Thai Journal of Obstetrics and Gynaecology
January 2023, Vol. 31, No. 1, pp. 64-71.

GYNAECOLOGY

Prevalence of Abnormal Glucose Metabolism in Thai Women with Polycystic Ovary Syndrome

Chayanit Wattanacheep, M.D.*,
Nuntasiri Eamudomkarn, M.D.*,
Srinaree Kaewrudee, M.D.*,
Woraluck Somboonporn, M.D.*,
Jen Sothornwit, M.D.*,
Nampet Jampathong, M.P.H.*

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

ABSTRACT

Objectives: To assess the prevalence and associated factors of abnormal glucose metabolism (AGM) including impaired fasting glucose (IFG), impaired glucose tolerance (IGT) and diabetes mellitus (DM) in Thai women with polycystic ovary syndrome (PCOS).

Materials and Methods: A retrospective study was conducted in PCOS women who came to the Srinagarind Hospital, Khon Kaen University during 2014 - 2020. Glucose metabolism was determined by a 75-g oral glucose tolerance test. IFG, IGT, and DM were defined according to the American Diabetes Association 2021 criteria. Logistic regression analysis was applied to assess factors associated with AGM. The 95% confidence interval (CI) was calculated to determine the precision of results.

Results: Of 188 patients, AGM was noted in 65 PCOS women, accounting for the prevalence of 34.6 % (95%CI 28.1 - 41.7). Among those with AGM, 10.1%, 23.9%, and 4.8% were diagnosed with IFG, IGT and DM, respectively. Compared to those without AGM, PCOS women with AGM trended to have higher body mass index, waist circumference, waist to hip ratio, blood pressure, and triglyceride level. These clinical parameters and anthropometric measures however were not independently associated with AGM by mean of multiple logistic regression analysis.

Conclusion: Abnormal glucose metabolism was prevalent among PCOS women residing in the Northeast Thailand. Approximately 5% of PCOS women in this study were diagnosed with type 2 DM. Anthropometric measures were not independently associated with AGM.

Keywords: abnormal glucose metabolism, impaired fasting glucose, impaired glucose tolerance, diabetes mellitus, PCOS.

Correspondence to: *Nuntasiri Eamudomkarn, M.D., Department of Obstetrics and Gynecology, Faculty of Medicine, Khon Kaen University, Khon Kaen 40002, Thailand. E-mail: pla_raa@hotmail.com*

Received: 29 September 2020, **Revised:** 24 December 2021, **Accepted:** 30 December 2021

ความชุกของภาวะการเผาผลาญน้ำตาลผิดปกติในสตรีไทยที่ได้รับการวินิจฉัยกลุ่มอาการถุงน้ำในรังไข่หลายใบ

ชญานิศ วัฒนาชีพ, นันทสิริ เอี่ยมอุดมกาล, ศรีนารี แก้วฤดี, วรลักษณ์ สมบูรณ์พร, เจน โสธรวิทย์, น้ำเพชร จำปาทอง

บทคัดย่อ

วัตถุประสงค์: *เพื่อศึกษาความชุกและปัจจัยที่เกี่ยวข้องของภาวะการเผาผลาญน้ำตาลผิดปกติ (abnormal glucose metabolism; AGM) ซึ่งประกอบด้วย ระดับน้ำตาลหลังงดน้ำและอาหารที่ผิดปกติ (impaired fasting glucose; IFG), ระดับน้ำตาลหลังกินน้ำตาล 2 ชั่วโมง ผิดปกติ (impaired glucose tolerance; IGT) และภาวะเบาหวาน (diabetes mellitus; DM) ในสตรีที่ได้รับการวินิจฉัยกลุ่มอาการถุงน้ำในรังไข่หลายใบ (Polycystic Ovary Syndrome; PCOS)*

วัสดุและวิธีการ: *การศึกษานี้เป็นการศึกษาย้อนหลัง (Retrospective study) โดยเก็บรวบรวมข้อมูลในสตรีที่ได้รับการวินิจฉัย PCOS ซึ่งมารับบริการที่โรงพยาบาลศรีนครินทร์ในช่วง พ.ศ. 2557-2563 การเผาผลาญน้ำตาลกลูโคส (glucose metabolism) ประเมินโดนการตรวจ 75-g Oral Glucose Tolerance Test (OGTT) เมื่อมารักษาครั้งแรก ภาวะการเผาผลาญน้ำตาลผิดปกติวินิจฉัยโดยใช้เกณฑ์ของ the American Diabetes Association (ADA) 2021 ปัจจัยที่เกี่ยวข้องของภาวะดังกล่าววิเคราะห์โดยวิธี logistic regression*

ผลการศึกษา: *ในสตรีที่ได้รับการวินิจฉัย PCOS จำนวน 188 ราย พบความชุกของภาวะการเผาผลาญน้ำตาลผิดปกติใน 65 ราย คิดเป็นร้อยละ 34.6 (95%CI, 28.1-41.7) โดย ในสตรีร้อยละ 10.1, ร้อยละ 23.9 และร้อยละ 4.8 ตรวจพบภาวะ IFG, IGT และ DM ตามลำดับ สตรีที่มีภาวะการเผาผลาญน้ำตาลผิดปกติ มีระดับดัชนีมวลกาย, เส้นรอบเอว, เส้นรอบเอวต่อสะโพก, ความดันเลือด และไตรกลีเซอไรด์ สูงกว่าสตรีที่มีค่าน้ำตาลปกติ อย่างไรก็ดี ไม่พบความสำคัญทางสถิติ ของปัจจัยดังกล่าวต่อการเผาผลาญน้ำตาลผิดปกติ เมื่อวิเคราะห์ด้วยวิธี logistic regression*

สรุป: *ความชุกของภาวะการเผาผลาญน้ำตาลผิดปกติพบได้สูงในสตรีที่ได้รับการวินิจฉัย PCOS ในภาคตะวันออกเฉียงเหนือของไทย โดยพบสตรีที่มีภาวะเบาหวาน 5%*

คำสำคัญ: *ภาวะการเผาผลาญน้ำตาลผิดปกติ, ระดับน้ำตาลสูงในเลือด, ภาวะการทนต่อน้ำตาลบกพร่อง, โรคเบาหวาน, กลุ่มอาการถุงน้ำในรังไข่หลายใบ*

Introduction

Polycystic ovary syndrome (PCOS) is a common endocrinopathy in reproductive-aged women[1]. It is a complex disorder characterized by hyperandrogenism, ovulatory dysfunction and polycystic ovarian morphology[2]. Apart from reproductive disturbance, women with PCOS carry higher risks of various metabolic disturbances, including diabetes mellitus, dyslipidemia, and cardiovascular disease[3,4].

Several hypotheses have been proposed to be the pathogenesis of PCOS, however the definite one has not been established. The pathophysiology of PCOS is complex and multifactorial involving endocrine, metabolic, genetic, epigenetic, and environmental factors[5]. Although insulin resistance is not a diagnostic criterion of PCOS, it may be central to the etiology of the syndrome[6]. Insulin resistance and compensatory hyperinsulinemia brings PCOS women to an increased risk of abnormal glucose metabolism (AGM). AGM consists of an impaired fasting glucose (IFG), impaired glucose tolerance (IGT) and type 2 diabetes mellitus (T2DM). The American Diabetic Association (ADA) recommends using a 75-g oral glucose tolerance test (OGTT) for investigating AGM[7]. Due to the fact that women with PCOS carry a higher risk of developing AGM, OGTT should be investigated for assessing glycemic status in all women with PCOS[3,8].

The prevalence of AGM among PCOS women varies according to the ethnicity of population assessed[9-13]. Asian, American, and European PCOS women carry 5, 4, and 3-fold increased risks of developing AGM[9,12,13]. To date, existing evidence regarding the prevalence of AGM among Thai women with PCOS are limited[14-17]. The prevalence of AGM among Thai women with PCOS varies widely across the regions, ranging from 20.0% to 45.9%[14-17]. T2DM, the most severe form of AGM, was noted in 5.6%-11.4% of Thai women with PCOS[14-17].

Since the cultural and food consumption behavior differ across the regions in Thailand which may have had a contributing effect on the glycemic status. The present study was accordingly undertaken with the aim to assess the prevalence and associated factors of AGM among PCOS women attending the gynecological endocrinology clinic at Srinagarind Hospital which is a tertiary hospital in Northeastern region of Thailand.

Materials and Methods

Study setting and participants

This study was a retrospective study conducted at the gynecological endocrinology clinic, Srinagarind Hospital, Khon Kaen University, Thailand. The study protocol was approved by the Khon Kaen University Ethics Committee for Human Research (HE631201). The data from reproductive-aged PCOS patients visiting the clinic between 2014-2020 were reviewed. A diagnosis of PCOS was based on the revised Rotterdam 2003 criteria[18]. 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 AGM in PCOS women.

Data collection and variables of interest

The demographic and laboratory data from the computer-based medical records system were extracted and collected to add to the data collection form that one of the authors made, then transferred to Microsoft Excel program and double checked by another author for correctness before analysis. The variables of interest included age, body weight, height, body mass index (BMI), waist circumference, waist-to-hip ratio (WHR) and blood pressure. The results of plasma glucose level and lipid profiles that were obtained from initial visit of each woman were collected.

Glucose metabolism was determined by a 75-g OGTT. Abnormal plasma OGTT was classified according to the ADA 2021 criteria[7]. IFG was defined as fasting plasma glucose (FPG) levels from 100 to 125 mg/dl. IGT was defined as a 2-hour plasma glucose (2-h PG) levels from 140 to 199 mg/dl. T2DM was defined as FPG ≥ 126 mg/dl or 2-h PG ≥ 200 mg/dl. Prediabetes state is the term used for individuals who have IFG or IGT which glucose levels are higher than

normal but not meet the diagnostic criteria for T2DM. Prediabetes is a serious health condition as the majority of individuals with prediabetes will eventually develop diabetes.

Statistical analysis

Statistical analysis was performed using Stata program version 10. Descriptive statistics including mean (standard deviation), median (interquartile range), and number (percentage) were used to report the characteristics of the patients. Comparisons between the groups were performed using the student's t-test, Mann-Whitney U test, Chi-squared test, or Fisher's exact test when appropriate. The independent risk factors associated with AGM were assessed using multiple logistic regression analysis. The 95% confidence interval (CI) was calculated to determine the precision of results. $P<0.05$ was considered statistically significant.

Results

During the study period, a total of 188 PCOS women attending the gynecological endocrinology clinic, Srinagarind Hospital were reviewed. The results of OGTT are demonstrated in Table 1. AGM was detected in 65 women, accounting for the prevalence of 34.6% (95%CI 28.1% to 41.7%). Of these, 10.1% had IFG (95%CI 6.5% to 15.4%), 23.9% had IGT (95%CI 18.3% to 30.6%) and 4.8% had T2DM (95%CI 2.5% to 9.0%). Pre-diabetes state was found in 30.9% of women (95%CI 24.6% to 37.9%)

Table 1. Prevalence of abnormal glucose metabolism in 188 Thai women with polycystic ovary syndrome.

Abnormal glucose metabolism[1]	Prevalence	
	n	% (95% confidence interval)
Overall	65	34.6 (28.1 - 41.7)
Pre-diabetes state[2]	58	30.9 (24.6 - 37.9)
- Impaired fasting glucose (IFG)	19	10.1 (6.5 - 15.4)
- Impaired glucose tolerance (IGT)	45	23.9 (18.3 - 30.6)
Diabetes mellitus (DM)[3]	9	4.8 (2.5 - 9.0)
- Fasting plasma glucose ≥ 126 mg/dl	6	3.2 (1.4 - 7.0)
- 2-hour glucose ≥ 200 mg/dl[4]	9	4.8 (2.5 - 9.0)

[1] Abnormal glucose metabolism: impaired fasting glucose (fasting plasma glucose = 100-125 mg/dl), impaired glucose tolerance (2-hour glucose = 140-199 mg/dl), or diabetes mellitus (DM)

[2] Pre-diabetes state: impaired fasting glucose (IFG) or impaired glucose tolerance (IGT) (13 women had IFG, 39 women had IGT, and 6 women had combined IFG plus IGT)

[3] Diabetes mellitus: fasting plasma glucose ≥ 126 mg/dl or 2-hour glucose ≥ 200 mg/dl (3 women had 2-hour glucose ≥ 200 mg/dl and 6 women had combined fasting plasma glucose ≥ 126 mg/dl plus 2-hour glucose ≥ 200 mg/dl)

[4] 6 women had combined fasting plasma glucose ≥ 126 mg/dl plus 2-hour glucose ≥ 200 mg/dl, 2 women had IFG plus 2-hour glucose ≥ 200 mg/dl, and 1 woman had 2-hour glucose ≥ 200 mg/dl alone

Table 2 demonstrates the clinical and laboratory characteristics of 188 women with PCOS. In comparison to those without AGM, women with AGM had significantly higher body weight, BMI, waist circumference, WHR, blood pressure, and triglyceride (TG) level. High density lipoprotein (HDL) level was lower among women with AGM when compared to those without AGM.

The significant factors associated with increased risk of AGM among PCOS women were age ≥ 30 years, BMI ≥ 25 kg/m^2 and waist circumference ≥ 80 cm with odds ratio of 2.35 (95%CI 1.18 to 4.68), 2.26 (95%CI 1.21 to 4.22) and 2.06 (95%CI 1.10 to 3.87), respectively (Table 3). After adjusted factors with multiple logistic regression analysis, these associations however were not statistically significant.

Table 2. Characteristics of 188 Thai women with polycystic ovary syndrome with abnormal glucose metabolism and those with normal glucose metabolism.

Characteristics	All PCOS women (n = 188)	Abnormal glucose metabolism[1] (n = 65)	Normal glucose metabolism (n =123)	p value
Age (years)	24 (21-29)	25 (21-30)	24 (21-29)	0.343
Body weight (kilograms)	66 (53-81)	71 (58-87)	61 (51-79)	0.018
Height (centimeters)	159.9 ± 6.1	158 (156-166)	160 (156-163)	0.638
Body mass index (kg/m^2)	25 (21-31)	27 (23-31)	24 (20-30)	0.011
Waist circumference (centimeters)	80 (70-92)	85 (76-92)	80 (68-90)	0.013
Waist to hip ratio	82.9 ± 6.6	84.9 ± 6.0	81.7 ± 6.7	0.002
Systolic blood pressure	120.5 (110.5-133)	130 (115-137)	119 (108-130)	0.003
Diastolic blood pressure	73.8 ± 12.0	76.4±12.9	72.4±11.3	0.030
Hypertension[2]	10 (5.3%)	6 (9.2%)	4 (3.3%)	0.097
Family history of DM	51 (27.1)	21 (32.3%)	30 (24.4%)	0.246
Glucose metabolism				
Fasting plasma glucose (mg/dl)	88 (83-94.5)	97 (88-104)	86 (80-90)	< 0.001
2-Hour glucose (mg/dl)	116 (95-146.5)	158 (145-179)	102 (91-119)	< 0.001
Lipid profiles				
Total cholesterol	191.5 (172- 215.5)	188 (171-206)	196 (172-218)	0.184
HDL	56 (46-69.5)	50 (42-59)	60 (50-72)	0.001
LDL	129 (110.5-152)	126 (114-148)	134 (109-156)	0.676
Triglyceride	114 (81.5- 154)	125 (88-161)	111 (79-141)	0.030

Data are presented as mean ± standard deviation, median (interquartile range) and number (%)

PCOS: polycystic ovary syndrome, DM: diabetes mellitus, HDL: high density lipoprotein, LDL: low density lipoprotein

[1] Abnormal glucose metabolism: impaired fasting glucose (fasting plasma glucose = 100-125 mg/dl), impaired glucose tolerance (2-hour glucose = 140-199 mg/dl), or diabetes mellitus (DM)

[2] Hypertension: systolic blood pressure ≥ 140 mmHg or diastolic blood pressure ≥ 90 mmHg

Table 3. Risk factors for abnormal glucose metabolism (AGM) in 188 PCOS women.

Factors	OR (95% CI)[1]	Adjusted OR (95% CI)[2]
Age ≥ 30 years	2.35 (1.18 - 4.68) *	1.86 (0.89 - 3.88)
BMI ≥ 25 kg/m^2	2.26 (1.21 - 4.22) *	1.51 (0.53 - 4.26)
Waist circumference ≥ 80 cm	2.06 (1.10 - 3.87) *	1.27 (0.46 - 3.53)
Hypertension	3.03 (0.82 - 11.14)	-
Dyslipidemia	1.59 (0.77 - 3.28)	-

Data were analyzed using logistic regression analysis.

[1] simple logistic regression analysis

[2] multiple logistic regression analysis adjusted with all factors in this table

* p-value < 0.05

PCOS: polycystic ovary syndrome, OR: odds ratio, CI: confidence interval, BMI: body mass index

Discussion

Our study revealed that the prevalence of AGM in PCOS women residing in Northeastern region of Thailand was 34.6% (95%CI 28.1% to 41.7%). Among women who had AGM, 30.9% had pre-diabetes state which include IFG and IGT. T2DM was noted in 4.8% (95%CI 2.5% to 9.0%) of patients. Patients' age and anthropometric measures however were not independently associated with the risk of AGM.

The prevalence of pre-diabetes state and T2DM noted in our study appeared to be higher than that in general Thai female population. In a study of Aekplakorn et al[19], which was undertaken among Thai population aged ≥ 20 years during 2004-2014, the prevalence of IFG and T2DM in female aged 20 - 29-year-old were 8.9% and 2.9%, respectively. Findings of our study thus reaffirmed that PCOS women is a subset of women with an increased risk of developing glucose abnormality. Determining glycemic status, therefore, is an essential assessment for PCOS women[20]. Interestingly, our result showed that 67.2% of women with pre-diabetes state and 11.1% of those with T2DM did not have IFG. Determining fasting plasma glucose alone, therefore, is insufficient to diagnose AGM in all PCOS women. These findings supported the use of a 75-g OGTT as a screening tool for AGM among PCOS women.

To our knowledge, there were only four studies assessing the prevalence of AGM in Thai PCOS women[14-17]. Three studies were conducted in Bangkok and the remaining one in Chiang Mai. All the prior studies recruited reproductive-aged PCOS women according to the revised Rotterdam diagnostic criteria[18]. Albeit of the same ethnicity and PCOS phenotype, the prevalence of AGM reported in these studies varies widely. Our study revealed lower AGM prevalence than that reported by Charnvises et al[16] and Weerakiet et al[15], which were undertaken among PCOS women residing in Bangkok. These two previous studies found prevalence of AGM among PCOS women to be 42.9% and 45.9%, respectively. In comparison to the previous study conducted in Chiang Mai by Pantasri et al[17], the prevalence in our study was also lower. Pantasri et al reported that approximately 43% of PCOS women residing in Chiang Mai were noted to have AGM. The difference of AGM prevalence among Thai PCOS women noted in our study compared to previously reported findings may be due to the fact that the PCOS women in our study appeared to be younger and had lower BMI than that in previous reports, thus, carrying a lower risk of AGM.

Another one study was undertaken in Bangkok by Wongwananuruk et al[14]. Although comparable in age of study samples, the prevalence of AGM in our study was higher than that in Wongwananuruk et al (34.6% versus 20%, respectively). The higher prevalence of AGM among PCOS women residing in Northeastern region of Thailand than those in Bangkok may be secondary to the impact of food consumption behaviors which vary across the regions. Data from the Thai National Health Examination Survey IV observed that the carbohydrate-rich consumption i.e. sticky rice was more common in the North and Northeast of Thailand[21]. Several studies demonstrated the association of consumption of carbohydrate-rich food and an increased risk of developing abnormal glycemic status[22-24]. This may have led to higher prevalence of AGM in our study when compared to the study conducted in Bangkok albeit of the same age-group of PCOS population.

The present study demonstrated that PCOS women with AGM had significantly higher body weight, BMI, waist circumference, waist to hip ratio, blood pressure, and triglyceride level in comparison to those without AGM. These findings were in line with the previous studies in Thai PCOS women which also reported the association of these factors and an increased risk of AGM[14-17]. By mean of univariate analyses, women with age ≥ 30-year-old, BMI ≥ 25 kg/m^2, and waist circumference ≥ 80 cm were shown to have higher risk for AGM. Nevertheless, these variables were not statistically significant when adjusted with multiple logistic regression analyses. This was in line with findings previously report which demonstrated that age and BMI were not independent risk factors for AGM in PCOS patients[16]. In addition, a systematic review and meta-analysis assessing insulin resistance

in PCOS patients reported that a reduction in insulin sensitivity among PCOS women was independent of BMI and age[25]. These findings might highlight multifactorial involvement in glucose abnormality in PCOS patients[26].

This was the first study assessing the prevalence of AGM among PCOS women residing in the Northeast Thailand. Our study was able to denote some findings that appeared to be unique for our setting. The diagnostic criteria applied in our study was according to the update standard criteria. However, our study had some limitations. Firstly, the design of the present study was retrospective. Therefore, some informative data, particularly data regarding physical manifestations of insulin resistance i.e. acanthosis nigricans, androgenic status, details of exercise, and drinking behavior, were unavailable. Secondly, this study was undertaken in a single tertiary care hospital in the Northeast Thailand which limits an extrapolation of our findings to Thai PCOS women of different settings.

Conclusion

Abnormal glucose metabolism was highly prevalent among PCOS women residing in the Northeast Thailand with a rate of 34.6% in the present study. Pre-diabetes glycemic status including IFG and IGT was found in 30.9% of PCOS women. Approximately 5% of PCOS women in our study were diagnosed with T2DM. Patients' age and anthropometric measures were not independently associated with AGM.

Acknowledgement

We would like to acknowledge Mr. Gurdeep Singh, for editing the manuscript via English Editing Publication Clinic, Khon Kaen University, Thailand.

Potential conflicts of interest

The authors declare no conflicts of interest.

References

1. Chang RJ, Dumesic DA. Polycystic ovary syndrome and hyperandrogenic states. Yen & Jaffe's Reproductive Endocrinology. 8th ed. Philadelphia: Elsevier 2018;520-55.
2. McCartney CR, Marshall JC. Clinical practice. Polycystic ovary syndrome. N Engl J Med 2016;375:54-64.
3. American College of Obstetricians and Gynecologists' Committee on Practice Bulletins-Gynecology. ACOG Practice Bulletin No. 194: Polycystic ovary syndrome. Obstet Gynecol 2018;131:e157-e71.
4. Carmina E. Diagnosis of polycystic ovary syndrome: from NIH Criteria to ESHRE-ASRM guidelines. Minerva Ginecol 2004;56:1-6.
5. Dumesic DA, Oberfield SE, Stener-Victorin E, Marshall JC, Laven JS, Legro RS. Scientific statement on the diagnostic criteria, epidemiology, pathophysiology, and molecular genetics of polycystic ovary syndrome. Endocr Rev 2015;36:487-525.
6. Dunaif A. Insulin resistance and the polycystic ovary syndrome: mechanism and implications for pathogenesis. Endocr Rev 1997;18:774–800.
7. American Diabetes Association. 2. Classification and diagnosis of diabetes: standards of medical care in diabetes-2021. Diabetes Care 2021;44(Suppl 1):S15-S33.
8. Legro RS, Arslanian SA, Ehrmann DA, Hoeger KM, Murad MH, Pasquali R, et al. Endocrine society. diagnosis and treatment of polycystic ovary syndrome: an endocrine society clinical practice guideline. J Clin Endocrinol Metab 2013;98:4565-92.
9. Teede HJ, Misso ML, Costello MF, Dokras A, Laven J, Moran L, et al; International PCOS Network. Recommendations from the international evidence-based guideline for the assessment and management of polycystic ovary syndrome. Hum Reprod 2018;33:1602-18.
10. Ehrmann DA, Barnes RB, Rosenfield RL, Cavaghan MK, Imperial J. Prevalence of impaired glucose tolerance and diabetes in women with polycystic ovary syndrome. Diabetes Care 1999; 22:141-6.
11. Legro RS, Kunselman AR, Dodson WC, Dunaif A. Prevalence and predictors of risk for type 2 diabetes mellitus and impaired glucose tolerance in polycystic ovary syndrome: a prospective, controlled study in 254 affected women. J Clin Endocrinol Metab 1999;84: 165-9.
12. Chen X, Yang D, Li L, Feng S, Wang L. Abnormal glucose tolerance in Chinese women with polycystic ovary syndrome. Hum Reprod 2006;21:2027-32.
13. Lee H, Oh JY, Sung YA, Chung H, Cho WY. The prevalence and risk factors for glucose intolerance in young korean women with polycystic ovary syndrome. Endocrine 2009;36:326-32.
14. Wongwananuruk T, Rattanachaiyanont M, Indhavivadhana S, Leerasiri P, Techatraisak K, Tanmahasamut P, et al. Prevalence and clinical predictors of insulin resistance

in reproductive-aged Thai women with polycystic ovary syndrome. Int J Endocrinol 2012;2012:529184.
15. Weerakiet S, Tingthanatikul Y, Boonnag P, Wansumrith S, Rattanasiri S, Leelaphiwat S. Can adiponectin predict abnormal glucose tolerance in Thai women with polycystic ovary syndrome? J Obstet Gynaecol Res 2008;34:55-61.
16. Charnvises K, Weerakiet S, Tingthanatikul Y, Wansumrith S, Chanprasertyothin S, Rojanasakul A. Acanthosis nigricans: clinical predictor of abnormal glucose tolerance in Asian women with polycystic ovary syndrome. Gynecol Endocrinol 2005;21: 161-4.
17. Pantasri T, Vutyavanich T, Sreshthaputra O, Srisupundit K, Piromlertamorn W. Metabolic syndrome and insulin resistance in Thai women with polycystic ovary syndrome. J Med Assoc Thai 2010;93:406-12.
18. Revised 2003 consensus on diagnostic criteria and long-term health risks related to polycystic ovary syndrome (PCOS). Human reproduction (Oxford, England) 2004;19:41-7.
19. Aekplakorn W, Chariyalertsak S, Kessomboon P, Assanangkornchai S, Taneepanichskul S, Putwatana P. Prevalence of diabetes and relationship with socioeconomic status in the Thai population: national health examination survey, 2004-2014. J Diabetes Res 2018;2018:1654530.
20. Leelaphiwat S, Munkrut N, Weerakiet S, Tingthanatikul Y. Incidence of diabetes mellitus in Thai women with polycystic ovary syndrome. J Med Assoc Thai 2019;102:853-60.
21. Aekplakorn W, Satheannoppakao W, Putwatana P, Taneepanichskul S, Kessomboon P, Chongsuvivatwong V, et al. Dietary patterns and metabolic syndrome in thai adults. J Nutr Metab 2015;2015:468759.
22. McNaughton SA, Mishra GD, Brunner EJ. Dietary patterns, insulin resistance, and incidence of type 2 diabetes in the Whitehall II Study. Diabetes Care 2008;31:1343-8.
23. Buscemi S, Nicolucci A, Mattina A, Rosafio G, Massenti FM, Lucisano G, et al. Association of dietary patterns with insulin resistance and clinically silent carotid atherosclerosis in apparently healthy people. Eur J Clin Nutr 2013;67:1284-90.
24. Mazidi M, Kengne AP, Mikhailidis DP, Toth PP, Ray KK, Banach M. Dietary food patterns and glucose/ insulin homeostasis: a cross-sectional study involving 24,182 adult Americans. Lipids Health Dis 2017;16:192.
25. Cassar S, Misso ML, Hopkins WG, Shaw CS, Teede HJ, Stepto NK. Insulin resistance in polycystic ovary syndrome: a systematic review and meta-analysis of euglycaemic-hyperinsulinaemic clamp studies. Hum Reprod 2016;31:2619-31.
26. Cooney LG, Dokras A. Cardiometabolic risk in polycystic ovary syndrome: current guidelines. Endocrinol Metab Clin North Am 2021;50:83-95.