ORIGINAL RESEARCH

# Visceral Adiposity Index as a Predictor of Chronic Kidney Disease in a Relatively Healthy Population in Taiwan

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**Objectives:** Abdominal obesity is an independent risk factor for cardiovascular disease and chronic kidney disease (CKD). Visceral adiposity index (VAI), a simple formula representing visceral adipose dysfunction, has already been proven to have a strong correlation with various cardiometabolic disorders. Limited studies are available regarding the relationship between VAI and renal function decline. Therefore, the purpose of this study was to evaluate the relationship between VAI and renal function and to estimate the risk of chronic kidney disease in a relatively healthy adult population in Taiwan.

**Design:** The design of the study is retrospective cross-sectional analysis.

**Subjects:** This study involved 23,570 subjects aged ≥18 years who underwent annual heath checkups between January and December 2013. A multivariate logistic regression model was used to assess the relationship between VAI and CKD. Receiver-operating characteristic curve and Youden index were developed to determine the discrimination power of VAI for metabolic syndrome and CKD.

**Intervention:** None, observational study.

**Main outcome measure:** The main outcome measure of this study was CKD.

**Results:** In our study, the adjusted odds ratio (OR) of abnormal VAI for CKD was 1.5 (95% confidence interval [CI], 1.08-2.08; $P = .016$) in all subjects. A higher VAI was superior in association with CKD in men than women (OR, 1.62; 95% CI, 1.13-2.32; $P = .009$ vs. OR, 1.28; 95% CI, 0.66-2.47; $P = .469$, respectively). The area under the curve for VAI was 0.694 (95% CI, 0.660-0.729; $P < .001$), and using a Youden index with a cut-off VAI value of 2.96 for CKD discrimination obtained a sensitivity of 67.7% and specificity of 65.1%.

**Conclusions:** A higher VAI score was associated with increased risks of CKD. VAI would be an applicable tool for early detection of CKD in relatively healthy adults in Taiwan, especially men.



## Introduction

MANY STUDIES HAVE demonstrated that there is a strong association between chronic kidney disease (CKD) and obesity. The prevalence of CKD increases with increasing body mass index (BMI) after adjusting for diabetes and hypertension. According to a United States Renal Data System report, Taiwan had the highest prevalence of treated end-stage renal disease in 2013.[1] Early recognition and management of CKD are critical.

In light of the impact of obesity on chronic systemic disease, the distribution of adipose tissue is rather important. Abdominal obesity and dysfunctional visceral fat, resulting in insulin resistance and an increased hypertension and diabetes risk, are key components of cardiometabolic disease.[2] As many studies have proven, compared with subcutaneous adipose tissue (SAT), visceral adipose tissue (VAT) is a more prominent contributor to cardiometabolic problems including metabolic syndrome (MetS), insulin resistance, dyslipidemia, and elevated liver enzyme.[3–5] Furthermore, cytokines secreted by VAT may contribute to inflammatory status, glomerular sclerosis, and further renal function impairment.[6]

Waist circumference (WC) and waist-to-hip ratio (WHR) are the most commonly used methods to measure abdominal obesity. However, both WC and WHR have limited accuracy in distinguishing between VAT and SAT. However, computed tomography and magnetic resonance imaging are not recommended for the quantitative evaluation of VAT and SAT in routine practice because of radiation exposure and the expense. Therefore, an easily applicable marker to measure body fat distribution and

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adipose dysfunction would be important and helpful for clinicians in a practical community survey.

In 2009, Amato and his research group developed the visceral adiposity index (VAI), a mathematical method that used both anthropometric (BMI and WC) and functional (triglycerides [TGs] and high-density lipoprotein [HDL]) parameters, as a simple surrogate marker representing visceral adipose dysfunction in a Caucasian population.[7] However, few studies have investigated the correlation between VAI and CKD. Research regarding the application of VAI to non-Caucasian populations and the relationship between VAI and CKD is still limited.

Therefore, the aim of this study was to apply the VAI to a Taiwanese adult population, to evaluate dysfunctional visceral adiposity, to identify the association of VAI with MetS and CKD.

## Subjects and Methods

### Subjects

This retrospective cross-sectional study involved subjects aged ≥18 years who underwent annual health checkups between January and December 2013. Subjects with incomplete data; a history of chronic disease or a medication that might alter their metabolic state or kidney function test (e.g., thyroid or hypothalamic diseases, adrenal disease, renal cancer, glomerulonephritis, renal failure on renal replacement therapy, liver cirrhosis, or diuretics use); who were pregnant; who did not complete the questionnaire; and/or who did not respond to questions regarding their medical, medication, or smoking history were excluded from the study. Informed consent was obtained from all participants. The Institutional Review Board of Chang Gung Memorial Hospital approved this study before recruiting the participants.

**Table 1.** Characteristics Represented Across VAI Quartiles (N = 23,570)

| | Total | | | | |
|---|---|---|---|---|---|
| | Q1 | Q2 | Q3 | Q4 | |
| Characteristics | (n = 5,893) | (n = 5,892) | (n = 5,893) | (n = 5,892) | *P* for Trend |
| VAI | 1.194 (1.002, 1.355) | 1.862 (1.680, 2.055)* | 2.834 (2.526, 3.211)*,† | 5.319 (4.339, 7.217)*,†,‡ | <.001§ |
| Age | 37 (33, 41) | 38 (35, 43)* | 39 (35, 44)*,† | 41 (37, 46)*,†,§ | <.001§ |
| BMI (kg/m$^2$) | 20.9 (19.2, 22.8) | 22.0 (20.1, 24.2)* | 23.6 (21.5, 25.9)*,† | 25.7 (23.5, 28.2)*,†,‡ | <0.001§ |
| Waist circumference (cm) | 70.0 (64.5, 76) | 74.0 (67.6, 81.0)* | 79.5 (72.5, 86.0)*,† | 85.5 (80.0, 92.0)*,†,‡ | <.001§ |
| SBP (mm Hg) | 113 (106, 122) | 116 (107, 125)* | 119 (111, 129)*,† | 124 (116, 134)*,†,‡ | <0.001§ |
| DBP (mm Hg) | 71 (66, 77) | 72 (67, 79)* | 75 (69, 81)*,† | 79 (73, 85)*,†,‡ | <.001§ |
| Total cholesterol (mg/dL) | 169 (152, 187) | 172 (154, 191)* | 179 (160, 200)*,† | 193 (171, 215)*,†,‡ | <.001§ |
| Triglycerides (mg/dL) | 53 (46, 62) | 75 (66, 85)* | 105 (91, 120)*,† | 175 (144, 226)*,†,‡ | <.001§ |
| HDL cholesterol (mg/dL) | 67 (60, 75) | 58 (52, 65)* | 51 (46, 57)*,† | 43 (39, 49)*,†,‡ | <.001§ |
| TG/HDL | 0.80 (0.67, 0.95) | 1.28 (1.08, 1.53)* | 2.04 (1.72, 2.41)*,† | 3.93 (3.17, 5.38)*,†,‡ | <.001§ |
| Chol/HDL | 2.49 (2.24, 2.80) | 2.93 (2.60, 3.31)* | 3.47 (3.02, 3.96)*,† | 4.39 (3.85, 5.04)*,†,‡ | <.001§ |
| Fasting glucose (mg/dL) | 85 (81, 89) | 86 (82, 90)* | 87 (83, 92)*,† | 89 (85, 95)*,†,‡ | <.001§ |
| Smoking (n, %) | | | | | |
| Current/previous smokers | 1,088 (18.5) | 1,216 (20.6) | 1,483 (25.2) | 1,874 (31.8) | <.001§ |
| None | 4,805 (81.5) | 4,676 (79.4) | 4,410 (74.8) | 4,018 (68.2) | <.001§ |
| Creatinine (mg/dL) | 0.9 (0.8, 1.1) | 0.9 (0.8, 1.1)* | 1.0 (0.8, 1.1)*,† | 1.0 (0.9, 1.2)*,†,‡ | <.001§ |
| eGFR (mL/min/1.73 m$^2$) | 90 (81, 97) | 86 (79, 95)* | 83 (77, 93)*,† | 81 (74, 91)*,†,‡ | <.001§ |
| CKD (n, %) | | | | | |
| eGFR<60 | 23 (0.4) | 32 (0.5) | 54 (0.9) | 123 (2.1) | <.001§ |
| eGFR ≥60 | 5,870 (99.6) | 5,860 (99.5) | 5,839 (99.1) | 5,768 (97.9) | <.001§ |
| Uric acid (mg/dL) | 5.0 (4.2, 6.1) | 5.4 (4.4, 6.4)* | 5.9 (4.9, 7.0)*,† | 6.6 (5.6, 7.7)*,†,‡ | <.001§ |
| MetS (n, %) | | | | | |
| Present | 9 (0.2) | 35 (0.6) | 187 (3.2) | 1,987 (33.7) | <.001§ |
| Absent | 5,884 (99.8) | 5,857 (99.4) | 5,706 (96.8) | 3,905 (66.3) | <.001§ |

BMI, body mass index; CKD, chronic kidney disease; DBP, diastolic blood pressure; eGFR, estimated glomerular filtration rate; HDL, high-density lipoprotein lipase cholesterol; hsCRP, high-sensitivity C-reactive protein; MetS, metabolic syndrome; SBP, systolic blood pressure; VAI, visceral adiposity index.

Continuous data are reported as median (interquartile range) and compared using the Kruskal–Wallis Test; Nominal data are shown as number (percentage) and compared using the Chi-square test. Ordinal data are shown as number (percentage) and compared using the Kruskal–Wallis test.

*Significant difference compared with the first quartile.

†Significant difference compared with the second quartile.

‡Significant difference compared with the third quartile.

§Significance for trend.