



## Viscus fat area contributes to the Framingham 10-year general cardiovascular disease risk in patients with type 2 diabetes mellitus

Lan Xu<sup>a,b,c</sup>, Ping Song<sup>a,b,c,d</sup>, Jin Xu<sup>a,b,c</sup>, Haiqing Zhang<sup>a,b,c</sup>, Chunxiao Yu<sup>a,b,c</sup>, Qingbo Guan<sup>a,b,c</sup>, Meng Zhao<sup>a,b,c</sup>, Xu Zhang<sup>a,b,c,\*</sup>

<sup>a</sup> Department of Endocrinology and Metabolism, Shandong Provincial Hospital affiliated to Shandong University, Jinan 250021, Shandong, China

<sup>b</sup> Institute of Endocrinology and Metabolic Diseases, Shandong Academy of Clinical Medicine, Jinan 250021, Shandong, China

<sup>c</sup> Shandong Clinical Medical Center of Endocrinology and Metabolism, Jinan 250021, Shandong, China

<sup>d</sup> Department of Endocrinology and Metabolism, Binzhou City People's Hospital, Binzhou 256600, Shandong, China

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### ABSTRACT

**Objective:** To explore the correlation of the viscus fat area (VFA) with the Framingham 10-year general cardiovascular disease risk in patients with type 2 diabetes mellitus (T2DM).

**Methods:** A total of 202 patients with T2DM were divided into two groups based on VFA (a VFA  $\geq 100$  cm<sup>2</sup> group and a VFA  $< 100$  cm<sup>2</sup> group), or four groups based on sex and age (a middle-aged male group, an elderly male group, a middle-aged female group, and an elderly female group). The correlation between the Framingham 10-year general cardiovascular disease risk and body fat indexes was analyzed.

**Results:** Patients in the VFA  $\geq 100$  cm<sup>2</sup> group had higher body fat indexes and Framingham Risk Scores (FRSs) and lower levels of high density lipoprotein-cholesterol (HDL-C) when compared to the VFA  $< 100$  cm<sup>2</sup> group ( $P < 0.05$ ). Female patients had higher body fat mass (BFM) and body fat percentage (BFP) levels and a lower VFA when compared to male patients. The VFA was significantly higher in the elderly than in the middle-aged patients. The waist hip fat ratio (WHFR) was significantly higher in elderly females than in elderly males ( $P < 0.05$ ). Elderly females had the highest FRS of all patients. Multiple stepwise regression analysis revealed the VFA as a contributor to the Framingham 10-year general cardiovascular disease risk after statistical correction for other multiple factors affecting cardiovascular disease risk.

**Conclusion:** The VFA is an independent factor that contributes to the Framingham 10-year general cardiovascular disease risk in patients with T2DM.

### 1. Introduction

Vascular complications are the main causes of death and disability due to diabetes mellitus. Epidemiological investigation has shown that a prevalence of diabetes in Chinese adults of 11.6%, and the total number ranks first in the world. The reason why Asians are more likely than Caucasians to have cardiovascular complications from diabetes may be a higher visceral fat accumulation in the Asian population [1]. The visceral fat area (VFA) had a more significant correlation with cardiovascular disease than did waist circumference, body mass index (BMI), or subcutaneous fat area (SFA) in patients with obesity, a demonstrated risk factor for multiple cardiovascular diseases [2]. Moreover, when compared with patients with peripheral obesity, patients with abdominal obesity had an increased risk of diabetes, dyslipidemia,

and cardiovascular and cerebrovascular diseases [3]. Studies have shown that viscus fat accumulation is superior to subcutaneous fat accumulation as a predictor of cardiovascular disease [4,5].

Body composition factors, such as VFA, body fat mass (BFM), body fat percentage (BFP), and waist-hip-fat ratio (WHFR), can be measured safely and non-invasively with the Inbody720 body composition analyzer [6,7], which has been confirmed as effective in multiple studies [8–11]. This analyzer has numerous advantages, including simple manipulation, rapid measurements, low price, and good accuracy, making the Inbody720 suitable for large-scale clinical studies. These body composition measurements, in turn, can be used to assess cardiovascular disease risk using the Framingham 10-year cardiovascular risk score (FRS). The FRS was created in 1948 by the Framingham Institute in the United States to assess an individual's risk of cardiovascular

\* Corresponding author at: Department of Endocrinology, Shandong Provincial Hospital affiliated to Shandong University. Address: No.324, Jing 5 Road, Jinan, Shandong 250021, China.

E-mail address: [zhangxu@medmail.com.cn](mailto:zhangxu@medmail.com.cn) (X. Zhang).

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disease over the next 10 years based on gender differences [12,13]. The FRS has proved to be a good approach to predict cardiovascular disease risk [14,15]. The FRS has also been applied to people in the Asian population and has served as an effective method to predict the 10-year general cardiovascular disease risk in that population [16].

Abdominal obesity is mainly caused by visceral fat accumulation and is closely related to insulin resistance and lipid metabolism disorders in patients with diabetes [17,18]. However, relatively few studies have investigated relationship between visceral fat accumulation and FRS in these patients. Therefore, the aim of the present study was to investigate the possible correlation between the VFA and FRS in patients with type 2 diabetes mellitus (T2DM). The overall goal was to establish the effects of abnormal distribution of body fat on cardiovascular disease risk to provide guidance for the clinical prevention and treatment of cardiovascular diseases in patients with diabetes.

## 2. Materials and methods

### 2.1. Subjects

This study was approved by the Ethics Committee of Shandong Provincial Hospital. Written informed consent was obtained from all patients.

This study included 202 patients with T2DM (96 males and 106 females; mean age  $60.16 \pm 7.91$  years [range 40–79 years]) from the epidemiological survey in Ningyang, Tai'an, Shandong Province, China conducted by the Shandong Provincial Hospital in 2014 (Table 1). All patients met the diagnostic criteria for diabetes according to the 1999 WHO guidelines. The patients were divided into two groups basing on VFA (a VFA  $\geq 100 \text{ cm}^2$  group and a VFA  $< 100 \text{ cm}^2$  group) [19]. They were further allocated to a middle-aged male group (40–60 years), an elderly male group (61–79 years), a middle-aged female group (40–60 years), and an elderly female group (61–79 years).

#### 2.1.1. Exclusion criteria

Patients with T2DM were excluded if they had severe renal

**Table 1**

Comparison of VFA  $< 100 \text{ cm}^2$  group and VFA  $\geq 100 \text{ cm}^2$  group of the baseline characteristics of patients with type 2 diabetes.

	VFA $< 100 \text{ cm}^2$	VFA $\geq 100 \text{ cm}^2$	T or $\chi^2$	P
Number (male/female)	37 (21/16)	165 (75/90)	–	–
Smoking history	15 (15/37)	42 (42/165)	3.396	0.065
Age (year)	$57.46 \pm 7.90$	$60.77 \pm 7.81$	–2.325	0.021*
Weight (kg)	$56.88 \pm 7.53$	$70.62 \pm 10.51$	–7.527	0.000**
BMI ( $\text{kg}/\text{m}^2$ )	$21.72 \pm 2.99$	$27.03 \pm 3.13$	–9.397	0.000**
WC (cm)	$88.49 \pm 11.51$	$94.71 \pm 8.81$	–3.655	0.000**
HC (cm)	$98.27 \pm 9.62$	$102.91 \pm 8.66$	–2.886	0.004**
WHR	$0.90 \pm 0.09$	$0.92 \pm 0.06$	–1.541	0.125
SBP (mm Hg)	$130.22 \pm 19.70$	$145.19 \pm 21.86$	–3.830	0.000**
DBP (mm Hg)	$75.24 \pm 11.96$	$81.56 \pm 11.96$	–2.902	0.004**
TC (mM)	$5.38 \pm 0.89$	$5.57 \pm 1.26$	–0.870	0.385
TG (mM)	$0.99 \pm 0.38$	$1.89 \pm 1.74$	–3.100	0.002**
LDL-C (mM)	$3.25 \pm 0.75$	$3.33 \pm 0.99$	–0.442	0.659
HDL-C (mM)	$1.52 \pm 0.27$	$1.32 \pm 0.33$	3.473	0.001**
UA ( $\mu\text{M}$ )	$299.17 \pm 94.03$	$324.08 \pm 91.09$	–1.495	0.137
FBG (mM)	$8.95 \pm 3.95$	$9.11 \pm 3.34$	–0.247	0.805
HbA1c (%)	$7.26 \pm 2.25$	$7.60 \pm 1.73$	–1.038	0.301
FINS (mU/L)	$6.12 \pm 10.00$	$10.77 \pm 12.33$	–2.138	0.034*
HOMA-IR	$2.63 \pm 5.78$	$4.55 \pm 5.83$	–1.808	0.072

BMI, body mass index; WC, waist circumference; HC, hip circumference; WHR, waist-to-hip ratio; SBP, systolic blood pressure; DBP, diastolic blood pressure; TC, total cholesterol; TG, triglycerides; LDL-C, low-density lipoprotein-cholesterol; HDL-C, high density lipoprotein-cholesterol; UA, uric acid; FBG, fasting blood glucose; HbA1C, glycated hemoglobin; FINS, fasting insulin levels; HOMA-IR, insulin resistance index.

\*  $P < 0.05$ .

\*\*  $P < 0.01$ .

insufficiency (glomerular filtration rate  $< 60 \text{ mL}/\text{min}$ ); myocardial infarction or medical history of angina; recent history of infection; malignant tumors; hyperthyroidism or hypothyroidism; metals in the body; a cardiac pacemaker; pregnancy; disabilities; or were taking lipid-lowering medicine in the past month. This study was one part of the REACTION study [20–23].

### 2.2. Measurement and calculation

Each patient's basic information, such as age, gender, height, weight, blood pressure, and smoking history, was recorded. The Inbody720 body composition analyzer was used to measure the distribution of body fat, including the VFA, BFM, BFP, and WHFR. A volume of 3 mL fasting blood was then collected and serum was isolated by centrifugation. The serum levels of fasting blood glucose (FBG), glycosylated hemoglobin (HbA1c), serum uric acid (UA), total cholesterol (TC), triglycerides (TG), low density lipoprotein-cholesterol (LDL-C), and high density lipoprotein-cholesterol (HDL-C) were analyzed.

The BMI is equal to the body weight (kg)/height ( $\text{m}^2$ ). The FRS was calculated based on the patient's age, gender, smoking history, systolic blood pressure (SBP), and TC and HDL-C levels [12,13]. According to the risk grade, the FRS was defined as low risk ( $< 10\%$ ), middle risk (10–20%), and high risk ( $> 20\%$ ) [24].

### 2.3. Statistical analysis

Statistical analyses were performed using SPSS21.0 software. Normally distributed measurement data were presented as mean  $\pm$  SD, and an independent sample *t*-test was used to assess the difference between two groups. Analysis of variance (ANOVA) was performed to analyze the differences between three or more groups. Measurement data with non-normal distributions were presented as medians and continuous variables between groups were compared with nonparametric tests. The enumeration data were shown as number/percentage (n/%), tested by the Chi square ( $\chi^2$ ) test. Pearson's rank correlation analysis was conducted on the data with normal distributions. Multiple stepwise regression analysis was used to analyze the risk factors for FRS. *P*-values  $< 0.05$  were taken as statistically significant.

## 3. Results

### 3.1. Comparison of the baseline characteristics of the VFA $< 100 \text{ cm}^2$ group and the VFA $\geq 100 \text{ cm}^2$ group

The measurements for age, weight, BMI, waist circumference (WC), hip circumference (HC), SBP, DBP, TG, fasting insulin (FINS), BFM, BFP, WHFR, VFA and FRS were higher in the VFA  $\geq 100 \text{ cm}^2$  group than in the VFA  $< 100 \text{ cm}^2$  group. By contrast, the HDL-C level was significantly lower in the VFA  $\geq 100 \text{ cm}^2$  group than in the VFA  $< 100 \text{ cm}^2$  group ( $P < 0.05$ ). (Table 1 and Table 2).

### 3.2. Comparison of baseline characteristics among groups with different ages and genders

Significant differences were noted in the BFM, BFP, WHFR, VFA, and FRS among the middle-aged men (40–60 years), elderly men (61–79 years), middle-aged women (40–60 years), and elderly women (61–79 years) ( $P < 0.05$ ). The BFM and BFP were significantly higher in the female patients than in the male patients. The VFA was also significantly higher in the elderly patients than in the middle-aged patients ( $P < 0.05$ ). No gender differences were observed for the WHFR in the middle-aged patients; however, the WHFR was significantly higher in the elderly females than in the elderly males ( $P < 0.05$ ). The FRS was significantly higher in elderly female patients than in the other patients ( $P < 0.05$ ). (Table 3).

**Table 2**  
Comparison of VFA < 100 cm<sup>2</sup> group and VFA ≥ 100 cm<sup>2</sup> group of body fat indexes and Framingham risk score (FRS).

	BFM (kg)	BFP	WHFR	VFA (cm <sup>2</sup> )	FRS
VFA < 100 cm <sup>2</sup> (37)	11.59 ± 3.80	20.25 ± 6.59	0.88 ± 0.03	74.80 ± 23.32	0.12 ± 0.07
VFA ≥ 100 cm <sup>2</sup> (165)	23.45 ± 5.67	33.27 ± 6.37	0.97 ± 0.04	139.4 ± 22.34	0.19 ± 0.09
T value	-12.13	-11.17	-12.32	-15.76	-4.376
P value	0.000**	0.000**	0.000**	0.000**	0.000**

VFA, viscus fat area; BFM, body fat mass; BFP, body fat percentage; WHFR, waist hip fat ratio; FRS, Framingham Risk Score.

\*\* P < 0.01.

**3.3. Comparison of body fat indexes in patients with T2DM and different FRS grades**

The patients with T2DM were divided into low-risk, middle-risk, and high-risk groups according to their FRS. A comparison of body fat indexes between the three groups showed a significantly higher VFA and WHFR in the high-risk group than in the other two groups, with an upward trend in the VFA and WHFR measurements with increasing FRS (P < 0.05). (Fig. 1A–D).

**3.4. Correlation analysis between the FRS and other variables in patients with T2DM**

As shown in Table 4, the FRS was positively correlated with the measurements of BMI, VFA, quantity of body fat, WHFR, BFP, TG, and low-density lipoprotein-cholesterol (LDL-C) levels (P < 0.05). The FRS was also negatively correlated with HDL-C levels (P < 0.05).

**3.5. Correlation analysis between VFA and other variables in patients with T2DM**

The correlation between the VFA and other variables was also analyzed. The VFA was positively correlated with age, UA, DBP and SBP

(P < 0.05). VFA was also negatively correlated with HDL-C (P < 0.05). (Fig. 2A–E).

**3.6. Analysis of the risk factors for FRS**

Table 5 shows the results of multiple stepwise regression analysis performed to identify the risk factors for FRS in both female and male patients. The FRS was significantly correlated with age, BMI, VFA, WHFR, BFP, VFA, TC, TG, UA, LDL-C, DBP, SBP, and HDL-C. Before adjustment for these factors, the VFA was significantly correlated with FRS (P < 0.01). After adjustment for BMI, HDL-C, TG, TC, UA, SBP, DBP, and fasting blood glucose (FBG), VFA remained significantly correlated with FRS. After adjustment for by BMI, HDL, TG, TC, UA, SBP, DBP, FBG, and LDL-C, VFA again remained significantly correlated with FRS (P < 0.05). Taken together, these results indicated that the VFA was a contributing factor to the Framingham 10-year general cardiovascular disease risk.

**4. Discussion**

The present study showed that patients with VFA ≥ 100 cm<sup>2</sup> had a high Framingham 10-year cardiovascular risk. No significant difference was determined for body fat volume between the four groups that

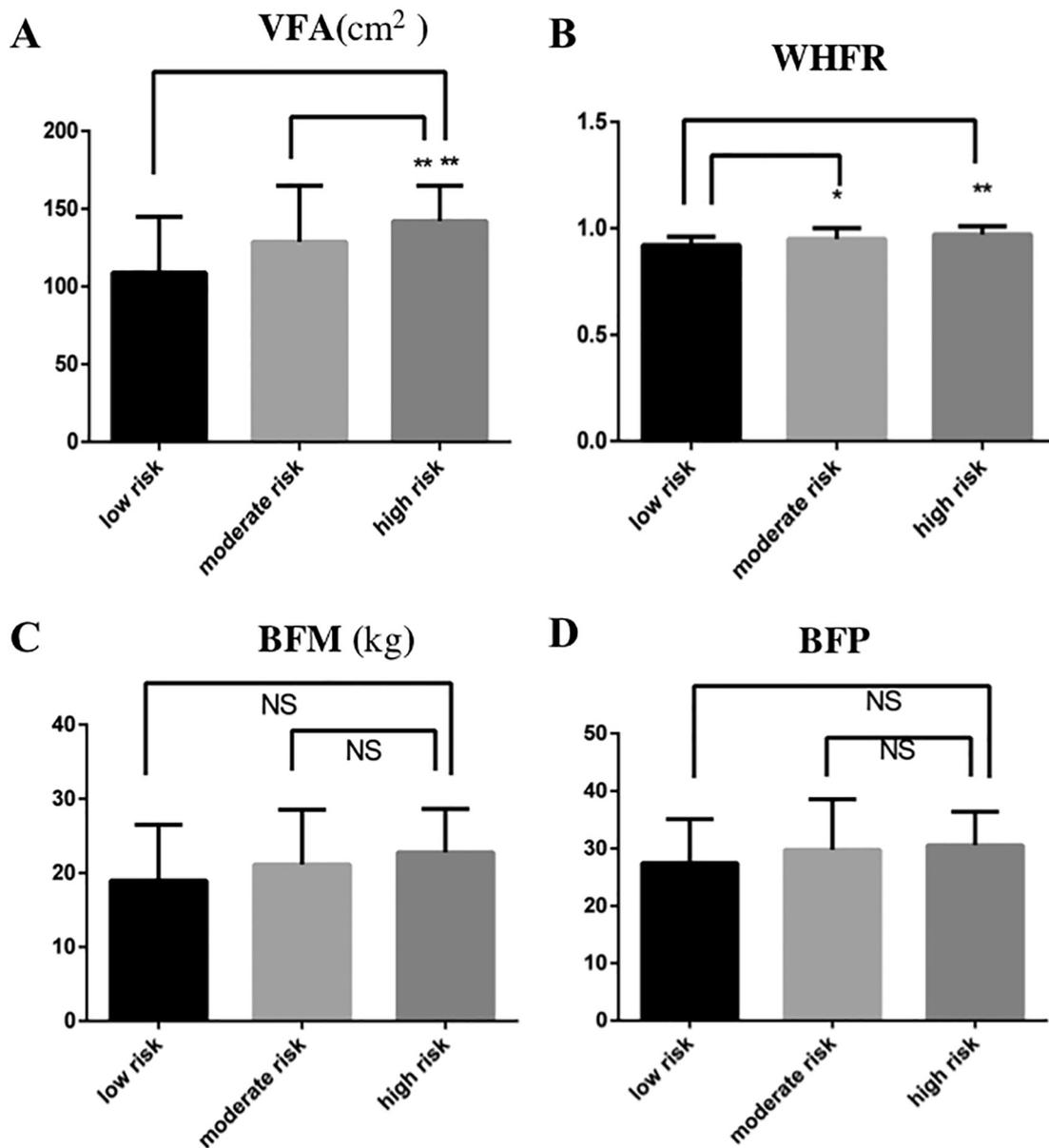
**Table 3**  
Comparison of Middle-aged men group, Elderly men group, Middle-aged women group, Elderly women group in clinical information.

	Middle-aged men group	Elderly men group	Middle-aged women group	Elderly women group	P
Cases (n)	55	41	51	55	-
Smoking history	34	21	0	2	0.000**
Age (year)	52.98 ± 4.93	67.17 ± 4.54	55.24 ± 4.48	66.69 ± 4.32	0
Weight (kg)	74.80 ± 10.76	70.46 ± 10.40	63.80 ± 10.72	63.45 ± 9.20	0.000**
BMI (kg/m <sup>2</sup> )	26.45 ± 3.46	25.34 ± 3.97	26.04 ± 4.10	26.23 ± 3.42	0.525
WC (cm)	94.14 ± 10.56	95.02 ± 10.94	92.37 ± 8.57	93.02 ± 8.59	0.557
HC (cm)	102.20 ± 10.06	102.83 ± 10.80	101.01 ± 8.36	102.27 ± 6.90	0.792
WHR	0.92 ± 0.08	0.93 ± 0.08	0.92 ± 0.06	0.91 ± 0.06	0.643
SBP (mm Hg)	137.0 ± 18.93	147.71 ± 26.62	139.61 ± 20.09	146.60 ± 22.42	0.038*
DBP (mm Hg)	81.96 ± 11.72	81.44 ± 14.68	79.92 ± 11.17	78.51 ± 11.51	0.459
TC (mM)	5.47 ± 1.27	5.29 ± 0.96	5.61 ± 1.13	5.72 ± 1.34	0.329
TG (mM)	(0.93–2.86) 1.73	(0.79–1.33) 0.93	(0.89–1.92) 1.42	(1.01–1.95) 1.29	0.05
LDL-C (mM)	3.15 ± 0.98	3.24 ± 0.81	3.32 ± 0.91	3.52 ± 1.04	0.197
HDL-C (mM)	1.24 ± 0.31	1.31 ± 0.33	1.46 ± 0.31	1.40 ± 0.32	0.003**
UA (uM)	349.94 ± 98.84	329.84 ± 107.28	294.26 ± 72.66	304.82 ± 84.79	0.007**
FBG (mM)	9.04 ± 3.53	8.77 ± 2.84	9.60 ± 4.22	8.86 ± 3.00	0.628
HbA1c (%)	7.31 ± 1.80	7.45 ± 1.77	7.77 ± 2.07	7.63 ± 1.71	0.591
FINS (mU/L)	10.23 ± 10.60	9.74 ± 15.50	8.19 ± 4.69	11.33 ± 14.98	0.607
HOMA-IR	4.48 ± 6.67	4.12 ± 7.55	3.90 ± 4.76	4.25 ± 4.76	0.966
BFM (kg)	19.56 ± 6.85	19.40 ± 6.86	22.72 ± 7.61	23.06 ± 6.27	0.007**
BFP	25.51 ± 6.42	26.81 ± 7.57	34.60 ± 7.13	35.85 ± 6.01	0.000**
WHFR	0.94 ± 0.04	0.95 ± 0.05	0.94 ± 0.06	0.97 ± 0.05	0.004**
VFA (cm <sup>2</sup> )	123.8 ± 39.33	137.6 ± 43.70	117.4 ± 25.74	133.08 ± 20.44	0.014*
VFA/BFM	6.38 ± 0.61	7.18 ± 1.09	5.39 ± 0.82	6.02 ± 1.12	0.000**
FRS	0.18 ± 0.08	0.17 ± 0.06	0.15 ± 0.09	0.25 ± 0.08	0.000**

BMI, body mass index; WC, waist circumference; HC, hip circumference; WHR, waist-to-hip ratio; SBP, systolic blood pressure; DBP, diastolic blood pressure; TC, total cholesterol; TG, triglycerides; LDL-C, low-density lipoprotein-cholesterol; HDL-C, high density lipoprotein-cholesterol; UA, uric acid; FBG, fasting blood glucose; HbA1C, glycated hemoglobin; FINS, fasting insulin levels; HOMA-IR, insulin resistance index; VFA, viscus fat area; BFM, body fat mass; BFP, body fat percentage; WHFR, waist hip fat ratio; FRS, Framingham Risk Score.

\* P < 0.05.

\*\* P < 0.01.



**Fig. 1.** Comparison of body fat indexes between patients with type 2 diabetes and different Framingham risk scores (FRS). The levels of VFA (A), WHFR (B), BFM (C) and BFP (D) in the low-risk group, middle-risk group, and high-risk group. \*\*,  $P < 0.01$ . VFA, viscus fat area; BFM, body fat mass; BFP, body fat percentage; WHFR, waist hip fat ratio.

**Table 4**  
The correlation analysis of the Framingham risk score (FRS) and other variables in patients with type 2 diabetes.

Variables	R	P value
BMI	0.221	0.002*
Quantity of body fat	0.189	0.007**
WHFR	0.294	0.000**
BFP	0.328	0.000**
VFA (cm <sup>2</sup> )	0.263	0.000**
TG (mM)	0.164	0.019*
UA (uM)	0.244	0.002**
LDL-C (mM)	0.342	0.000**

BMI, body mass index; WHFR, waist hip fat ratio; BFP, body fat percentage; VFA, viscus fat area; TG, triglycerides; HDL-C, high density lipoprotein-cholesterol.

\*  $P < 0.05$ .  
\*\*  $P < 0.01$ .

differed in age and sex. Both men and women had a tendency to increase visceral fat area with age, but older women had a higher Framingham 10-year cardiovascular risk when compared to the other three groups.

T2DM accounts for 90% of patients with diabetes mellitus. Patients with T2DM can also have an incidence of abdominal obesity as high as 45.4% [25]. Multiple studies have confirmed that visceral fat cells have metabolic activities that include the secretion of vasoactive substances such as inflammatory factors, adipocyte factors, anti-coagulant molecular markers, and growth factors, and that these factors directly or indirectly contribute to atherosclerosis and an increased risk of cardiovascular diseases [26–30]. The viscus fat also has a richer blood supply and nerve distribution when compared to subcutaneous fat, as well as a more active fat metabolism and a more sensitive response to the human sympathetic nervous system, which eventually lead to an increased metabolic risk [31–36]. Patients with viscus fat accumulation also show higher scores for the Framingham 10-year general cardiovascular disease risk when compared to patients with subcutaneous fat

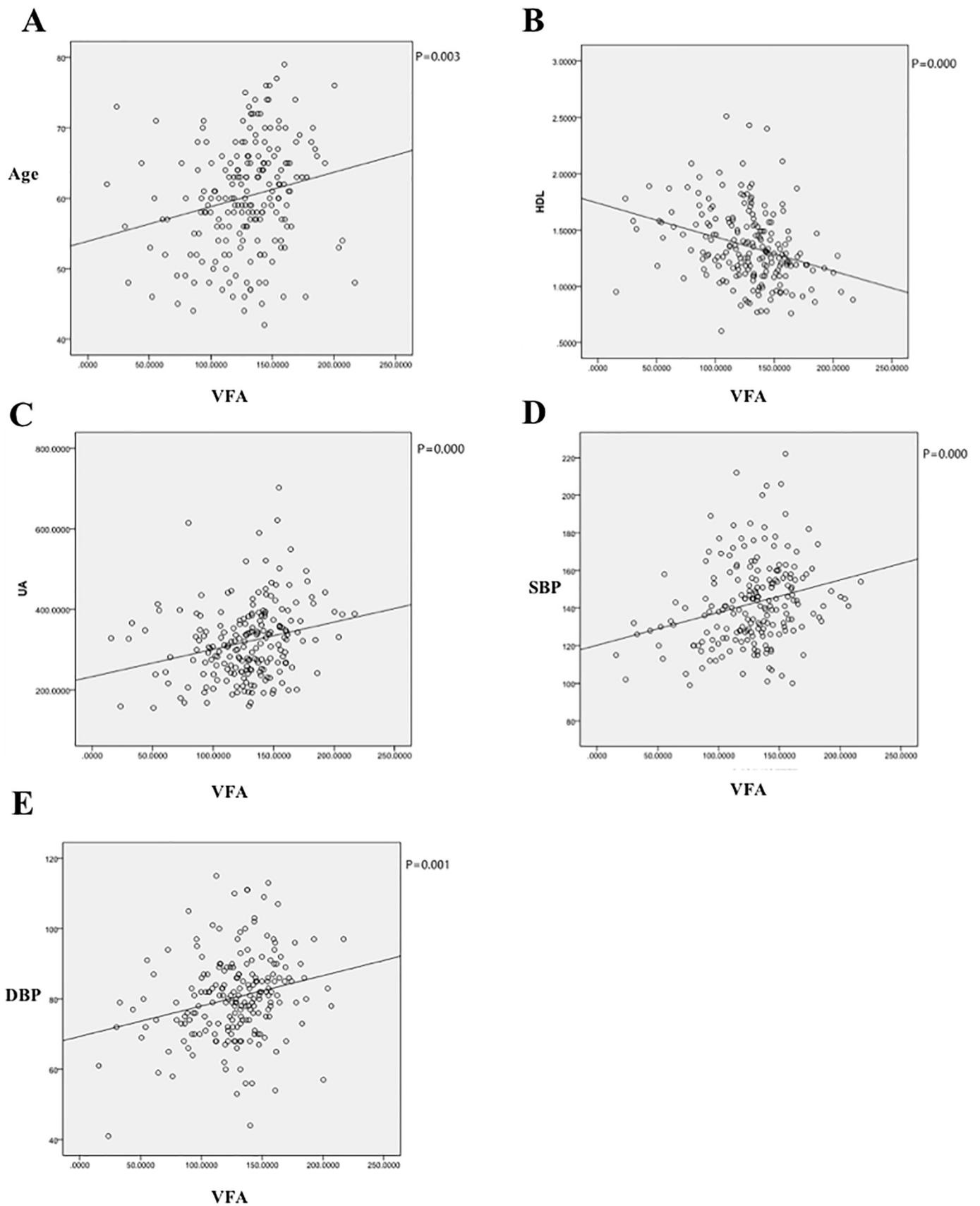


Fig. 2. Correlation analysis between VFA and other variables in patients with type 2 diabetes. A significant correlation was observed between VFA and age (A), HDL-C (B), UA (C), SBP (D) and DBP (E). VFA, viscus fat area; HDL-C, high density lipoprotein-cholesterol; UA, uric acid; SBP, systolic blood pressure; DBP, diastolic blood pressure.

**Table 5**  
Analysis of the risk factors affecting the Framingham risk score (FRS) in patients with type 2 diabetes.

Gender	Variables	Adjusted	NSCC	Standard error	SCC	T	P
Male	VFA	Adjusted 1	0.001	0.000	0.298	2.068	0.042*
		Adjusted 2	0.001	0.000	0.323	2.193	0.031*
		No adjusted	0.000	0.000	0.268	2.700	0.008**
Female	VFA	Adjusted 1	0.002	0.000	0.426	4.492	0.000**
		Adjusted 2	0.002	0.000	0.415	4.306	0.000**
		No adjusted	0.000	0.000	0.379	4.175	0.000**

LDL-C: low-density lipoprotein-cholesterol; VFA: visceral fat area; FRS: Framingham Risk Score; NSCC: not standardized correlation coefficient; SCC: standardized correlation coefficient. Adjusted 1: adjusted by body mass index (BMI), high density lipoprotein-cholesterol (HDL-C), triglycerides (TG), total cholesterol (TC), uric acid (UA), systolic blood pressure (SBP), diastolic blood pressure (DBP) and fasting blood glucose (FBG). Adjusted 2: adjusted by BMI, HDL, TG, TC, UA, SBP, DBP, FBG and LDL-C.

\*  $P < 0.05$ .

\*\*  $P < 0.01$ .

accumulation [37,38]. Patients with high levels of viscus fat also have a high risk of coronary atherosclerosis [39], and viscus fat accumulation is also an independent risk factor for long-term cardiovascular events in patients with T2DM [40].

In the present study, we found that the FRS was significantly higher in the VFA  $\geq 100 \text{ cm}^2$  group than in the VFA  $< 100 \text{ cm}^2$  group, consistent with previous studies. We also found that the BFM and BFP were significantly higher in female patients than in male patients and that the VFA was significantly higher in the elderly patients than in the middle-aged patients. No gender difference was noted in the WHFR of middle-aged patients; however, the WHFR was significantly higher in the elderly females than in elderly males. These differences in fat distribution may reflect differences in sex hormones and body structures [41]; however, the relevant molecular mechanisms still require further study.

The ratio of middle-aged men ( $< 50$  years) dying from heart disease is much higher than that of age-matched women ( $< 50$  years) [42]. Consistent with this, in the present study, we found that the FRS was significantly higher in middle-aged male patients (40–60 years) than in age-matched female patients. We also found that the FRS was significantly higher in elderly female patients (61–79 years) than in age-matched male patients, indicating an increased risk of cardiovascular diseases in females with increasing age. The VFA was also significantly higher in the elderly female patients, which might reflect stimulation of subcutaneous fat by estrogen [43]. Since estrogen levels decrease after menopause, this could promote viscus fat accumulation and increase the risk of atherosclerosis [44].

The findings stratified by the FRS in this study showed that the VFA and WHFR were significantly higher in the high-risk group than in the other two groups. An upward trend was apparent in the VFA and WHFR with the increase in the FRS; in contrast, no significant difference was noted for BFM and BFP, indicating a close correlation between the VFA and the FRS. The correlation analysis showed a positive correlation between the VFA and the FRS. After data correction for multiple factors affecting cardiovascular disease risk, such as TG and LDL-C, in multiple stepwise regression analysis, the VFA was still a risk factor for a high FRS. Taken together, these results indicate that the VFA is an independent factor that contributes to the Framingham 10-year general cardiovascular disease risk in patients with T2DM, and they provide a theoretical basis for clinical prevention and treatment of cardiovascular diseases in patients with diabetes.

One notable observation was the positive correlation evident between the VFA and SBP, DBP, and UA in this study. The presence of viscus fat has been closely associated with insulin resistance [45,46], and insulin resistance exacerbates vascular endothelial injury to cause

vascular remodeling and eventually to lead to high blood pressure [47], which might account for the high risk of high blood pressure in patients with abdominal obesity. Visceral fat has a strong lipolytic effect, which causes an increase in pentose phosphate pathway activity. This, in turn, mediates the synthesis of purines by accelerating the mobilization of free fatty acids to the liver and portal system, thereby prompting the increased synthesis of UA [48]. Obesity can also cause kidney disease, and the long-term effects of viscus fat can include compression of glomeruli and the development of UA excretion disorder. Obesity can also induce renal medulla changes and promote renal tubule reabsorption, which further increases blood UA levels [49]. These findings might be responsible for the positive correlation between the VFA and UA found in our study.

This study is close to clinical, with strict inclusion criteria, and its results enrich the data on the relationship between visceral fat and FRS in diabetic patients. However, the study also had some deficiencies, such as (1) the failure to adequately account for the use of hypoglycemic and antihypertensive drugs in patients with diabetes and hypertension, (2) the small sample size, (3) the possibility of regional bias, (4) the use of only a cross sectional study, (5) and failure to account for possible effects of diet and other lifestyle factors on VFA. Thus, the results need to be confirmed by further large-scale multicenter prospective studies.

In conclusion, the VFA was an independent factor that contributed to the Framingham 10-year general cardiovascular disease risk in patients with T2DM. VFA increased with age and especially in elderly females. The VFA was also significantly correlated with blood pressure, blood lipid, and UA, indicating a synergic effect on cardiovascular diseases in patients with diabetes. Therefore, patients with T2DM who have high levels of visceral fat require more attention and early intervention to delay the occurrence and development of cardiovascular complications.

#### Ethics approval and consent to participate

The study protocols were approved by the Animal Research Committee of Zhengzhou University and conformed to the international guidelines on the ethical use of animals.

#### Consent for publication

The study was undertaken with Zhengzhou University.

#### Availability of data and material

Not applicable.

#### Conflict of interests

The authors have no actual or potential conflicts of interest to declare.

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#### Authors' contributions

XZ put forward the concept of the study, designed the study, prepared the manuscript and contributed to the statistical analysis. LX and

CY contributed to the data acquisition. PS and QG contributed to the quality control of data and algorithms. JX and MZ analyzed the data and interpretation. HZ edited the manuscript.

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