

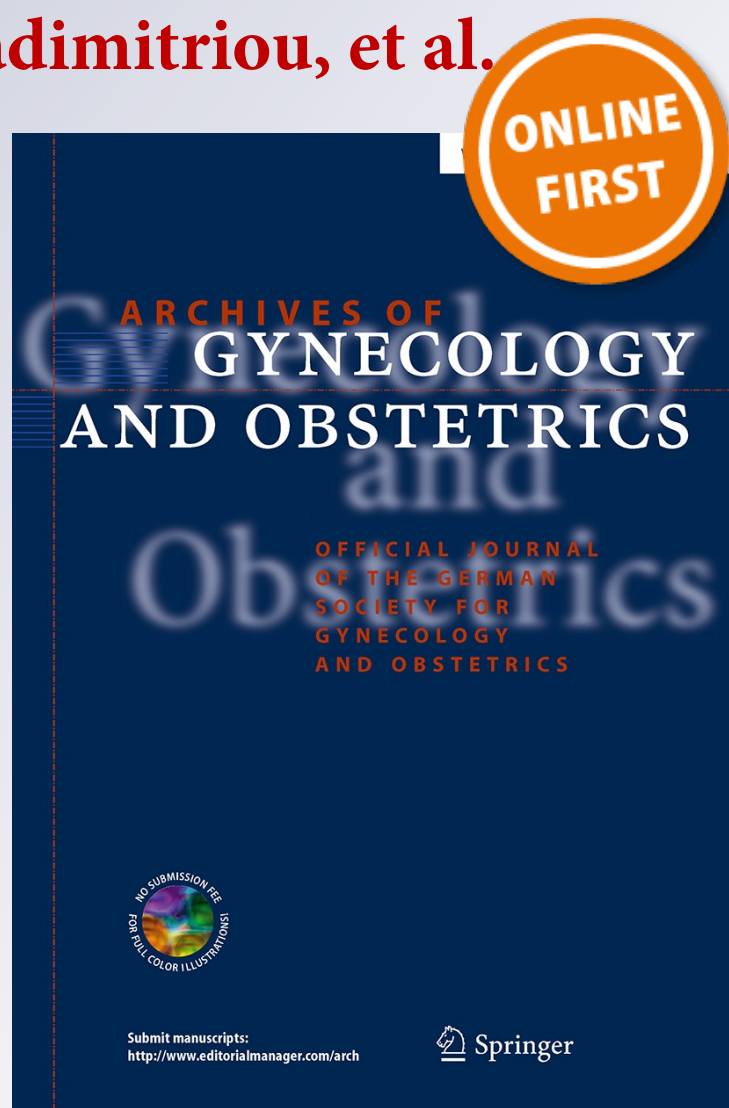
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Archives of Gynecology and Obstetrics

ISSN 0932-0067

Arch Gynecol Obstet
DOI 10.1007/s00404-015-3964-y



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Metabolic syndrome in Greek women with polycystic ovary syndrome: prevalence, characteristics and associations with body mass index. A prospective controlled study

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Received: 27 May 2015 / Accepted: 9 November 2015
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Abstract

Purpose The aim of this study was to estimate the prevalence, to evaluate the characteristics of the metabolic syndrome (MetS) in Greek women with polycystic ovary syndrome (PCOS) and to investigate the correlation of MetS with body mass index (BMI).

Methods In a prospective controlled study, 230 Greek female patients with PCOS and 155 age-matched healthy controls were enrolled. Diagnosis of PCOS was based on the revised criteria of Rotterdam. Both groups were examined for MetS. Diagnosis of MetS was based on the revised criteria of International Diabetes Federation (IDF). **Results** The prevalence of the MetS was 12.6 %, nearly sevenfold higher than the controls. Elevated fasting plasma glucose (7.0 vs. 1.9 %) and elevated triglycerides (10.4 vs. 3.2 %) were more frequent in the PCOS cohort ($p < 0.05$). Women with PCOS presented statistically higher BMI in comparison with the controls ($p < 0.001$). Subsequently, the prevalence of MetS was estimated in three groups: normal, overweight and obese subdivided according to BMI. The latter two groups showed significant differences compared with the healthy controls (24.5 vs. 8.8 %, $p = 0.050$).

Conclusion In conclusion, this study showed high prevalence of MetS and increased BMI in Greek PCOS women. In addition, it demonstrated the higher prevalence of MetS in obese PCOS women in comparison with the controls. These results are placing them at increased risk

for cardiovascular disease and diabetes in the future and underline the necessity of periodic screening, appropriate diet and exercise program.

Keywords Polycystic ovary syndrome · Prevalence · Characteristics · Metabolic syndrome · International diabetes foundation

Introduction

Polycystic ovary syndrome (PCOS) is a common endocrinopathy affecting 4–8 % of women in the reproductive age group [1, 2]. Different diagnostic criteria of PCOS have been proposed by several groups [3, 4]. Clinical or biochemical hyperandrogenism, ovarian dysfunction in the form of oligo-ovulation or anovulation and polycystic ovaries on ultrasound are the parameters used for defining PCOS after excluding other androgen excess disorders. Two out of three of these parameters define PCOS by Rotterdam criteria [4].

Although the cardinal features of PCOS are ovarian dysfunction and hyperandrogenism, it is not merely a reproductive disorder, but rather a metabolic disorder. There is a high prevalence of insulin resistance (IR) and compensatory hyperinsulinemia in women with PCOS [5]. The long-term health consequences of the syndrome indicate that women with PCOS are at increased risk for developing glucose intolerance or type 2 diabetes mellitus (T2DM) [5–7], hypertension, dyslipidemia [high serum total cholesterol, high serum low-density lipoprotein cholesterol (LDL-C), decreased serum high-density lipoprotein cholesterol (HDL-C) or high serum triglycerides], and atherosclerosis [8–10] and, therefore, at risk of having metabolic syndrome (MetS) as well. IR and

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hyperinsulinemia appear to play an important role in pathogenesis of PCOS. IR and ovarian hyperandrogenism aggravate each other, forming a vicious cycle, but the primary initiating factor remains controversial. Several mechanisms have been proposed for the role of insulin in exacerbating hyperandrogenism [11, 12].

There are multiple definitions of MetS [13–15]. The MetS is associated with high risk for developing T2DM [16] and cardiovascular disease [17], also with cardiovascular mortality [18]. T2DM and cardiovascular risk factors defining the MetS are prevalent in PCOS [7, 8, 19]. The International Diabetes Federation (IDF) has proposed a new definition addressing both clinical and research needs, providing an accessible diagnostic tool suitable for worldwide use [14].

The prevalence of the MetS is high in women with PCOS. In addition, the prevalence shows a marked variation between countries and ethnic groups, probably due to differences in diet, lifestyle and genetic factors [19–23]. It must be noted that the prevalence of MetS in PCOS is affected by the criteria used to diagnose both MetS and PCOS [20, 24, 25].

The IDF criteria of MetS are new and there are scant studies utilizing this definition in Greek literature. Moreover, the reported studies in Greek have presented statistically significant difference in age between PCOS women and controls. The current study aimed to estimate prospectively the prevalence and characteristics of MetS by IDF criteria in Greek PCOS women, in comparison with age-matched healthy control group and to check whether MetS is associated with body mass index (BMI) in these women.

Materials and methods

Subjects

The studied groups consisted of 385 Greek Caucasian women; 230 PCOS (age 24.7 ± 5.7 years BMI $26.0 \pm 7.1 > 30 \text{ kg/m}^2$) women and 155 (age 24.1 ± 6.1 years BMI $23.0 \pm 4.3 > 30 \text{ kg/m}^2$) age-matched healthy females as controls, who were born in Greece by Greek parents and were living in the prefecture of Attica in Greece, regardless of socio-economic and education background, with different regions of origin, and aged 14–44 years old. All women with PCOS were outpatients at the Reproductive Endocrinology Outpatient Clinic, of the 3rd Department of Obstetrics and Gynecology of the University General Hospital 'Attikon', during the last 5 years. Diagnosis of PCOS was based on the revised criteria of Rotterdam, which require the presence of at least two of the following three features: (1) oligo- or anovulation (< 8 spontaneous haemorrhagic episodes/yr), (2) biochemical

hyperandrogenemia or manifestations of hyperandrogenemia, (3) polycystic ovaries on ultrasound (≥ 12 follicles with a diameter of 2–9 mm were identified, or when increased ovarian volume was evident $> 10 \text{ cm}^3$) [4]. None of the studied women had galactorrhoea or any endocrine or systemic disease that could possibly affect reproductive physiology. None of the women reported the use of medications that could interfere with the normal function of the hypothalamic–pituitary–gonadal axis during the last semester. The control group consisted of 155 healthy volunteer females (students, medical and paramedical students, nurses and doctors), who had normal ovulatory cycles (26–35 days) and no sign of hyperandrogenism. Both groups were examined for MetS. Diagnosis of MetS was based on the criteria of IDF; for the subjects 16+ years, we used the criteria of IDF for adults [14], and for the subjects 10 to < 16 years, we used the criteria of IDF for the children/adolescents [26]. The criteria of IDF for the adults require the presence of central obesity $\geq 80 \text{ cm}$, plus any two of the four factors; fasting serum glucose $\geq 100 \text{ mg/dL}$, fasting serum triglycerides $\geq 150 \text{ mg/dL}$, serum HDL-C $< 40 \text{ mg/dL}$, and blood pressure $\geq 130/85 \text{ mmHg}$. If BMI is $> 30 \text{ kg/m}^2$, central obesity can be assumed and waist circumference (WC) does not need to be measured.

From 43 children/adolescents subjects, of this data, 12 girls were 10 to < 16 age. The IDF criteria for these girls were the same as for adults, except abdominal obesity (WC) ≤ 90 th percentile, and the serum levels of HDL-C $< 40 \text{ mg/dL}$.

BMI (kg/m^2) was calculated by dividing weight (in kg) by height squared (in meters) to assess obesity. Overweight was defined as BMI $> 25 \text{ kg/m}^2$ and obese $> 30 \text{ kg/m}^2$. In addition, for BMI of children/adolescent's, Cole's curves [27] were used. Estimated values for overweight and obese girls change depending on age.

The protocol complies with Greek and European Union Legislation and has received ethics approval by the Hospital Ethics Board. Informed consent was obtained from all participants.

Study design

Personal and family history

All subjects completed a detailed questionnaire regarding their menstrual cycle characteristics (age of first menstrual cycle, frequency of menstruation, qualitative and quantitative characteristics of menses). Chronic anovulation was defined as less than eight (8) cycles per year. Lifestyle variables were evaluated and emphasis was given on smoking, alcohol consumption, extensive exercise and use of hormonal treatment. Women were asked about family

history of diabetes mellitus, hypertension or cardiovascular disease. The presence of first degree relatives with irregular menses was also recorded. Positive pregnancy test, personal history of acute or chronic disease and treatment with compounds affecting sex hormones (oral contraceptives) or other medications within the previous 6 months served as exclusion criteria.

Clinical examination

In both groups, regardless of BMI, measurements such as weight, height, BMI, WC (in centimeters) and blood pressure (mm/Hg) were measured by a single examiner. WC was taken midway between the lowest rib margin and iliac crest. Circumferences were measured to within 1 mm using soft measuring tape in the standing position. Systolic and diastolic blood pressure was measured with an automatic sphygmomanometer, in sitting position and the mean of the three measurements was recorded. Excess terminal hair growth was assessed through a whole body overview using the Ferriman and Gallwey scale (F–G). Patients scoring 8 or greater were considered hirsute [28]. Each woman was examined by two examiners with experience in reproductive disorders. Presence of signs of acne vulgaris, androgenetic alopecia, and acanthosis nigricans, a cutaneous sign of hyperinsulinaemia, were also recorded, although no specific scoring system was applied.

Ultrasound scans

Both of study groups underwent an abdominal ultrasonography or transvaginal pelvic ultrasound based on the marital status to assess the ovarian size and morphology. Three-dimensional ovarian morphology and size was examined on the 6th–8th menstrual cycle day by two different operators in the same day [29]. The following mathematic model was used to estimate ovarian volume: $V = \frac{\pi}{6} \times D^{\text{length}} \times D^{\text{width}} \times D^{\text{thickness}}$, where D stands for ovarian diameter. Sonographic diagnosis of PCO was set either when ≥ 12 follicles with a diameter of 2–9 mm were identified, or when increased ovarian volume was evident ($>10 \text{ cm}^3$).

Biochemical measurements

From all subjects, venous blood samples were obtained after an overnight fast for the realization of the examinations; fasting serum glucose, fasting serum triglycerides and serum HDL-C. From the PCOS women, venous blood samples were obtained on the 3rd–6th day after the onset of a spontaneous or progesterone-induced menstruation, early in the morning, after an overnight fast. Complete blood

counts and routine coagulation tests [prothrombin time (PT)/international normalized ratio (INR) and activated partial thromboplastin time (APTT)] were immediately calculated to identify women suffering from an undiagnosed acute or chronic disease.

Rests of the blood samples were centrifuged; serum was collected and stored at -70°C until assayed. Thyroid tests (FT3/FT4/TSH), prolactin (PRL) and cortisol were quantified, as part of the differential diagnosis workup, to rule out abnormal thyroid function, hyperprolactinaemia and Cushing syndrome, respectively. 17- α -OH-progesterone (17-OHP) was also measured; for women with plasma levels greater than 1.5 ng/mL, a Synacthen test using tetracosactide was performed (Novartis Pharma S.A.). Following this approach, women with congenital adrenal hyperplasia were identified and excluded from the study.

Additional examinations

Measurements of follicle-stimulating hormone (FSH), luteinizing hormone (LH) and estradiol (E2), total testosterone, free testosterone (F-T), $\Delta 4$ -androstenedione ($\Delta 4$ -A) and dehydroepiandrosterone-sulfate (DHEA-S), sex-hormone-binding globulin (SHBG).

Serum progesterone (Pg) levels were determined on day 21–24 of the menstrual cycle. Hyperandrogenaemia was defined as serum total testosterone or $\Delta 4$ -A level greater than 2.2 and 10.5 nmol/L, respectively.

Assays

Hormone measurements were performed by the ADVIA Centaur system for FSH, LH. Measurements of T3, T4, TSH and PRL were performed by the ADVIA Centaur system with coefficients of variance (CV) of 3.44, 5.55, 5.87 and 4.8 %, respectively. Total testosterone, DHEA-S and cortisol measurements were performed with the analysis of Elecsyl 1010/2020 and Modstar analytics E 170 by Roche with CV of 5.6, 6 and 7 %, respectively. $\Delta 4$ -A, 17-OHP and F-T measurements were performed with RIA kits (Diagnostic Setters International Inc, Corporate Headquarters and Medical Center Blvd, Webster Texas 77598, 4217 USA), with CV of 6.3, 9.7 and 9.7 %, respectively. Glucose, HDL-C, and triglycerides measurements were performed by the electrochemiluminescence method on Cobas[®] 8000 modular analyzer with CV 1.3, 1.5, 2 %, respectively.

Statistical analysis

Continuous variables are presented with mean and standard deviation (SD). Qualitative variables are presented with absolute and relative frequencies. For the comparison of

proportions, Chi-square and Fisher's exact tests were used. Student's *t* tests were computed for the comparison of mean values between the two study groups. All *p* values reported are two tailed. Statistical significance was set at 0.05 and analyses were conducted using SPSS statistical software (version 19.0).

Results

The studied groups consisted of 230 subjects with PCOS and 155 controls. The mean age was 24.7 years (SD = 5.7 years) for the PCOS group and 24.1 years (SD = 6.1 years) for the controls ($p = 0.325$). Presence of BMI and MetS components for the two study groups is presented in Table 1. The most frequent MetS component in both study groups was central obesity, followed by low HDL-C and elevated blood pressure. Elevated triglycerides and glucose levels were the less frequent components. Central obesity according to WC measures was found in 68.4 % of the controls and 72.2 % of the subjects with PCOS ($p = 0.424$). Elevated fasting plasma glucose (7.0 vs. 1.9 %) and elevated triglycerides (10.4 vs. 3.2 %) were more frequent in the PCOS group as compared with the controls ($p < 0.05$). Low HDL-C levels (26.1 vs. 20.0 %) and increased blood pressure (15.7 vs. 11.0 %) were not significantly different between the two groups. In addition, the measurements of BMI in both study groups showed that the proportion of overweight and obese was significantly higher in PCOS women to the respective controls (42.6 vs. 21.9 % $p < 0.001$) in Table 1.

The proportion of participants with MetS was 12.6 % in the PCOS group, significantly higher as compared with the correspondence proportion (1.9 %) in the control group ($p < 0.001$)—Fig. 1.

When the mean values of BMI, WC, glucose, triglycerides, HDL-C, systolic blood pressure (SBP) and diastolic blood pressure (DBP) (Table 2) were compared, were found significantly higher levels of BMI, triglycerides, SBP and DBP were found in the PCOS group in comparison with controls. The mean WC tended to be higher in the PCOS group ($p = 0.054$). The number of MetS components in the two study groups is presented in Table 3. Including central obesity, the percentage of those with presence of one or three components was higher in the PCOS group. Table 4 shows the presence of MetS components in PCOS subjects without MetS and controls. The presence of MetS components as defined from IDF criteria was not different between the two groups, but the mean DBP levels were higher in PCOS subjects without MetS in comparison with controls ($p = 0.001$). In addition, the levels of triglycerides tended to be higher in the PCOS subjects without MetS ($p = 0.073$). Table 5 shows the

Table 1 Characteristics and presence of metabolic syndrome components in the two study groups

	Group		<i>p</i> ^a
	Control (<i>N</i> = 155) <i>N</i> (%)	PCOS (<i>N</i> = 230) <i>N</i> (%)	
Age (years)	24.1 (6.1)	24.7 (5.7)	0.325
BMI			
Normal	121 (78.1)	132 (57.4)	<0.001
Overweight	21 (13.5)	36 (15.7)	
Obese	13 (8.4)	62 (27.0)	
Overweight/obese	34 (21.9)	98 (42.6)	
MetS components			
Waist circumference (cm)			
<80	49 (31.6)	64 (27.8)	0.424
≥80	106 (68.4)	166 (72.2)	
Glucose (mg/dL)			
<100	152 (98.1)	214 (93.0)	0.026
≥100	3 (1.9)	16 (7.0)	
Triglycerides (mg/dL)			
<150	150 (96.8)	206 (89.6)	0.009
≥150	5 (3.2)	24 (10.4)	
HDL-C (mg/dL)			
≥50	124 (80.0)	170 (73.9)	0.168
<50 ^b	31 (20.0)	60 (26.1)	
SBP (mmHg)			
<130	144 (92.9)	201 (87.4)	0.082
≥130	11 (7.1)	29 (12.6)	
DBP (mmHg)			
<85	147 (94.8)	211 (91.7)	0.243
≥85	8 (5.2)	19 (8.3)	
SBP/DBP			
Normal	138 (89.0)	194 (84.3)	0.191
≥130/85 mmHg	17 (11.0)	36 (15.7)	
MetS: presence/absence			
No	152 (98.1)	201 (87.4)	<0.001
Yes	3 (1.9)	29 (12.6)	

PCOS polycystic ovary syndrome, BMI body mass index, MetS metabolic syndrome, HDL-C high-density lipoprotein cholesterol, SBP systolic blood pressure, DBP diastolic blood pressure

^a Chi-square test

^b < 40 for adolescents

proportion of normal weight status in subjects with MetS tended to be significantly greater in the PCOS group in comparison with controls (3.8 vs. 0 %, $p = 0.061$), while in overweight subjects showed no statistical difference. The proportion of the obese group with MetS was significantly higher in the PCOS group in comparison with controls (32.3 vs. 0.0 %, $p = 0.015$). The WC did not differ significantly between women with PCOS and

Fig. 1 Presence of MetS and its components in PCOS group and controls

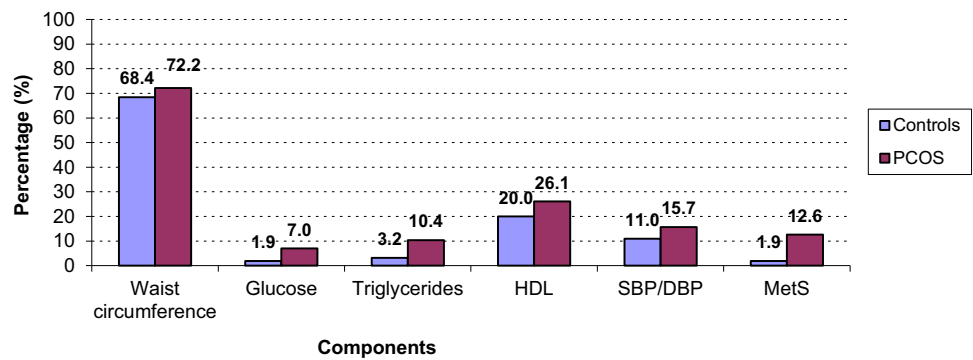


Table 2 Mean values of BMI, waist circumference, glucose, triglycerides, HDL-C, SBP and DBP in PCOS and control group

	Group		<i>p</i> ^a
	Control mean (SD)	PCOS mean (SD)	
BMI	23.0 (4.3)	26.0 (7.1)	<0.001
Waist circumference (cm)	88.7 (13.3)	91.6 (15.5)	0.054
Glucose (mg/dL)	81.8 (9.4)	81.9 (12.5)	0.916
Triglycerides (mg/dL)	73.8 (32.5)	94.2 (63.2)	<0.001
HDL-C (mg/dL)	61.7 (17.8)	61.3 (26.6)	0.889
SBP (mmHg)	109.8 (11.1)	112.8 (12.4)	0.016
DBP (mmHg)	67.3 (8.9)	71.4 (8.8)	<0.001

BMI body mass index, *HDL-C* high-density lipoprotein cholesterol, *SBP* systolic blood pressure, *DBP* diastolic blood pressure, *SD* standard deviation

^a Student's *t* test

Table 3 Number of metabolic syndrome components in the two study groups

No of components	Group		<i>p</i>
	Control <i>N</i> (%)	PCOS <i>N</i> (%)	
0	36 (23.2)	50 (21.7)	0.731 ^a
1	80 (51.6)	94 (40.9)	0.038 ^a
2	36 (23.2)	57 (24.8)	0.726 ^a
3	2 (1.3)	24 (10.4)	<0.001 ^a
4	1 (0.6)	3 (1.3)	0.651 ^b
5	0 (0)	2 (0.9)	0.518 ^b

PCOS polycystic ovary syndrome

^a Chi-square test

^b Fisher's exact test

controls, while the levels of glucose were higher in obese and overweight subjects with PCOS (data not shown).

Discussion

The prevalence of the MetS differs from country to country depending on the habits of diet, lifestyle, and many other factors that increase the risk of incidence of

the syndrome. Many studies from all over the world have reported upon the prevalence of the MetS on the general population and on women with PCOS [19–23, 30–32]. This study showed the prevalence of MetS as defined by the IDF in Greek women diagnosed with PCOS according to the Rotterdam criteria. The results of present data indicate that Greek women with PCOS have a 6.6-fold increased risk of MetS compared with Greek healthy women participating in this study. It was found that an overall 12.6 % prevalence of clustered metabolic abnormalities was consistent with MetS. In comparison with other studies with similar diagnosed PCOS women, the prevalence of metabolic abnormalities in this study group is almost 3 times lower than the 33.8 % prevalence in German [33], and four times lower than the 46.2 % in India [34] and 40 % in Australia [25]. The diagnosis of MetS in these studies was based on the IDF criteria as well. A corresponding Greek study based on the National Cholesterol Education Program Adult Treatment Panel (NCEP APT III) and the IDF criteria found 15.8 and 28.9 %, respectively [24], while a Greek multicentre study estimating the prevalence of the female general population found 10.1 % in the respective age-matched groups [31]. The prevalence in USA has been reported at 43 and 47.3 % in adult females with PCOS (by NCEP APT III

Table 4 Comparison of the presence of metabolic syndrome components between polycystic ovary syndrome subjects without metabolic syndrome and controls

	Group		<i>p</i>
	Control	PCOS without MetS	
Waist circumference (cm)			
≤80	49 (31.6)	64 (31.8)	0.963 ^a
>80	106 (68.4)	137 (68.2)	
Waist circumference (cm), mean (SD)	88.7 (13.3)	88.6 (12.8)	0.954 ^c
Glucose (mg/dL)			
<100	152 (98.1)	190 (94.5)	0.089 ^a
≥100	3 (1.9)	11 (5.5)	
Glucose (mg/dL), mean (SD)	81.8 (9.4)	81.4 (12.3)	0.751 ^c
Triglycerides (mg/dL)			
<150	150 (96.8)	195 (97.0)	1.000 ^b
≥150	5 (3.2)	6 (3.0)	
Triglycerides (mg/dL), mean (SD)	73.8 (32.5)	80.7 (38.6)	0.073 ^c
HDL-C (mg/dL)			
≥50	124 (80.0)	167 (83.1)	0.455 ^a
<50 ^d	31 (20.0)	34 (16.9)	
HDL-C (mg/dL), mean (SD)	61.7 (17.8)	63.8 (26.8)	0.393 ^c
SBP (mmHg)			
<130	144 (92.9)	187 (93.0)	0.962 ^a
≥130	11 (7.1)	14 (7.0)	
SBP (mmHg), mean (SD)	109.8 (11.1)	111.2 (10.8)	0.224 ^c
DBP (mmHg)			
<85	147 (94.8)	189 (94.0)	0.742 ^a
≥85	8 (5.2)	12 (6.0)	
DBP (mmHg), mean (SD)	67.3 (8.9)	70.4 (8.0)	0.001 ^c
SBP/DBP			
Normal	138 (89.0)	181 (90.0)	0.755 ^a
≥130/85 mmHg	17 (11.0)	20 (10.0)	

PCOS polycystic ovary syndrome, MetS metabolic syndrome, HDL-C high-density lipoprotein cholesterol, SBP systolic blood pressure, DBP diastolic blood pressure, SD standard deviation

^a Chi-square test

^b Fisher's exact test

^c Student's *t* test

^d < 40 for adolescents

criteria) [20, 23], and the prevalence in Sao Paulo has been reported at 38.4 % in women with PCOS (by NCEP APT III criteria) [35]. A few studies have demonstrated a higher prevalence of MetS in women with PCOS when NCEP APT III, IDF and American Heart Association and the National Heart, Lung, and Blood Institute (AHA/NHLBI) definitions were applied [19, 20, 22]. In addition, others studies reported that women with PCOS have greater BMI than controls [19–21, 35]. In our data, the results show that the BMI of Greek women with PCOS is significantly higher than this of the control group ($p < 0.001$), as another Greek study [24] has reported. On the other hand, the Greek study [24], has shown that the prevalence of MetS does not differ between BMI-matched

women with PCOS and controls, a finding not confirmed by present data. In the previously reported study [24], the PCOS women were younger than controls, and the ratio of PCOS women to controls was 1:4. In this study, as well as in an Italian study [20], the proportion of obese subjects with MetS was significantly greater in the PCOS group in comparison with controls ($p = 0.015$), while the proportion of normal weight status subjects with MetS tended to be significantly greater in the PCOS group in comparison with controls ($p = 0.061$). In addition, the study from South America reported that if the original criteria were considered, the prevalence of MetS would be 28.8 %, with a null prevalence for a BMI <24.9 kg/m² and increasing progressively according to the BMI [35].

Table 5 Presence of metabolic syndrome in subgroups by body mass index in polycystic ovary syndrome group and controls

		Group				
		Control (<i>N</i> = 155)		PCOS (<i>N</i> = 230)		<i>p</i>
		<i>N</i>	%	<i>N</i>	%	
BMI = normal						
Metabolic syndrome						
No	121	100.0	127	96.2	0.061 ^a	
Yes	0	0.0	5	3.8		
BMI = overweight						
Metabolic syndrome						
No	18	85.7	32	88.9	0.701 ^a	
Yes	3	14.3	4	11.1		
BMI = obese						
Metabolic syndrome						
No	13	100.0	42	67.7	0.015 ^a	
Yes	0	0.0	20	32.3		

PCOS polycystic ovary syndrome, BMI, body mass index

^a Fisher's exact test

In accordance of the IDF criteria, the most frequent MetS components in both study groups were the increased WC, followed by low HDL-C and elevated blood pressure. BMI was one more feature of PCOS women most frequently found. The same results have also been reported by others studies; in Australia the most common individual component of the MetS in the PCOS group was an elevated WC, followed by reduced HDL-C [25]; in India the abnormalities of metabolic factors were the lipid abnormalities, the fast plasma glucose abnormality and elevated blood pressure [34]. These findings agree in part with studies from the USA (by NCEP APT III criteria) which reported low HDL-C occurred most frequently when followed by high blood pressure, but did not mention the increase of WC [21, 23], while, the most common component of the MetS in PCOS women, in South America's study (by NCEP APT III criteria) was the low HDL-C levels followed by the elevated WC [35]. Despite the fact that the most frequent components in present data were the elevated WC, the low HDL-C levels and the elevated blood pressure, only the BMI, the glucose and the triglycerides levels show statistical significance between the study groups. Furthermore, when the means values from Mets abnormalities were evaluated, significantly higher levels of BMI, triglycerides, SBP and DBP were found in the PCOS group in comparison with those found in controls. These PCOS women probably are candidates for long-terms cardiovascular risk and needs follow-up. The mean WC tended to be higher in the PCOS group. All

previous findings, about the frequent and the mean values of the components show that the majority of the women with PCOS and control group presented at least one abnormality. Other than elevated BMI, 24.8 % of the women with PCOS had two abnormalities. Among study groups, the presence of three components was statistically significant ($p > 0.001$). However, an unexpected finding in a young healthy control was the higher proportions of the presence of one component, in comparison with PCOS women ($p = 0.038$).

Above study have reported that 69 % of the women with PCOS had two or more of the abnormalities present [21], and one more study have reported that any three of these features were found in nine cases (52.9 %) of adolescents and at least two features were in 18 cases (48.6 %) of adults [34]. In addition the prevalence of one or no factors was observed in 43.9 % of the women and the prevalence of three or more factors was seen in 38.4 % of them [35].

Finally, in the present study found that between the Greek PCOS women without MetS and the healthy age-matched control group, only the mean DBP levels were statistically significant ($p = 0.001$). In addition, the levels of triglycerides tended to be higher in the PCOS subjects without MetS ($p = 0.073$). In contrast, the studies from North and South America have reported significant differences to the lipid profile and blood pressure between the PCOS women with MetS and without MetS [20, 34], placing the PCOS cohort at increased risk for cardiovascular disease.

The limitation of this study was the relatively small number of women in both study groups, although the ratio of PCOS women and age-matched healthy controls was about 1:1. In Greek PCOS population there is a bigger study group, but the controls group was not age matched with PCOS and the ratio of PCOS women to controls was 1:4.

In conclusion, in the present prospective controlled study, it was found that: (a) the prevalence of the Mets was nearly sevenfold higher in Greek PCOS women compared with the control group, (b) the increased BMI was much more common in Greek PCOS women than in the age-matched healthy controls, and (c) the prevalence of MetS in obese PCOS women was significantly higher in comparison with the controls, findings which was reported for the first time in the literature. It is important to emphasize that the high prevalence of MetS in women with PCOS, places them an increased risk of long-term cardiovascular disease and T2DM. The results of this study call attention to the need for comprehensive screening and education of women with PCOS regarding appropriate diet and exercise program.

Acknowledgments We thank Ms Ifigenia Giannelou for the English review and Ms Chara Tzavara for the statistical analysis of the study.

Compliance with ethical standards

Conflict of interest No company or institute supported the present study financially or otherwise and none of the authors have any potential conflicts of interest associated with this study. They also declare that they have had full control of all primary data and that they agree to allow the Journal to review their data if requested.

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