUO) Phenotypes in PCOS: Association with Endocrine-Metabolic Profile, Adherence to the Mediterranean Diet, and Body Composition. Nutrients [Internet]. November 2021 [cited April 29, 2024];13(11):3925. Retrieved from: https://www.mdpi.com/2072-6643/13/11/3925

13.   Mei S, Ding J, Wang K, Ni Z, Yu J. Mediterranean Diet Combined With a Low-Carbohydrate Dietary Pattern in the Treatment of Overweight Polycystic Ovary Syndrome Patients. Front Nutr [Internet]. April 4, 2022 [cited May 25, 2024];9. Retrieved from: https://www.frontiersin.org/articles/10.3389/fnut.2022.876620

14.   Wang Q, Sun Y, Xu Q, Liu W, Wang P, Yao J, et al. Higher dietary inflammation potential and certain dietary patterns are associated with polycystic ovary syndrome risk in China: A case-control study. Nutr Res [Internet]. April 1, 2022 [cited April 29, 2024];100:1-18. Retrieved from: https://www.sciencedirect.com/science/article/pii/S027153172200001X

145

15.   Mu L, Zhao Y, Li R, Lai Y, Chang HM, Qiao J. Prevalence of polycystic ovary syndrome in a metabolically healthy obese population. Int J Gynecol Obstet [Internet]. 2019 [cited May 2, 2024];146(2):164-9. Retrieved from: https://onlinelibrary.wiley.com/doi/abs/10.1002/ijgo.12824

16.   Hoover SE, Gower BA, Cedillo YE, Chandler-Laney PC, Deemer SE, Goss AM. Changes in Ghrelin and Glucagon following a Low Glycemic Load Diet in Women with PCOS. J Clin Endocrinol Metab [Internet]. May 1, 2021 [cited April 2, 2024];106(5):e2151-61. Retrieved from: https://doi.org/10.1210/clinem/dgab028

17.   Camerlingo C. A low glycemic index, energy-restricted diet but not Lactobacillus rhamnosus supplementation changes fecal short-chain fatty acid and serum lipid concentrations in women with overweight or obesity and polycystic ovary syndrome [Internet]. European Review. 2022 [cited April 29, 2024]. Retrieved from: https://www.europeanreview.org/article/28001

18.   Shishehgar F, Mirmiran P, Rahmati M, Tohidi M, Ramezani Tehrani F. Does a restricted energy low glycemic index diet have a different effect on overweight women with or without polycystic ovary syndrome? BMC Endocr Disord [Internet]. Sep 2, 2019 [cited April 29, 2024];19(1):93. Retrieved from: https://doi.org/10.1186/s12902-019-0420-1

19.   Panjeshahin A, Salehi-Abargouei A, Anari AG, Mohammadi M, Hosseinzadeh M. Association between empirically derived dietary patterns and polycystic ovary syndrome: A case-control study. Nutrition [Internet]. November 1, 2020 [cited April 29, 2024];79-80:110987. Retrieved from: https://www.sciencedirect.com/science/article/pii/S0899900720302707

20.   Szczuko M, Zapalowska-Chwyć M, Drozd R. A Low Glycemic Index Decreases Inflammation by Increasing the Concentration of Uric Acid and the Activity of Glutathione Peroxidase (GPx3) in Patients with Polycystic Ovary Syndrome (PCOS). Molecules [Internet]. January 2019 [cited May 25, 2024];24(8):1508. Retrieved from: https://www.mdpi.com/1420-3049/24/8/1508