

“HALF THE DYSLIPIDEMIA OF INSULIN RESISTANCE” IS THE DYSLIPIDEMIA OF INSULIN-RESISTANT BLACKS

Anne E. Sumner, MD

(*Ethn Dis.* 2009;19:462–465)

Key Words: Triglyceride, High Density Lipoprotein-Cholesterol, Metabolic Syndrome, Insulin Resistance, Blacks

Even though the dyslipidemia of insulin resistance is characterized by increased triglyceride (TG) and low high density lipoprotein-cholesterol (HDL-C) levels, insulin-resistant Blacks usually have normal TG levels.^{1,2} Therefore, the universality of the concept of the dyslipidemia of insulin resistance needs re-examination. Overall, a lack of appreciation of the absence of hypertriglyceridemia in insulin-resistant Blacks has led to the development of health screening programs that are not optimally effective in Blacks. For example, paradigms used to identify individuals at risk for type 2 diabetes mellitus (T2DM) and cardiovascular disease (CVD) often require that TG be elevated.³ Therefore, these programs often lead to the under-diagnosis of risk of T2DM and CVD in Blacks.⁴ As the dyslipidemia of insulin resistance, particularly elevated TG, is part of many screening programs,^{3,5–13} we need to critically review the effectiveness of these programs in Blacks.

The observation that Blacks often have only “half the dyslipidemia of insulin resistance” (ie, normal TG and low HDL-C levels) challenges established dogma that in the presence of insulin resistance, increased TG and low HDL-C are a couplet.¹⁴ To understand the physiology of insulin resistance, pathways that allow “half the dyslipidemia of insulin resistance” to occur in Blacks must be explored.

In this commentary, syndromes that emphasize elevated TG to predict risk for T2DM and CVD are identified and their effectiveness in Black populations examined. Then pathways that could

account for the finding of “half the dyslipidemia of insulin resistance” in Blacks are described.

SYNDROMES

Syndromes that were designed to predict the presence of insulin resistance, pre-diabetes, T2DM or CVD include: Metabolic Syndrome (MetSyn), the simple clinical model of the Framingham Offspring Study, the enhanced diabetes prediction model of the Atherosclerosis Risk in the Community (ARIC) study and the Overweight-Lipid Syndrome.^{3,6,9,13} All of these syndromes incorporate both TG and HDL-C into their scoring system (Table 1, Panel A). Syndromes that use TG but not HDL-C include: the Hypertriglyceridemic Waist Syndrome, the Enlarged Waist Elevated TG Syndrome, the Rancho Bernardo Study, the Abbreviated Metabolic Syndrome and the Lipid Accumulation Product.^{5,7,8,10–12} (Table 1, Panel B)

Among the syndromes that incorporate both TG and HDL-C levels into their scoring systems, the MetSyn is the most well-known. However there is a “Metabolic Syndrome Paradox”; meaning the prevalence of the MetSyn is lower in Blacks than Whites even though the prevalence of T2DM and CVD is higher in Blacks.^{1,4,15–17} It has been postulated that the relative under-diagnosis of MetSyn in Blacks is explained by the observation that Blacks are significantly more likely than other ethnic groups to have normal TG levels despite insulin resistance.¹ In fact, the majority of Blacks with MetSyn have normal TG levels and low HDL

From Clinical Endocrinology Branch, National Institute of Diabetes, Digestive and Kidney Diseases, National Institutes of Health, Bethesda, Maryland 20892-1612.

Address correspondence and reprint requests to Anne E. Sumner, MD; NIDDK; 9000 Rockville Pike; Bethesda, MD 20892-1612; 301-402-4240; 301-435-5873 (fax); AnneS@intra.niddk.nih.gov

Table 1. Syndromes which predict insulin resistance, pre-diabetes, T2DM or CVD

Panel A: Syndromes that Require Measurement of both TG and HDL-C	
Syndrome	Other Parameters Measured
Metabolic Syndrome ³	Waist circumference, blood pressure, fasting glucose
Simple Clinical Model Framingham Offspring Study ¹³	Waist circumference, blood pressure, fasting glucose, age, family history of type 2 diabetes
Enhanced DM Prediction Model ARIC Study ⁶	Waist circumference, blood pressure, fasting glucose, age, family history of type 2 diabetes, race, height, uric acid
Overweight-Lipid Syndrome ⁹	Body mass index
Panel B: Syndromes that Require Measurement of TG without HDL-C	
Syndrome	Other Parameters Measured
Hypertriglyceridemic Waist Syndrome ^{9,11}	Waist circumference
Enlarged Waist Elevated TG Syndrome ¹²	Waist circumference
Rancho Bernardo Study ⁷	Fasting glucose, age, sex
Abbreviated Metabolic Syndrome ¹⁰	Waist circumference, fasting glucose
Lipid Accumulation Product ⁵	Body mass index

levels.¹⁷ In contrast, Whites with MetSyn frequently have elevated TG and low HDL levels.¹⁷

As 99% of the participants in the Framingham cohort are White, the Simple Clinical Model of the Framingham Offspring Study was field-tested only in Whites.¹³ This model uses the same TG threshold as MetSyn (ie, TG \geq 150 mg/dL). Therefore, as the MetSyn does not perform well in Blacks, it is possible that the Simple Clinical Model of the Framingham Offspring Study will not be effective in Blacks. In contrast, Blacks were included in the development and validation phases of the Enhanced Diabetes Prediction Model of ARIC.⁶ This model's scoring system gives additional points for Black race. These added points for Black race could be an effective way to offset the low frequency of elevated TG in Blacks. Further, unlike other scoring systems, the ARIC Enhanced Diabetes Prediction Model has sex-specific TG thresholds. As Black women have lower TG levels than Black men, consideration of sex differences in TG levels may enhance early identification of cardiometabolic and diabetic risk in Black women.

The Overweight-Lipid Syndrome was designed to predict insulin resis-

tance.⁹ This syndrome incorporates both TG and HDL-C levels but, in contrast to MetSyn, HDL-C level is not scored as an independent variable. HDL-C is considered only within the context of the TG/HDL-C ratio. For diagnosis, the Overweight-Lipid Syndrome requires that either TG \geq 130 mg/dL or that the TG/HDL-C ratio \geq 3. As this syndrome was developed in a cohort in whom less than 2% of the participants were Black, we tested the Overweight-Lipid Syndrome in Blacks. In our study neither TG nor TG/HDL-C ratio predicted insulin resistance in overweight Blacks.²

Without consideration of HDL-C levels, the Hypertriglyceridemic Waist Syndrome, the Enlarged Waist Elevated TG Syndrome, the Rancho Bernardo Study, the Abbreviated Metabolic Syndrome and the Lipid Accumulation Product all use TG levels.^{5,7,8,10-12} (Table 1) Of all these syndromes, the Hypertriglyceridemic Waist Syndrome is the most well-known.^{8,11} In Whites, the Hypertriglyceridemic Waist Syndrome predicts the presence of the Metabolic Triad. The three characteristics of the Metabolic Triad are hyperinsulinemia, hyperapolipoprotein B and small, dense low-density lipoprotein particles. While

the Metabolic Triad is highly predictive of premature CVD, the assays required to diagnose the Metabolic Triad are expensive and not widely available. Therefore Despres and colleagues^{8,11} undertook careful testing of a largely White population and found that the Metabolic Triad was highly associated with hypertriglyceridemia and central obesity. Based on this observation, Despres and colleagues^{8,11} coined the term Hypertriglyceridemic Waist Syndrome and defined it as TG \geq 177 mg/dL and central obesity (men: waist circumference [WC] \geq 90 cm, women: WC \geq 85 cm).^{8,11} However, this high threshold for TG might preclude in Blacks the effectiveness of the Hypertriglyceridemic Waist Syndrome to serve as proxy for the Metabolic Triad. Testing the Hypertriglyceridemic Waist Syndrome in overweight, glucose-intolerant Blacks, we found that the prevalence of the Metabolic Triad was approximately 50% but the prevalence of Hypertriglyceridemic Waist Syndrome was less than 10% (unpublished data). We speculate that this failure of the Hypertriglyceridemic Waist Syndrome to predict the Metabolic Triad may prove to be emblematic of the failure, in Blacks, of syndromes that require TG to be elevated.

ETIOLOGY OF "HALF THE DYSLIPIDEMIA OF INSULIN RESISTANCE"

Part A: Normal TG Levels in the Presence of Insulin Resistance

Even though TG levels are lower in Blacks than Whites, the reasons for this difference have not been extensively investigated. Factors that influence TG levels include body size (ie, obesity), diet, exercise and genetics. Based on the high prevalence of obesity, a high fat intake and a low rate of exercise, Blacks should have higher TG than Whites. However, the reverse is true. TG levels are higher in Whites than Blacks. Clearly, there will not be a simple

explanation for this conundrum. From a metabolic perspective, we believe that normal TG levels in insulin-resistant Blacks are a function of both decreased production and increased clearance. The factors responsible for decreased production of TG are low visceral adipose tissue (VAT) mass and low intrahepatic TG content. High lipoprotein lipase (LPL) activity and low apolipoprotein CIII (apoCIII) levels account for increased clearance.

The Relationship of VAT and Intrahepatic Fat to TG Production

Visceral adipose tissue (VAT) is located within the peritoneal cavity and is measured, albeit imprecisely, by waist circumference (WC). Metabolically, VAT functions in an insulin-resistant manner; meaning in VAT, insulin is less effective in suppressing lipolysis and epinephrine has a greater lipolytic effect. As a result, VAT is a source, but not the only source of free fatty acids (FFA), used in the liver for synthesis of TG. For reasons that await elucidation, higher VAT volumes are associated with more FFA reaching the liver.^{14,18} With increased exposure to FFA, hepatic fat content increases. Consequently, hepatic production and secretion of very low density lipoprotein (VLDL) particles increases.^{14,18} Fasting TG levels are a measure of TG in VLDL particles.

This association between VAT, intrahepatic fat and increased production of the TG rich particles (ie, VLDL) occurs in Blacks and Whites. The difference is that Blacks have less VAT and consequently less intrahepatic fat than Whites.¹⁹ This is true even when Blacks and Whites are matched by BMI or WC.¹⁹ As Blacks have less VAT and less intrahepatic fat than Whites, it is logical that blacks would have lower TG levels as well. It is unknown why ethnic differences in VAT and intrahepatic fat occur.

The Relationship of LPL Activity and Intrahepatic Fat to TG Clearance

From the perspective of TG clearance, there are at least three reasons why

TG levels are lower in Blacks than Whites. First, LPL activity is higher in Blacks than Whites.²⁰ LPL is the major enzyme responsible for clearing TG-containing lipoproteins from the circulation. As LPL activity levels are higher in Blacks than Whites, clearance of TG-containing lipoprotein particles is greater in Blacks than Whites. Second, apoCIII levels are lower in Blacks than Whites.²¹ ApoCIII, an apolipoprotein found on the surface of TG containing lipid particles, inhibits LPL activity. Lower apoCIII levels in Blacks than Whites allow for greater LPL activity in Blacks. Third, insulin resistance in Whites is highly associated with impaired LPL activity.²² However, in Blacks insulin resistance does not appear to interfere with LPL activity.²³ Therefore, in Blacks, even in the presence of insulin resistance, LPL is able to function effectively and clear TG containing lipoprotein particles from the circulation. Ethnic differences in apoCIII levels and LPL activity merit investigation.

Part B: Low HDL in the Presence of Insulin Resistance

For both Blacks and Whites insulin resistance is associated with low HDL-C levels.¹⁴ Hepatic lipase is the enzyme responsible for clearing HDL particles from the circulation. However, in the presence of insulin resistance, hepatic lipase activity increases and HDL-C levels decline.¹⁴ Blacks and Whites share this manifestation of the dyslipidemia of insulin resistance. This means that insulin-resistant Whites have low HDL-C levels and increased TG, while insulin-resistant Blacks usually have low HDL-C levels with normal TG levels.

CONCLUSION

The phrase “half the dyslipidemia of insulin resistance” describes the observation that insulin-resistant Blacks typically have normal TG and low HDL-C. Even as the etiology of normal TG levels in the presence of insulin-resis-

tance in Blacks awaits elucidation, from a public health screening point of view, lower TG levels in Blacks than Whites must be recognized. If TG thresholds are set too high to identify health risk in Blacks, Blacks will not have the opportunity to maximally benefit from interventions designed to prevent or mitigate T2DM and CVD.

ACKNOWLEDGMENTS

The author would like to thank Dr. Bernard V. Miller, III and Omoye E. Imoisili and Anita V. Tambay for their thoughtful critiques. Anne E. Sumner, MD is supported by the Intramural Research Program of NIDDK, NIH.

REFERENCES

1. Sumner AE, Cowie CC. Ethnic differences in the ability of triglyceride levels to identify insulin resistance. *Atherosclerosis*. 2008;196:696–703.
2. Sumner AE, Finley KB, Genovese DJ, Criqui MH, Boston RC. Fasting triglyceride and the triglyceride-HDL cholesterol ratio are not markers of insulin resistance in African Americans. *Arch Intern Med*. 2005;165:1395–1400.
3. Grundy SM. Metabolic syndrome pandemic. *Arterioscler Thromb Vasc Biol*. 2008;28:629–636.
4. Park Y-W, Zhu S, Palaniappan L, Heshka S, Carnethon MR, Heymsfield SB. The metabolic syndrome, prevalence and associated risk factor findings in the US population from the Third National Health and Nutrition Examination Survey, 1988-1994. *Arch Intern Med*. 2003;163:427–436.
5. Kahn HS. The lipid accumulation product is better than BMI for identifying diabetes. *Diabetes Care*. 2006;29:151–153.
6. Kahn HS, Cheng YJ, Thompson TJ, Imperatore G, Gregg EW. Two risk scoring systems for predicting incident diabetes mellitus in U.S. adults age 45 to 64 years. *Ann Intern Med*. 2009;150:741–751.
7. Kanaya AM, Wassel Fyr CL, de Rekeneire N, et al. Predicting the development of diabetes in older adults. *Diabetes Care*. 2005;28:404–408.
8. Lemieux I, Pascot A, Couillard C, et al. Hypertriglyceridemic waist, a marker of the atherogenic metabolic triad (hyperinsulinemia; hyperapoprotein B; small dense LDL) in men? *Circulation*. 2000;102:179–184.
9. McLaughlin T, Abbasi F, Cheal K, Chu J, Lamendola C, Reaven GM. Use of metabolic markers to identify overweight individuals who

- are insulin resistant. *Ann Intern Med.* 2003;139:802–809.
10. Meigs JB, Williams K, Sullivan LM, et al. Using metabolic syndrome traits for efficient detection of impaired glucose tolerance. *Diabetes Care.* 2004;27:1417–1426.
 11. St. Pierre J, Lemieux I, Perron P, et al. Relationship of the “hypertriglyceridemic waist” phenotype to earlier manifestations of coronary artery disease in patients with glucose intolerance and type 2 diabetes mellitus. *Am J Cardiol.* 2007;99:369–373.
 12. Tanko LB, Bagger YZ, Qin G, Alexandersen P, Larsen PJ, Christiansen C. Enlarged waist combined with elevated triglycerides is a strong predictor of accelerated atherogenesis and related cardiovascular mortality in postmenopausal women. *Circulation.* 2005;111:1883–1890.
 13. Wilson PWF, Meigs JB, Sullivan L, Fox CS, Nathan DM, D’Agostino RB. Prediction of incident diabetes mellitus in middle-aged adults. *Arch Intern Med.* 2007;167:1068–1074.
 14. Adiels M, Olofsson S-O, Taskinen M-R, Boren J. Overproduction of very low-density lipoproteins is the hallmark of the dyslipidemia in the metabolic syndrome. *Arterioscler Thromb Vasc Biol.* 2008;28:1225–1236.
 15. AHA Statistics Committee and Stroke Statistics Subcommittee. Heart disease and stroke statistics 2009 update: a report from the American Heart Association statistics committee and stroke statistics subcommittee. *Circulation.* 2009;119:e21–e181.
 16. Cowie CC, Rust KF, Byrd-Holt D, et al. Prevalence of diabetes and impaired fasting glucose in adults in the U.S. population, national health and nutrition examination survey 1999–2002. *Diabetes Care.* 2006;29:1263–1268.
 17. Ford ES, Giles WH, Dietz WH. Prevalence of the metabolic syndrome among US adults, findings from the third national health and nutrition examination survey. *JAMA.* 2002;287:356–359.
 18. Despres J-P, Lemieux I. Abdominal obesity and metabolic syndrome. *Nature.* 2006;444:881–887.
 19. Guerrero R, Vega GL, Grundy SM, Browning JD. Ethnic differences in hepatic steatosis: an insulin resistance paradox? *Hepatology.* 2009;49:791–801.
 20. Despres J-P, Couillard C, Gagnon J, et al. Race, visceral adipose tissue, plasma lipids, and lipoprotein lipase activity in men and women, the health, risk factors, exercise training, and genetics (HERITAGE) family study. *Arterioscler Thromb Vasc Biol.* 2000;20:1932–1938.
 21. Florez H, Mendez A, Casanova-Romero P, et al. Increased apolipoprotein C-III levels associated with insulin resistance contribute to dyslipidemia in normoglycemic and diabetic subjects from a triethnic population. *Atherosclerosis.* 2006;188:134–141.
 22. Maheux P, Azhar S, Kern PA, Chen Y-DI, Reaven GM. Relationship between insulin-mediated glucose disposal and regulation of plasma and adipose tissue lipoprotein lipase. *Diabetologia.* 1997;40:850–858.
 23. Sumner AE, Vega GL, Genovese DJ, Finley KB, Bergman RN, Boston RC. Normal triglyceride levels despite insulin resistance in African Americans: role of lipoprotein lipase. *Metabolism.* 2005;54:902–909.