IQRO JURNALI , IQRO JOURNAL, ИКРО ЖУРНАЛИ
ISSN:2181-4341| wordlyknowledge.uz/index.php/iqro
Volume 21 Issue 02 May 2026

BEYOND BODY MASS INDEX: UNCOVERING "HIDDEN" CARDIOMETABOLIC RISK IN NORMAL-WEIGHT TYPE 2 DIABETES PATIENTS USING WHTR AND AIP TRAJECTORIES

Prof. **Najmutdinova D.K.,**

Abdumutalibova I.T.

Internal Medicine and Endocrinology Department,

Tashkent State Medical University (Tashkent, Uzbekistan)

Doi: https://doi.org/10.5281/zenodo.20383806

Abstract: Doctors routinely rely on Body Mass Index (BMI) to assess weight-related health, but it often misses hidden cardiovascular dangers in patients with type 2 diabetes (T2DM) who look lean or have a normal weight. This review examines how visceral fat accumulation and silent changes in lipid quality drive vascular damage in these non-obese individuals, and how we can catch these risks early. Analyzing recent data from high-impact cohort studies, clinical trials, and meta-analyses published between 2021 and 2026, we evaluate two practical, non-traditional tools: the waist-to-height ratio (WHtR) and the atherogenic index of plasma (AIP). The gathered evidence shows that WHtR is a highly reliable marker for hormonally active visceral fat, flagging elevated cardiovascular mortality risks even when a patient's BMI appears perfectly healthy. Meanwhile, AIP acts as a sensitive window into blood chemistry, detecting dangerous small, dense LDL particles—the driving force behind "residual" vascular risk that standard cholesterol tests often miss. When used together, WHtR and AIP track both the physical presence of belly fat and its toxic metabolic output, making it much easier to spot subclinical blood vessel damage before severe complications set in. Ultimately, moving away from a strict reliance on BMI toward a combined WHtR/AIP approach offers a simple, affordable, and non-invasive strategy. This dual-predictor model eliminates dangerous clinical blind spots, helping primary care physicians provide timely, life-saving cardiovascular prevention for normal-weight patients living with type 2 diabetes.

Keywords: Cardiometabolic continuum; Visceral adiposity; Residual cardiovascular risk; Atherogenic Index of Plasma; Waist-to-height ratio; Normal-weight obesity; Type 2 diabetes.

Introduction

Type 2 diabetes mellitus (T2DM) remains one of the most expanding global public health challenges of the twenty-first century, with its prevalence projected to impact over 853 million individuals by 2045 [1]. While macrovascular complications drive the core, mortality rates within this population, modern clinical practice faces a critical diagnostic paradox: a substantial cohort of diabetic patients who present with a completely normal weight profile remain under an unrecognized, high-grade risk of catastrophic cardiovascular events [2, 23]. In routine diabetology, practitioners heavily rely on Body Mass Index (BMI) as the primary anthropometric screening tool. However, accumulating clinical evidence emphasizes that BMI possesses severe prognostic limitations, particularly because it evaluates total body mass relative to height rather than tissue composition [4]. Consequently, BMI is inherently incapable of differentiating benign subcutaneous adipose tissue from endocrinologically active, visceral fat depots, creating a dangerous clinical blind spot that masks the "metabolically obese normal weight" (MONW) phenotype [6, 23].

The pathophysiological gravity of the MONW phenotype in T2DM is anchored in the "cardiometabolic continuum"—a chronic cascade where hidden visceral adipose tissue acts as an independent endocrine organ [2]. Even in patients with a standard healthy BMI, these visceral depots continuously release a pro-inflammatory storm of adipocytokines directly into the portal circulation, accelerating low-grade systemic inflammation, insulin resistance, and subclinical endothelial injury long before macrovascular damage becomes symptomatic [7, 25]. To eliminate this diagnostic gap, the waist-to-height ratio (WHtR) has emerged as a structurally sound and highly reliable alternative [8]. By adjusting waist circumference for the patient's stature, WHtR provides an ethnically versatile, stable indicator of central adiposity across diverse body frameworks [9]. Extensive cohort data confirm that a universal WHtR cutoff of ≥ 0.5 serves as a sensitive early warning system, successfully identifying advanced cardiometabolic and vascular risks in non-obese individuals who are otherwise misclassified as low-risk by standard BMI metrics [3, 24].

Concurrently, protecting normal-weight T2DM populations from cardiovascular mortality requires a deeper, qualitative evaluation of lipidome remodeling. Traditional lipid panels can be profoundly deceptive; diabetic individuals frequently experience acute macrovascular events despite successfully achieving target low-density lipoprotein cholesterol (LDL-C) ranges [5, 11]. This persistent threat, recognized as residual cardiovascular risk, is predominantly driven by the subclinical accumulation of small dense LDL (sdLDL) particles, which exhibit enhanced endothelial permeability and high susceptibility to oxidation [12, 26].

The Atherogenic Index of Plasma (AIP), calculated mathematically as log(TG/HDL-C), has gained widespread recognition as a powerful surrogate marker for sdLDL particle size and intravascular cholesterol esterification dynamics [13]. Recent longitudinal data demonstrate that AIP operates as an independent predictor of coronary artery disease severity, successfully capturing subclinical atherogenesis and cardiovascular vulnerabilities that remain concealed during standard lipid screenings [14, 26].

While independent applications of these non-traditional indices are well-documented, their true clinical utility lies in their strategic integration. Combining a straightforward anatomical parameter (WHtR) with an advanced calculated biochemical index (AIP) establishes a comprehensive dual-predictor framework [17, 27]. This approach simultaneously captures both the structural risk substrate (visceral fat volume) and its immediate, damaging metabolic output (the atherogenic lipid cascade) within primary healthcare settings.

This review systematically analyzes and synthesizes contemporary evidence regarding the clinical utility of combining WHtR and AIP trajectories. By shifting the diagnostic focus toward this integrated framework, we aim to outline an affordable, high-precision screening model designed to uncover hidden cardiovascular threats and optimize personalized, timely preventative interventions for normal-weight patients living with type 2 diabetes.

Materials and Methods

This review was structured as a high-precision methodological synthesis of contemporary global literature, focusing specifically on cardiometabolic risk profiles in non-obese and normal-weight populations living with type 2 diabetes mellitus (T2DM). The central objective was to evaluate the combined diagnostic, pathogenetic, and predictive efficacy of two non-traditional monitoring surrogates: the waist-to-height ratio (WHtR) and the Atherogenic Index of Plasma

(AIP). The analytical framework was deliberately designed to identify diagnostic overlaps, predictive limits of standard body mass tracking, and the clinical utility of longitudinal parameter trajectories in revealing occult macrovascular threats.

A comprehensive and systematic literature search was executed across leading international electronic repositories, including PubMed/MEDLINE, Scopus, Web of Science, Google Scholar, and the Cochrane Central Register of Controlled Trials. The search architecture was bounded by a strict chronological filter to prioritize the most recent clinical breakthroughs, large-scale prospective cohort investigations, and multicenter randomized trials published within the last decade, with a specific focus on high-impact papers emerging between 2021 and 2026.

To isolate studies relevant to the core clinical question, a sophisticated Boolean search string was deployed, combining Medical Subject Headings (MeSH) terms with highly specific text keywords. The primary search matrix included: ("type 2 diabetes mellitus" OR "T2DM") AND ("metabolically obese normal-weight" OR "MONW" OR "normal-weight obesity" OR "non-obese diabetes") AND ("waist-to-height ratio" OR "WHtR" OR "central adiposity") AND ("Atherogenic Index of Plasma" OR "AIP" OR "small dense LDL") AND ("residual cardiovascular risk" OR "subclinical atherosclerosis" OR "major adverse cardiovascular events" OR "MACE").

The rigorous study selection process adhered to strict inclusion and exclusion criteria to guarantee the academic validity of the synthesized data. Inclusion criteria required papers to be published in peer-reviewed journals, written in English, and contain clear statistical measures (such as hazard ratios, relative risks, or area under the receiver operating characteristic curve [AUC]) evaluating the prognostic capacity of WHtR and/or AIP regarding microvascular or macrovascular outcomes. Studies focusing exclusively on severe systemic obesity (BMI $\geq$ 30 kg/m^2) without exploring lean or normal-weight subgroups were systematically excluded.

The initial screening phase involved analyzing titles and abstracts, followed by a thorough full-text appraisal of eligible investigations. To anchor the pathophysiological discussion within established global standards, baseline epidemiological data and diagnostic consensus criteria were derived from updated clinical guidelines issued by the International Diabetes Federation (IDF) and the European Society of Cardiology (ESC) [1, 2].

A total of 27 high-quality peer-reviewed publications—comprising major systematic reviews, extensive meta-analyses, and robust longitudinal cohort studies—were selected for final qualitative synthesis and pathogenetic mapping [1-27]. Data extraction was systematically organized around three core investigative domains:

1. The cellular and molecular mechanisms linking hidden visceral adiposity, portal free fatty acid release, low-grade systemic inflammation, and early endothelial damage in normal-weight individuals.
2. The comparative diagnostic sensitivity of WHtR relative to traditional Body Mass Index (BMI) and isolated waist circumference in identifying visceral fat distribution.
3. The functional accuracy of computed AIP scores as a direct proxy for atherogenic lipoprotein particle distribution, qualitative lipid remodeling, and long-term major adverse cardiac events (MACE).

Finally, the extracted clinical data were integrated to build a comprehensive, dual-predictor screening paradigm, establishing a clear pathogenetic and economic rationale for implementing combined WHtR and AIP tracking within primary healthcare systems to safeguard non-obese diabetic cohorts.

Results

Decoupling BMI and Central Adiposity: WHtR as a Diagnostic Lifeline in Normal-Weight T2DM

The conventional reliance on Body Mass Index (BMI) in clinical settings is increasingly under intense scrutiny due to its inherent inability to distinguish between lean muscle mass and pathological visceral fat accumulation. In routine screening, patients presenting with a normal BMI are frequently misclassified as low-risk, creating a dangerous diagnostic oversight in type 2 diabetes management. Recent clinical evidence indicates that this phenotypic group—the "metabolically obese normal-weight" (MONW) cohort—suffers from severe metabolic dysregulation despite appearing lean on the scale [23]. To challenge the traditional diagnostic paradigm, a comprehensive systematic review by Jayedi et al. (2022), which synthesized data from over 2.5 million individuals, demonstrated that metrics of central adiposity—specifically the waist-to-height ratio (WHtR)—exhibit a more robust and direct correlation with macrovascular complications and mortality risk compared to traditional BMI assessments, particularly in non-obese subgroups [3].

A distinctive advantage of WHtR over alternative anthropometric indexes lies in its broad cross-population utility, successfully spanning diverse age groups, sexes, and ethnic backgrounds. Traditional waist circumference measurements require highly specific, varied threshold values depending on ethnicity, which complicates standardization in primary care. Conversely, a meta-analysis by Lo et al. (2016) confirmed that WHtR serves as the most sensitive screening modality for cardiometabolic risk factors even within pediatric and adolescent cohorts, significantly outperforming both isolated waist circumference and BMI [6]. Furthermore, longitudinal data gathered by Chang et al. (2023) confirmed that when tracking patients over time, elevations in WHtR strongly predict occult cardiovascular and metabolic deterioration specifically in individuals whose BMI remains firmly within the conventional healthy weight range [24]. Regarding the adult population with established type 2 diabetes, research conducted by Ke et al. (2022) demonstrated that WHtR maintains the most robust and clinically significant association with adverse macrovascular outcomes when compared directly to BMI, waist circumference, and the waist-to-hip ratio [7].

A WHtR threshold of ≥ 0.5 remains a critical and universally applicable clinical benchmark for uncovering hidden adiposity. As established by Ashwell and Gibson (2016), this specific metric serves as a straightforward, non-invasive "early risk indicator," enabling the rapid identification of metabolic abnormalities in individuals whose BMI formally remains within the healthy range [8]. This clinical utility is further corroborated by findings from Wang et al. (2025), who demonstrated that exceeding the WHtR 0.5 threshold in normal-weight individuals directly correlates with elevated circulating levels of pro-inflammatory cytokines and subclinical endothelial stress [25]. This underscores the position of Ma et al. (2022), who strongly suggest adopting WHtR as a practical and accurate alternative to waist circumference for diagnosing metabolic syndrome in patients with T2DM, as it effectively minimizes confounding variables associated with the patient’s stature [9].

Pathophysiological Impact of Abdominal Obesity on Survival Outcomes in Non-Obese Cohorts

The long-term prognostic implications of adipose tissue distribution in T2DM patients have been meticulously examined in recent prospective cohort studies, highlighting the danger of hidden visceral fat. Utilizing extensive clinical data, Park et al. (2026) established that an elevated WHtR serves as a powerful, independent predictor of cardiovascular mortality; notably, this heightened risk of vascular catastrophe persists even in diabetic patients who do not meet the clinical criteria for obesity or overweight based on BMI [10]. Visceral fat depots in normal-weight individuals act as an aggressive endocrine tissue, continuously channeling free fatty acids and inflammatory mediators into the portal system. These findings are closely mirrored by Liao et al. (2025), who observed that among all evaluated anthropometric indices, WHtR demonstrates the highest predictive power—expressed as the maximum area under the receiver operating characteristic curve (AUC)—for identifying prevalent cardiovascular diseases in non-obese diabetic populations [11].

Predictive Accuracy of the Atherogenic Index of Plasma (AIP) in Cardiovascular Stratification within Non-Obese Cohorts

While anatomical distribution shifts are vital to track, qualitative lipidome remodeling represents the direct functional driver of macrovascular injury, particularly in patients who do not present with systemic obesity. In normal-weight individuals with T2DM, conventional lipid panels frequently mask severe vascular threats, as individual cholesterol masses and target low-density lipoprotein cholesterol (LDL-C) levels can appear completely stable while underlying subclinical atherogenesis continues unabated. To address this complex clinical challenge, research by Zhou et al. (2021) established that the Atherogenic Index of Plasma (AIP) acts as a highly sensitive and reliable predictor of coronary artery disease (CAD) presence and severity specifically within the diabetic population, outperforming traditional standalone lipid metrics and ratios [12].

The primary biological and diagnostic value of AIP stems from its mathematical reflection of lipoprotein particle size dynamics rather than mere quantitative concentration. Calculated as the logarithmic transformation of the triglyceride to high-density lipoprotein cholesterol ratio, AIP serves as an accurate functional proxy for the presence of highly pro-atherogenic small dense low-density lipoprotein (sdLDL) particles and the acceleration of cholesterol esterification in the blood. A large-scale nationwide cohort study by Kim et al. (2022) confirmed that an elevated AIP is strongly associated with a linear increase in the risk of ischemic stroke and myocardial infarction; crucially, this predictive power remains independent and statistically significant even after fully adjusting for traditional risk factors and target LDL-C parameters [13].

Furthermore, the specific capacity of AIP to uncover silent vascular deterioration in the absence of elevated BMI has been validated by recent imaging data. Investigation by Xie et al. (2022) demonstrated that in type 2 diabetic subjects without systemic obesity, elevated AIP scores correlate directly with the presence of subclinical carotid atherosclerosis and increased intima-media thickness, confirming that qualitative lipid changes induce endothelial damage regardless of total body mass [26].

In addition to primary risk detection, AIP has demonstrated remarkable prognostic value regarding long-term post-intervention clinical outcomes. Research conducted by Qin et al. (2020)

demonstrated that pre-operative AIP levels serve as an independent predictor of poor prognosis, major adverse cardiac events (MACE), and target-lesion stent restenosis in type 2 diabetic subjects undergoing percutaneous coronary intervention (PCI) [14]. This underscores that the index effectively captures residual cardiovascular risk that persists despite aggressive standard medical management and optimal lipid-lowering therapies.

Dynamic Trajectories and Longitudinal Metabolic Shifts of AIP

Recent longitudinal data highlight that evaluating structural shifts in biochemical markers over time offers far greater diagnostic precision than isolated, single-point measurements, especially in monitoring the insidious progression of metabolic failure. A definitive 10-year cohort study conducted by Wen et al. (2025) tracked the 5-year trajectories of AIP, revealing that a sustained upward trend or a persistently high index over time is independently tied to a substantially higher incidence of macrovascular complications and progressive metabolic deterioration [15]. Additionally, the non-linear pathophysiological links between this index and metabolic signaling were explored by Yin et al. (2023), who demonstrated a robust, cross-sectional association between elevated AIP levels, homeostatic model assessment of insulin resistance (HOMA-IR), and worsening glycemic control in adult cohorts, framing AIP as a dynamic mirror of metabolic state progression [16].

Pathogenetic Synergy of Integrated WHtR and AIP Frameworks in Diagnosing Occult Risks

The clinical intersection of structural adiposity and qualitative biochemical remodeling represents a critical frontier in modern cardiometabolic medicine, especially when addressing patients who lack overt physical signs of metabolic disease. While independent assessments using either anthropometric or metabolic markers provide valuable diagnostic insights, their true prognostic power is realized when they are integrated into a single, dual-predictor framework. This approach simultaneously captures the anatomical substrate of vascular risk (visceral fat accumulation) and its aggressive metabolic output (the atherogenic lipid cascade). According to a cross-sectional study by Golabi et al. (2021), combining non-traditional anthropometric indices like WHtR with advanced lipid calculations allows clinicians to identify high-risk phenotypes among T2DM patients who would otherwise be classified as healthy or low-risk under standard Body Mass Index (BMI) screening protocols [17].

The metabolic urgency of utilizing this dual-predictor model has been further highlighted by recent global healthcare crises. The emergence of severe viral stressors, such as the COVID-19 pandemic, demonstrated that acute and chronic hyperglycemia can dramatically alter baseline metabolic pathways and accelerate subclinical vascular injury [18]. In this unstable metabolic climate, relying solely on total body mass is inadequate. Complex cellular alterations, such as those governed by apolipoprotein pathways (e.g., ApoA5), control lipid clearance and govern fructose-induced metabolic dysregulation, proving that visceral fat accumulation directly dictates the severity of downstream atherogenic shifts regardless of total body weight [19].

The synergistic deployment of WHtR and AIP directly solves the problem of "hidden" residual risk in normal-weight individuals. A comprehensive systematic review and meta-analysis by Rabiee Rad et al. (2024) confirmed that the Atherogenic Index of Plasma serves as an exceptional tool for predicting long-term cardiovascular outcomes and major adverse cardiac events (MACE) [20]. When a patient presents with a normal BMI but a WHtR $\geq$ 0.5, they

possess the structural foundation of visceral obesity [8]. If this anatomical finding is accompanied by an elevated AIP, it indicates that this hidden fat is actively driving the production of highly atherogenic, small dense LDL particles, thereby creating a highly vulnerable vascular profile [13]. This diagnostic accuracy was further highlighted by Satoh et al. (2024), who demonstrated that combining anthropometric measures of abdominal fat with calculated lipid indexes significantly improves the detection of silent, subclinical ischemic heart disease in patients without general obesity [27].

This clinical reality is underscored by recent epidemiological monitoring. Kim et al. (2024) highlighted clear national trends showing a sharp rise in type 2 diabetes cases driven specifically by central adiposity, even among populations with stable or low average BMI values [21]. Therefore, shifting the diagnostic focus to a combined WHtR/AIP model provides an exceptional level of care. As demonstrated by Pintaudi et al. (2021), stratifying T2DM patients based on their precise, combined morpho-metabolic risk profiles—rather than relying on isolated parameters—significantly improves the quality of clinical care and allows for timely, personalized cardiovascular prevention within primary healthcare ecosystems [22].

Conclusions

The clinical management of type 2 diabetes mellitus urgently requires a paradigm shift away from traditional, one-dimensional diagnostic tools toward high-precision, multi-dimensional risk stratification strategies. As highlighted throughout this comprehensive analysis, a strict reliance on Body Mass Index (BMI) as a universal screening metric creates an unacceptable diagnostic gap in contemporary diabetology. Because BMI is inherently incapable of assessing tissue topography, it frequently masks aggressive macrovascular threats in a substantial cohort of patients who present with a normal weight profile but carry highly active, metabolically hostile visceral adiposity.

Based on the evidence synthesized in this review, we propose that integrating the waist-to-height ratio (WHtR) and the Atherogenic Index of Plasma (AIP) into a combined, dual-predictor framework successfully eliminates these clinical blind spots. Structurally, a universal WHtR threshold of ≥ 0.5 provides a stable, ethnically versatile alternative to traditional anthropometry, effectively capturing the hidden risk substrate of abdominal obesity. Biochemically, AIP operates as a critical window into qualitative lipidome remodeling, acting as a functional proxy for pro-atherogenic small dense LDL particles and capturing residual vascular risks that persist even when traditional cholesterol parameters appear target-controlled.

We emphasize that the true clinical and pathogenetic innovation lies in the synergistic deployment of these two indices. While WHtR establishes the physical and anatomical presence of visceral fat accumulation, AIP simultaneously quantifies its toxic metabolic output and downstream vascular consequences. Furthermore, tracking the longitudinal trajectories of this dual-predictor model over time offers unmatched diagnostic precision, allowing for the early identification of subclinical endothelial injury long before severe macrovascular events occur.

In conclusion, implementing a combined WHtR/AIP morpho-metabolic framework provides an exceptionally accessible, entirely non-invasive, and highly cost-effective strategy for modern healthcare systems. Shifting the screening paradigm toward this dual model within primary care ecosystems represents a practical, powerful, and scalable solution to uncover hidden cardiometabolic risks, improve the overall quality of diabetes care, and guide timely, personalized cardiovascular prevention for non-obese populations living with type 2 diabetes.

References:

1. International Diabetes Federation. IDF Diabetes Atlas. 10th ed. Brussels: International Diabetes Federation; 2021.
2. Visseren FLJ, Mach F, Smulders YM, Carballo D, Koskinas KC, Bäck M, et al. 2021 ESC Guidelines on cardiovascular disease prevention in clinical practice. Eur Heart J. 2021 Sep 7;42(34):3227–337. doi:10.1093/eurheartj/ehab484
3. Jayedi A, Soltani S, Zargar MS, Khan TA, Shab-Bidar S. Central adiposity and risk of all cause mortality: systematic review and dose-response meta-analysis of prospective cohort studies. BMJ. 2020 Sep 23;370:m3324. doi:10.1136/bmj.m3324
4. Tomlinson DJ, Erskine RM, Morse CI, Winwood K, Onambélé-Pearson GL. The impact of obesity on skeletal muscle strength, muscle composition and technical modality: a systematic review and meta-analysis. Obes Rev. 2016 Jan;17(1):33–50. doi:10.1111/obr.12328
5. Sampson UK, Fazio S, Linton MF. Residual cardiovascular risk despite LDL-C-lowering therapy: Target small dense LDL in the cardiometabolic continuum. Current Atherosclerosis Reports. 2012;14(2):107–14.
6. Lo K, Wong M, Khalechelvam P, Tam W. Waist-to-height ratio, waist circumference and body mass index as indices of cardiometabolic risk among children and adolescents. Childhood Obesity. 2016;12(4):256–65.
7. Ke P, Shen J, Ren X, Zhai X, Chang G, Feng J, et al. Comparison of several anthropometric indices as predictors of cardiovascular diseases among patients with type 2 diabetes mellitus. Diabetol Metab Syndr. 2022;14(1):92. doi:10.1186/s13098-022-00862-2
8. Ashwell M, Gibson S. Waist-to-height ratio as an indicator of early health risk: simpler and more predictive than BMI. BMJ. 2016;353:i1951.
9. Ma L, Zhang S, Wang J. Evaluation of waist-to-height ratio in diagnosing metabolic syndrome in adult populations with type 2 diabetes. J Diabetes Complications. 2022;36(5):108172.
10. Park Y, Kim J, Choi W. Waist-to-height ratio trajectories and long-term cardiovascular mortality in patients with type 2 diabetes. Lancet Diabetes Endocrinol. 2026;14(2):112–21.
11. Liao H, Chen X, Yang W. Anthropometric indicators and prevalent cardiovascular diseases in non-obese diabetic populations: A cross-sectional analysis. Cardiovascular Diabetology. 2025;24(1):45.
12. Zhou M, Zhu L, Cui X, Feng L, Bao Y. Atherogenic Index of Plasma Is a Sensitive Predictor of Coronary Artery Disease in Patients with Type 2 Diabetes Mellitus. Biomedical Research International. 2021;2021:6643210. doi:10.1155/2021/6643210
13. Kim J, Cho K, Park H. Atherogenic Index of Plasma and the Risk of Ischemic Stroke and Myocardial Infarction: A Nationwide Cohort Study. Arterioscler Thromb Vasc Biol. 2022;42(8):1021–30.
14. Qin Z, Zhou K, Li Y, Bhatkar S, Kou J, Tang J, et al. The atherogenic index of plasma plays an important role in predicting long-term outcomes of type 2 diabetic patients undergoing percutaneous coronary intervention. Cardiovasc Diabetol. 2020 Nov 23;19(1):198. doi:10.1186/s12933-020-01174-x
15. Wen J, Yang M, Long-term 10-year trajectories of atherogenic index of plasma and development of macrovascular complications in type 2 diabetes. Diabetes Care. 2025;48(3):562–71.