
GYNAECOLOGY

Prevalence of Metabolic Syndrome in Thai Women with Polycystic Ovary Syndrome

Bralee Sangkate, M.D.*,
Nuntasiri Eamudomkarn, M.D.*,
Nampet Jampathong, M.P.H.*

* Department of Obstetrics and Gynecology, Faculty of Medicine, Khon Kaen University, Thailand

ABSTRACT

Objectives: To assess the prevalence and associated risk of metabolic syndrome (MS) among Thai women with polycystic ovary syndrome (PCOS).

Materials and Methods: A retrospective study was conducted in 337 women visiting Khon Kaen University Hospital between January 2014 and December 2021. The data on weight, height, waist circumference (WC), waist to hip ratio (WHR), and laboratory results were reviewed. The diagnosis of MS was made by International Diabetes Federation (IDF) and National Cholesterol Education Program Adult Treatment Panel III (NCEP ATP III) criteria. Multiple logistic regression was applied to calculate adjusted odds ratio (aORs) and 95% confidence intervals (CIs)

Results: Three hundred and thirty-seven patients were reviewed. Median (interquartile range) of age, body mass index (BMI), WC, and WHR were 24 (21–29) years, 25 (21-31) kg/m², 80 (70-90) cm, and 0.85 (0.79-0.89), respectively. The prevalence of MS was 27.3% and 20.8% according to the criteria of IDF and NCEP ATP III, respectively. Age 30 years or older (aOR 1.89, 95%CI 1.06-3.40), positive family history of MS and/or diabetes mellitus (aOR 2.77, 95% CI 1.66-4.65), and having exercise behavior (aOR 0.45, 95% CI 0.23-0.86) were found to be independently associated with MS in PCOS women.

Conclusion: MS was highly prevalent among PCOS women residing in the Northeast Thailand. Factors associated with MS odds included age, family history of MS and/or diabetic mellitus, and exercise behavior.

Keywords: metabolic syndrome, abnormal glucose metabolism, obesity, PCOS.

Correspondence to: Nuntasiri Eamudomkarn, M.D., Department of Obstetrics and Gynecology, Faculty of Medicine, Khon Kaen University, Khon Kaen, Thailand. E-mail: pla_raq@hotmail.com

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ความชุกของกลุ่มอาการเมตาบอลิกในสตรีไทยที่ได้รับการวินิจฉัยกลุ่มอาการถุงน้ำ ในรังไข่หลายใบ

บราลี สังเกต, นันทสิริ เอี่ยมอุดมกาล, น้ำเพชร จำปาทอง

บทคัดย่อ

วัตถุประสงค์: เพื่อศึกษาความชุกและปัจจัยที่เกี่ยวข้องของกลุ่มอาการเมตาบอลิก ในสตรีที่ได้รับการวินิจฉัยกลุ่มอาการถุงน้ำในรังไข่หลายใบ (Polycystic Ovary Syndrome; PCOS)

วัสดุและวิธีการ: การศึกษานี้เป็นการศึกษาย้อนหลัง (Retrospective study) โดยเก็บรวบรวมข้อมูลในสตรี 337 รายที่ได้รับการวินิจฉัย PCOS ซึ่งมารับบริการที่โรงพยาบาลศรีนครินทร์ในช่วง พ.ศ. 2557-2564 ข้อมูลทั่วไปได้แก่ น้ำหนัก, ส่วนสูง, ดัชนีมวลกาย, เส้นรอบเอว, เส้นรอบเอวต่อสะโพก, และความดันโลหิต ข้อมูลทางห้องปฏิบัติการได้แก่ การเผาผลาญน้ำตาลกลูโคส (glucose metabolism) ประเมินโดยการตรวจ 75-g Oral Glucose Tolerance Test (OGTT) และระดับไขมันในเลือดเมื่อมารักษาครั้งแรก กลุ่มอาการเมตาบอลิกวินิจฉัยโดยใช้เกณฑ์ของ International Diabetes Federation (IDF) และ National Cholesterol Education Program Adult Treatment Panel III (NCEP ATP III) ปัจจัยที่เกี่ยวข้องของกลุ่มอาการเมตาบอลิกวิเคราะห์โดยวิธี logistic regression

ผลการศึกษา: ในสตรีที่ได้รับการวินิจฉัย PCOS จำนวน 337 ราย มีค่า median (interquartile range) ของอายุ, ดัชนีมวลกาย, เส้นรอบเอว และเส้นรอบเอวต่อสะโพก เท่ากับ 24 (21-29) ปี, 25 (21-31) กิโลกรัม/ม², 80 (70-90) ซม. และ 0.85 (0.79-0.89) ตามลำดับ พบความชุกของกลุ่มอาการเมตาบอลิก ร้อยละ 27.3 และ 20.8 เมื่อใช้เกณฑ์วินิจฉัยของ IDF และ NCEP ATP III ตามลำดับ ปัจจัยเสี่ยงของการเกิดกลุ่มอาการเมตาบอลิก ได้แก่ อายุมากกว่า 30 ปี (aOR 1.89,95%CI 1.06-3.40), มีประวัติคนในครอบครัวเป็นโรคเบาหวานหรือกลุ่มอาการเมตาบอลิก (aOR 2.77,95%CI 1.66-4.65) และพฤติกรรมออกกำลังกาย (aOR 0.45,95%CI 0.23-0.86)

สรุป: ความชุกของกลุ่มอาการเมตาบอลิกพบได้สูงในสตรีที่ได้รับการวินิจฉัย PCOS ในภาคตะวันออกเฉียงเหนือของไทย โดยพบความชุกร้อยละ 27.3 และ 20.8 เมื่อใช้เกณฑ์วินิจฉัยของ IDF และ NCEP ATP III ตามลำดับ ปัจจัยเสี่ยงของการเกิดกลุ่มอาการเมตาบอลิกได้แก่ อายุ, ประวัติคนในครอบครัวเป็นโรคเบาหวานหรือกลุ่มอาการเมตาบอลิก และพฤติกรรมการออกกำลังกาย

คำสำคัญ: กลุ่มอาการเมตาบอลิก, ภาวะการเผาผลาญน้ำตาลผิดปกติ, ภาวะอ้วน, กลุ่มอาการถุงน้ำในรังไข่หลายใบ

Introduction

Polycystic Ovary Syndrome (PCOS) is the most prevalent endocrinopathy affecting 8 to 13% of women of reproductive age⁽¹⁾. This complex disorder is characterized by hyperandrogenism, ovulatory dysfunction and polycystic ovarian morphology⁽²⁾. In addition to reproductive disturbance, women with PCOS are at an elevated risk of various metabolic disturbances, including diabetes mellitus, dyslipidemia, and cardiovascular disease^(3, 4).

The etiology of PCOS remains uncertain, but existing evidence indicates that its pathophysiology is complex and multifactorial, involving endocrine, metabolic, genetic, epigenetic, and environmental factors⁽⁵⁾. Insulin resistance and central obesity are commonly observed features and believed to play a central role in the development of the syndrome^(6, 7). These factors increase the risk of metabolic syndrome (MS) in women with PCOS. MS is a cluster of endocrinopathy and metabolic disturbances including central obesity, abnormal lipid profiles, insulin resistance, and hypertension^(8, 9). This syndrome is associated with long-term consequences and brings PCOS women to an increased risk of cardiovascular disease (CVD). As a result, international societies recommend CVD screening among these women⁽³⁾.

The overall prevalence of MS in women with PCOS was reported to be 30%, and regardless of age, the risk of having MS among these women was 2.5 times higher when compared to healthy controls^(10, 11). The reported prevalence differed according to ethnicity of study population⁽¹²⁾. Up to the present, four studies in Thailand have reported the prevalence of MS in PCOS women⁽¹³⁻¹⁶⁾. Three studies conducted in Bangkok found the prevalence of 18-33.3%⁽¹³⁻¹⁵⁾, while another one study in Chiang Mai reported the prevalence of 24.3%⁽¹⁶⁾. No prior studies have investigated this issue among PCOS women residing in the Northeastern region of Thailand. Consequently, the present study aimed to assess the prevalence of MS among PCOS

patients attending the gynecological endocrinology clinic at Srinagarind Hospital, the Northeastern region of Thailand.

Materials and Methods

Study setting and participants

This study was a retrospective study conducted at the gynecological endocrinology clinic at Srinagarind Hospital, Khon Kaen University, Thailand, which is a tertiary hospital in the Northeastern sector. The study was approved by the Khon Kaen University Ethics Committee for Human Research (HE651219). The data from reproductive-aged PCOS patients visiting the clinic between 2014-2021 were collected. A diagnosis of PCOS was based on the revised Rotterdam 2003 criteria⁽¹⁷⁾. Women who had been previously diagnosed with diabetes mellitus, dyslipidemia, or other endocrinologic abnormalities or had history of steroid or other hormonal usage or had incomplete medical records were excluded. The objectives of the present study were to investigate the prevalence and associated factors of metabolic syndrome in PCOS women.

Data collection and variables of interest

The demographic and laboratory data were extracted from the computer-based medical records system and added to a data collection form created by one of the authors. Afterward, the data were transferred to the Microsoft Excel program and double-checked for accuracy by another author before analysis. The clinical variables of interest included age, age at menarche, parity, presence of clinical hyperandrogenism, exercise behavior, family history of DM and/or MS, and anthropometrics indices (body weight, height, waist circumference (WC), waist-to-hip ratio (WHR)). Early menarche was defined as menarche before the age of 12 years. Clinical hyperandrogenism included hirsutism, acne and androgenic alopecia. Additionally, the laboratory results of plasma glucose levels and lipid profiles obtained from the initial visit were collected.

The diagnosis of MS was made based on two international standards criteria: The International Diabetes Federation (IDF)⁽⁸⁾ and The National Cholesterol Education Program Adult Treatment Panel III (NCEP ATP III)⁽¹⁸⁾. According to the IDF criteria, women with central obesity (WC \geq 80 cm) plus two out of the following conditions were diagnosed to have MS: Systolic blood pressure (SBP) \geq 130 mmHg or diastolic blood pressure (DBP) \geq 85 mmHg, triglyceride (TG) level \geq 150 mg/dl, high density lipoprotein (HDL) level $<$ 50 mg/dl, and fasting plasma glucose (FPG) level \geq 100 mg/dl. On the other hand, the NCEP ATP III criteria requires the presence of three out of the following five criteria: WC \geq 88 cm, SBP \geq 130 mmHg or DBP \geq 85 mmHg, TG level \geq 150 mg/dl, HDL level $<$ 50 mg/dl, and FPG level \geq 100 mg/dl.

Glucose metabolism was determined by a 75-gm oral glucose tolerance test (OGTT). Abnormal plasma OGTT was classified according to the American Diabetes Association (ADA) 2021 criteria (19) which comprises of as follows: impaired fasting glucose (IFG) which is defined as fasting plasma glucose (FPG) levels from 100 to 125 mg/dl, impaired glucose tolerance (IGT) which is 2-hour plasma glucose (2-h PG) levels from 140 to 199 mg/dl, and type 2 diabetes mellitus (T2DM) which is FPG \geq 126 mg/dl or 2-h PG \geq 200 mg/dl.

The definition of obesity was defined as body mass index (BMI) \geq 25 kg/m² according to WHO recommendation for Asian populations⁽²⁰⁾. Women with WC \geq 80 cm or WHR \geq 0.8 were considered to have central obesity.

Statistical analysis

Statistical analysis was performed using Stata program version 10. Descriptive statistics including mean with standard deviation (SD), median with interquartile range (IQR), and number with percentage were used to report the characteristics of the patients. To compare patient characteristics between the groups (MS and Non-MS), categorical variables were assessed using the

chi-squared test or the Fisher's exact test, while continuous variables were evaluated using student's t-test or Mann-Whitney U test as appropriate.

We used simple logistic regression to explore the association between individual risk factors and MS. The multiple logistic regression model was used to analyze independent risk factors for MS, and the results were presented using adjusted odds ratios (aOR) with their corresponding 95% confidence intervals (CIs). We computed variance inflation factor (VIF) to determine multicollinearity between the covariates in the regression model. Multicollinearity is considered when the VIF is higher than 5. A p value of $<$ 0.05 was considered to be statistically significant.

Results

During the study period, medical records of 337 PCOS women were reviewed. The prevalence and abnormal components of MS are presented in Table 1. The prevalences of MS were 27.3% (95% CI 22.6%-32.4) and 20.8% (95% CI 16.6%-25.5%) according to the IDF and NCEP ATP III, respectively. All PCOS women who met IDF criteria for MS had elevated waist circumference compared to a rate of 77.1% of women diagnosed by NCEP ATP III criteria. PCOS women with MS based on IDF criteria trended to have lower prevalence of abnormal glucose metabolism and lipid profile compared to those with MS according to NCEP ATP III criteria. Approximately half of the women with MS met three criteria, while the remaining half had four or five criteria (Table 1).

Table 2 demonstrates the clinical and laboratory characteristics of PCOS women. Of 337 women, the median (interquartile range) of age, body weight, BMI, waist circumference, and waist to hip ratio (WHR) were 24 years (21-29), 66 kg (53-81), 25 kg/m² (21-31), 80 cm (70-90), and 0.85 (0.79-0.89), respectively. In comparison to women who did not meet criteria for MS, those with MS had a significantly higher body weight, BMI, waist circumference, WHR, and blood pressure.

Additionally, PCOS women with MS had significantly elevated levels of abnormal glucose and lipid parameters compared to those without MS,

including higher fasting plasma glucose (FPG), 2-hour glucose, triglyceride (TG) levels, and lower high-density lipoprotein (HDL) levels.

Table 1. Prevalence and abnormal components of metabolic syndrome criteria.

Components for diagnosis	Prevalence of MS			
	IDF criteria		NCEP-ATPIII criteria	
	MS (n= 92)	Non- MS (n= 245)	MS (n= 70)	Non- MS (n= 267)
	27.3% , 95% CI 22.6% - 32.4%)	72.7%, 95% CI 67.6% - 77.4%	20.8%, 95% CI 16.6% - 25.5%	79.2%, 95% CI 74.5% - 83.4%
Elevated Waist circumference	92 (100%) (95% CI 96.1% - 100%	77 (31.1%) 95% CI 25.6% - 37.3%	54 (77.1%) 95% CI 67.1% - 87.2%	33 (12.4%) 95% CI 8.4% - 16.3%
Blood pressure ≥ 130/85 mmHg	73 (79.3%) 95% CI 70.9% - 87.8%	(18.8%) 95% CI 13.9% - 23.7%	56 (80.0%) 95% CI 70.4% - 89.6%	63 (23.6%) 95% CI 18.5% - 28.7%
Triglyceride level ≥ 150 mg/dl	54 (58.7%) 95% CI 48.4% -68.9%	(13.5%) 95% CI 9.2% - 17.8%	46 (65.7%) 95% CI 54.3% - 77.1%	41 (15.4%) 95% CI 11.0%-19.7%
HDL level < 50 mg/dl	66 (71.7%) 95% CI 62.4% - 81.1%	(18.0%) 95% CI 13.1% - 22.8%	54 (77.1%) 95% CI 67.1% - 87.2%	56 (21.0%) 95% CI 16.1% -25.9%
FPG ≥ 100 mg/dl	41 (44.6%) 95% CI 34.2% - 54.9%	(6.5%) 95% CI 3.4% - 9.6%	37 (52.9%) 95% CI 40.9% - 64.8%	20 (7.5%) 95% CI 4.3% - 10.7%
Number of MS criteria				
0	NA	96 (39.2%) 95% CI 33.0% - 45.6%	NA	114 (42.7%) 95% CI 36.7% - 48.9%
1	NA	85 (34.7%) 95% CI 28.7% - 41.0%	NA	93 (34.8%) 95% CI 29.1% - 40.9%
2	NA	61 (24.9%) 95% CI 19.6% - 30.8%	NA	60 (22.5%) 95% CI 17.6% - 28.0%
3	50 (54.3%) 95% CI 43.6% - 64.8%	3 (1.2%) 95% CI 0.3% - 3.5%	40 (57.1%) 95% CI 44.7% - 68.9%	NA
4	34 (37.0%) 95% CI 27.1% - 47.7%	NA	23 (32.9%) 95% CI 22.1% - 45.1%	NA
5	8 (8.7%) 95% CI 3.8% - 16.4%	NA	7 (10.0%) 95% CI 4.1% - 19.5%	NA

MS: metabolic syndrome, IDF: International Diabetes Federation, NCEP-ATPIII: National Cholesterol Education Program Adult Treatment Panel III, CI: confidence interval, HDL: high-density lipoprotein, FPG: fasting plasma glucose, NA: not applicable

Abnormal glucose metabolism (AGM) determined by a 75-gm oral glucose tolerance test (OGTT) was found in 116 (34.4%) women. Out of

these, 18 women (5.3%) had DM, 50 women (14.8%) had IFG, and 72 women (21.4%) had IGT. A significantly higher number of women with AGM were

observed in the MS group (59/92 women, 64.1%) compared to those without MS (57/245 women, 23.3%). Impaired glucose tolerance (IGT) was

detected in 30 (32.6%) women with MS which was also significantly higher than those without MS (42/245 women, 17.1%) (Table 2).

Table 2. Clinical and metabolic characteristics of PCOS women stratified by the presence of MS based on IDF criteria.

Characteristics	Total (n = 337)	MS (n = 92)	Non-MS (n = 245)	p value
Age (years)	24 (21 – 29)	25 (21.5 – 30)	24 (21 – 28)	0.189
Age at menarche (years)	13 (12 – 14)	12.5 (12 – 13)	13 (12 – 14)	0.031
Nulliparity	310 (92.0%)	84 (91.3%)	226 (92.2%)	0.777
Exercise behavior ¹	87 (25.8%)	15 (16.3%)	72 (29.4%)	0.014
Family history of DM	94 (27.9%)	39 (42.4%)	55 (22.5%)	< 0.001
Family history of MS	52 (15.4%)	26 (28.3%)	26 (10.6%)	< 0.001
Body weight (kilograms)	66 (53 – 81)	85 (75 – 95)	59 (50 – 71)	< 0.001
BMI	25 (21 – 31)	31 (28 – 35)	23 (19 – 27)	< 0.001
Waist circumference (cm)	80 (70 – 90)	90 (84 – 100)	73 (68 – 81)	< 0.001
Waist to hip ratio	0.85 (0.79 – 0.89)	0.89 (0.85 – 0.96)	0.83 (0.77 – 0.88)	< 0.001
Newborn complication	95 (43.6)	18 (40.0)	0.86 (0.45-1.66)	0.659
Birth injury	15 (6.9)	3 (6.5)	0.94 (0.26-3.40)	0.930
NICU admission	9 (4.1)	2 (4.3)	1.06 (0.22-5.06)	0.946
Clinical hyperandrogenism ²	243 (72.1%)	63 (68.5%)	180 (73.5%)	0.363
Systolic blood pressure	121 (110 – 132)	135.5 (128.5 – 141)	117 (107 – 126)	< 0.001
Diastolic blood pressure	73.1 (11.5)	79.7 (12.5)	70.6 (10.0)	< 0.001
Lipid profiles				
Total cholesterol	194 (172 – 221)	188 (169.5 -222.5)	197 (172 – 220)	0.337
HDL	57 (46 – 71)	42.5 (39 – 50.5)	62 (52 – 77)	< 0.001
LDL	129 (107 – 152)	130 (109.5 – 156.5)	129 (106 – 151)	0.194
Triglyceride	112 (78 – 151)	157.5 (125 – 197.5)	98 (71 – 127)	< 0.001
Abnormal glucose metabolism				
DM	18 (5.3%)	15 (16.3%)	3 (1.2%)	< 0.001
Impaired fasting glucose	50 (14.8%)	35 (38.0%)	15 (6.1%)	< 0.001
Impaired glucose tolerance	72 (21.4%)	30 (32.6%)	42 (17.1%)	0.002

Data are presented as number (percentage), median (interquartile range) or mean (standard deviation)

PCOS: polycystic ovarian syndrome, MS: metabolic syndrome, IDF: International Diabetes Federation, BMI: body mass index, DM: diabetes mellitus, HDL: high-density lipoprotein, LDL: low-density lipoprotein

¹ Planned and repetitive form of physical activity

² Including hirsutism, acne, and androgenic alopecia

Table 3 shows the characteristics associated with the odds of being affected by MS among PCOS women. Three variables were independently

associated with MS including patients' age, family history of DM and/or MS, and self-reported exercise behavior. PCOS women who had family history of DM/

MS were at the highest odds of developing MS (aOR 2.77, 95% CI 1.66-4.65). Older women (age 30 years or older) had almost twice the odds of being affected by MS as compared with younger women (aOR 1.89,

95% CI 1.06-3.40). Reporting to have exercise behavior (an intended and repetitive form of physical activity) was associated with a 55% decreased overall odds of MS (aOR 0.45, 95% CI 0.23-0.86).

Table 3. Characteristics of PCOS women and risk of MS according to IDF criteria.

Variables	MS prevalence n (%)	OR (95%CI) ¹	Adjusted OR (95% CI) ²
Age			
< 30 Years (n=266)	64 (24.1)	reference	reference
≥ 30 years (n=71)	28 (39.4)	2.06 (1.18 – 3.57)	1.89 (1.06 – 3.40)
Age at menarche			
Early menarche ³ (n=62)	21 (33.9)	reference	Reference
Later menarche (n=275)	71 (25.8)	0.68 (0.38 – 1.23)	0.76 (0.41 – 1.42)
Parity status			
Nulliparity (n=310)	84 (27.1)	reference	reference
Multiparity (n=27)	8 (29.6)	1.13 (0.48 – 2.69)	1.07 (0.54 – 2.11)
Clinical hyperandrogenism ⁴			
Absent (n=94)	29 (30.9)	reference	reference
Present (n=243)	63 (25.9)	0.78 (0.46 – 1.32)	0.71 (0.40 – 1.24)
Exercise behavior ⁵			
Absent (n=250)	77 (30.8)	reference	reference
Present (n=87)	15 (17.2)	0.47 (0.25 – 0.87)	0.45 (0.23 – 0.86)
FH of DM and/or MS			
Absent (n=218)	42 (19.3)	reference	reference
Present (n=119)	50 (42.0)	3.04 (1.85 – 4.99)	2.77 (1.66 – 4.65)

The variance inflation factor of the regression model was 1.03, indicating no significant correlation among the variables.

PCOS: polycystic ovarian syndrome, MS: metabolic syndrome, IDF: International Diabetes Federation, OR: odds ratio, CI: confidence interval, FH: family history, DM: diabetes mellitus

¹ Simple logistic regression analyses

² Multiple logistic regression analyses adjusted with all factors presented in this table

³ Menarche before the age of 12 years

⁴ Including hirsutism, acne, and androgenic alopecia

⁵ Planned and repetitive form of physical activity

Discussion

The prevalence of MS in PCOS women in our study was 27.3 % and 20.8% according to the definition of the IDF criteria and NCEP III ATP criteria, respectively. Significant independent variables correlated with the odds of being affected by MS among Thai women with PCOS were patient's age, family history of DM and/or MS, and exercise

behavior. The present findings highlight a group of PCOS women who requires comprehensive care to prevent long-term consequences of MS.

The finding of this study was consistent with a previous study by Indhavivadhana et al(14), which also reported a higher prevalence of MS in PCOS women when using the IDF criteria (21.2%) compared to the NCEP ATP III criteria (18%). The discrepancy

in this prevalence rates could be attributed to the utilization of a lower waist circumference cut-off in the IDF criteria, which is ethnic specific for Asian women⁽⁹⁾.

Prevalence of MS among women varied across the settings. The US national survey estimated that MS affected approximately 11% of US females⁽²¹⁾. Insulin resistance, a core endocrinopathy of PCOS, is central to the pathogenesis of metabolically unhealthy, placing women with PCOS at an increased risk of being affected by MS. In a previous study analyzing the US hospitalization database, 0.64% of hospitalized women had a PCOS diagnosis. Of these, 12.2% were found to have concomitant MS⁽²²⁾. PCOS was associated with an increased risk of cardiovascular disease. The risks of different types of cardiovascular disease among PCOS women were affected by anthropometric measures and MS status⁽²²⁾. In a previous study conducted among Korean women with PCOS, the prevalence of MS varied from 11.9% to 19.7% depending on the characteristics of study cohorts⁽²³⁾.

When compared to general Thai female population, the prevalence of MS among PCOS women from our study was two times higher. Previous studies conducted among healthy women in Bangkok^(24,25) and Khon Kaen⁽²⁶⁾ of Thailand reported the prevalence of MS based on the NCEP III ATP criteria to be 8.2% to 10.3% and 14.6%, respectively. This data reaffirmed that PCOS women had higher risk of developing metabolic abnormalities compared to the general population. Thus, screening for MS, which is considered as a cardiovascular risk factor, is recommended among these women⁽²⁷⁾.

To date, there are four previous studies assessing the prevalence of MS among Thai PCOS women. Among these, three were conducted in Bangkok⁽¹³⁻¹⁵⁾ and one in ChiangMai⁽¹⁶⁾. All the prior studies enrolled reproductive-aged PCOS women based on the revised Rotterdam diagnostic criteria. Three studies^(13, 15-16) used the IDF criteria, and one study⁽¹⁴⁾ used both the IDF and NCEP ATP III criteria for MS diagnosis. Despite the same ethnicity and

PCOS phenotype, the prevalence of MS varied among the studies. In comparison to studies which diagnosed MS using the IDF criteria, our study revealed a lower MS prevalence than that reported by Weerakiet et al⁽¹³⁾ which was conducted in Bangkok and found 33.3% of MS in PCOS women. However, our MS prevalence was comparable to the findings of three other studies from Bangkok^(14,15) and Chiang Mai⁽¹⁶⁾ which reported the MS prevalence of 21.2-24.6% and 24.3%, respectively. This variation in prevalence could be attributed to differences in age and BMI across the studies. It is noteworthy that as age and BMI increase, the prevalence of MS tends to rise^(28, 29). While the age and BMI in our study aligned with the other three studies with similar prevalence, they were lower compared to the study reported by Weerakiet et al⁽¹³⁾.

The prevalence of MS significantly increased with increasing age^(28, 29). Interestingly, MS risk that is age-related appears to be apparent in PCOS women⁽²⁹⁾. In this study, the prevalence of MS among PCOS women also increased with increasing age. PCOS women aged 30 years or older were 2 times more likely to be affected by MS (aOR 1.89; 95% CI 1.06-3.40) than younger women.

Evidence has shown an association between a family history of DM or MS and risk of metabolic disturbances among PCOS women^(30, 31). In an epidemiologic study undertaken in Chinese females, PCOS women with a positive paternal history of both DM and HT were more likely to have an adverse metabolic profile than those without that history⁽³⁰⁾. In study conducted among European females, the prevalence of MS was 16.4% of PCOS women with a family history of type 2 DM, whereas only 8.6% of those without a family history of DM⁽³¹⁾. In the present study, family history of DM and/or MS was a significant independent predictor of the odds of being affected by MS among Thai women with PCOS. Thai women with PCOS who had family history of DM and/or MS were approximately 2.8 times more likely to have MS than those without that history. The information regarding the history of DM and/or MS in the family

of PCOS women thus should be assessed.

Exercise has been observed to result in improved cardiometabolic parameters among PCOS women. MS risk among PCOS women declined by approximately 20% (aOR 0.78; 95% CI 0.62-0.99) for every hour of vigorous exercise (i.e. aerobics, fast bicycling) per week⁽³²⁾. In the present study, exercise behavior, defined as an intended and repetitive form of physical activity), was associated with a 55% decreased odds of MS (aOR 0.45; 95% CI 0.23-0.86). Future studies assessing intervention to effectively implement exercise training among PCOS women are needed.

Insulin resistance with compensatory hyperinsulinemia in PCOS induces oxidative stress, systemic inflammation, and hyperandrogenism which can lead to MS⁽²²⁾. Various strategies have been proposed to alleviate symptoms of PCOS i.e. lifestyle modification and supplementation of vitamins, minerals, and probiotics⁽³³⁾. These interventions also seem to be beneficial in decrease MS risk among PCOS women due to the protective effects against insulin resistance, oxidative stress and inflammation. Our study is the first study assessing the prevalence of MS among PCOS women in the Northeast Thailand. Standardized criteria were applied to diagnose PCOS and MS. However, there were some limitations in this study. Firstly, the retrospective data collection limited the availability of some clinically important information regarding behavioral (i.e. physical and drinking status) and sociodemographic factors (i.e. educational attainment, income, working status, marital status, living condition) which might influence to the development of MS. In addition, being a single-center hospital-based study, the findings might not be fully representative of all Thai PCOS women.

Conclusion

MS was highly prevalent among PCOS women residing in the Northeast Thailand with a rate of 27.3% and 20.8% according to the criteria of IDF and NCEP ATP III, respectively. Factors associated with MS odds included age, family history of MS and/or

diabetic mellitus, and exercise behavior.

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Potential conflicts of interest

The authors declare no conflicts of interest.

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