

Usefulness of a new anthropometric indicator – VAI (Visceral Adiposity Index) in the evaluation of metabolic and hormonal disorders in women with polycystic ovary syndrome

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Abstract

Background. Visceral adiposity index (VAI) is a new anthropometric indicator that makes it possible to define the risk of obesity-related cardiometabolic complications even before the diagnosis of metabolic syndrome.

Objectives. Evaluating the usefulness of VAI in order to differentiate metabolically unhealthy women (MU-PCOS) and defining the usefulness of this index in everyday practice.

Material and methods. A prospective study was conducted among 43 women who met the Rotterdam criteria for diagnosing polycystic ovarian syndrome. Body composition was measured using bioelectrical impedance analysis. Statistical analysis was performed using STATISTICA v. 10 and relevant statistical tests. The adopted significance level was $p = 0.05$.

Results. Based on the study results, a significant positive correlation was found between the value of VAI and the concentration of insulin ($r = 0.33$; $p < 0.01$), HOMA index ($r = 0.46$; $p < 0.01$) and FAI ($r = 0.54$; $p < 0.01$). It was also shown that there is a significant negative correlation between VAI and the concentration of SHBG ($r = -0.53$; $p < 0.01$) and HDL cholesterol ($r = -0.88$; $p < 0.01$). In the group of metabolically unhealthy women, the research showed a significantly higher value of free testosterone, SHBG, DHEAS and FAI ($p < 0.05$).

Conclusions. Visceral adiposity index makes it possible to introduce early prevention of metabolic disorders (including cardiometabolic disorders), as well as to evaluate the increase of hyperandrogenemia in women with polycystic ovary syndrome. The use of the cut-off point of $VAI = 1.675$ is a simple way to evaluate women with MU-PCOS.

Key words: polycystic ovarian syndrome, visceral adiposity index, metabolic disorders

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Background

Visceral adiposity index (VAI) is a recent anthropometric indicator indirectly reflecting the risk of obesity-related cardiometabolic complications. Its application allows early evaluation of such risk, even prior to diagnosing overt metabolic syndrome.¹ VAI can be considered a marker of adipose tissue dysfunction as it provides reliable data when used in the general population and in patients with polycystic ovary syndrome, acromegaly, type 2 diabetes, viral hepatitis C, non-alcoholic fatty liver diseases.¹ This index allows accurate identification of visceral adipose tissue in women with polycystic ovary syndrome, determining intra-abdominal adipose tissue content in a similar way to a computed tomography (CT) scan performed in this group of female patients.² VAI is an empirical-mathematical model, gender-specific and based on anthropometric measurements, such as BMI and waist circumference, and biochemical parameters, namely triglyceride (TG) and high-density lipoprotein cholesterol (HDL-C) concentrations.³

Fig. 1 illustrates the formula of the visceral adiposity index for women.

Fig.1. Waist circumference (cm), BMI (kg/m²), TG (mmol/L), HDL (mmol/L)

$$VAI = \left(\frac{\text{waist circumference}}{36.58 + (1.86 \times \text{BMI})} \right) \times \left(\frac{\text{TG}}{0.81} \right) \times \left(\frac{1.52}{\text{HDL}} \right)$$

Polycystic ovary syndrome (PCOS) manifests itself in menstrual disorders, clinical and biochemical hyperandrogenism and polycystic ovaries on ultrasound. In addition, it is also responsible for higher risk of cardiovascular diseases, impaired glucose tolerance and type 2 diabetes.⁴ Insulin resistance and android (abdominal) obesity in PCOS women are not always associated with increased BMI. Excess body weight is not necessary for increased cardiometabolic risk to occur in this group of patients, however it leads to the exacerbation of clinical symptoms of the syndrome in question.⁵ Since VAI is a simple and easy method for evaluation of cardiometabolic risk, it can be a useful tool for the assessment of metabolic risk related to visceral obesity both in everyday medical practice and in population studies. Values of VAI > 1.675 make it possible to differentiate women with metabolically unhealthy polycystic ovary syndrome (MU-PCOS) from women with metabolically healthy polycystic ovary syndrome (MH-PCOS). Nevertheless, the index should not be used for individuals who are under 16 years of age, who have morbid obesity (BMI > 40 kg/m²), who are diagnosed with pendulous abdominal skin folds or hypertriglyceridemia, nor in subjects who are being treated with fibrates and/or are following a low-energy diet.¹

Objectives

Application of the cut-off point for VAI = 1.675 in order to distinguish women with metabolically unhealthy polycystic ovary syndrome (MU-PCOS) and to determine the usefulness of the index in question among women diagnosed with polycystic ovary syndrome in everyday clinical practice.

Material and methods

The prospective study was conducted among 43 women hospitalized at the Department of Endocrinology and Gynecology of Silesian University, and fulfilling the Rotterdam criteria for diagnosing polycystic ovary syndrome. The diagnosis of the syndrome had to include at least 2 of the following 3 criteria: oligoovulation or anovulation, clinical and/or biochemical hyperandrogenism, polycystic ovaries on ultrasound after exclusion of other causes of the above-mentioned symptoms. The exclusion criteria applied in the study were: diagnosis of androgen excess disorders (congenital or late-onset congenital adrenal hyperplasia, androgen-secreting tumors, Cushing's disease/syndrome, hyperprolactinemia, idiopathic hirsutism), uncontrolled thyroid disorders, mental disorders, morbid obesity (BMI > 40 kg/m²), pendulous abdominal skin folds, hypertriglyceridemia, low-energy diet, use of hormonal contraception in the past 6 months, taking fibrates or steroids, and being over the age of 40.

Prior to conducting the actual studies, the consent of the Bioethics Committee was obtained, no. KNW/0022/KBI/53/14, dated June 3rd, 2014. Body composition was evaluated by bioelectrical impedance analysis utilizing a Tanita BC-420 MA Body Composition Analyzer (product in accordance with the Medical Device Directive MDD 93/42 EEC). The standard anthropometric measurement method was applied for the circumference of the waist, hips, wrist, shoulder and calf. A stadiometer (Tanita HR-100 Height Rod) was used to measure body height. Waist-to-hip ratio (WHR) was adopted in the study. It can be calculated by dividing the waist circumference (in cm) at the umbilical level by the hip circumference (in cm) at the superior iliac spine level. Values higher than or equal to 0.85 indicate abdominal obesity and lower than 0.85 gluteal-femoral obesity. The value of waist-to-height ratio (WHtR) was obtained by dividing the waist circumference (in cm) at the umbilical level by the body height (in cm). Results higher than 0.5 indicate increased risk of obesity-related cardiovascular diseases.

Blood samples were collected in the morning during routine patient examinations in the ward. The tests were performed by means of the immunoenzymatic method (ELISA) using commercial test kits in an accredited analytical laboratory monitored by the external quality as-

surance programs. Laboratory blood tests included complete lipidogram, levels of glucose, total testosterone, free testosterone, sex hormone binding globulin (SHBG), dehydroepiandrosterone (DHEAS), insulin, homeostatic model assessment of insulin resistance (HOMA-IR), and free androgen index (FAI).

The studied women were divided into 2 groups with metabolically healthy polycystic ovary syndrome (MH-PCOS; VAI < 1.675) and metabolically unhealthy polycystic ovary syndrome (MU-PCOS; VAI > 1.675). The statistical analysis of the obtained results was conducted with STATISTICA v. 10.0. The Shapiro-Wilk test was utilized to verify normal distribution for the analyzed variables. Statistical tests to verify particular study hypotheses were properly selected in order to reveal differences or correlations between the variables. For the differences between the study groups to be determined, the following tests were applied: the Student's *t*-test (normal distribution) and the Mann-Whitney *U*-test (abnormal distribution). The results showing normal distribution were expressed as an average value (\bar{x}) \pm standard deviation (SD). The parameters with abnormal distribution were expressed as median and interquartile ranges. For assessment of the correlations between the analyzed variables, the Spearman rank correlation was used. The significance level of $p = 0.05$ was adopted.

Results

The study was carried out in a group of women at the age of 18–38 (26.52 ± 5.73). The average values of the selected anthropometric parameters were as follows: body weight 73.54 ± 19.07 kg; waist circumference 87.07 ± 16.58 cm; BMI 27.16 ± 6.91 kg/m²; WHR 0.82 ± 0.08 ; WHtR 0.53 ± 0.1 ; fat mass percentage (FM%) 34.01 ± 9.7 . Table 1 illustrates the detailed characteristics of the MH-PCOS and MU-PCOS women.

Table 1. Comparison of data from patient groups before and after the operation

Parameters	MH-PCOS (n = 28)	MU-PCOS (n = 15)	p-value
Age (years)	26 (22.5–31)	25.27 \pm 5.57	0.3021
Body weight (kg)	61.3 (54.9–70.25)	89.8 (74–103.2)	< 0.01
Waist circumference (cm)	79.52 \pm 11.9	100.5 \pm 16.03	< 0.01
BMI (kg/m ²)	22.85 (20.7–25.25)	32.61 \pm 6.44	< 0.01
WHR	0.78 \pm 0.06	0.89 \pm 0.08	< 0.01
WHtR	0.47 (0.43–0.52)	0.62 \pm 0.09	< 0.01
FM%	29.77 \pm 7.98	42.9 (37–46.1)	< 0.01

FM% – fat mass percentage.

Significant differences were revealed between the study groups of women, which concerned the average values of the following anthropometric parameters and indicators: body weight, waist circumference, BMI, WHR, WHtR and FM%. The average values of the analyzed tests were significantly higher in the MU-PCOS group than in the MH-PCOS group ($p < 0.01$).

The study also revealed significant differences between the MH-PCOS and MU-PCOS groups with regard to the average values of the following biochemical studies: concentrations of triglycerides, HDL cholesterol, SHBG, free testosterone, DHEAS and HOMA-IR ($p < 0.05$) (Table 2).

Table 2. Analysis of the differences of the average values of the selected biochemical studies between the groups of MH-PCOS and MU-PCOS women

Parameters	MH-PCOS (n = 28)	MU-PCOS (n = 15)	p-value
Testosterone (nmol/L)	2.01 \pm 0.73	2.15 (1.63–3.12)	0.1327
Free testosterone (pmol/L)	15.19 (11.13–30.93)	32.66 (17.86–44.83)	< 0.05
SHBG (nmol/L)	60 \pm 29.54	27.70 (18.25–52.60)	< 0.05
DHEAS (umol/L)	8.36 \pm 3.41	10.82 \pm 3.21	< 0.05
FAI	3.3 (3.1–5.5)	6.65 (4.8–12.75)	< 0.05
Glucose (mmol/L)	5.0 (4.67–5.22)	5.25 \pm 0.5	0.0647
Insulin (pmol/L)	65.65 (43.05–87.54)	85.31 \pm 37.02	0.2082
HOMA	1.66 (1.0–2.5)	2.72 \pm 1.21	< 0.05
TC (mmol/L)	4.84 \pm 0.63	4.56 \pm 0.67	0.1729
HDL-C (mmol/L)	1.83 \pm 0.39	1.16 (1.09–1.27)	< 0.01
LDL-C (mmol/L)	2.64 \pm 0.66	2.56 \pm 0.68	0.7064
TG (mmol/L)	0.81 \pm 0.26	1.6 (1.37–2.03)	< 0.01

TC – total cholesterol.

The study involved a correlation analysis between VAI and the studied variables for the whole PCOS group ($n = 43$). The analysis showed a positive correlation between the VAI value and body weight ($r = 0.69$; $p < 0.01$), WHR ($r = 0.67$; $p < 0.01$), WHtR ($r = 0.72$; $p < 0.01$) and visceral adipose tissue ($r = 0.69$; $p < 0.01$), as well as FM% ($r = 0.69$; $p < 0.01$). The correlation analysis was also performed for biochemical studies (Table 3).

It was found that, along with an increase in the VAI value, the concentrations of insulin, triglycerides, HOMA-IR and FAI also significantly increased ($p < 0.05$). A negative correlation was reported between VAI and serum HDL cholesterol and SHGB concentrations ($p < 0.01$). No significant

Table 3. Evaluation of the correlations between the VAI value and the selected biochemical studies in the study groups of women (n = 43)

VAI	R*	p-value
Glucose (mmol/L)	0.14	0.3690
Insulin (pmol/L)	0.33	< 0.05
TC (mmol/L)	-0.13	0.4016
HDL-C (mmol/L)	-0.88	< 0.01
LDL-C (mmol/L)	0.09	0.5878
TG (mmol/L)	0.94	< 0.01
SHBG (nmol/L)	-0.53	< 0.01
Testosterone (nmol/L)	0.20	0.2053
Free testosterone (pmol/L)	0.30	0.0507
DHEAS (umol/L)	0.30	0.0551
HOMA	0.46	< 0.01
FAI	0.54	< 0.01

*Spearman's rank correlation.

correlations were revealed between VAI and the concentrations of glucose, complete cholesterol, LDL cholesterol, testosterone, free testosterone and DHEAS ($p > 0.05$).

Discussion

VAI, similarly to a computed tomography scan, is an effective indicator of visceral adipose tissue. This was concluded by Jee-Young Oh et al., who had assessed the correlation between VAI and insulin resistance in a group of 180 Korean women with polycystic ovary syndrome. The study revealed a positive correlation between visceral fat area (VFA), measured by a CT scan, and VAI ($r = 0.57$; $p < 0.01$).² The authors of this manuscript found significant dependence between VAI and the indicator of visceral adipose tissue measured by the bioelectrical impedance analysis. In another study, which comprised a group of 193 women with PCOS, Androulakis II et al. observed a significant positive correlation between VAI and the concentrations of insulin ($r = 0.57$; $p < 0.01$), SHBG ($r = -0.22$; $p < 0.05$) and HOMA-IR ($r = 0.55$, $p < 0.01$). The same observation was made by the authors of this paper. The authors of the quoted study revealed significantly higher values of VAI and HOMA in the group of PCOS women with menstrual disorders versus the female group with normal ovulation.⁷ In the research conducted by the authors of this manuscript, the studied women were not divided according to menstrual disorders.

Amato MC et al., relying on studies conducted in a group of 224 women with PCOS, found that in addition to the fasting plasma glucose level, VAI value and DHEAS concentration can also be considered useful in determining the risk of diabetes in the screening tests for all women with polycystic ovary syndrome.⁸ The authors of this manuscript did not reveal a significant dependence between VAI and the fasting plasma glucose level. Such a correlation, however, was found between insulin and HOMA concentrations ($p < 0.05$). Moreover, a correlation analysis between VAI and FAI was performed. On the basis of the results obtained, it can be claimed that the index in question is also an effective tool in assessing the severity of hyperandrogenemia in PCOS women. The correlation results between VAI and FAI have not been published by other researchers as yet. Very few studies have evaluated the usefulness of VAI in PCOS women. Therefore, it is necessary to carry out reliable, large population-based studies among European women diagnosed with polycystic ovary syndrome.

Conclusions

Following the studies conducted by the authors of this manuscript, it may be concluded that utilizing VAI during routine medical examinations makes possible early prevention of metabolic disorders (including cardiometabolic disorders), as well as assessment of hyperandrogenemia severity in women with polycystic ovary syndrome. The cut-off point for VAI = 1.675 is an easy tool for evaluating women with metabolically unhealthy polycystic ovary syndrome (MU-PCOS).

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