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Hypertriglyceridemic waist: a simple clinical phenotype associated with coronary artery disease in women

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ABSTRACT

The aim of the present study was to compare the ability of the hypertriglyceridemic waist phenotype and the National Cholesterol Education Program–Adult Treatment Panel III (NCEP-ATP III) clinical criteria to predict coronary artery disease (CAD) risk in a sample of women. We studied 254 women among whom the presence/absence of CAD was assessed by angiography. The *hypertriglyceridemic waist phenotype* was defined as having both a high waist circumference (≥85 cm) and increased fasting triglyceride levels (≥1.5 mmol/L), whereas the presence of at least 3 of the 5 NCEP-ATP III criteria was used as the "reference" screening approach to identify women with the features of the metabolic syndrome. Women with hypertriglyceridemic waist were characterized by higher adiposity indices as well as by a more disturbed fasting metabolic risk profile compared with women without this phenotype. Similar differences were observed when comparing the metabolic profile of women with vs without at least 3 of the NCEP-ATP III clinical criteria. Moreover, differences in the Framingham risk score were essentially similar when women were considered at low or high risk by either hypertriglyceridemic waist or by NCEP-ATP III clinical criteria ($P < .0001$). Finally, both clinical phenotypes were predictive of CAD (hypertriglyceridemic waist: relative odds ratio, 2.1; 95% confidence interval, 1.1-3.8; $P = .02$; NCEP-ATP III clinical criteria: relative odds ratio, 2.5; 95% confidence interval, 1.4-4.6; $P < .003$). These results suggest that hypertriglyceridemic waist is a simple screening tool to identify women with clustering metabolic abnormalities and at increased CAD risk.

Author contributions: All authors were involved in the development of the study protocol. Patricia Blackburn wrote the initial draft of the manuscript and performed statistical analyses. Isabelle Lemieux and Benoît Lamarche contributed to writing the manuscript and intellectual input into the paper. Jean Bergeron was responsible for lipoprotein-lipid profile measurement and contributed to the revision of the paper. Patrice Perron, Gérald Tremblay, and Daniel Gaudet were involved in data collection and contributed to recruiting and screening the patients. Jean-Pierre Després was the principal investigator on the research programs that led to the production of the paper and was responsible for study design, project supervision, and intellectual input into the manuscript. All the authors read, commented upon, and made a significant contribution to the submitted manuscript.

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1. Introduction

Cardiovascular disease (CVD) remains one of the leading causes of death despite advances in the understanding of factors contributing to its etiology and of its management by lifestyle modification and pharmacotherapy. Established risk factors (lipid and nonlipid variables) clearly increase the risk of CVD [1]. However, there is evidence that variables other than traditional risk factors may further improve discrimination of individuals at increased CVD risk [2-4]. For instance, the contribution of a constellation of cardiometabolic risk factors that includes the high triglyceride–low high-density lipoprotein (HDL) cholesterol dyslipidemia, insulin resistance, elevated blood pressure, an impaired fibrinolysis, a prothrombotic state as well as an inflammatory profile, that is, features of the metabolic syndrome, has been recognized to significantly increase relative risk of CVD [5-7].

As the measurement of some of these emerging risk markers is not always available to clinicians, some organizations have proposed simple clinical criteria to identify individuals likely to have the metabolic syndrome [5-10]. The metabolic syndrome has been suggested to be particularly useful for the simple identification of individuals who are abdominally obese, insulin resistant, and at increased risk for CVD and type 2 diabetes mellitus. For instance, the National Cholesterol Education Program–Adult Treatment Panel III (NCEP-ATP III) criteria are currently used in clinical practice to identify subjects likely to have features of the metabolic syndrome [5,10]. The 5 screening variables used to identify individuals with the metabolic syndrome are waist circumference, triglycerides, HDL cholesterol levels, fasting glycemia, and blood pressure. Since the publication of these screening criteria, several prospective observational studies have shown that the risk of CVD among subjects with the metabolic syndrome is increased by about 1.5- to 2-fold, whereas the risk of type 2 diabetes mellitus is increased by about 3- to 5-fold, compared with individuals without the metabolic syndrome [2,11-14].

We have also been interested in developing a simple and rapid screening approach to help clinicians identify individuals with abdominal obesity and with features of the metabolic syndrome who are at increased risk of type 2 diabetes mellitus and CVD [15]. In 2000, Lemieux et al [15] proposed that the simultaneous measurement and interpretation of waist circumference and of fasting triglyceride levels (the so-called hypertriglyceridemic waist phenotype; defined in men by a waist circumference ≥90 cm and triglyceride levels ≥2.0 mmol/L) could be useful to identify male individuals at increased risk of coronary artery disease (CAD) and characterized by the simultaneous presence of altered cardiometabolic risk markers. Since this early report, numerous group have studied the validity of the hypertriglyceridemic waist concept; and it is more and more recognized that this phenotype might be an inexpensive clinical method for the early screening of individuals likely to have cardiometabolic risk markers increasing their risk of type 2 diabetes mellitus, CVD, or CAD [16].

In this regard, we have recently reported that the hypertriglyceridemic waist phenotype may be as discriminant as NCEP-ATP III criteria to identify men characterized by altered cardiometabolic risk markers [17]. In the present study, we tested the ability of the hypertriglyceridemic waist phenotype to predict CAD in women compared with the predictive performance of the commonly used NCEP-ATP III criteria.

2. Methods

2.1. Subjects' characteristics

This study was conducted in a sample of 254 women aged 32 to 82 years (mean age ± standard deviation, 56.2 ± 9.0 years). Patients were recruited at the Saguenay-Lac-St-Jean regional hospital in Chicoutimi after an angiographic procedure for the investigation of retrosternal pain. Patients covered a wide range of body mass index values (15.8-48.3 kg/m^2). The prevalence of familial hypercholesterolemia has been reported to be approximately 6-fold higher in this region compared with other populations (1.2% vs 0.2%) [18]; and therefore, women affected by this condition were excluded from the study. Menopausal women were included in the study (n = 176). The menopausal status was based on the absence of menstrual cycle for at least 12 months. Patients gave their written consent to participate in the study that was approved by the Chicoutimi Hospital Ethics Committee.

2.2. Anthropometric measurements

Waist circumference, body weight, and height were measured according to the procedures recommended at the Airlie Conference [19]. Body mass index is the ratio of body weight (kilograms) over height squared (square meters).

2.3. Plasma lipoprotein-lipid measurements

Plasma total cholesterol, triglyceride, and HDL cholesterol levels were measured using enzymatic assays [20]. Total cholesterol was determined in plasma, whereas HDL cholesterol was measured in the supernatant after precipitation of apolipoprotein B–containing lipoproteins with dextran sulfate and magnesium chloride [21]. Low-density lipoprotein (LDL) cholesterol was calculated with the Friedewald formula when triglyceride levels were less than 4.5 mmol/L [22]. When triglyceride levels were greater than or equal to 4.5 mmol/L, LDL cholesterol levels were directly measured using a Technicon RA-500 analyzer (Bayer, Tarrytown, NY) as previously described [23]. Total apolipoprotein B concentrations were measured by a nephelometric method using polyclonal antibodies on the BN ProSpec system (Dade Behring, Marburg, Germany).

2.4. Fasting glucose and insulin levels

Fasting plasma glucose was enzymatically measured [24], whereas fasting plasma insulin was assessed by radioimmunoassay with polyethylene glycol separation [25]. Nondiabetic and diabetic women were classified according to previously

established diagnosis of type 2 diabetes mellitus or by their fasting glucose concentrations (nondiabetic, fasting glucose <7.0 mmol/L; diabetic, fasting glucose ≥7.0 mmol/L). We have used the homeostasis model assessment (HOMA-IR model) formula (insulin resistance = [fasting insulin {microunits per milliliter}] × [fasting glucose {millimoles per liter}]/22.5) to estimate insulin resistance as previously described [26].

2.5. Assessment of CAD

Coronary angiographic disease was assessed by angiography according to previously published procedures [27]. Briefly, 4 coronary arteries were considered for the assessment of coronary stenosis: left main, left anterior descending, circumflex, and right coronary. Patients with at least 1 lesion leading to a minimum 50% lumen narrowing of any of these 4 coronary arterial segments were included in the CAD(+) group. Patients not fulfilling this criterion were classified in the CAD(–) group. Interpretation of coronary angiograms was performed independently by 2 cardiologists and 1 radiologist who were unaware of the patient's inclusion in the study.

2.6. LDL and HDL particle size determination

Nondenaturing 2% to 16% polyacrylamide gradient gel electrophoresis was performed on whole plasma kept at –80°C before use by using a procedure previously described [28]. High-density lipoprotein particle size was measured by nondenaturing 4% to 30% polyacrylamide gradient gel electrophoresis, as previously described [29].

2.7. Screening tools for the metabolic syndrome

The NCEP-ATP III criteria [5,30] and the hypertriglyceridemic waist phenotype [15] were used to identify individuals at increased risk of having features of the metabolic syndrome and at increased cardiometabolic risk. With the NCEP-ATP III criteria, metabolic syndrome was diagnosed in women when 3 or more of the following factors were present: waist circumference greater than 88 cm, triglyceride levels of at least 1.7 mmol/L, HDL cholesterol less than 1.3 mmol/L, blood pressure of at least 130/at least 85 mm Hg, and fasting glucose of at least 5.6 mmol/L. In the present study, we did not have measurements of systolic and diastolic blood pressure; but diagnosis of hypertension was recorded. Thus, hypertension was used instead of elevated blood pressure values to screen for the presence of this NCEP-ATP III criterion. For women, the hypertriglyceridemic waist phenotype was defined as a waist circumference of 85 cm or more and a triglyceride level of 1.5 mmol/L or more [31,32].

2.8. Framingham risk score

A Framingham risk score was calculated for all subjects that is calculated based on categorical values of age, total cholesterol, HDL cholesterol, blood pressure, smoking, and diabetes [1]. The presence/absence of hypertension was used instead of blood pressure values in the calculation of the Framingham risk score.

2.9. Statistical analyses

Data are expressed as mean ± standard deviation in tables and as mean ± standard error in figures. Group differences for continuous variables were examined using Student unpaired *t* tests. Fasting triglyceride levels were log-transformed because values were not normally distributed. Multiple logistic regression models were used for modeling risk relations between metabolic syndrome and angiographically assessed CAD. Women were divided into 2 groups according to the presence/absence of the NCEP-ATP III or hypertriglyceridemic waist. Women without metabolic syndrome as assessed by NCEP-ATP III or hypertriglyceridemic waist criteria were considered as the reference group, to whom a CAD odds ratio of 1.0 was assigned for comparison purposes. Comparison of prevalence data among subgroups was performed by the likelihood χ^2 analysis. Data were analyzed using the SAS version 9.2 statistical package program (SAS Institute, Cary, NC). In all analyses, a *P* value ≤ .05 was considered as being statistically significant.

3. Results

Physical characteristics and fasting cardiometabolic risk profile of women with or without the NCEP-ATP III or the hypertriglyceridemic waist criteria are presented in Table 1. The prevalence of women with the hypertriglyceridemic waist phenotype or the NCEP-ATP III criteria reached 40.6% and 46.1%, respectively. Adiposity indices such as body mass index and waist circumference (a marker of abdominal obesity) were higher in women at increased cardiometabolic risk irrespective of the screening approach used ($P < .0001$). Although there were no significant differences in LDL cholesterol levels between women with and without the hypertriglyceridemic waist phenotype, women with this phenotype presented a more disturbed fasting plasma lipoprotein-lipid profile that included increased triglyceride levels, reduced HDL cholesterol concentrations, and an increased total cholesterol to HDL cholesterol ratio ($P < .003$). Essentially, similar differences were observed when comparing women with vs without the NCEP-ATP III criteria ($P < .0001$). Women with the hypertriglyceridemic waist or the NCEP-ATP III criteria also had evidence of impaired plasma glucose-insulin homeostasis, as they showed increases in both fasting glucose and insulin levels, as well as a more severe insulin resistance state as estimated from the HOMA-IR model ($P < .004$). There were no significant differences in the proportion of menopausal women or of smokers between low– and high–cardiometabolic risk subgroups. The proportion of women with type 2 diabetes mellitus was also higher among women meeting either the NCEP-ATP III or the hypertriglyceridemic waist criteria compared with subjects without these 2 phenotypes ($P \leq .0004$).

The LDL peak particle size was significantly smaller in women at increased cardiometabolic risk irrespective of clinical criteria used to diagnose the condition (hypertriglyceridemic waist: 257.4 ± 4.9 vs 258.9 ± 4.8 Å, $P < .02$; NCEP-ATP III criteria: 256.6 ± 4.8 vs 259.8 ± 4.5 Å, $P < .0001$) (Fig. 1). Women with the hypertriglyceridemic waist phenotype were also

Table 1 – Physical characteristics and fasting cardiometabolic risk profile of women with or without the NCEP-ATP III or the hypertriglyceridemic waist criteria

Variables	NCEP-ATP III criteria		HyperTG waist	
	Without	With	Without	With
No. of subjects (%)	137 (53.9)	117 (46.1)	151 (59.4)	103 (40.6)
Age (y)	55.5 ± 9.5	57.1 ± 8.4	56.1 ± 9.8	56.5 ± 7.9
Body mass index (kg/m^2)	24.9 ± 4.2	29.3 ± 5.4*	24.7 ± 4.7	30.1 ± 4.2†
Waist circumference (cm)	80.7 ± 9.5	94.7 ± 12.1*	80.2 ± 10.7	96.8 ± 8.6†
Cholesterol (mmol/L)	5.75 ± 1.29	6.06 ± 1.35	5.70 ± 1.28	6.17 ± 1.35†
LDL cholesterol (mmol/L)	3.50 ± 1.14	3.68 ± 1.13	3.53 ± 1.17	3.65 ± 1.08
HDL cholesterol (mmol/L)	1.35 ± 0.38	1.03 ± 0.31*	1.26 ± 0.38	1.11 ± 0.37†
Triglycerides (mmol/L)	1.84 ± 1.28	2.77 ± 1.52*	1.90 ± 1.38	2.80 ± 1.43†
Cholesterol to HDL cholesterol ratio	4.70 ± 1.81	6.41 ± 2.41*	5.05 ± 2.10	6.13 ± 2.36†
Apolipoprotein B (g/L)	0.78 ± 0.27	0.83 ± 0.27	0.79 ± 0.29	0.81 ± 0.25
Fasting insulin (μU/mL)	13.3 ± 8.3	18.4 ± 11.0*	13.1 ± 7.5	19.2 ± 12.0†
Fasting glucose (mmol/L)	5.22 ± 0.71	6.46 ± 2.55*	5.50 ± 1.57	6.21 ± 2.26†
HOMA-IR	3.16 ± 2.34	5.44 ± 4.50*	3.31 ± 2.52	5.51 ± 4.68†
Smokers (%)	27.0	29.9	27.8	29.1
Type 2 diabetes mellitus (%)	5.8	43.6*	15.2	35.0†
Menopausal status (%)	83.2	81.2	81.0	84.1
Medication use				
Hormone replacement therapy (%)	57.4	50.5	52.8	56.3
Antihypertensive drugs (%)	51.5	70.4*	48.3	58.3
Hypolipidemic drugs (%)	48.2	57.3	55.0	67.7†

Data are means ± standard deviation unless otherwise indicated. HyperTG indicates hypertriglyceridemic.
The significant difference with the corresponding subgroup is indicated as follows:
* Different from women without the NCEP-ATP III criteria ($P \leq .03$).
† Different from women without the hypertriglyceridemic waist phenotype ($P < .05$).

characterized by an increased proportion (38.6%) of small LDL particles (<255 Å) and by a lower proportion (30.4%) of large particles (>260 Å) compared with women without this phenotype (32.5% and 36.4% for small and large LDL, respectively; $P < .03$) (Fig. 1). Similar differences in the proportion of small (41.8 vs 29.1%, $P < .0001$) and large (27.3 vs 39.7%, $P < .0001$) LDL particles were observed between women with/without the NCEP-ATP III criteria. In addition, women with the hypertriglyceridemic waist phenotype were characterized by smaller HDL particles (80.4 ± 2.3 vs 81.0 ± 2.5 Å, $P = .04$), with such difference being essentially similar to the one observed between women meeting vs not meeting the NCEP-ATP III criteria (80.4 ± 2.1 vs 81.1 ± 2.7 Å, $P < .03$) (Fig. 2).

To further estimate the global cardiovascular risk associated with the presence of cardiometabolic risk markers, we calculated the Framingham risk score among women with/without the NCEP-ATP III or hypertriglyceridemic waist criteria. Fig. 2 shows that women at increased cardiometabolic risk (according to either NCEP-ATP III or hypertriglyceridemic waist) were characterized by a higher Framingham risk score compared with women without these phenotypes ($P < .0001$). Differences in the Framingham risk score were similar irrespective of the screening tool used (either hypertriglyceridemic waist or NCEP-ATP III).

We found that 44.8% and 51.6% of women who were CAD positive were also characterized by the hypertriglyceridemic waist phenotype or by the NCEP-ATP III clinical criteria, respectively. Fig. 2 presents the unadjusted odds ratio of CAD associated with the presence of the NCEP-ATP III or the hypertriglyceridemic waist criteria. The odds ratio of being affected by CAD was increased by 2.1-fold (95% confidence interval, 1.1-3.8; $P = .02$) among women with the hypertriglyceridemic waist phenotype compared with women without this phenotype. The presence of the NCEP-ATP III criteria was also significantly associated with an increased CAD risk (odds ratio, 2.5; 95% confidence interval, 1.4-4.6; $P < .003$). Finally, after adjustment for the Framingham risk score (traditional risk factors), the odds of being affected by CAD were no longer significant regardless of the screening tool used.

As a large proportion of women having the hypertriglyceridemic waist phenotype also met the NCEP-ATP III criteria (77.7%), we were also interested to compare the cardiometabolic risk profile of women with none, only one, or both phenotypes (Table 2). We found that women with the NCEP-ATP III criteria or the hypertriglyceridemic waist phenotype observed in isolation were characterized by a more disturbed fasting plasma lipoprotein-lipid profile compared with women without any of these 2 screening phenotypes. However, the plasma lipoprotein-lipid profile and the Framingham risk score were slightly more deteriorated in women with the NCEP-ATP III criteria alone compared with women with only the hypertriglyceridemic waist phenotype. By using the NCEP-ATP III criteria, about 9% of women were identified as not having the metabolic syndrome even though they presented an altered cardiometabolic risk profile (they had hypertriglyceridemic waist). Finally, women with both phenotypes were characterized by the worse cardiometabolic risk profile.

4. Discussion

Results of this study suggest that both the NCEP-ATP III clinical criteria and the hypertriglyceridemic waist phenotype

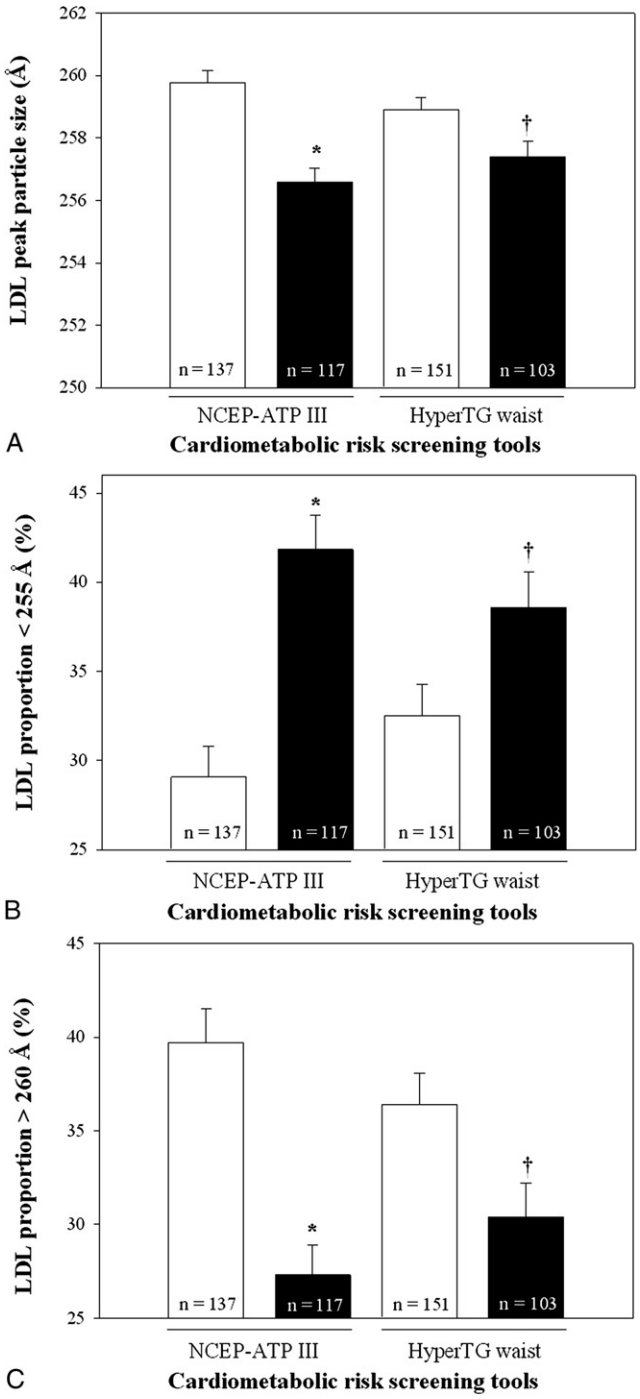

Fig. 1 – (A) Low-density lipoprotein peak particle size, (B) relative proportion of small LDL particles (<255 Å), and (C) relative proportion of large LDL particles (>260 Å) among women without (□) and with (■) the NCEP-ATP III or the hypertriglyceridemic waist (hyperTG waist) criteria. Numbers below each bar represent the frequency of women in each subgroup. *P ≤ .03 different from women without the NCEP-ATP III criteria; †P < .03 different from women without the hyperTG waist phenotype.

allow the identification of a subgroup of women with increased abdominal adiposity who are at increased CAD risk. Other studies have reported associations between the hypertriglyceridemic waist phenotype and NCEP-ATP III clinical criteria [17,33-36]. We have recently shown that hypertriglyceridemic waist may be as discriminant as the NCEP-ATP III criteria to identify men with an altered cardiometabolic risk profile [17]. Gazi et al [37] also evaluated the proportion of subjects with the NCEP-ATP III criteria or the hypertriglyceridemic waist phenotype characterized by the simultaneous presence of hyperinsulinemia, elevated apolipoprotein B, and small LDL particles, that is, the atherogenic metabolic triad, which had been reported to be predictive of a substantially increased risk of developing ischemic heart disease [3]. Among men, 52.3% of subjects with the NCEP-ATP III criteria and 66.7% characterized by the hypertriglyceridemic waist phenotype had the metabolic triad [37]. The corresponding percentages among women were 42.3% and 50%, suggesting that hypertriglyceridemic waist performed slightly better than the NCEP-ATP III criteria to identify these high-risk individuals [37]. Results presented by Lemieux et al [15] in the initial study introducing the hypertriglyceridemic waist concept showed that more than 80% of men with a waist circumference of at least 90 cm and fasting triglyceride levels of at least 2.0 mmol/L were carriers of the atherogenic metabolic triad. Results of the present study provide further support to the concept that the simultaneous measurement and interpretation of waist circumference and fasting triglyceride levels could be used as an inexpensive screening approach to identify women characterized by metabolic abnormalities predictive of an increased risk of CAD. In addition, Lemieux et al [38] have shown that the hypertriglyceridemic waist phenotype was quite prevalent among adult men of French Canadian/European origin (about 20%). Similar results have been reported in US and European populations [31,39]. In the present study, we found that the prevalence of women with the hypertriglyceridemic waist phenotype reached 40.6%. This prevalence is higher than what has been reported in most other populations. This could be explained by the fact that women were recruited after an angiographic procedure for the investigation of retrosternal pain and consequently were at high risk of CVD.

In the present study, we found that LDL peak particle size and average HDL particle size were smaller in women with the hypertriglyceridemic waist phenotype or the NCEP-ATP III clinical criteria. We found that even in the absence of significant differences in LDL cholesterol levels, individuals meeting the NCEP-ATP III criteria or the hypertriglyceridemic waist phenotype had an increased proportion of small LDL particles (<255 Å) and a lower proportion of large (>260 Å) LDL particles. These results are concordant with other studies reporting altered electrophoretic characteristics of LDL particles in subjects characterized either by the hypertriglyceridemic waist phenotype or by the NCEP-ATP III clinical criteria [17,37]. However, to the best of our knowledge, this is the first study that compared the ability of the hypertriglyceridemic waist phenotype and of the NCEP-ATP III criteria to also screen for the presence of small HDL particles. The present results underline the clinical importance of the hypertriglyceridemic

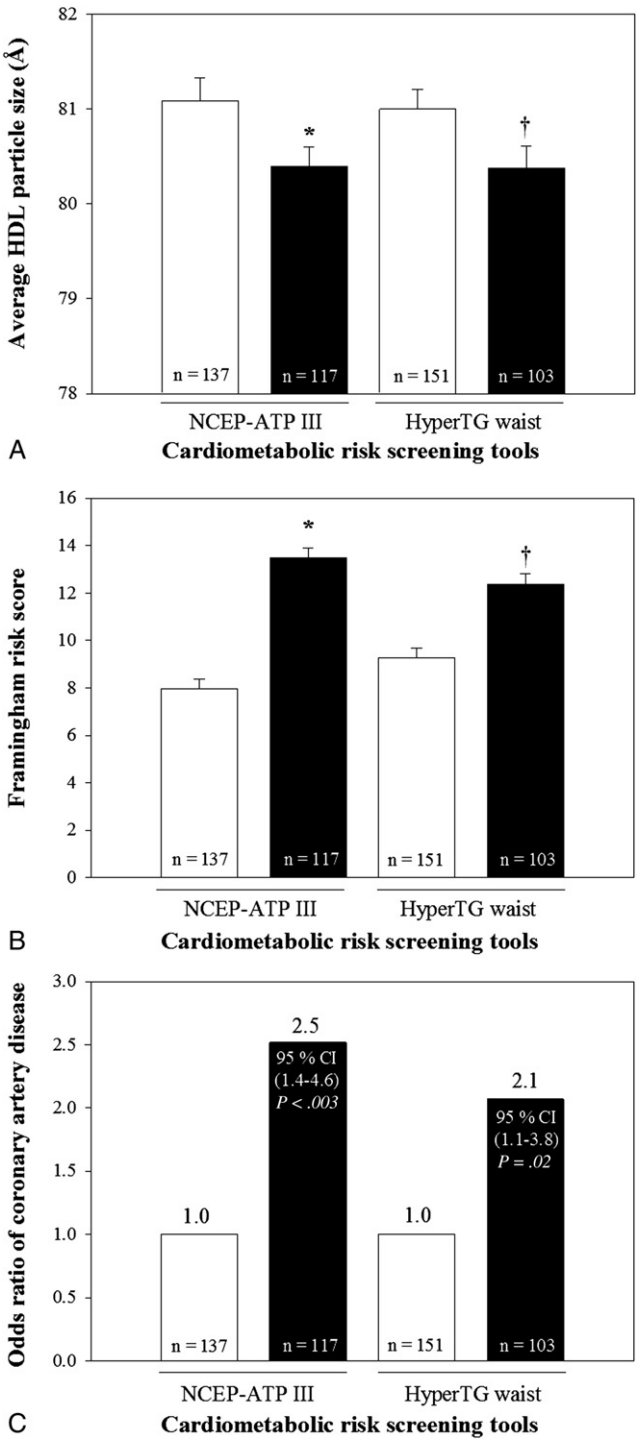

Fig. 2 – (A) Average HDL particle size, (B) 10-year Framingham risk score, and (C) unadjusted odds ratio of finding CAD, as defined by stenosis greater than 50% in a major coronary vessel measured by angiography, among women without (□) and with (■) the NCEP-ATP III or the hypertriglyceridemic waist (hyperTG waist) criteria. Numbers below each bar represent the frequency of women in each subgroup. *P ≤ .03 different from women without the NCEP-ATP III criteria; †P = .04 different from women without the hyperTG waist phenotype.

waist phenotype and of the NCEP-ATP III criteria as useful indices of electrophoretic characteristics of LDL and HDL particles that represent potentially important features of the metabolic syndrome involved in the modulation of CVD and type 2 diabetes mellitus risk.

To date, a few prospective studies have examined the utility of the hypertriglyceridemic waist phenotype in estimating CVD risk [31,34,36]. The most recent article by Arsenault et al [31] on the large EPIC-Norfolk study clearly showed that hypertriglyceridemic waist was predictive of increased coronary heart disease risk in both men and women (n = 21 787) followed for 9.8 years. In addition, Tankó et al [36] investigated the usefulness of the hypertriglyceridemic waist phenotype compared with NCEP-ATP III criteria in estimating future risk of cardiovascular mortality and the annual progression rate of aortic calcification in a large cohort of postmenopausal women. The presence of the hypertriglyceridemic waist phenotype was associated with the highest risk of fatal cardiovascular events over the 8.5-year follow-up [36]. Moreover, women characterized by the hypertriglyceridemic waist phenotype also had a higher annual progression rate of aortic calcification compared with those who had NCEP-ATP III criteria [36]. Results of the present study are quite in line with these previous observations.

We and other groups have reported an increased Framingham risk score among subjects with deteriorated cardiometabolic risk markers [2,17,37]. In the present study, we found that the risk of CAD was attenuated in women with an elevated cardiometabolic risk after adjustment for the Framingham risk score. Results from the Hoorn Study also suggested that the association between cardiovascular risk and metabolic syndrome was weaker after adjustment for the Framingham risk score [2]. Inversely, Girman et al [40] reported that the adjustment for the Framingham risk score did not eliminate the association between metabolic syndrome and cardiovascular risk. These results suggest that when subjects characterized by the hypertriglyceridemic waist phenotype do not have classic risk factors, their Framingham risk score may not be adequate to estimate their cardiovascular risk. In this regard, it has been suggested that adding diagnosis of the metabolic syndrome to traditional risk factors included in the Framingham risk score could enhance CVD risk prediction [41]. These results suggest that the combination of traditional cardiovascular risk markers and nontraditional markers could facilitate the identification of subjects at high risk of CVD.

Results of the present study suggest that the hypertriglyceridemic waist phenotype may be as discriminant as NCEP-ATP III criteria to identify women with an altered cardiometabolic risk profile and at risk of CAD. Tankó et al [36] suggested that the relative advantage of the hypertriglyceridemic waist phenotype compared with the NCEP-ATP III clinical criteria included a somewhat easier accessibility in general practice. In the present study, about 9% of women were characterized by the hypertriglyceridemic waist phenotype in isolation (not meeting NCEP-ATP III) but were nevertheless characterized by an altered cardiometabolic risk profile. If clinicians had only used the NCEP-ATP III criteria to evaluate the presence/absence of nontraditional CVD risk factors, a significant proportion of these women would not have been considered

Table 2 – Physical characteristics and fasting cardiometabolic risk profile of women with or without the NCEP-ATP III or the hypertriglyceridemic waist criteria

Variables	No NCEP-ATP III and no hyperTG waist	NCEP-ATP III only	HyperTG waist only	NCEP-ATP III and hyperTG waist
No. of subjects (%)	114 (44.9)	37 (14.6)	23 (9.0)	93 (31.5)
Age (y)	55.4 ± 9.9	58.2 ± 9.2	55.8 ± 7.8	56.6 ± 8.0
Body mass index (kg/m^2)	24.2 ± 4.0	26.4 ± 6.2 *	28.3 ± 3.2 *,†	30.7 ± 4.4 *,†,‡
Waist circumference (cm)	78.6 ± 8.9	85.4 ± 13.9 *	90.7 ± 4.9 *,†	98.6 ± 8.7 *,†,‡
Cholesterol (mmol/L)	5.63 ± 1.29	5.93 ± 1.24	6.34 ± 1.18 *	6.13 ± 1.40
LDL cholesterol (mmol/L)	3.46 ± 1.14	3.77 ± 1.24	3.72 ± 1.10	3.63 ± 1.08
HDL cholesterol (mmol/L)	1.34 ± 0.37	1.00 ± 0.29 *	1.36 ± 0.44 †	1.04 ± 0.32 *,‡
Triglycerides (mmol/L)	1.66 ± 1.10	2.64 ± 1.85 *	2.72 ± 1.74 *	2.83 ± 1.35 *
Cholesterol to HDL cholesterol	4.61 ± 1.76	6.38 ± 2.47 *	5.13 ± 1.99 †	6.43 ± 2.39 *,‡
Apolipoprotein B (g/L)	0.77 ± 0.28	0.85 ± 0.33	0.80 ± 0.26	0.82 ± 0.24
Fasting insulin (μU/mL)	12.9 ± 7.3	14.0 ± 7.6	15.1 ± 12.3	20.4 ± 11.8 *,†,‡
Fasting glucose (mmol/L)	5.18 ± 0.73	6.49 ± 2.70 *	5.41 ± 0.58 †	6.44 ± 2.49 *,‡
HOMA-IR	3.02 ± 2.02	4.29 ± 3.34	3.82 ± 3.53	5.98 ± 4.87 *,†,‡
LDL peak particle size (Å)	259.7 ± 4.6	256.5 ± 4.8 *	260.1 ± 4.4 †	256.6 ± 4.8 *,‡
LDL <255 Å (%)	29.8 ± 20.6	40.7 ± 23.9 *	25.4 ± 18.0 †	42.4 ± 19.9 *,‡
LDL >260 Å (%)	38.7 ± 21.2	29.5 ± 20.3 *	44.6 ± 20.2 †	26.4 ± 16.0 *,‡
HDL particle size (Å)	81.8 ± 2.7	80.6 ± 2.1	80.6 ± 2.8	80.3 ± 2.1
Framingham risk score	7.8 ± 4.5	13.9 ± 4.3 *	9.0 ± 4.2 †	13.3 ± 4.5 *,‡

Data are means ± standard deviation. HyperTG indicates hypertriglyceridemic (see Table 1).
The significant difference with the corresponding subgroup is indicated as follows:
* Different from women without the NCEP-ATP III criteria and the hyperTG waist phenotype.
† Different from women with the NCEP-ATP III criteria only.
‡ Different from women with the hyperTG waist phenotype only ($P < .02$).

as being at increased cardiometabolic risk. Even if a large proportion of women are characterized by both screening tools, the present study suggests that the hypertriglyceridemic waist phenotype and NCEP-ATP III do not necessary identify the same subgroups of high-risk patients. This conclusion is concordant with the findings reported by Chateau-Degat et al [42] who found that only 40% of people with the metabolic syndrome (assessed using various clinical criteria with a special focus on abdominal obesity) had the hypertriglyceridemic waist phenotype. The optimal screening tool to identify subjects with the metabolic syndrome and at high risk of CVD remains an open but important question to be resolved.

4.1. *Limitations, strengths, and clinical implications*

Some aspects of our study merit underlining. First, this study was restricted to women of only one racial group; and the sample size may not have captured a representative study population. Second, CAD was measured by angiography, which could underestimate the extent of atherosclerotic disease [43]. In this regard, this may have limited our ability to detect associations between the hypertriglyceridemic waist phenotype and risk of CAD. Third, we did not have measurements of systolic and diastolic blood pressure. Thus, hypertension was used instead of elevated blood pressure values to screen for the presence of this NCEP-ATP III criterion. This may underestimate the number of women characterized by the NCEP-ATP III criteria. However, results of the present study are novel and provide further evidence that hypertriglyceridemic waist represents a useful, simple, inexpensive, and discriminant screening phenotype to identify individuals likely to be characterized by the atherogenic and diabetogenic features of the metabolic syndrome.

Meanwhile, our study provides evidence that nonmenopausal and menopausal women with elevated values for 2 simple markers, waist circumference and fasting triglyceride levels, should receive further attention once identified in screening approaches.

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Conflicts of Interest

None to declare.

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