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Nonlinear Dynamics of Red Blood Cell Distribution Width and Visceral Adiposity Index: Insights from the 2005-2018 NHANES Data

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Abstract

Background

Red blood cell distribution width (RDW) has been widely associated with inflammation and metabolic disorders. However, its relationship with the visceral adiposity index (VAI) remains unexplored in adult populations. This study aimed to investigate the association between RDW and VAI using data from a nationally representative cohort.

Methods

We analyzed data from 14,568 adults aged 20 years and older who participated in the National Health and Nutrition Examination Survey (NHANES) from 2005 to 2018, with complete RDW and VAI data. Linear regression analysis, curve fitting, threshold effect analysis, and subgroup analysis were employed to examine the relationship between RDW and VAI.

Results

Multivariate linear regression revealed a significant inverse association between RDW and VAI (β = -0.56; 95% confidence interval: -0.84 to -0.28). Subgroup analyses and interaction tests indicated that this inverse relationship was more pronounced in male hypertensive patients. A nonlinear approach incorporating smoothed curve modeling and threshold effect evaluation revealed an inflection point at RDW = 12.9%.

Conclusions

RDW is inversely associated with VAI, particularly in male hypertensive patients. The results indicate that RDW could be a valuable and cost-effective indicator for identifying metabolic dysfunction and visceral adiposity in high-risk populations.

Introduction

Obesity represents a major public health concern in the United States (US), affecting 41% of adults and 19.7% of children (Valentine and Nikolajczyk, 2024). The association between obesity and elevated mortality rates, as well as a wide range of health issues, such as diabetes, hypertension, cardiovascular diseases, metabolic syndrome, and certain cancers, is well established (Sun et al., 2022). These health challenges underscore the critical need for effective obesity prevention and management strategies. Growing evidence suggests that visceral fat, as opposed to subcutaneous fat, is more strongly linked to a variety of negative outcomes associated with obesity (Fukuda et al., 2018). The visceral adiposity index (VAI) is a method for estimating visceral fat based on straightforward body measurements and metabolic parameters, calculated using body mass index (BMI), waist circumference (WC), triglycerides levels (TG), and high-density lipoprotein cholesterol (HDL-C) (Ávila et al., 2024).

Earlier research has identified a robust association between the VAI and visceral fat quantified by magnetic resonance imaging (MRI), and it is considered a reliable proxy marker for adipose tissue distribution and metabolic function (Amato et al., 2010). Compared to traditional obesity indices, the VAI shows a stronger correlation and greater reliability in predicting health risks, including metabolic dysfunction, glucose metabolism disorders, and cardiometabolic conditions (D. Chen et al., 2024; J. Chen et al., 2024; Huang et al., 2024).

Red cell distribution width (RDW) is a key indicator in a standard complete blood test, reflecting variations in red blood cell size (Zhou et al., 2021). In recent years, RDW has gained increasing attention in medical research. RDW

values are commonly observed to fall within the interval of 11.5% to 14.5%. (Zhang et al., 2023). Traditionally, RDW is considered part of routine anemia evaluation, particularly in iron deficiency anemia (Malandrino et al., 2012; Salvagno et al., 2015; Szczepanek-Parulska et al., 2017). Additionally, RDW's ease of measurement and low cost make it a valuable tool for assessing inflammation in clinical practice. As a potential marker of inflammation, RDW has demonstrated predictive value across various diseases. Research suggests that elevated RDW may indicate abnormal red blood cell production under inflammatory conditions or represent a manifestation of systemic inflammation and chronic disease (Lippi et al., 2009). For instance, in cardiovascular diseases, increased RDW is strongly correlated with the initiation and progression of atherosclerosis, cardiac insufficiency, and coronary artery disease (Fava et al., 2019). Similarly, the association of RDW with inflammation has been extensively validated across various conditions, including diabetes, chronic kidney disease, infectious diseases, and cancer (Ferreira et al., 2021; Wei et al., 2020; Wen et al., 2022; Yilmaz and Sozel, 2021).

Obesity, particularly the excessive accumulation of visceral fat, plays a significant role in driving persistent mild inflammation (Kolb, 2022). Visceral fat secretes a range of cytokines and hormones, along with adiponectin, which contribute to a systemic chronic inflammatory response (Millar et al., 2024). Nevertheless, the association between RDW and VAI is still not well understood. Consequently, we performed a study employing a cross-sectional design and using data from the US population through the National Health and Nutrition Examination Survey (NHANES) 2005–2018 sample to examine the association of RDW with VAI and determine the significance of RDW in predicting obesity.

Materials and methods

Study population

The NHANES represents a significant, ongoing cross-sectional study conducted in the US to provide objective data regarding health-related issues and address emerging public health concerns (Curtin et al., 2012). Each participant provided written informed consent and trained healthcare professionals conducted data collection. This study utilizes data from the 2005–2018 wave of the NHANES. A total of 30,441 participants younger than 20 years, 3,488 participants missing RDW data, 479 lacking BMI data, 1,386 without WC data, 18,039 without TG data, 300 pregnant individuals, and 1,489

individuals previously diagnosed with cancer were excluded. 14568 people were enrolled in the research. The sample selection workflow is depicted in Fig. 1.

Red blood cell distribution width

RDW was assessed using a Coulter analyzer at the Mobile Examination Centers (MECs). RDW was determined based on the fluctuations in erythrocyte size distribution, measured as the coefficient of variation, and presented as a percentage, with a normal range of 11.5% to 14.5% (Ani and Ovbiagele, 2009; Gunter and McQuillan, 1990). This study examined RDW as both a continuous and categorical variable, divided into quartiles (Q1 = 9.7%–12.4%, Q2 = 12.4%–12.9%, Q3 = 13%–13.7%, Q4 = 13.8%–37.8%).

Visceral Adiposity Index

The VAI is formulated as an assessment tool for visceral fat functionality, integrating variables such as WC, BMI, TG, and HDL-C. This index is obtained through a formula tailored to sex differences, where TG and HDL-C are quantified in millimoles per liter, BMI in kilograms per square meter, and WC in centimeters.

$$\text{For Men} VAI = \frac{WC}{(39.68 + 1.88 \times BMI)} \times \frac{TG}{1.03} + \frac{1.31}{HDL - C}$$

$$\text{For Women} VAI = \frac{WC}{(36.58 + 1.89 \times BMI)} \times \frac{TG}{0.81} + \frac{1.52}{HDL - C}$$

Covariables

Our study also included covariates that may influence the relationship between RDW and VAI, including age (in years), gender (male/female), racial/ethnic background (Non-Hispanic White, Non-Hispanic Black, Mexican American, Other races), education level (less than high school/more than high school), poverty-to-income ratio (less than 1.5/1.5–3.5/greater than 3.5), marital status (married/in a domestic partnership/widowed/divorced/separated/never married), smoking at least 100 cigarettes (yes/no), physical activity (yes/no), and hypertension. Hypertension was defined by meeting at least one of the following criteria: (1) physician-diagnosed hypertension; (2) ongoing use of antihypertensive drugs; or (3) hypertension is defined as systolic pressure ≥ 140 mmHg or diastolic pressure ≥ 90 mmHg (Gou et al., 2022). Diabetes was diagnosed based on the fulfillment of at least one of the specified criteria: (1) diagnosis by a physician; (2) ongoing use of antidiabetic drugs; (3) HbA1c level ≥ 6.5%; or (4) fasting blood glucose concentration of 7.0 mmol/L or higher (Gou et al., 2022). Additional covariates comprised BMI (kg/m^2, less than 1.5/1.5–3.5/greater than 3.5), alcohol consumption (average number of drinking days in the past year), HDL-C, TG, LDL (low-density lipoprotein), and total cholesterol (all in mg/dL), waist circumference measured in centimeters, white blood cell count reported as 1000 cells per microliter (μL), and hematocrit (%).

Statistical analysis

The NHANES employed a multi-stage sampling design; thus, appropriate weights were applied in all statistical analyses to ensure nationally representative results. Categorical data are shown as percentages (%), whereas continuous data are summarized as means ± standard error (SE). Group comparisons were carried out using one-way analysis of variance (ANOVA) for continuous measures and chi-square tests for categorical measures, with a significance level set at $p < 0.05$. Linear regression analyses were conducted to examine the relationships among RDW, RDW quartiles, and VAI, with results reported as regression coefficients (β), 95% confidence intervals (CI), and linear trends. A smoothing spline regression model was used to investigate the non-linear relationship between RDW and VAI, while a two-piecewise linear regression model identified the inflection point, with model fit evaluated using log-likelihood ratio tests. Subgroup analyses were performed to assess RDW-VAI associations across categories of sex, age, race/ethnicity, physical activity, smoking status, hypertension, diabetes, and BMI, with interaction tests evaluating consistency across subgroups. All statistical analyses were conducted using R software (version 4.2.2) and EmpowerStats (version 4.2).

Ethics approval and consent to participate

The NHANES study protocol was approved by the National Center for Health Statistics Research Ethics Review Board. All participants provided written informed consent. The present study analyzed de-identified publicly available data and was conducted in accordance with the Declaration of Helsinki. No additional ethical approval was required.

Results

Baseline characteristics

Table 1 outlines the initial participant characteristics stratified by RDW quartile groups. This study included 14,568 participants, with an average age of 48.34 ± 17.11 years, of which 50.29% were female. The ranges of RDW for tertiles 1-4 were 9.7-12.4, 12.4-12.9, 13-13.7 and 13.8-37.8, respectively. The mean RDW for all participants was 13.28±1.36 and the mean VAI was 4.62±5.81. A statistically significant variation was observed across the RDW quartiles regarding age, gender, race, educational attainment, income-to-poverty ratio, marital status, smoking history, physical activity, hypertension, diabetes, BMI, alcohol use, triglyceride, LDL, total cholesterol, waist circumference, white blood cell count, hematocrit, and VAI (all $p < 0.05$). In our study, participants with higher RDW levels tended to be older, female, non-Hispanic white, high school educated, with poverty-to-income ratios of 1.5-3.5, married or in a partner, no smoking at least 100 cigarettes, no physical activity, no hypertension, no diabetes, BMI≥30 kg/m^2, low frequency of alcohol consumption, to have higher values in waist circumference and white blood cell count, and to have lower values in triglyceride, LDL, total cholesterol and hematocrit than those of the other subgroups (all $p < 0.05$).

Association between the RDW and VAI

In this study, a multiple linear regression analysis was employed to explore the association between RDW and VAI. As presented in Table 2. Higher RDW values were significantly associated with lower VAI levels. Treating RDW as a continuous variable, each one-unit increase was linked to a reduction in VAI by β= -0.09 (95% CI: -0.16 to -0.02), β= -0.05 (95% CI: -0.12 to 0.02), and β= -0.13 (95% CI: -0.21 to -0.05) in the unadjusted, minimally adjusted, and fully adjusted models, respectively. RDW was additionally transformed from a continuous variable into quartiles as a categorical variable. The computed beta coefficients corresponding to the second, third, and top quartile of RDW showed a decrease of β= -0.45 (95% CI: -0.70 to -0.19), β= -0.57 (95% CI: -0.81 to -0.33), and β= -0.56 (95% CI: -0.84 to -0.28), respectively, when compared to the lowest grouping (quartile 1). Across all three models, a statistically significant trend was observed ($p < 0.001$). Additionally, the results from the smoothed curve fitting (Fig. 2) demonstrated a U-shaped relationship between RDW and VAI, with 12.9 identified as the inflection point (Table 3).

Subgroup analyses

Interaction assessments and subgroup evaluations were carried out, focusing on variables such as age, gender, racial background, physical activity, smoking history, hypertension, diabetes, and BMI to assess whether the association between RDW and VAI holds across broader populations and to identify any potential differences related to population characteristics. As shown in Table 4, our results indicate that these associations are not consistent. A significant interaction between RDW and VAI was observed in the subgroups characterized by sex and hypertension ($p < 0.05$), whereas no statistically significant relationship was detected in the subgroups defined by age, race, physical activity, smoking history (at least 100 cigarettes), diabetes, and BMI. Specifically, we found that the negative correlation between RDW and VAI was significant among male patients (β = -0.29, 95% CI: -0.43 to -0.15, p for interaction = 0.0202)(Fig. 3).

Although a negative correlation was also observed among female patients (β = -0.09, 95% CI= -0.18 to -0.00), it was less pronounced. Additionally, the negative correlation between RDW and VAI was significant among hypertensive patients (β = -0.25, 95% CI: -0.38 to -0.13, p for interaction = 0.0220), as shown in Figure 4. Therefore, our findings suggest that the association showing an inverse trend between RDW and VAI may be more applicable to male patients with hypertension.

Discussion

This study demonstrates a significant inverse association between RDW and VAI, with a more pronounced effect observed in male hypertensive patients. Additionally, a nonlinear pattern was identified, with a critical inflection point at RDW = 12.9%. This study appears to be the first to examine the relationship between RDW and VAI in a nationally representative adult population, highlighting the potential role of RDW as a metabolic health marker.

Numerous studies have established RDW as an inflammatory marker associated with several metabolic conditions, such as obesity, diabetes, and metabolic syndrome (MetS). However, previous findings regarding the association between RDW and MetS have been inconsistent. For instance, a large-scale cross-sectional study of 217,567 Spanish workers found a significant positive association between elevated RDW levels and MetS, although RDW exhibited limited diagnostic utility in this context (Sánchez-Chaparro et al., 2010). Similarly, a study of 3,529 patients undergoing coronary angiography reported that an RDW ≥14% was significantly associated with MetS, with a 1.8-fold increased risk of hypertension (Laufer Perl et al., 2015). These studies suggest that elevated RDW may reflect increased metabolic risk. However, contradictory findings have also been reported. For example, an animal model study demonstrated that high-fat diet-induced weight gain did not necessarily lead to higher RDW levels, suggesting a context-dependent relationship between RDW and metabolic factors (Fujita et al., 2013). Furthermore, a Swedish cohort study involving 26,709 non-diabetic participants found that insulin, glucose, HOMA, waist circumference, and triglyceride levels were inversely correlated with RDW, indicating that higher RDW levels might be associated with a healthier metabolic profile in certain populations (Engström et al., 2014). These discrepancies highlight the complex and multifactorial nature of RDW's relationship with metabolic health, suggesting that its role may vary depending on population characteristics and study design. Building on these insights, our study further investigated the relationship between RDW and VAI and found that a significant inverse correlation exists between them.

This study identified a significant inverse association between RDW and VAI, which may be influenced by multiple factors, including systemic inflammation, oxidative stress, erythropoiesis regulation, and metabolic dysfunction. RDW is a well-established marker of systemic inflammation and oxidative stress (Cao et al., 2024), both of which play critical roles in visceral fat accumulation and metabolic abnormalities. According to Ananthaseran S. et al., excessive oxidative stress accelerates erythrocyte senescence and enhances phagocytic clearance, leading to increased RDW variability (Kiefer and Snyder, 2000). Furthermore, inflammatory cytokines such as IL-6 and TNF-α have been shown to suppress erythropoiesis while stimulating neutrophil and platelet production, further influencing RDW levels (Ananthaseshan et al., 2022). In the context of visceral fat accumulation, chronic low-grade inflammation may disrupt the erythropoiesis process, thereby affecting RDW levels. Furthermore, this study identified a nonlinear relationship between RDW and VAI. When RDW was below 12.9%, it exhibited a significant negative correlation with VAI. A lower RDW may indicate that the body maintains a relatively stable erythropoiesis process, accompanied by lower systemic inflammation levels. Under these conditions, fat metabolism is likely more balanced, and adipose tissue function remains relatively normal. Consequently, despite a lower RDW, VAI does not significantly decrease. However, when RDW exceeds 12.9%, the association between RDW and VAI becomes nonsignificant, potentially due to physiological compensatory mechanisms triggered by increased inflammation and metabolic stress, which may attenuate the direct impact of RDW on visceral fat accumulation.

In this study, RDW was inversely associated with VAI, with this association being particularly pronounced among male patients with hypertension. This finding of gender differences is consistent with other studies. For example, a cross-sectional analysis of an elderly Chinese cohort reported that elevated RDW was linked to a significantly lower risk of MetS in men, while no significant association was observed in women (Yan et al., 2019). This is consistent with our finding that RDW is negatively associated with VAI in men, further supporting a possible protective role for

RDW in men's metabolic health. This may be due to the higher levels of androgens, such as testosterone, in males, which promote erythropoiesis and subsequently increase blood viscosity (Guo et al., 2013; Guo et al., 2015). To accommodate this increased blood viscosity, the body may reduce the RDW by decreasing the generation of immature and irregular red blood cells and making red blood cells more uniform. Another study, similar to our findings, also observed that the RDW was lower in the hypertensive group (Emamian et al., 2017), further supporting the potential specific physiological mechanisms of RDW in hypertensive patients. Among hypertensive individuals, elevated hematocrit and increased erythrocyte production may also result in higher blood viscosity (Taco-Vasquez et al., 2019), and the body adjusts accordingly to lower RDW. Moreover, in response to hypertension-induced oxidative stress, the body may enhance its antioxidant defense mechanisms to mitigate red blood cell membrane damage, maintain erythrocyte uniformity (Krzemińska et al., 2022), and prevent an increase in RDW.

The association between RDW and VAI carries significant clinical implications. First, as a widely available and cost-effective biomarker, RDW may serve as an indirect indicator of metabolic health and visceral fat accumulation. Its routine measurement in clinical practice could facilitate the early identification of individuals at risk for metabolic syndrome, particularly among hypertensive patients. Second, our study suggests that RDW values below 12.9% may be associated with a healthier metabolic profile, highlighting the potential need for defining optimal RDW thresholds for metabolic risk assessment. Additionally, the observed sex differences underscore the importance of considering gender-specific risk factors in metabolic health evaluations.

This study has several notable strengths. The study cohort is population-representative and sufficiently large to enable stratified analyses. It is also one of the first to explore the relationship between RDW and VAI, providing novel insights into the role of RDW in metabolic health. Unlike previous studies that primarily examined linear associations, our study uniquely identifies a nonlinear relationship, with a critical inflection point at RDW = 12.9%. This finding highlights the complexity of RDW’s association with visceral adiposity and suggests that its role may vary across different metabolic states. However, the cross-sectional design limits causal inferences, and residual confounding cannot be entirely ruled out. Future studies should incorporate E-value calculations to assess the potential impact of unmeasured confounders and further validate the clinical significance of RDW as a biomarker for metabolic dysfunction and visceral adiposity.

Declarations

Ethics Approval

The NHANES dataset used in this study is publicly available and was approved by the National Center for Health Statistics Research Ethics Review Board.

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Author Contribution Statement

Conceptualization: Tan Tongcai, Fengfeng Shi. Formal analysis: Tan Tongcai, Wei Yang, Zhitao Xu, Yong Liu. Supervision: Fengfeng Shi, Zhitao Xu. Writing – original draft: Tan Tongcai, Fengfeng Shi. Writing – review & editing: Tan Tongcai, Fengfeng Shi.

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Declaration of Interest

The authors declare that they have no conflict of interest.

Availability of Data and Material

The datasets analyzed in this study are publicly available from the National Health and Nutrition Examination Survey database.

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Tables

Table 1. Characteristics of participants in the NHANES 2005–2018 cycle

Characteristics	All participants	Red blood cell distribution width				*p*-value
		Q1	Q2	Q3	Q4	
		(9.7-12.4)	(12.4-12.9)	(13-13.7)	(13.8-37.8)	
Participants	14568	N=3537	N=3248	N=4127	N=3656	
Age (years)	48.34±17.11	42.09 ± 14.92	45.11 ± 15.80	47.74 ± 16.03	50.77 ± 16.83	<0.0001
Gender(%)						<0.0001
Male	7242(49.71%)	51.03	54.66	52.74	38.68	
Female	7326(50.29%)	48.97	45.34	47.26	61.32	
Race/ethnicity, (%)						<0.0001
Non-Hispanic White	5817(39.93%)	71.59	69.67	66.75	51.52	
Non-Hispanic Black	3059(21%)	5.78	7.96	9.95	23.46	
Mexican American	2417(16.59%)	9.20	9.05	9.13	9.30	
Other races	3275(22.48%)	13.43	13.32	14.17	15.72	
Education level, (%)						<0.0001
< high school	3725(25.57%)	14.47	16.87	16.71	20.49	
High school	3289(22.58%)	21.41	23.08	22.32	26.98	
> high school	7539(51.75%)	64.12	60.05	60.97	52.53	
Income to poverty ratio, (%)						<0.0001
1.5	4981(34.19%)	20.66	22.59	23.99	31.15	
1.5–3.5	5602(38.45%)	33.98	37.21	36.46	40.02	
3.5	3985(27.35%)	45.36	40.20	39.55	28.82	
Marital status, (%)						<0.0001
Married/Living with a partner	8795(60.37%)	66.56	65.65	63.49	59.87	
Widowed/Divorced/Separated	3041(20.87%)	13.05	16.13	18.23	23.44	
Never married	2730(18.74%)	20.39	18.23	18.29	16.69	
Smoked at least 100 cigarettes,(%)						0.0003
Yes	6456(44.32%)	43.13	43.74	47.09	46.75	
No	8100(55.6%)	56.87	56.26	52.91	53.25	
Physical activity,(%)						<0.0001
Yes	4781(32.82%)	43.92	41.07	43.01	38.35	
No	8061(55.33%)	56.08	58.93	56.99	61.65	

Hypertension,(%)						<0.0001
Yes	5876(40.33%)	28.03	31.78	37.97	47.90	
No	8692(59.67%)	71.97	68.22	62.03	52.10	
Diabetes,(%)						<0.0001
Yes	2781(19.09%)	9.42	11.67	16.09	21.94	
No	11787(80.91%)	90.58	88.33	83.91	78.06	
BMI,(kg/m^2)						<0.0001
25	4299(29.51%)	37.84	31.76	28.80	21.30	
25–30	4827(33.13%)	35.00	35.79	31.81	27.90	
≥30	5442(37.36%)	27.16	32.45	39.39	50.80	
Alcohol use	2.86±2.82	2.39 ± 2.41	2.29 ± 2.17	2.23 ± 2.18	1.94 ± 2.10	<0.0001
HDL-C, (mg/dL)	53.81±15.99	54.17 ± 15.60	53.95 ± 15.40	54.22 ± 16.29	54.36 ± 17.87	0.7809
Triglyceride, (mg/ dL)	125.94±105.79	133.22±113.15	127.13 ± 99.58	120.96 ± 94.99	117.47 ± 95.99	<0.0001
LDL, (mg/dL)	113.81±35.55	113.81 ± 32.54	115.98 ± 34.59	113.95 ± 35.72	112.14 ± 36.60	0.0002
Total cholesterol, (mg/dL)	192.23±41.24	194.04 ± 38.93	194.77 ± 40.21	192.00 ± 40.87	189.67 ± 42.67	<0.0001
Waist circumference, (cm)	98.93±16.27	94.95 ± 14.74	97.73 ± 15.59	100.03 ± 16.47	104.31 ± 18.34	<0.0001
White blood cell count,(1000 cells/uL)	6.79±2.18	6.52 ± 1.76	6.69 ± 1.87	6.88 ± 2.03	7.16 ± 2.45	<0.0001
Hematocrit, (%)	41.98±4.30	42.81 ± 3.73	42.89 ± 3.59	42.95 ± 3.79	40.60 ± 4.96	<0.0001
VAI	4.62±5.81	4.76 ± 6.07	4.52 ± 5.20	4.39 ± 5.22	4.51 ± 5.04	0.0231

Mean ± SD for continuous variables: the p-value was calculated by the weighted linear regression model. (%) for categorical variables: the P value was calculated by the weighted chi-square test. Abbreviation: BMI, body mass index; HDL-C, high-density lipoprotein cholesterol; LDL, Low-density lipoprotein; VAI, visceral fat index.

Table 2. Association between the RDW and VAI.

	Crude Model (Model 1)	Partially Adjusted Model (Model 2)	Fully Adjusted Model (Model 3)
	β(95%CI), *p*-Value	**β(95% CI), *p*-Value**	**β(95% CI), *p*-Value**
RDW	-0.09 (-0.16, -0.02)	-0.05 (-0.12, 0.02)	-0.13 (-0.21, -0.05)
RDW quartile			
Quartile 1(9.7-12.4)	Reference	Reference	Reference
Quartile 2(12.4-12.9)	-0.23 (-0.48, 0.02)	-0.28 (-0.52, -0.03)	-0.45 (-0.70, -0.19)
Quartile 3(13-13.7)	-0.36 (-0.60, -0.13)	-0.43 (-0.67, -0.20)	-0.57 (-0.81, -0.33)
Quartile 4(13.8-37.8)	-0.25 (-0.51, 0.01)	-0.17 (-0.44, 0.10)	-0.56 (-0.84, -0.28)
p for trend	0.017	0.041	<0.001

Model 1: no covariates were adjusted.

Model 2: age, gender, and race were adjusted.

Model 3: age, gender, race, education level, income-to-poverty ratio, marital status, smoking status, alcohol use, physical activity, hypertension, diabetes, total cholesterol, white blood cell count, and hematocrit were adjusted.
Abbreviations: RDW, red blood cell distribution width; VAI, visceral fat index.

Table 3. Threshold effect analysis of RDW on VAI using the two-piecewise linear regression model.

VAI	Adjusted β (95% CI) P value
RDW	
Inflection point	12.9
RDW<12.9	-0.72 (-0.97, -0.47)
RDW>12.9	0.01 (-0.09, 0.10)
Log likelihood ratio	<0.001

Age, gender, race, education level, income-to-poverty ratio, marital status, smoking status, alcohol use, physical activity, hypertension, diabetes, LDL, total cholesterol, white blood cell count, and hematocrit were adjusted.
Abbreviations: RDW, red blood cell distribution width; VAI, visceral fat index; LDL, low-density lipoprotein.

Table 4. Subgroup analysis of the association between RDW and VAI.

Subgroup	Beta(95%CI)	P for interaction
Sex		0.0202
Male	-0.29 (-0.43, -0.15)	
Female	-0.09 (-0.18, -0.00)	
Age(years)		0.9145
Below 40	-0.11 (-0.24, 0.01)	
40-60	-0.14 (-0.26, -0.03)	
Over 60	-0.16 (-0.32, 0.01)	
Race/Ethnicity		0.4797
Non-Hispanic White	-0.19 (-0.30, -0.09)	
Non-Hispanic Black	-0.07 (-0.24, 0.09)	
Mexican American	-0.04 (-0.26, 0.17)	
Other Race	-0.09 (-0.30, 0.12)	
Physical activity		0.5225
Yes	-0.16 (-0.29, -0.04)	
No	-0.11 (-0.21, -0.02)	
Smoked at least 100 cigarettes		0.9325
Yes	-0.13 (-0.24, -0.01)	
No	-0.13 (-0.23, -0.04)	
Hypertension		0.0220
Yes	-0.25 (-0.38, -0.13)	
No	-0.07 (-0.17, 0.02)	
Diabetes		0.1722
Yes	-0.24 (-0.43, -0.06)	
No	-0.11 (-0.19, -0.03)	
BMI		0.2486
Below 25	-0.12 (-0.26, 0.03)	
25-30	-0.28 (-0.42, -0.15)	
Over 60	-0.21 (-0.33, -0.09)	

Age, gender, race, education level, income-to-poverty ratio, marital status, smoking status, alcohol use, physical activity, hypertension, diabetes, LDL, total cholesterol, white blood cell count, and hematocrit were adjusted.
Abbreviations: RDW, red blood cell distribution width; VAI, visceral fat index; LDL, low-density lipoprotein, BMI, body mass index.

Figures

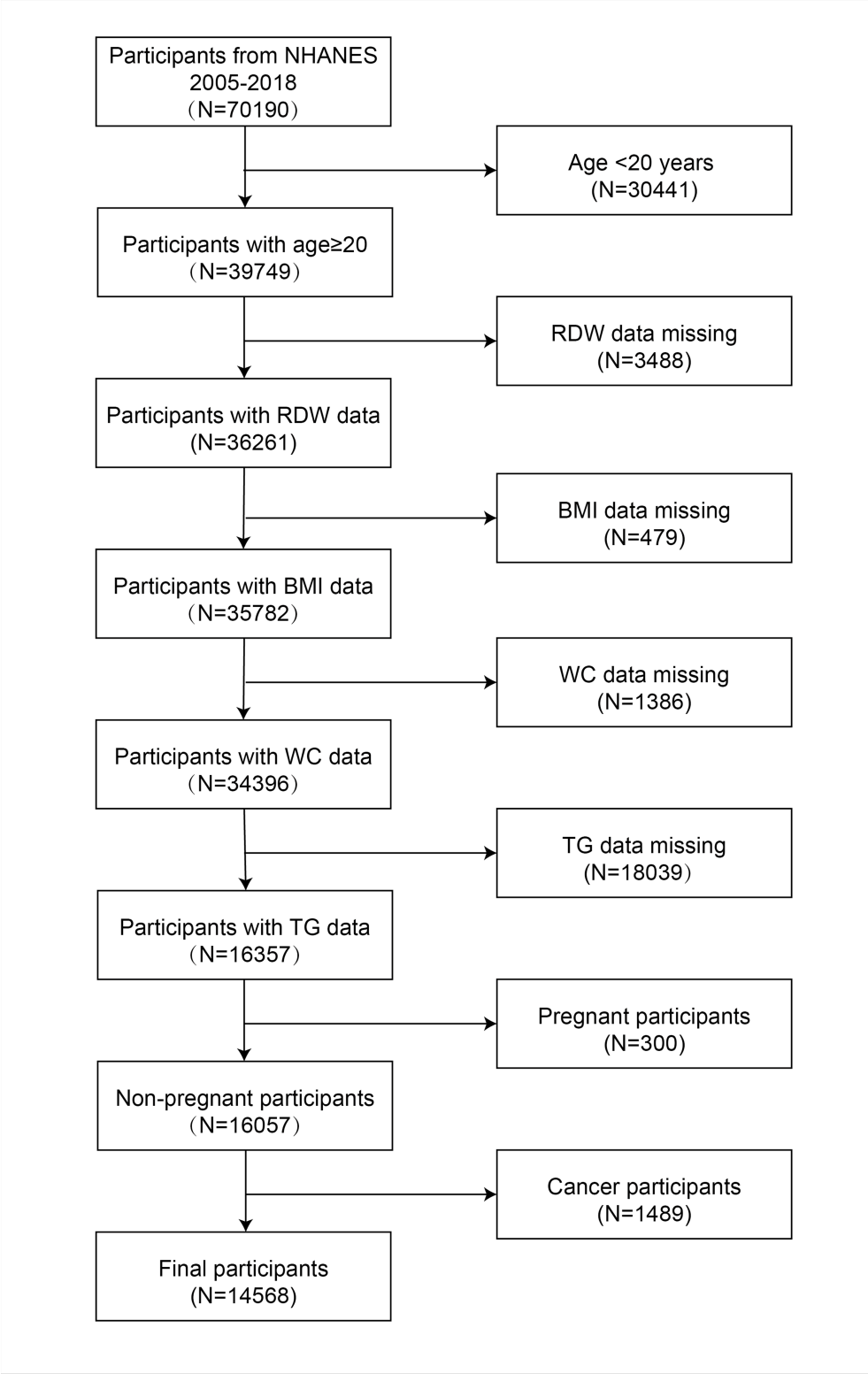


Figure 1

The flowchart of participant selection. NHANES, National Health and Nutrition Examination Survey; RDW, red blood cell distribution width; BMI, body mass index; WC, waist circumference, TG, Triglyceride.

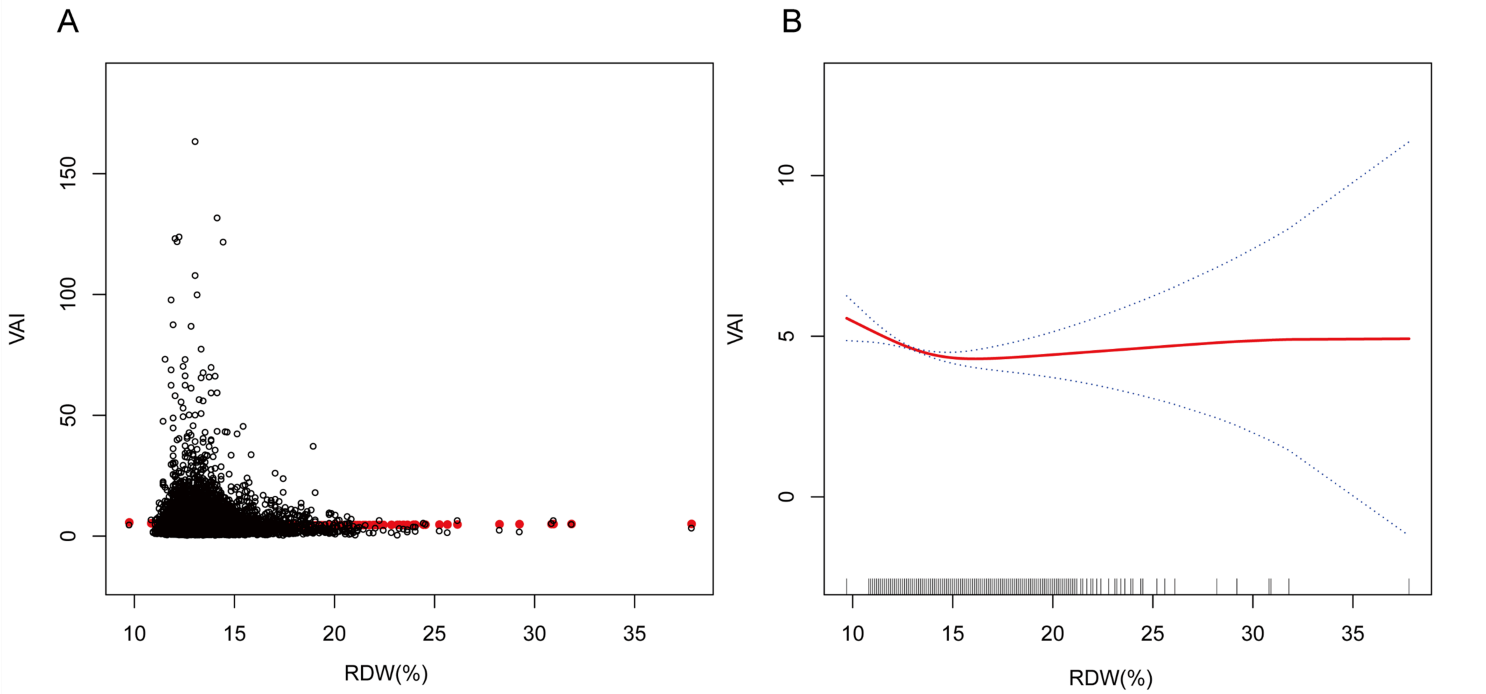


Figure 2

The nonlinear associations between RDW and VAI. (A) Each black point represents a sample. (B)The solid red line represents the smooth curve fit between variables. Blue bands represent the 95% confidence interval from the fit. Abbreviations: RDW, red blood cell distribution width; VAI, visceral fat index.

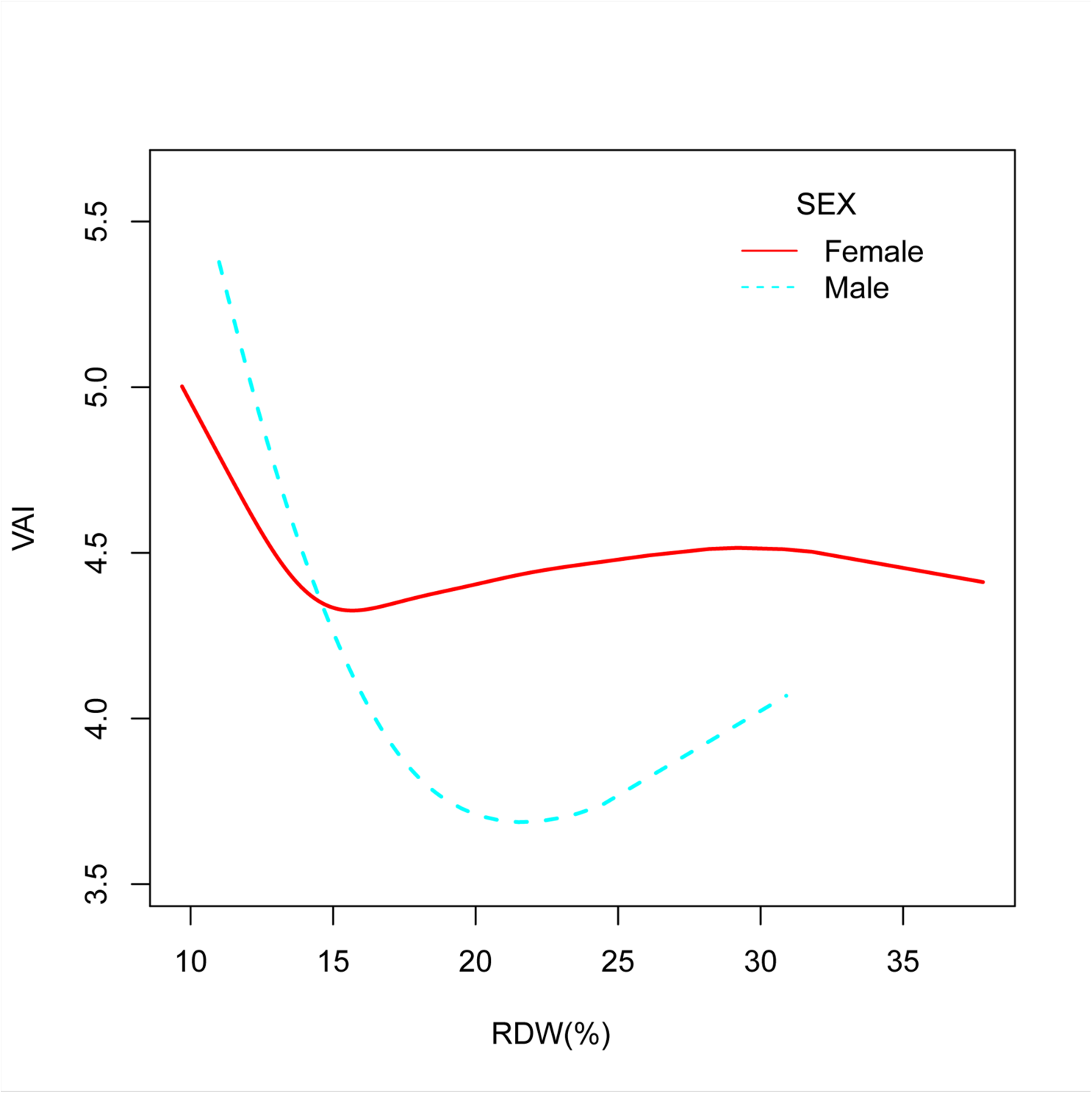


Figure 3

The association between RDW and VAI stratified by sex. Abbreviations: RDW, red blood cell distribution width; VAI, visceral fat index.

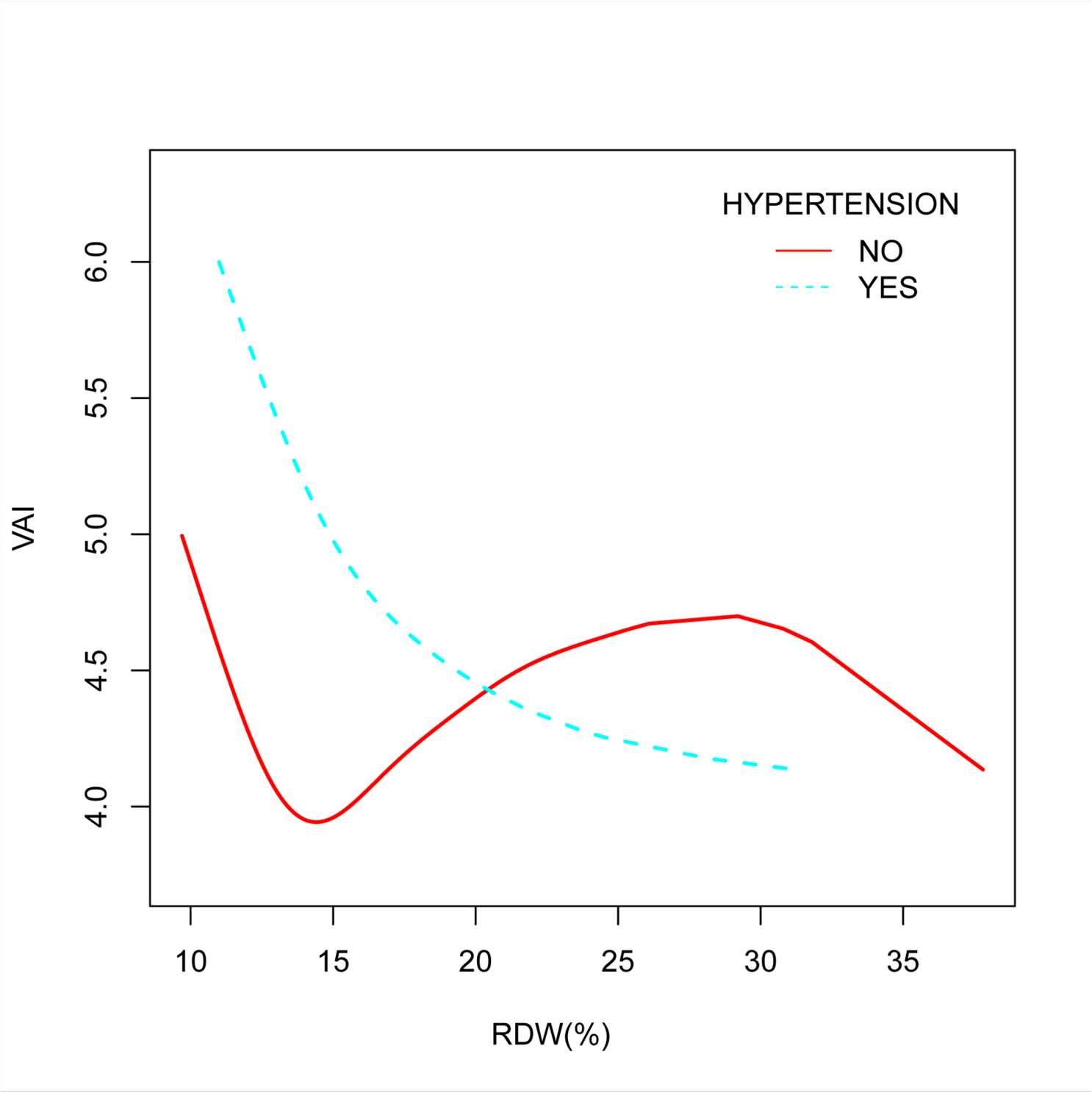


Figure 4

The association between RDW and VAI stratified by hypertension. Abbreviations: RDW, red blood cell distribution width; VAI, visceral fat index.