Evaluation of Insulin Resistance Markers in Polycystic Ovary Syndrome Patients Receiving Metformin, Finasteride or Both

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ABSTRACT

Background: Polycystic ovary syndrome (PCOS) is a widespread endocrine disorder affecting approximately 6–15% of women of reproductive age worldwide. It is characterized by hyperandrogenism, chronic anovulation, and polycystic ovarian morphology, and is often associated with metabolic disturbances, particularly insulin resistance (IR). IR is observed in 35%–80% of PCOS patients and plays a critical role in the pathogenesis of both reproductive and metabolic dysfunctions in this condition. Effective management of IR is essential to improve clinical outcomes in PCOS. Several markers have been developed to assess IR, including non-insulin-based indices such as the Triglyceride-Glucose (TyG) index, TyG index adjusted for Body Mass Index (TyG-BMI), and the triglyceride to HDL-cholesterol ratio (TG/HDL-c), in addition to insulin-based measures like the Homeostatic Model Assessment of Insulin Resistance (HOMA-IR). Metformin, an insulin sensitizer, and finasteride, an antiandrogen, are utilized in the management of PCOS, either alone or in combination. Evaluating the effects of these therapies on IR markers is crucial for optimizing treatment strategies.

Objective: To compare the effects of metformin, finasteride, or their combination on insulin resistance markers in Iraqi women with PCOS.

Patients and method: This non randomized interventional study enrolled 150 female patients diagnosed with polycystic ovary syndrome (PCOS) according to the Rotterdam criteria (2003), with an age range of 18 to 39 years. The participants were assigned into three equal groups (n = 50). The metformin group received an initial oral dose of 500 mg once daily, which was escalated by 500 mg every 1 to 2 weeks with meals, up to a maximum dose of 2500 mg/day over a 3-month period. The finasteride group was administered 5 mg orally once daily for 3 months. The combination group received both agents at the aforementioned doses and durations. Baseline and post-treatment data were collected for age, body mass index (BMI), and insulin resistance markers for comparative evaluation.

Results: After treatment, all three modalities—metformin, finasteride, and their combination—significantly reduced mean HOMA-IR levels ($p < 0.001$), with metformin alone showing the greatest reduction. In addition, all treatments significantly decreased the triglyceride-glucose (TyG) index, TyG-BMI index, and TG/HDL ratio ($p < 0.001$), with the combination therapy demonstrating the most pronounced effect.

Conclusion: Metformin alone was more effective in reducing insulin resistance, as indicated by HOMA-IR. In contrast, the combination of metformin and finasteride produced greater improvements in insulin sensitivity, reflected by the TyG index, TyG-BMI index, and TG/HDL ratio, suggesting potential added value of the combination in managing insulin-related disturbances in women with PCOS.

Key words: IR Markers, PCOS, Metformin, Finasteride.

تقييم مؤشرات مقاومة الإنسولين لدى مريضات متلازمة تكيس المبايض المعالَجات بالميتفورمين، الفيناسترايد أو بكليهما

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الخلاصة

الخلفية: متلازمة تكيّس المبايض (PCOS) هي اضطراب هرموني واسع الانتشار يصيب نحو ٦–١٥% من النساء في سن الإنجاب حول العالم. وتتميّز بفرط الأندروجين، واضطراب التبويض المزمن، ووجود مبايض متعددة الكيسات، وغالبًا ما ترتبط باضطرابات أيضية، خاصة مقاومة الإنسولين (IR). وتُلاحظ مقاومة الإنسولين لدى ٣٥% إلى ٨٠% من المصابات، وتُعد من

العوامل الأساسية التي تسهم في حدوث المشكلات التناسلية والأيضية المرتبطة بهذه المتلازمة. ويُعد التحكم في مقاومة الإنسولين ضروريًا لتحسين الحالة الصحية للمريضة. وقد تم تطوير عدة مؤشرات لتقييم مقاومة الإنسولين، منها مؤشرات لا تعتمد على قياس الإنسولين مثل: مؤشر ثلاثي الغليسريد/الغلوكوز (TyG)، ومؤشر TyG المعدّل وفقًا لمؤشر كتلة الجسم (TyG-BMI)، ونسبة ثلاثي الغليسريد إلى الكوليسترول الجيد (TG/HDL-c)، بالإضافة إلى مؤشرات تعتمد على الإنسولين مثل HOMA-IR. يُستخدم كل من الميتفورمين، كمحسّس للإنسولين، والفيناسترايد، كمضاد لهرمونات الذكورة، في علاج متلازمة تكيّس المبايض سواء كلٌّ على حدة أو معًا. ويُعد تقييم تأثير هذه العلاجات على مؤشرات مقاومة الإنسولين أمرًا مهمًا لتحديد أنسب استراتيجيات العلاج.

الهدف: تقييم ومقارنة تأثير كل من الميتفورمين، الفيناسترايد، ومزيجهما على مؤشرات مقاومة الإنسولين لدى نساء عراقيات مصابات بمتلازمة تكيس المبايض

المرضى والطريقة: شملت هذه الدراسة التدخلية غير العشوائية ١٥٠ مريضة تم تشخيصهن بمتلازمة تكيس المبايض (PCOS) وفقًا لمعايير روتردام (٢٠٠٣)، وكانت أعمارهن تتراوح بين ١٨ و٣٩ عامًا. تم توزيع المشاركات إلى ثلاث مجموعات متساوية (n = 50). تلقت مجموعة الميتفورمين جرعة ابتدائية فموية مقدارها ٥٠٠ ملغ مرة واحدة يوميًا، وتمت زيادة الجرعة بمقدار ٥٠٠ ملغ كل ١ إلى ٢ أسبوع مع الوجبات، لتصل إلى الجرعة القصوى البالغة ٢٥٠٠ ملغ/يوم خلال فترة ثلاثة أشهر. أما مجموعة الفيناسترايد فقد تلقت ٥ ملغ فموياً مرة واحدة يوميًا لمدة ٣ أشهر. بينما تلقت مجموعة العلاج المشترك العقارين معًا بنفس الجرعات والفترات المذكورة أعلاه. تم جمع البيانات قبل وبعد العلاج لكل من العمر، ومؤشر كتلة الجسم (BMI)، ومؤشرات مقاومة الإنسولين لغرض التقييم المقارن.

النتائج: بعد العلاج، أدت جميع أنماط العلاج الثلاثة — الميتفورمين، الفيناسترايد، ومزيجهما — إلى انخفاض كبير في متوسط مستويات HOMA-IR ($p < 0.001$)، وكان الميتفورمين وحده هو الذي أظهر أعلى نسبة من هذا الانخفاض. بالإضافة إلى ذلك، أدت جميع العلاجات إلى انخفاض كبير في مؤشر الكلوكوز-الدهون الثلاثية (TyG)، ومؤشر TyG-BMI، ونسبة TG/HDL ($p < 0.001$)، مع تسجيل أقوى تأثير في مجموعة العلاج المشترك.

الاستنتاج: كان الميتفورمين وحده أكثر فعالية في خفض مقاومة الإنسولين، كما يتضح من انخفاض مؤشر HOMA-IR. في المقابل، أدى الجمع بين الميتفورمين والفيناسترايد إلى تحسينات أكبر في حساسية الإنسولين، كما يظهر من انخفاض مؤشري TyG وTyG-BMI ونسبة TG/HDL، مما يشير إلى أن للعلاج المشترك فائدة إضافية محتملة في إدارة الاضطرابات المرتبطة بالإنسولين لدى النساء المصابات بمتلازمة تكيس المبايض.

الكلمات المفتاحية: علامات مقاومة الإنسولين، متلازمة تكيس المبايض، ميتفورمين، فيناسترايد.

INTRODUCTION

Polycystic Ovary Syndrome (PCOS) is a prevalent endocrine disorder among women, characterized by a range of reproductive, cardiometabolic, dermatological, and psychological symptoms. Women with PCOS often experience subfertility, irregular menstrual cycles, excess body weight, hirsutism, acne, and a perceived loss of feminine identity [1]. Insulin resistance (IR) is typically defined as a pathological condition involving diminished responsiveness or sensitivity to the metabolic actions of insulin. It is a well-established predictor of several disorders. In PCOS, insulin resistance plays a crucial role in the development and persistence of the syndrome and contributes significantly to the associated metabolic abnormalities [2].IR in PCOS results from impaired insulin action in various target tissues, leading to elevated basal compensatory insulin levels and a reduced insulin response to hyperglycemia. PCOS affects multiple organs and tissues [3]. While Body Mass Index (BMI) is an independent predictor of IR in women with PCOS, it is not commonly used as a surrogate marker. Notably, insulin resistance in PCOS is not always correlated with body fat; thus, BMI may not accurately predict IR in lean women. However, BMI shows a stronger association with IR in overweight and obese women [4].

Several markers are used to assess IR, including the Homeostatic Model Assessment of Insulin Resistance (HOMA-IR) [5], the Triglyceride to High-Density Lipoprotein Cholesterol ratio (TG/HDL-C), the Triglyceride-Glucose (TyG) index, and the TyG index adjusted for BMI (TyG-BMI) [6]. HOMA-IR has been extensively utilized in studies to evaluate insulin resistance among women with PCOS [7]. Abnormal lipid metabolism, a hallmark of PCOS, affects up to 70% of patients [8]. Insulin resistance is closely linked to dyslipidemia, leading to elevated triglycerides (TGs), increased low-density lipoprotein cholesterol (LDL-C), and decreased high-density lipoprotein cholesterol (HDL-C) levels [9].Barrios et al. evaluated the relationship between insulin resistance and the TG/HDL-C ratio in women with PCOS and found significantly elevated HOMA-IR values and TG/HDL-C ratios [10]. The TyG-BMI index has emerged as a valuable tool for identifying individuals at risk of developing Type 2 Diabetes Mellitus (T2DM), a common comorbidity

in PCOS [11]. First introduced in 2008, the TyG index is a specific and reliable parameter for detecting IR in apparently healthy individuals. It offers a cost-effective and less complex alternative to the hyperinsulinemic-euglycemic clamp test, particularly in low-resource settings [12].

Metformin, a biguanide-class insulin sensitizer [13], is commonly used off-label as a first-line treatment for overweight and metabolic disturbances in women with PCOS. It improves the underlying insulin resistance by enhancing insulin sensitivity in the liver and peripheral tissues and reducing hepatic glucose production [14]. Finasteride, a competitive inhibitor of 5-alpha-reductase—the enzyme that converts testosterone to the more potent androgen dihydrotestosterone (DHT)—is a well-tolerated antiandrogen with minimal side effects. It has been effectively used in PCOS management [15]. Interestingly, despite its primary role as an antiandrogen, finasteride may also improve IR in women with PCOS, given the interplay between elevated androgen levels and insulin resistance, two key pathophysiological features of the syndrome [16].

This study aimed to evaluate and compare the effects of finasteride, metformin, and their combination on insulin resistance markers in women with PCOS.

PATIENTS AND METHOD

This non randomized interventional study was conducted at the Maternity and Pediatrics Hospital in Al-Diwaniyah Province, Iraq, between September 21, 2024, and March 31, 2025. A total of 150 unmarried female patients diagnosed with polycystic ovary syndrome (PCOS) based on the Rotterdam criteria (2003) and exhibiting insulin resistance were enrolled. Eligible participants were between 18 and 39 years of age and were allocated equally into three treatment groups (n = 50 per group). Patients with conditions that could confound the diagnosis or interfere with the intervention, such as hyperprolactinemia, congenital adrenal hyperplasia, Cushing's syndrome, androgen-secreting tumors, malignancy, type 1 diabetes mellitus, history of type 2 diabetes, pregnancy, or lactation, were excluded.

The first group received oral metformin starting at 500 mg once daily with meals, which was increased by 500 mg every 1–2 weeks until reaching a maximum dose of 2,500 mg daily over a 3-month period. The second group was treated with 5 mg of oral finasteride once daily for the same duration. The third group received a combination of both medications at the respective doses and timelines used in the monotherapy groups.

Baseline data collected included age, body mass index (BMI), and laboratory measures relevant to insulin resistance and metabolic status. BMI was calculated according to the following formula [21]: BMI = body weight (kg) / height (m^2). Laboratory assessments included fasting serum insulin, fasting glucose, triglycerides (TG), and high-density lipoprotein cholesterol (HDL-C). The same parameters were reassessed after 90 days of intervention to evaluate treatment efficacy.

Several indices were calculated to assess insulin resistance and related metabolic dysfunction. The HOMA-IR index was determined using the formula: fasting insulin (mU/mL) × fasting glucose (mmol/L) / 22.5. The TyG index, an alternative marker of insulin resistance, was computed as the natural logarithm of [fasting glucose (mg/dL) × TG (mg/dL) / 2]. In addition, the TyG-BMI index was calculated by multiplying the TyG value by the patient's BMI. The triglyceride-to-HDL-C ratio, a marker of atherogenic dyslipidemia, was calculated by dividing TG by HDL-C levels.

All participants provided written informed consent after receiving a full explanation of the study's objectives and procedures. The study protocol was reviewed and approved by the Research Ethics Committee of the College of Medicine, University of Al-Qadisiyah, ensuring compliance with ethical standards for human research.

Statistical Analysis

The data were gathered, summarized, analyzed, and presented using SPSS software (version 23) and Microsoft Excel 2010. To assess normality, quantitative (numeric) variables were initially tested using the Kolmogorov-Smirnov test. If the data followed a standard distribution, they were conveyed as the mean (a amount of central tendency) and standard deviation (a amount of dispersion), in addition to reporting the minimum and maximum values.

The statistical tests used in the analysis included:

1. One-way ANOVA, which was applied to compare mean differences among three groups followed by LSD multiple comparison test.
2. Paired samples t-test, which was conducted to evaluate changes in mean numeric values before and after treatment within each group.
3. A P-value of ≤ 0.05 was deliberated the onset for statistical importance.

RESULTS

Assessment of mean age among study groups is shown in table 1. There was no significant difference (p = 0.633). The mean age of metformin group is 27.78 ±3.79 years with a range of 18 to 36 years. The mean age of finasteride group was 27.72 ±4.14 years with a range of 18 to 39 years. The mean age of combination group was 28.38 ±3.48 years with a range of 21 to 39 years.

Before initiation of treatment, comparison of mean body mass index (BMI), mean HOMA-IR, mean TyG index, mean TyG-BMI, and mean TG/HDL exposed no important differences (p > 0.05), as shown in table 2. After treatment, all three modalities of treatment, metformin, finasteride and combination were able to reduce mean BMI, mean HOMA-IR, mean TyG index, mean TyG-BMI, and mean TG/HDL significantly (p<0.001). Changes in mean BMI were comparable among the all three modalities of treatment; metformin alone resulted in best reduction with respect to HOMA-IR; however, with respect to other variables, the magnitude of reduction caused by combination was the best, table 2.

Table 1: Comparison of mean age among study groups

Characteristic	**Metformin group n = 50**	**Finasteride group n = 50**	**Combination group n = 50**	**p**
Age (years)				
Mean ±SD	27.78 ±3.79	27.72 ±4.14	28.38 ±3.48	0.633 O NS
Range	18 -36	18 -39	21 -39	

SD: standard deviation; n: number of cases; O: one way ANOVA; NS: not significant

Table 2: Comparison of mean BMI, HOMA-IR, TyG index, TyG-BM index, and TG/HLD among study groups

Characteristic	Metformin group n = 50	Finasteride group n = 50	Combination group n = 50	P (One way ANOVA)
BMI				
Before	29.14 ±1.96	29.64 ±1.75	29.79 ±1.74	0.291 NS
After	28.44 ±1.88 a	28.31 ±1.76 a	28.78 ±1.72 a	<0.061 NS
P (paired-t-test)	<0.001 ***	<0.001 ***	<0.001 ***	
HOMA-IR				
Before	3.57 ±0.77	3.51 ±0.65	3.53 ±0.68	0.301 NS
After	2.85 ±0.42 b	3.26 ±0.60 a	3.21 ±0.63 a	<0.001 ***
P (paired-t-test)	<0.001 ***	<0.001 ***	<0.001 ***	
TyG index				
Before	5.29 ±0.59	5.20 ±0.50	5.22 ±0.52	0.327 NS
After	4.10 ±0.50 a	4.67 ±0.47 a	4.07 ±0.38 b	0.014 *
P (paired-t-test)	<0.001 ***	<0.001 ***	<0.001 ***	
TyG-BMI				
Before	154.08 ±31.54	156.30 ±22.50	156.72 ±25.82	0.311 NS
After	116.66 ±20.60 a	132.50 ±20.76 a	115.94 ±17.37 b	0.002 **
P (paired-t-test)	<0.001 ***	<0.001 ***	<0.001 ***	<0.001 ***
TG/HDL				
Before	3.16 ±0.54	3.13 ±0.53	3.13 ±0.40	0.401 NS
After	2.55 ±0.47 a	2.72 ±0.42 a	2.20 ±0.43 b	<0.001 ***
P (paired-t-test)	<0.001 ***	<0.001 ***	<0.001 ***	

BMI: body mass index; SD: standard deviation; NS: not significant; ***: significant at p≤ 0.001; data were expressed as mean SD; a, b and c letters were used to show the level of significance after doing LSD multiple comparison test

DISCUSSION

In this study, and after treatment, all three modalities of treatment, metformin, finasteride and combination were able to reduce mean HOMA-IR significantly and the magnitude of reduction caused by metformin alone was the best. These results concerning HOMA-IR is indeed, in line with that of [17] who stated that combination treatment was not superior to monotherapy in improving HOMA-IR and that metformin alone was associated with the best reducing effect [18]. From above data, it appears that the goal of controlling insulin resistance in women with PCOS stays best achieved by using the monotherapy with metformin than using combination of finasteride and metformin. With regard to the mechanistic action of metformin, its primary therapeutic function is to inhibit hepatic glucose construction, increase insulin sensitivity in peripheral tissues, and diminish intestinal glucose absorption [19]. Finasteride mechanism of action on HOMA-IR may be related to its anti-androgenic effect because reduction in androgen can lead to improvement in insulin sensitivity. The effect of combination of both drugs is in need for future experimental studies in order to understand the lack of additive effect.

In this study, all three modalities of treatment, metformin, finasteride and combination were able to reduce mean the (TyG) index and TyG-BMI index significantly and the magnitude of reduction caused by combination was the best. After searching the international network looking for similar article design, i.e., evaluation of effect of metformin and/or finasteride in females with PCOS, the researcher failed to find such article; therefore, a point of originality in the current study is the evaluation of such an effect. Indeed, previously, it has been stated that metformin is efficient alone or in combination with other classes of anti-diabetic agents in reducing the TyG in patients with diabetes mellitus [20]. Thus, the added bit of information in this study is that metformin is effective in women with PCOS in reducing the TyG index, braining insight to a new way of evaluating the efficacy of pharmacological agents in improving insulin sensitivity in this class of patients. Indeed, to the greatest of our information, this stays the first training to show the synergistic effect of adding finasteride to metformin to get better improvement of insulin sensitivity in females through PCOS by the anti-androgenic effect of finasteride and increase AMPK by metformin. However, the exact mechanism by which finasteride improved the TyG-glucose index and TyG-BMI index is unknown and further experimental research work might be needed to explore such mechanism. The combination of both agents might act via some sort of additive effect.

In this study, after treatment, all three modalities of treatment, metformin, finasteride and combination were able to reduce mean TG/HDL significantly and the magnitude of reduction caused by combination was the best. The effect of metformin in improving dyslipidemia in current study is supported by findings of previous authors [21,22]. In numerous investigations, metformin has demonstrated a favorable impact on lipid profiles, enhancing, although inconsistently, various components of dyslipidemia; consequently, the administration of metformin has resulted in elevated ranks of (HDL) cholesterol, cheap concentrations of (LDL) cholesterol, and/or diminished triglyceride levels [23,24].

Metformin has the potential to mitigate the disturbances in lipid metabolism associated through various mechanisms. By enhancing insulin sensitivity, metformin decreases the rate of lipolysis, consequently decelerating the transformation of free fatty acids into lipoprotein precursors in the hepatic system. Additionally, by lowering plasma glucose concentrations, metformin reduces the proportion of irreversibly glycated low- density lipoprotein cholesterol (LDL-C), which is removed from the circulatory system with diminished efficiency. Furthermore, metformin ameliorates dyslipidemia through the induction of weight reduction in individuals exhibiting impaired glucose metabolism. Typically, the weight loss observed following metformin administration is modest and primarily results from a reduction in fat mass rather than an increase in energy expenditure [25].

Regarding finasteride, it has been demonstrated that finasteride diminishes total plasma cholesterol levels and postpones the progression of atherosclerosis in experimental investigations, while individuals utilizing finasteride exhibited reduced plasma concentrations of cholesterol and LDL-cholesterol compared to those not administering the medication [26,27]. Thus, the combination of metformin and finasteride provide synergistic Cooperation probably via different mechanisms in reducing serum level of TG and increases serum HDL, thus improving dyslipidemia in women with PCOS. An important mechanism that should receive attention is that weight reduction in women with PCOS may also contribute to lipid metabolism.

CONCLUSION

The current study found that metformin, finasteride, and their combination led to measurable improvements in insulin resistance markers among women with PCOS. Although metformin was the most effective in reducing HOMA-IR, combination therapy showed superior outcomes in other insulin resistance indices, including the TyG index, TyG-BMI index, and the TG/HDL-C ratio. These results suggest that combining metformin with finasteride may offer enhanced benefits in improving insulin sensitivity compared to either drug alone.

Declaration Statement

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Conflicts of Interest

The authors have no relevant financial or non-financial interests to disclose.

Ethics Approval

The study protocol was reviewed and approved by the Ethical Approval Committee of the College of Medicine, University of Al-Qadisiyah.

All participants were fully informed about the study objectives and procedures, and verbal informed consent was obtained prior to their involvement in the study.

Authors' Contributions

Eman Abdul-Kadhim Abdul-Jabbar developed the research idea, carried out the study, collected and analyzed the data, and wrote the entire manuscript.

Prof. Asmaa Abduljaleel Swadi supervised all stages of the study, provided academic guidance, and critically reviewed the work.

Both authors approved the final version of the manuscript.

REFERENCES

1. Wang, G, Liu, X, Zhu, S, & Lei, J. (2023). Experience of mental health in women with polycystic ovary syndrome: A descriptive phenomenological study. Journal of Psychosomatic Obstetrics & Gynecology, 44, 2218987. doi.org/10.1080/0167482X.2023.2218987
2. Polak K, Czyzyk A, Simoncini T, Meczekalski B. New markers of insulin resistance in Polycystic ovary syndrome. J Endocrinol Invest. 2017;40:1–8. doi:10.1007/s40618-016-0523-8.
3. Diamanti-Kandarakis, E, & Dunaif, A. Insulin resistance and the polycystic ovary syndrome revisited: An update on mechanisms and implications. Endocrine Reviews. 2012; 33(6), 981–1030. doi.org/10.1210/er.2011-1034
4. Amisi CA, Ciccozzi M, Pozzilli P. Wrist circumference: A new marker for insulin resistance in African women with Polycystic ovary syndrome. World J Diabetes. 2020;11(2):42–51. doi:10.4239/wjd.v11.i2.42.
5. Silva CC, et al. The threshold value for identifying insulin resistance (HOMA-IR) in an admixed adolescent population: A hyperglycemic clamp validated study. Arch Endocrinol Metab. 2023;67:119–125. doi:10.20945/2359-3997000000533.
6. Li H, et al. Relationship between six insulin resistance surrogates and nonalcoholic fatty liver disease among older adults: A cross-sectional study. Diabetes Metab Syndr Obes. 2023;16:1685–1696. doi:10.2147/DMSO.S409983.
7. Amisi C, Mputu L, Mboloko E, Bieleli E, Pozzili P. Biological insulin resistance in Congolese woman with Polycystic ovary syndrome (PCOS). Gynecol Obstet Fertil. 2013;41:707–710. doi:10.1016/j.gyobfe.2013.08.002.
8. Wild RA. Dyslipidemia in PCOS. Steroids. 2012;77:295–299. doi:10.1016/j.steroids.2011.12.002.
9. Brehm A, Pfeiler G, Pacini G, Vierhapper H, Roden M. Relationship between serum lipoprotein ratios and insulin resistance in obesity. Clin Chem. 2004;50:2316–2322. doi:10.1373/clinchem.2004.037556.
10. Roa Barrios M, Arata-Bellabarba G, Valeri L, Velázquez-Maldonado E. Relationship between the triglyceride/high-density lipoprotein-cholesterol ratio, insulin resistance index and cardiometabolic risk factors in women with Polycystic ovary syndrome. Endocrinol Nutr. 2009;56:59–65. doi:10.1016/S1575-0922(09)70553-4.

11. Zheng, S., Shi, S., Ren, X., Han, T., Li, Y., Chen, Y., & Zhang, B. (2016). Triglyceride glucose–waist circumference, a novel and effective predictor of diabetes in first-degree relatives of type 2 diabetes patients: Cross-sectional and prospective cohort study. Journal of Translational Medicine, 14, 260. https://doi.org/10.1186/s12967-016-1020-8
12. Simental-Mendía, L. E., Rodríguez-Morán, M., & Guerrero-Romero, F. (2008). The product of fasting glucose and triglycerides as surrogate for identifying insulin resistance in apparently healthy subjects. Metabolic Syndrome and Related Disorders, 6(4), 299–304. https://doi.org/10.1089/met.2008.0034
13. Bennett WL, Aschmann HE, Puhan MA, et al. A benefit-harm analysis of adding basal insulin vs. sulfonylurea to metformin to manage type II diabetes mellitus in people with multiple chronic conditions. J Clin Epidemiol. 2019;113:92–100. doi:10.1016/j.jclinepi.2019.03.014.
14. Melin, J., Forslund, M., Alesi, S., Piltonen, T., Romualdi, D., Spritzer, P. M., Tay, C. T., Peña, A. S., Witchel, S. F., Mousa, A., & Teede, H. (2023). The impact of metformin with or without lifestyle modification versus placebo on polycystic ovary syndrome: A systematic review and meta-analysis of randomized controlled trials. European Journal of Endocrinology, 189(Suppl. 1), S37–S63. https://doi.org/10.1093/ejendo/lvad098
15. Azziz R. The evaluation and management of hirsutism. Obstet Gynecol. 2003;101:995–1007. doi:10.1016/s0029-7844(02)02725-4.
16. Ganie MA, Khurana ML, Nisar S, Shah PA, Shah ZA, Kulshrestha B, et al. Improved efficacy of low-dose spironolactone and metformin combination than either drug alone in the management of women with polycystic ovary syndrome (PCOS): a six-month, open-label randomized study. J Clin Endocrinol Metab. 2013;98:3599–3607. doi:10.1210/jc.2013-1040.
17. Diri H, Bayram F, Simsek Y, Caliskan Z, Kocer D. Comparison of finasteride, metformin, and finasteride plus metformin in PCOS. Acta Endocrinol (Buchar). 2017;13(1):84–89. doi:10.4183/aeb.2017.84.
18. Jeong JW, Jang CW, Yu TY. Is there a link between 5α-reductase inhibitors and hypoglycemia? Chonnam Med J. 2021;57(3):230–231. doi:10.4068/cmj.2021.57.3.230.
19. Attia GM, Almouteri MM, Alnakhli FT. Role of metformin in Polycystic Ovary Syndrome (PCOS)-related infertility. Cureus. 2023;15(8):e44493. doi:10.7759/cureus.44493.
20. Yaribeygi H, Ramezani M, Katsiki N, Mirmohammadkhani M, Tabaei NS. Efficacy of adding sitagliptin to ongoing metformin on metabolic profile, triglyceride-glucose index, vitamin D3, and liver tests in patients with type 2 diabetes mellitus and nonalcoholic fatty liver disease: a double-blind randomized clinical trial. Curr Ther Res Clin Exp. 2024;101:100764. doi:10.1016/j.curtheres.2024.100764.
21. Duleba AJ. Medical management of metabolic dysfunction in PCOS. Steroids. 2012;77(4):306–311. doi:10.1016/j.steroids.2011.11.014.
22. Shamim H, Jean M, Umair M, Muddaloor P, Farinango M, Ansary A, et al. Role of metformin in the management of Polycystic Ovarian Syndrome-associated acne: a systematic review. Cureus. 2022;14(8):e28462. doi:10.7759/cureus.28462.
23. Diamanti-Kandarakis E, Alexandraki K, Protogerou A, Piperi C, Papamichael C, Aessopos A, et al. Metformin administration improves endothelial function in women with polycystic ovary syndrome. Eur J Endocrinol. 2005;152(5):749–756. doi:10.1530/eje.1.01910.
24. Banaszewska B, Pawelczyk L, Spaczynski RZ, Duleba AJ. Effects of simvastatin and metformin on polycystic ovary syndrome after six months of treatment. J Clin Endocrinol Metab. 2011;96(11):3493–3501. doi:10.1210/jc.2011-0501.
25. Lin SH, Cheng PC, Tu ST, Hsu SR, Cheng YC, Liu YH. Effect of metformin monotherapy on serum lipid profile in statin-naïve individuals with newly diagnosed type 2 diabetes mellitus: a cohort study. PeerJ. 2018;6:e4578. doi:10.7717/peerj.4578.
26. McQueen J, Pinos I, Amengual J. Finasteride reduces total cholesterol in LDLR-deficient mice. Curr Dev Nutr. 2021;5(Suppl 2):35. doi:10.1093/cdn/nzab033_035.
27. McQueen P, Molina D, Pinos I, Krug S, Taylor AJ, LaFrano MR, et al. Finasteride delays atherosclerosis progression in mice and is associated with a reduction in plasma cholesterol in men. J Lipid Res. 2024;65(3):100507. doi:10.1016/j.jlr.2024.100507.