DOI: 10.38103/jcmhch.17.8.16

Original research

INVESTIGATION OF ATHEROGENIC INDICES IN OVERWEIGHT AND OBESE PATIENTS WITH PREDIABETES

Tran Thua Nguyen[1], Cao Quoc Hoai[1], Tran Quang Nhat[1]
[1]General Internal Medicine and Geriatric Department, Hue Central Hospital, Vietnam

ABSTRACT

Objective: *To evaluate atherogenic indices and the associations between these atherogenic indices and selected factors: body mass index (BMI), waist circumference, and physical activity in overweight and obese patients with prediabetes.*

Methods: *A Cross-sectional descriptive study on 104 overweight or obese patients with prediabetes treated at the Department of General Internal Medicine-Geriatrics, Hue Central Hospital, from June 2020 to Augus 2022.*

Results: *The prevalence of elevated TC/HDL-C was highest at 68.3%. Elevated TG/HDL-C and LDL-C/HDL-C accounted for 20.2% and 66.3%, respectively.*

Compared with the overweight group, the obese group had 1.1-fold higher odds of elevated TC/HDL-C and 1.5-fold higher odds of elevated LDL-C/HDL-C. Participants with increased waist circumference had 2.2-fold higher odds of elevated TG/HDL-C than those without increased waist circumference. Weak, statistically significant positive linear correlations were observed for: BMI with TC/HDL-C (r = 0.197), BMI with LDL-C/HDL-C (r = 0.280), Waist circumference with TC/HDL-C (r = 0.196). Waist circumference with TG/HDL-C (r = 0.283).

Conclusions: *In overweight and obese adults with prediabetes, atherogenic dyslipidemia is common particularly elevated TC/HDL-C and LDL-C/HDL-C. Obesity increased the odds of elevated TC/HDL-C and LDL-C/HDL-C, and greater waist circumference was associated with higher TG/HDL-C*

Keywords: *Atherogenic indices, overwieght and obese patient, prediabetes.*

I. INTRODUCTION

Prediabetes is defined as a metabolic state in which blood glucose levels are higher than normal but do not meet diagnostic thresholds for diabetes mellitus. It encompasses individuals with impaired fasting glucose (IFG), impaired glucose tolerance (IGT), or elevated glycated hemoglobin (HbA1c). In 2021, the International Diabetes Federation (IDF) estimated that 541 million adults (≈10.6%) had IGT; this figure is projected to rise to 622.7 million by 2030 [1] . Prediabetes confers a high risk of progression to diabetes, with annual conversion rates of approximately 5-10% [2]. Overweight and obesity are strongly associated with insulin resistance (IR) and are among the principal risk factors driving IR, which plays a central role in the pathogenesis of multiple disorders, notably type 2 diabetes mellitus (T2DM).

Atherogenic indices (AI) including LDL-C/HDL-C, TG/HDL-C, and TC/HDL-C have recently been recognized as valuable predictors of cardiovascular events, with predictive performance that surpasses traditional single lipid measures [3]. According to the American Diabetes Association (ADA), approximately 20% of individuals with prediabetes already exhibit macrovascular complications [4]. Therefore, determining the prevalence of elevated AI among patients with prediabetes-particularly those who are overweight or obese-may enable early cardiovascular risk

Received: 25/6/2025. **Revised:** 05/11/2025. **Accepted:** 19/11/2025.
Corresponding author: Cao Quoc Hoai. Email: qhoai95@gmail.com. Phone: +84 972 926 130

stratification and prompt correction of dyslipidemia at the prediabetic stage, thereby helping to prevent vascular events in this population. Accordingly, we conducted this study with the following objectives: To evaluate atherogenic indices and examine the associations between these atherogenic indices and selected factors: body mass index (BMI), waist circumference, and physical activity in overweight and obese patients with prediabetes..

II. MATERIALS AND METHODS

2.1. Sujects

A cross-sectional descriptive study was conducted on 104 overweight or obese patients with prediabetes treated at the Department of General Internal Medicine-Geriatric, Hue Central Hospital, from June 2020 to August 2022.

Inclusion criteria: The first was a diagnosis of prediabetes according to ADA (2019), identified by at least one of the following: impaired fasting glucose with fasting plasma glucose 5.6 - 6.9 mmol/L (100 - 125 mg/dL); impaired glucose tolerance with 2 - hour plasma glucose after a 75 - g oral glucose load 7.8 - 11.0 mmol/L (140 - 199 mg/dL); or HbA1c 5.7% - 6.4%. The second component was overweight or obesity defined by WHO Asia criteria (February 2000), including overweight with BMI 23.0 to < 25.0 kg/m² or obesity with BMI ≥ 25.0 kg/m².

Exclusion Criteria: Previously diagnosed diabetes mellitus; Prior treatment for prediabetes or dyslipidemia; Current use of medications affecting blood glucose or lipids, or presence of severe acute illness.

2.2. Study variables

Clinical indices included age, sex, height, weight, BMI, waist circumference, physical activity. Laboratory indices comprised HbA1c, fasting plasma glucose, 2-hour plasma glucose during OGTT, and lipid profile. Atherogenic indices were calculated as the ratios TC/HDL-C, TG/HDL-C, and LDL-C/HDL-C; elevated values were defined as TC/HDL-C ≥ 4; TG/HDL-C ≥ 2.4; and LDL-C/HDL-C ≥ 2.3 [5-7].

Physical activity: Physical activity was categorized as active when participants engaged in regular exercise meeting the recommended duration; and inactive when they reported no exercise, irregular exercise, or insufficient duration.

2.3. Data analysis

Data were analyzed using SPSS version 20.0.

2.4. Research ethics

The study was conducted in accordance with the requirements of the Ethics Committee of Hue University of Medicine and Pharmacy.

III. RESULTS

3.1. General characteristics of participants

The study included 104 overweight or obese patients with prediabetes, with mean age was 64.1 ± 13.6 years; most patients were > 60 years (69.1%). Women predominated (75% vs 25% men).

The proportion of patients classified as overweight (by BMI) was 55.8%; class I and class II obesity accounted for 40.4% and 3.8%, respectively. The mean BMI was 25.1 ± 1.9 kg/m².

The mean waist circumference (WC) in men and women was 90.2 ± 5.7 cm and 90.2 ± 8.3 cm, respectively. Increased WC was observed in 86/104 patients (82.7%). Its prevalence was higher in women (93.6%) than in men (50%).

There is a clear difference in physical activity levels between males and females. Males show a much higher proportion of active individuals compared to females, while inactivity is notably more common among females. The association is statistically significant (p < 0.05) (Table 1).

Table 1: Physical activity (PA) of participants.

PA	Total (n = 104)		Male (n = 26)		Female (n = 78)		p
	SL	%	SL	%	SL	%	
Active	75	72.1	23	88.5	52	66.7	< 0.05
Inactive	29	27.9	3	11.5	26	33.3	

3.2. Characteristics of atherogenic indices in overweight and obese patients with prediabetes

The prevalence of elevated TC/HDL-C was highest at 68.3%. The prevalences of elevated TG/HDL-C and LDL-C/HDL-C were 20.2% and 66.3%, respectively. The mean values of TC/HDL-C and LDL-C/

HDL-C exceeded their predefined cutoffs, whereas TG/HDL-C remained within its cutoff range (Table 2).

Table 2: Distribution and mean values of atherogenic indices (AI)

AI	Classification	n	%	$\overline{X}$ ± SD (mmol/l)
TC/HDL-C	Nomal	33	31.7	4.5 ± 1.2
	Elevated	71	68.3	
TG/HDL-C	Nomal	83	79.8	2.1 ± 1.5
	Elevated	21	20.2	
LDL-C/HDL-C	Nomal	35	33.7	2.7 ± 1.0
	Elevated	69	66.3	

The mean TC/HDL-C, TG/HDL-C, and LDL-C/HDL-C were 4.5, 2.1, and 2.7, respectively. TG/HDL-C was significantly higher in women than in men ($p < 0.05$) (Table 3).

Table 3: Mean values of atherogenic indices by sex

AI	Total (n=104)		Male (n=26)		Female (n=78)		p
	$\overline{x}$	SD	$\overline{x}$	SD	$\overline{x}$	SD	
TC/HDL-C	4.5	1.2	4.8	0.9	4.5	1.3	$p > 0.05$
TG/HDL-C	2.1	1.5	1.8	1.2	2.2	1.8	$p < 0.05$
LDL-C/HDL-C	2.7	1.0	2.9	0.9	2.7	1.0	$p > 0.05$

3.3. Associations between atherogenic indices and BMI, waist circumference, and physical activity

The mean TC/HDL-C and LDL-C/HDL-C were higher in obese patients than in overweight patients. In the obese group, the likelihood of elevated TC/HDL-C was 1.1-fold higher and of elevated LDL-C/HDL-C was 1.5 - fold higher compared with the overweight group (Table 4).

Table 4: Atherogenic indices and BMI of participants

AI	Classification	Overweight (n=58)		Obese (n=46)		p; OR 95%CI
		n	%	n	%	
TC/HDL-C	Nomal	18	31.0	15	32.6	> 0.05; 1.114 0.484-2.563
	Elevated	40	69.0	31	67.4	
	$\overline{X}$ ± SD	4.5 ± 1.1		4.6 ± 1.3		
TG/HDL-C	Nomal	44	75.9	39	84.8	> 0.05; 0.430 0.152-1.217
	Elevated	14	24.1	7	15.2	
	$\overline{X}$ ± SD	2.1 ± 2.0		2.1 ± 1.9		
LDL-C/HDL-C	Nomal	21	36.2	14	30.4	> 0.05; 1.551 0.675-3.567
	Elevated	37	63.8	32	69.6	
	$\overline{X}$ ± SD	2.7 ± 0.9		2.8 ± 1.0		

Patients with increased waist circumference had a 2.2-fold higher likelihood of elevated TG/HDL-C than those without increased waist circumference; however, this was not statistically significant ($p > 0.05$). Conversely, the prevalence of elevated LDL-C/HDL-C was higher in patients without increased waist circumference, also not statistically significant ($p > 0.05$) (Table 5).

Table 5: Atherogenic indices and waist circumference of participants

AI	Classification	Increased WC n = 86 (n, %)		Nomal WC n = 18 (n, %)		p; OR 95% CI
TC/HDL-C	Nomal	28	32.6	5	27.8	> 0.05; 0.797 0.258-2.456
	elevated	58	67.4	13	72.2	
	$\overline{X}$ ± SD	4.5 ± 1.2		4.5 ± 1.0		
TG/HDL-C	Nomal	67	77.9	16	88.9	> 0.05; 2.269 0.479-10.750
	elevated	19	22.1	2	11.1	
	$\overline{X}$ ± SD	2.3 ± 2.1		1.5 ± 1.0		
LDL-C/HDL-C	Nomal	30	34.9	5	27.2	> 0.05; 0.718 0.234-2.206
	elevated	56	65.1	13	72.2	
	$\overline{X}$ ± SD	2.7 ± 1.0		2.9 ± 0.8		

There were statistically significant, weak positive correlations between TC/HDL-C and BMI ($r = 0.197$; $p = 0.045$) and between LDL-C/HDL-C and BMI ($r = 0.280$; $p = 0.004$) (Figure 1).

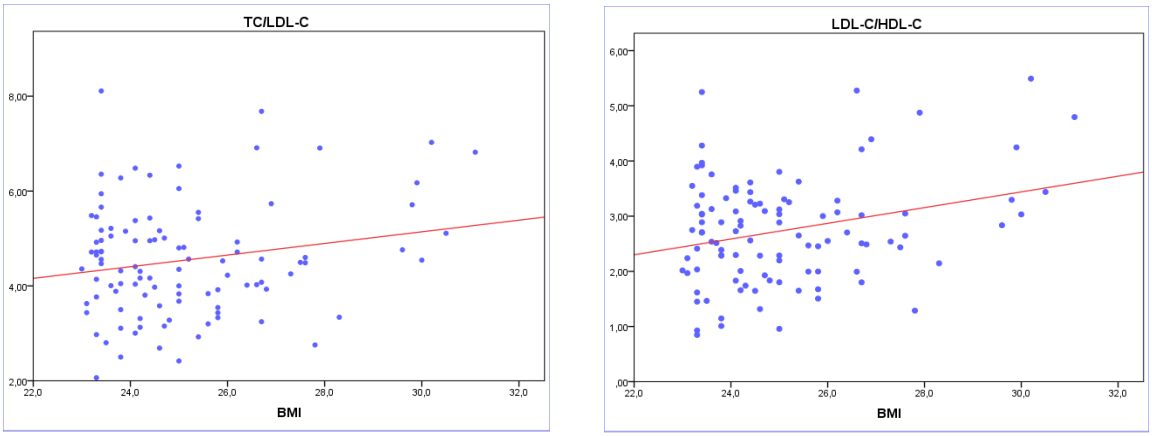

Figure 1: Correlations of TC/HDL-C and LDL-C/HDL-C with BMI

There were statistically significant, weak positive correlations between TC/HDL-C and waist circumference (WC) ($r = 0.196$; $p = 0.046$), and between TG/HDL-C and WC ($r = 0.283$; $p = 0.004$)) (Figure 2).

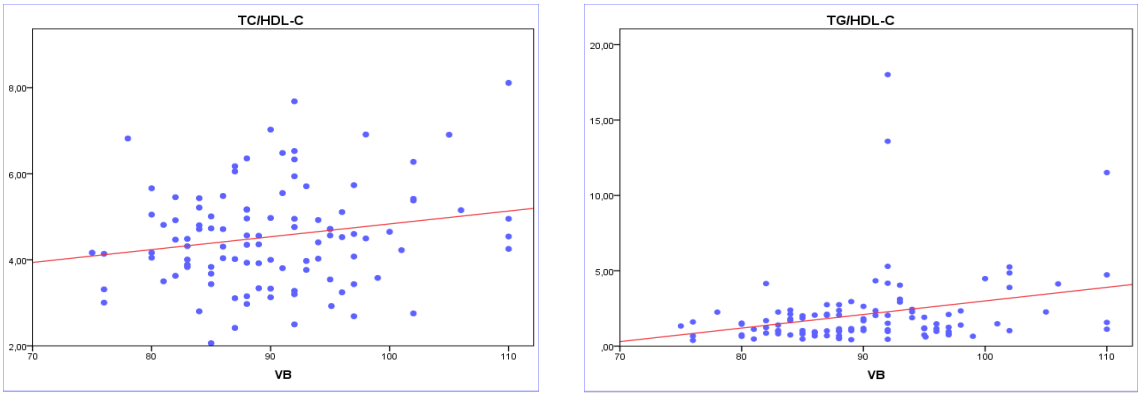

Figure 2: Correlations TC/HDL-C and TG/HDL-C with waist circumference

The mean TC/HDL-C and TG/HDL-C were higher in the physically active group than in the physically inactive group; however, the differences were not statistically significant (p > 0.05) (Table 6).

Table 6: Atherogenic indices and physical activity of participants

AI	Classsification	Active (n = 75)		Inactive (n = 29)		p; OR 95% CI
		n	%	n	%	
TC/HDL-C	Nomal	24	32.0	9	31.0	> 0.05; 1.046 0.415-2.635
	elevated	51	68.0	20	69.0	
	$\overline{X}$ ± SD	4.6 ± 1.2		4.4 ± 1.2		
TG/HDL-C	Nomal	58	77.3	25	86.2	> 0.05; 0.546 0.167-1.787
	elevated	17	22.7	4	13.8	
	$\overline{X}$ ± SD	2.3 ± 2.0		1.6 ± 1.3		
LDL-C/HDL-C	Nomal	25	33.3	10	34.5	> 0.05; 0.950 0.385-2.345
	elevated	50	66.7	19	65.5	
	$\overline{X}$ ± SD	2.7 ± 0.9		2.7 ± 1.1		

IV. DISCUSSION

4.1. General characteristics of participants.

The study included 104 overweight or obese patients with prediabetes, with mean BMI was 25.1 kg/m². Overweight accounted for 55.8%, and obesity for 44.2% (class I 40.4%, class II 3.8%). Mean waist circumference was 90.2 cm; 86/104 patients met the criterion for increased waist circumference (men ≥ 90 cm; women ≥ 80 cm) accounted for 82.7%. Abdominal obesity was more prevalent in women than in men (93.6% vs 50%).

According to the ADA (2019), as little as 150 minutes per week of moderate - to vigorous-intensity physical activity confers measurable benefits for individuals with prediabetes. Even moderate-intensity activity improves insulin sensitivity and reduces abdominal adiposity in both children and adults. In a 3 - year follow-up of patients with prediabetes, Jaana Lindström et al. reported that those receiving a combined diet and exercise intervention had a 3-year conversion rate to diabetes of 9%, compared with 20% in the non-intervention group [8].

In our study, the prevalence of physical inactivity was 27.9%. Women had a significantly higher prevalence of physical inactivity than men (33.3% vs 11.5%; p < 0.05).

4.2. Characteristics of atherogenic indices in overweight and obese patients with prediabetes.

Multiple investigators have reported that ratios of conventional lipid parameters provide greater utility for assessing insulin resistance than single lipid measures, particularly the TG/HDL-C ratio.

In our cohort, the mean atherogenic ratios were TC/HDL-C 4.5 ± 1.2, TG/HDL-C 2.1 ± 1.5, and LDL-C/HDL-C 2.7 ± 1.0; only TG/HDL-C differed significantly by sex. Tran MT found that atherogenic ratios in individuals with prediabetes were significantly higher than in normoglycemic controls, with mean values TC/HDL-C 4.2, TG/HDL-C 3.5, and LDL-C/HDL-C 2.9; our TC/HDL-C and LDL-C/HDL-C were similar, whereas TG/HDL-C was lower [9].

Atherogenic ratios are linked to the development of prediabetes and diabetes. In Chinese adults, Rongpeng Gong showed that higher TG/HDL-C was positively associated with the risks of prediabetes and diabetes, and predicted future impaired glucose tolerance, thereby increasing incident diabetes risk [10]. In Borrayo G. (253 normal-weight women aged 40 - 60 years), TG/HDL-C was associated with prediabetes (OR 1.83, 95% CI 1.07 - 3.13) and insulin resistance (OR 3.27, 95% CI 1.78 - 6.01); TG/HDL-C ≥ 3.0 emerged as a potential risk factor for prediabetes and insulin resistance in this group [11].

In our study, the prevalence of abnormal ratios was highest for TC/HDL-C (68.3%), followed by LDL-C/HDL-C (66.3%), with TG/HDL-C (20.2%) the lowest. Mean TC/HDL-C (4.5 ± 1.2) and LDL-C/HDL-C (2.7 ± 1.0) exceeded their respective thresholds, whereas TG/HDL-C (2.1 ± 1.5) was within the predefined cutoff range. By the Krintus schema, our mean TG/HDL-C ≈ 2.1 falls in the insulin-resistance risk band, aligning with the insulin-resistance pathophysiology characteristic of prediabetes.

4.3. Associations between atherogenic indices and BMI, waist circumference, and physical activity.

In a cross-sectional study by Yumei Yang et al. involving 1,608 patients, the TC/HDL-C ratio was 3.64 ± 1.00 in non-obese individuals (BMI < 25 kg/m²) and 4.09 ± 0.95 in those with obesity (BMI ≥ 25 kg/m²) ($p < 0.001$). The corresponding values for TG/HDL-C were 1.16 ± 1.02 and 1.96 ± 1.26 ($p < 0.001$), and for LDL-C/HDL-C were 2.13 ± 0.77 and 2.35 ± 0.07 ($p < 0.001$) [12].

In our cohort of 104 overweight/obese patients with prediabetes, mean TC/HDL-C and LDL-C/HDL-C were higher in the obese group (4.6 and 2.8, respectively) than in the overweight group (4.5 and 2.7), though the differences were not statistically significant ($p > 0.05$) - a pattern consistent with Yang et al. TG/HDL-C had the same mean (2.1) in both overweight and obese groups. Additionally, we observed weak positive correlations between BMI and TC/HDL-C ($r = 0.197$) as well as BMI and LDL-C/HDL-C ($r = 0.280$).

Central adiposity, hypertriglyceridemia, and low HDL-C are canonical components of the metabolic syndrome. The TG/HDL-C ratio is closely linked to abdominal obesity and insulin resistance. In our data, the mean TG/HDL-C was higher in participants with increased waist circumference (WC) than in those without (2.3 vs 1.5, $p > 0.05$), with a weak positive correlation between TG/HDL-C and WC ($r = 0.283$). Patients with increased WC had a 2.3-fold higher prevalence of elevated TG/HDL-C than those without increased WC. Conversely, the prevalence of elevated LDL-C/HDL-C was higher in participants without increased WC ($p > 0.05$), and WC correlated weakly with TC/HDL-C ($r = 0.196$). These findings are directionally consistent with the above pathophysiological framework, although our sample size may have limited statistical power to detect between-group differences.

Physical activity primarily lowers triglycerides and raises HDL-C, thereby indirectly improving TG/HDL-C; several recent studies report inverse associations between physical activity and atherogenic ratios [12].

V. CONCLUSION

The prevalence of elevated TC/HDL-C was highest at 68.3%. Elevated TG/HDL-C and LDL-C/HDL-C accounted for 20.2% and 66.3%, respectively.

Compared with the overweight group, the obese group had 1.1-fold higher odds of elevated TC/HDL-C and 1.5-fold higher odds of elevated LDL-C/HDL-C. Participants with increased waist circumference had 2.2 - fold higher odds of elevated TG/HDL-C than those without increased

waist circumference. Weak, statistically significant positive linear correlations were observed for: BMI with TC/HDL-C (r = 0.197), BMI with LDL-C/HDL-C (r = 0.280), Waist circumference with TC/HDL-C (r = 0.196). Waist circumference with TG/HDL-C (r = 0.283).

Conflict of interest

The authors declare that they have no conflicts of interest related to the content of this study.

REFERENCES

1. Magliano JD, Boyko EJ. IDF Diabetes Atlas 10th. 2021.
2. Ministry of Health, Decision No. 3087/QĐ-BYT dated July 16, 2020 on promulgating the professional document "Guidelines for diagnosis and treatment of prediabetes". 2021.
3. Guo W, Qin P, Lu J, Li X, Zhu W, Xu N, et al. Diagnostic values and appropriate cutoff points of lipid ratios in patients with abnormal glucose tolerance status: a cross-sectional study. Lipids in health and disease. 2019; 18(1): 130.
4. American Diabetes A. 2. Classification and Diagnosis of Diabetes: Standards of Medical Care in Diabetes-2019. Diabetes Care. 2019; 42(Suppl 1): S13-s28.
5. Millán J, Pintó X, Muñoz A, Zúñiga M, Rubiés-Prat J, Pallardo LF, et al. Lipoprotein ratios: Physiological significance and clinical usefulness in cardiovascular prevention. Vasc Health Risk Manag. 2009; 5: 757-65.
6. Jellinger PS, Smith DA, Mehta AE, Ganda O, Handelsman Y, Rodbard HW, et al. American Association of Clinical Endocrinologists' Guidelines for Management of Dyslipidemia and Prevention of Atherosclerosis. Endocr Pract. 2012; 18 Suppl 1: 1-78.
7. Edwards MK, Blaha MJ, Loprinzi PD. Influence of sedentary behavior, physical activity, and cardiorespiratory fitness on the atherogenic index of plasma. J Clin Lipidol. 2017; 11(1): 119-125.
8. Lindström J, Louheranta A, Mannelin M, Rastas M, Salminen V, Eriksson J, et al. The Finnish Diabetes Prevention Study (DPS): Lifestyle intervention and 3-year results on diet and physical activity. Diabetes Care. 2003; 26(12): 3230-6.
9. Tram Minh Triet, Survey of serum leptin concentration and some cardiovascular risk factors in prediabetic patients, in Doctoral thesis. 2019, Hue University of Medicine and Pharmacy: Hue.
10. Gong R, Liu Y, Luo G, Liu W, Jin Z, Xu Z, et al. Associations of TG/HDL Ratio with the Risk of Prediabetes and Diabetes in Chinese Adults: A Chinese Population Cohort Study Based on Open Data. Int J Endocrinol. 2021; 2021: 9949579.
11. Borrayo G, Basurto L, González-Escudero E, Diaz A, Vázquez A, Sánchez L, et al. TG/HDL-C ratio as cardio-metabolic biomarker even in normal weight women. Acta Endocrinol (Buchar). 2018; 14(2): 261-267.
12. Yang Y, Wang B, Yuan H, Li X. Triglycerides to High-Density Lipoprotein Cholesterol Ratio Is the Best Surrogate Marker for Insulin Resistance in Nonobese Middle-Aged and Elderly Population: A Cross-Sectional Study. Int J Endocrinol. 2021; 2021: 6676569.