RESEARCH

Lipid accumulation product independently correlate with hepatic steatosis quantified by controlled attenuation parameter in women with polycystic ovary syndrome

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Abstract

Objective: To explore the independent associations of the new adiposity indices lipid accumulation product (LAP) index, visceral adiposity index (VAI), and product of triglycerides and glucose (TyG) with the risks of hepatic steatosis (HS) in women with polycystic ovary syndrome (PCOS).

Design: This is a cross-sectional study with 101 women with PCOS undergoing controlled attenuation parameter (CAP) measurement who were recruited from November 2018 to August 2019. Multivariable logistic regression analysis was performed to determine the associations of adiposity indices with HS.

Result(s): Among the 101 PCOS patients, the prevalence rate of HS was 70.3%. The PCOS patients with HS have higher percentage of overweight/obesity status, higher level of aminotransferase (AST and ALT), homeostasis model assessment of insulin resistance (HOMA-IR), LAP, VAI, TyG, waist circumference (WC), and BMI ($P < 0.05$). Partial correlation analysis showed LAP, WC and BMI were significantly positively associated with CAP ($P < 0.05$) after controlling for confounding factors. Besides, BMI, WC, and CAP were gradually elevated with the increase of LAP level. Further, multivariable logistic regression analysis showed adjusted odd ratio (OR) with associated 95% CI (OR (95% CI)) were respectively 1.09 (1.03–1.16) for LAP, 1.14 (1.05–1.23) for WC, 1.28 (1.08–1.51) for BMI, respectively.

Conclusions: The present study demonstrates that in women with PCOS, except for the traditional adiposity indices (WC and BMI), LAP is independently correlated with the risk of HS.

Introduction

Polycystic ovary syndrome (PCOS) is the most common gynecological endocrine disorder, which affects approximately 5–10% of women in reproductive age and is characterized by chronic anovulation and hyperandrogenism, with women often presenting menstrual cycle disturbances and hirsutism or acne (1). Women with PCOS have an increased long-term risk of developing metabolic syndrome (MetS), hypertension,

and increasing cardiovascular morbidity and mortality as well as nonalcoholic fatty liver disease (NAFLD) (2).

A growing body of clinical and experimental evidences suggest that PCOS and NAFLD share similar clinical presentations including dyslipidemia, hypertension, and glycemic dysregulation (3). NAFLD is one of the most common forms of liver diseases, which is typically characterized by more than 5% accumulation of hepatocellular lipids and comprises a spectrum of disease stages ranging from simple hepatic steatosis (HS) to nonalcoholic steatohepatitis (NASH) (4). Previous studies suggest that the prevalence of NAFLD is remarkably increasing in young women with PCOS, regardless of overweight/obesity and other features of the MetS, in which the prevalence of NAFLD in women with PCOS ranges from approximately 35–70% (3, 5).

The gold standard for the diagnosis and staging of NAFLD is a liver biopsy. However, liver biopsy cannot be performed in all patients, as it is an expensive and invasive procedure which limits its use for the screening of population (6). Thus, several studies developed noninvasive imaging techniques such as ultrasonography, computerized tomography (CT) and MRI to clinically assess HS in NAFLD (7, 8). However, ultrasonography is observer dependent, CT induces radiation exposure, and MRI is not routinely accessible. These limitations may be overcome by the controlled attenuation parameter (CAP) feature, which is a new ultrasound-based technique for measuring fat content in the liver using signals acquired by a transient elastography probe (9). In a recent individual patient data meta-analysis on CAP accuracy for non-invasive grading of liver steatosis, Karlas and colleagues (10) reported the optimal cut-offs of CAP were 248 dB/m for those above steatosis grade S0.

Previous studies indicated that waist circumference (WC) (11) and BMI (12) are useful predictive factors for risk of NAFLD. Recently, different metabolic indices combining both anthropometric and lipid measures have been used as a valuable indicator of visceral adipose function (13) and a new continuous marker of lipid overaccumulation (14). The new body fat indices such as lipid accumulation product (LAP) index, visceral adiposity index (VAI), and product of triglycerides and glucose (TyG) can accurately predict insulin resistance (IR), prediabetes, and type 2 diabetes mellitus (T2DM) (15, 16, 17, 18). In the present study, we aimed to explore whether the new adiposity indices (LAP, VAI, and TyG) could predict the risk of HS quantified by CAP in women with PCOS. We also aimed to evaluate whether the new adiposity indices are better than the traditional anthropometric parameters (WC and BMI) to predict the risk of HS.

Patients and methods

Participants

The cross-sectional study was performed between November 2018 and August 2019, which screened a total of 141 women aged from 20 to 40 years at the Department of Endocrinology and Diabetes, the First Affiliated Hospital of Xiamen University, Xiamen, China. The diagnosis of PCOS was established according to the Rotterdam criteria (19). Briefly, PCOS is diagnosed by the presence of at least two out of the following three features: clinical and/or biochemical hyperandrogenism, chronic oligo-anovulation, and polycystic ovarian morphology (19). All participants were excluded if they had other related diseases, such as thyroid dysfunction, late-onset congenital adrenal hyperplasia, or androgen-secreting tumors. The other exclusion criteria included alcohol consumption >20 g/day, presence of known liver disease such as viral or autoimmune hepatitis, viral hepatitis, and treatment with hepatotoxic medications. Face-to-face interview was conducted for each patient to collect lifestyle habits, present and previous history of health and medications. Among the eligible patients, 38 patients without CAP data and 2 patients with the alanine aminotransferase (ALT) level over three-folds of upper limit of the normal range were excluded from the study. All the left 101 patients had complete data on clinical and CAP assessment data. This study was approved by the Human Research Ethics Committee of the First Affiliated Hospital of Xiamen University (Xiamen, China). Written informed consent was obtained from each participant.

Anthropometric and laboratory measurements

Following a 12-h overnight fasting, participants underwent weight, height and WC measurements by using a calibrated scale after removing shoes and heavy clothes. BMI was calculated as the weight in kilograms divided by the square of the height in meters. WC was measured at the midpoint between the inferior costal margin and the superior border of the iliac crest on the mid-axillary line. Arterial blood pressure was measured with OMRON electronic sphygmomanometer after sitting for at least 15 min. Three readings were taken at 5-min intervals and the mean was recorded.

Fasting blood samples were used to measure fasting plasma glucose (FPG), transaminases and lipid profiles. All biochemical measurements were tested in the central laboratory of the First Affiliated Hospital, Xiamen University. Serum aspartate aminotransferase (AST), ALT, Triglyceride (TG), total cholesterol (TC), and high-density lipoprotein cholesterol (HDL-c) were determined on HITACHI 7450 analyzer (HITACHI, Tokyo, Japan). Low-density lipoprotein cholesterol (LDL-c) was calculated by Friedewald's formula which is: LDL-c = (TC − HDL-c) − TG/5 (20). Serum ALT and AST were measured by standard enzymatic methods. FPG concentration was measured by the hexokinase method. Serum fasting insulin concentration was measured by electrochemiluminescence immunoassay (Roche Elecsys Insulin Test, Roche Diagnostics). Assay sensitivities were 1.0 μU/mL and total coefficients of variation (CV) ≤7%. Testosterone, luteinizing hormone (LH), and follicle-stimulating hormone (FSH) were also measured by chemiluminescent immunoassay analysis (Siemens Healthcare Diagnostics Inc; SIMENS ADVIA centaur XP immunoassay System, Erlangen, Germany). Assay sensitivities were 7 ng/dL for testosterone, 0.07 IU/L for LH, and 0.3 IU/L for FSH. The intra- and inter-assay CV were <8% and 10% for T, <3% and 2.9% for LH, <2.9% and 2.7% for FSH, respectively.

Calculation of indexes

LAP and VAI were calculated using the published formula (21). $LAP = (WC − 58) \times TG$, where TG is expressed in mmol/l. VAI was calculated as:

$$VAI = \left[\frac{WC}{(36.58 + 1.89 \times BMI)} \right] \times \left(\frac{TG}{0.81} \right) \times \left(\frac{1.52}{HDL\text{-}c} \right)$$

in which TG and HDL-c levels are expressed in mmol/L, WC in cm and BMI in kg/m^2. The TyG index (18) was calculated as:

$$\ln \left(TG \times \frac{FBG}{2} \right)$$

where both TG and FPG are expressed in mg/dL. Homeostasis model assessment of insulin resistance (HOMA-IR) was calculated using the following formula (22): $HOMA\text{-}IR = FINS \times FPG/22.5$, where FINS is fasting serum insulin (mU/L) and FPG is expressed in mmol/L.

CAP assessment

Transient elastography with CAP is a Food and Drug Administration (FDA)-approved modality for the diagnosis and assessment of the severity of HS, which was performed using FibroScan® (Echosens, Paris, France) by experienced operators in this study (23). Results were considered valid only for transient elastography with at least ten successful shots, a successful rate of 60% or higher, and an interquartile median ratio of less than 30%. HS was diagnosed based on CAP measurement. We applied the following CAP cutoff derived from a meta-analysis by Karlas *et al.* (10): HS group was defined as CAP ≥248 dB/m, the control group as CAP <248 dB/m, respectively.

Statistical analyses

All analyses were performed with SPSS, version 21.0 software (IBM Corporation). Based on the average of LAP between the two groups by the cut-offs of 248 dB/m of CAP, α being set to 5%, power being 90%, and *P* values being two-sided, the total sample size will be at least 66 subjects. The Kolmogorov–Smirnov test and the respective histogram test were conducted for the normality of the continuous variables and found the variables (age, HbA1c, SBP, DBP, BMI, WC, FBG, TC, LDL-c, CAP and TyG) following the normal distributions. Other variables (ALT, AST, TG, HDL-c, T, LH/FSH ratio, HOMA-IR, VAI and LAP) did not follow normal distributions. Data are presented as mean±s.d. for normally distributed variables or median (interquartile range (IQR)) for non-normally distributed variables or number and percentage for categorical variable. Differences between two groups were analyzed by the unpaired Student's *t* test for the quantitative variables with a normal distribution, Mann–Whitney test for the quantitative variables with a normal distribution, and chi-square test for categorical variables, respectively. One-way ANOVA with Tukey *post hoc* test was used to assess the differences of BMI, WC and CAP between different LAP tertiles. The correlation of clinical characteristics with CAP was analyzed using the Spearman correlation analysis. A partial correlation analysis was performed between the adiposity indices (LAP, VAI, and TyG) and anthropometric parameters (WC and BMI) with CAP after controlling for age, blood pressure (BP), liver enzymes, and lipid profiles and HOMA-IR. Multivariate logistic regression analysis

was used to calculate adjusted odds ratios (ORs) and 95% CIs of LAP, WC and BMI for HS in different models with adjustment for potential confounders. All *P* values are two-sided and *P*<0.05 was considered significant.

Results

Demographic data

Of the 101 PCOS patients, 71 (70.3%) women had HS. The clinical characteristics of patients included in the study are summarized in Table 1. Compared with controls, the PCOS patients in HS group have higher level of ALT, AST, HOMA-IR, and CAP (Table 1; *P*<0.05). The anthropometric adiposity parameters (BMI and WC) are much higher in the HS group (*P*≤0.001). In HS group, there are higher percentage of overweight/ obesity patients than that in control group. Similarly, the new adiposity indices (LAP, VAI, and TyG) are also increasing in the HS group (*P*<0.05). However, there are no significant differences for age, systolic blood pressure (SBP), diastolic blood pressure (DBP), FBG, lipid profiles (TG, TC, HDL-c, and LDL-c) (*P*>0.05). Both testosterone

and the ratio of LH to FSH are also not significant between two groups (*P*>0.05).

Association of adiposity indices with CAP

We firstly investigated the correlation of clinical characteristics with CAP by Pearson's correlation analysis and found transaminases (ALT (*r*=0.48, *P*<0.001), AST (*r*=0.39, *P*<0.017)), FBG (*r*=0.29, *P*=0.003), TG (*r*=0.24, *P*=0.02), HOMA-IR (*r*=0.46, *P*=0.002), the traditional adiposity indices (BMI (*r*=0.51, *P*<0.001), WC (*r*=0.46, *P*<0.001)), and the new adiposity indices (LAP (*r*=0.36, *P*<0.001), VAI (*r*=0.26, *P*=0.009), and TyG (*r*=0.30, *P*=0.003)) are positively correlated with CAP (Table 2).

To further explore the strength of the associations between adiposity indices with CAP, the partial correlation analysis was introduced with controlling for age, BP, ALT, AST, TG, TC, HDL-c, LDL-c, and HOMA-IR (Table 3). The anthropometric adiposity parameters (WC (*r*=0.25, *P*=0.03), BMI (*r*=0.33, *P*=0.003)) still show significantly positively correlated with CAP (Table 3). However, of the three new adiposity indices, only LAP (*r*=0.23, *P*=0.04) is significantly correlated with CAP. Neither VAI (*r*=−0.12,

Table 1 Anthropometric information, biochemical characteristics of women with PCOS in HS group compared with control group.

	Control (*n* = 30)	**HS** (*n* = 71)	***P* value**[a]
Age (years)	26.8 ± 5	27.2 ± 5	0.76
SBP (mmHg)	119 ± 12	122 ± 14	0.28
DBP (mmHg)	82 ± 10	84 ± 10	0.54
BMI (kg/m^2)	25.7 ± 4.9	30.8 ± 4.6	<0.001
Weight status			<0.001
<25 kg/m^2 (*n*, %)	17 (56.7)	7 (9.9)	
25–30 kg/m^2 (*n*, %)	7 (23.3)	22 (31.0)	
≥30 kg/m^2 (*n*, %)	6 (20)	42 (59.1)	
WC (cm)	84.42 ± 10.54	96.48 ± 11.94	<0.001
ALT (U/L)	17 (12–25)	31 (19–58)	<0.001
AST (U/L)	17 (14–18)	21 (16–34)	0.001
FBG (mmol/L)	4.85 ± 0.56	5.15 ± 0.95	0.11
HDL-c (mmol/L)	1.16 (1.01–1.36)	1.19 (1.04–1.30)	0.55
LDL-c (mmol/L)	2.64 ± 0.67	2.82 ± 0.67	0.24
TG (mmol/L)	1.21 (0.81–1.75)	1.48 (1.09–2.04)	0.09
TC (mmol/L)	5.03 ± 0.82	5.14 ± 0.85	0.53
T (ng/dL)	66.04 (46.50–94.79)	55.75 (45.74–78.17)	0.36
LH/FSH ratio	1.69 (0.85–1.87)	1.40 (1.05–1.89)	0.77
HOMA-IR	2.63 (1.68–3.72)	4.16 (2.87–6.20)	0.001
VAI	1.85 (1.12–2.87)	2.51 (1.64–3.46)	0.05
LAP	32.19 (17.91–59.83)	56.31 (33.36–76.81)	0.003
TyG	8.44 ± 0.56	8.73 ± 0.57	0.02
CAP (dB/m)	207.73 ± 34.82	311.99 ± 42.59	<0.001

Values are expressed as mean ± S.D. or median (IQR) or number (percentage).
[a]Differences between two groups were analyzed by the unpaired Student's *t* test or Mann–Whitney test or chi-square test.
ALT, alanine aminotransferase; AST, aspartate aminotransferase; CAP, controlled attenuation parameter; DBP, diastolic pressure; FBG, fasting plasma glucose; FSH, follicle-stimulating hormone; HOMA-IR, homeostasis model assessment of insulin resistance; LAP, lipid accumulation product; LDL-c, low-density lipoprotein cholesterol; LH, luteinizing hormone; SBP, systolic pressure; T, testosterone; TC, total cholesterol; TG, triglycerides; TyG, product of triacylglycerol and glucose; VAI, visceral adiposity index; WC, waist circumference.

Table 2 The correlation of clinical characteristics with CAP in all participants.

	CAP (dB/m)[a]	
	r (*n* = 101)	*P* value
Age (years)	0.07	0.51
SBP (mmHg)	0.20	0.05
DBP (mmHg)	0.16	0.12
BMI (kg/m^2)	0.51	<0.001
WC (cm)	0.46	<0.001
ALT (U/L)	0.48	<0.001
AST (U/L)	0.39	<0.001
FBG (mmol/L)	0.29	0.003
HDL-c (mmol/L)	−0.10	0.33
LDL-c (mmol/L)	0.11	0.28
TG (mmol/L)	0.24	0.02
TC (mmol/L)	0.05	0.60
T (ng/dL)	0.03	0.79
LH/FSH ratio	−0.07	0.51
HOMA-IR	0.46	<0.001
LAP	0.36	<0.001
VAI	0.26	0.009
TyG	0.30	0.003

[a]*P* value for test of significance of the association using the Spearman correlation analysis.
ALT, alanine aminotransferase; AST, aspartate aminotransferase; BMI, body mass index; CAP, controlled attenuation parameter; DBP, diastolic pressure; FBG, fasting plasma glucose; FSH, follicle-stimulating hormone; HDL-c, high-density lipoprotein cholesterol; HOMA-IR, homeostasis model assessment of insulin resistance; LAP, lipid accumulation product; LDL-c, low-density lipoprotein cholesterol; LH, luteinizing hormone; SBP, systolic pressure; T, testosterone; TC, total cholesterol; TG, triglycerides; TyG, product of triacylglycerol and glucose; VAI, visceral adiposity index; WC, waist circumference.

P=0.29) nor TyG (*r*=0.06, *P*=0.57) are associated with CAP (Table 3). While all subjects were allocated into three tertiles of LAP, the two anthropometric adiposity indices (BMI and WC) and the HS parameter (CAP) were gradually elevated with the increase of LAP (*P*<0.001) (Fig. 1).

We further investigated the potential role of the three adiposity indices (LAP, WC, and BMI) in predicting

Table 3 The partial correlation of the adiposity indices with CAP in all participants.

	CAP (dB/m)	
	r (*n* = 80)	*P* value
WC	0.25	0.03
BMI	0.33	0.003
LAP	0.23	0.04
VAI	−0.12	0.29
TyG	0.06	0.57

[a]*P* value adjusted for age, SBP, DBP, ALT, AST, TG, TC, HDL-c, LDL-c, HOMA-IR for test of significance of the association using partial correlation analysis.
BMI, body mass index; CAP, controlled attenuation parameter; LAP, lipid accumulation product; TyG, product of triacylglycerol and glucose; VAI, visceral adiposity index; WC, waist circumference.
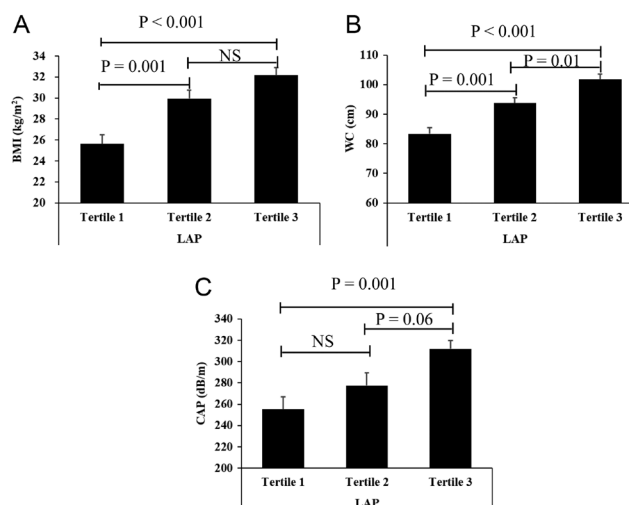
Figure 1
The differences of BMI, WC and CAP between LAP tertiles in women with PCOS.

the risk of HS by performing a multivariable logistic regression analysis (Table 4). After adjusting for age, BP in model 1, the adjusted ORs with associated 95% CI for HS (CAP ≥ 248 dB/m) were 1.04 (1.01–1.06, *P*=0.002) for LAP, 1.11 (1.06–1.18, *P*<0.001) for WC, 1.30 (1.15–1.48, *P*≤0.001) for BMI, respectively. In model 2 and model 3, with additionally adjusting for ALT, AST, TG, TC, LDL-c, HDL-c, and HOMA-IR, the three adiposity indices are still correlated with HS (*P*<0.05) (Table 4). These results

Table 4 Multivariate logistic regression analysis for the association of LAP, WC and BMI with CAP in women with PCOS.

	CAP	
	OR (95%)	*P* value[a]
LAP		
Model 1	1.04 (1.01–1.06)	0.002
Model 2	1.09 (1.03–1.15)	0.003
Model 3	1.09 (1.03–1.16)	0.004
WC		
Model 1	1.11 (1.06–1.18)	<0.001
Model 2	1.13 (1.05–1.22)	0.001
Model 3	1.14 (1.05–1.23)	0.002
BMI		
Model 1	1.30 (1.15–1.48)	<0.001
Model 2	1.27 (1.09–1.48)	0.003
Model 3	1.28 (1.08–1.51)	0.004

[a]*P* values adjusted for different cofounding factors for CAP using multivariate logistic regression analysis. Model 1, adjusted for age, SBP, DBP; Model 2, additionally adjusted for ALT, AST, TG, TC, LDL-c, HDL-c; Model 3, additionally adjusted for HOMA-IR.
BMI, body mass index; CAP, controlled attenuation parameter; DBP, diastolic pressure; HOMA-IR, homeostasis model assessment of insulin resistance; LAP, lipid accumulation product; SBP, systolic pressure; WC, waist circumference.

strongly indicate that the adiposity indices could be useful to predict the risk of HS in women with PCOS.

Discussion

CAP is recently developed as a new ultrasound-based technique for measuring fat content in the liver and is a novel non-invasive method with good diagnostic accuracy for diagnosing liver steatosis (24). In the present study, we report the prevalence of HS diagnosed by CAP ≥248 dB/m was 70.3% in women with PCOS. Meanwhile, there are much higher levels of aminotransferases (ALT and AST), insulin resistance (HOMA-IR), the traditional adiposity indices (WC and BMI), higher percentage of overweight/ obesity subjects, and the new adiposity indices (LAP, TyG, and VAI) in the HS group than that in the control group. Besides, the partial correlation analysis showed only LAP, WC and BMI are correlated with CAP after adjusting for age, BP, liver enzymes, lipid profiles and HOMA-IR. Further, BMI, WC, and CAP were gradually elevated with the increase of LAP level. Finally, the multivariable logistic analysis showed that elevated LAP, WC, and BMI but neither VAI nor TyG, were independently associated with an increase in ORs for HS with PCOS. These data indicate that adiposity indices including LAP, WC, and BMI could predict for fatty liver well in women with PCOS.

Previous studies suggest that the prevalence of NAFLD is remarkably increased in women with PCOS ranging from approximately 35 to 70% (3, 5). Obesity and IR seem to represent common pathogenetic factors of PCOS and NAFLD (2). VAT plays a key role in the association of metabolic risks with IR (25). The three combined metabolic indices LAP, VAI, and TyG have been introduced as indicators of visceral adipose function and IR (15), which also could discriminate prediabetes and diabetes (17). In women with PCOS, LAP, a newly developed biomarker which mainly reflects the abdominal obesity, is associated with IR and MetS in women with PCOS (21, 26, 27). Polyzos *et al.* (28) reported that LAP level is higher in PCOS patients with MetS than that in those without. Also, Vassilatou and colleagues (29) observed that LAP is a useful indicator for detecting NAFLD diagnosed by ultrasonography in Caucasian premenopausal women with PCOS. In the present study, the prevalence rate of HS was 70.3% in women with PCOS, which is consistent with previous studies (30, 31). LAP is also higher in HS group than that in control group, and further LAP could independently predict the risk for HS after controlling for the potential confounding factors. IR contributes to

the pathogenesis of both PCOS and NAFLD. IR assessed by HOMA-IR has been independently associated with NAFLD (5). Obese PCOS women with IR influenced liver function by generating liver steatosis and NAFLD (32). As an abdominal adiposity marker, LAP has the strongest diagnostic accuracy for detection of IR in comparison with BMI, WC and WHR (33). Even in the lean women with PCOS, LAP was promising in early identification of IR (21). By the reduction in HS after both decreased liver fat content and a reduction in TG level, the potential role of LAP was supported in the pathogenesis of NAFLD in patients with PCOS (34). Therefore, LAP appears to represent an inexpensive, readily available, integrated marker of HS risk in patients with PCOS (5).

Previous studies indicated that VAI was useful as a predictor for diabetes (35) and cardiometabolic disease risk (36). However, there is some controversy regarding of the association between VAI and NAFLD. In recent two reports, the researchers found that VAI was associated with IR but not with steatosis in patients with NAFLD proven by liver biopsy (37, 38), meaning VAI may not be a good tool to predict NAFLD. In the current study, we also did not find the significant difference of VAI between two groups with or without HS. TyG is a simple and clinically useful surrogate marker of HOMA-IR in apparently healthy individuals (39). In a cross-sectional study enrolled asymptomatic women aged 20 to 65 years, Simental-Mendía *et al.* (40) observed that TyG could screen simple steatosis and NASH, as well as that in another cross-sectional study conducted by Zhang *et al*. (41). However, in another cross-sectional study, TyG did not present significant correlations with the presence of NAFLD (42). In our study, we also did not observe the significant predicting effect of TyG for HS assessed by CAP. The possible reason maybe the different study subjects enrolled by different assessment methods for HS.

WC and BMI are the most commonly used as the reliable markers of visceral adiposity and global adiposity, respectively. In Chinese childbearing women with PCOS, Dou *et al.* (43) observed that WC and BMI are valuable in screening of PCOS, and BMI can be used in the diagnosis of PCOS. Also, both community-based retrospective longitudinal cohort study (44) and real-world data (12) indicate that BMI is one of the most useful predictive factors for risk of NAFLD. Similarly, our results showed that both WC and BMI can predict the risk of HS in patients with PCOS.

We should acknowledge the following limitations in the present study. The first limitation was that most of our PCOS patients were overweight/obese with relatively

higher prevalence of HS, which may therefore underestimate the true associations of adiposity indices with HS in PCOS subjects. The second limitation was that our sample size might not have enough power to find significant associations between either VAI or TyG with HS. The third limitation was that the current study is a cross-sectional design. Therefore, a cohort with larger sample size, especially from a prospective cohort study design, should be conducted to validate our findings in future.

Conclusion

In conclusion, the present study demonstrates that in women with PCOS, except for the traditional adiposity indices (WC and BMI), LAP is independently correlated with the risk of HS.

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