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Comparison of diagnostic criteria of the metabolic syndrome in 3 ethnic groups of Canada

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Abstract

The metabolic syndrome (MetS) is a cluster of metabolic abnormalities in which visceral obesity is a prominent feature. Although a matter of debate, the MetS essentially represents “at risk obesity.” The purpose of this study was to compare the various definitions of MetS, with a special focus on abdominal obesity, and to explore sex and ethnic differences in the prevalence and nature of this syndrome in 3 ethnic groups residing in the Canadian province of Québec. The study population included adult participants of 3 cross-sectional health surveys conducted in southern Québec, James Bay, and Nunavik between 1990 and 1992. A total of 2613 adults (18-74 years old) were included: 1417 Quebecers, 817 Indian Crees, and 379 Inuit. The prevalence of MetS varied by definitions, and the highest agreement was observed between the National Cholesterol Education Program–Adult Treatment Panel III and the International Diabetes Federation (79%). Most women (25%), regardless of ethnic origin, presented with a “triad” profile characterized by high waist circumference, elevated triglycerides, and low high-density lipoprotein, whereas 20% of men had the “deadly quartet” of high blood pressure with the triad mentioned above. Furthermore, our results highlight an obvious difference in the impact of the increased abdominal obesity on metabolic parameters such as insulin resistance measured by the homeostasis model assessment according to ethnic origin ($P < .001$). These 3 unique population-based samples suggest that abdominal obesity does not have a similar deleterious impact according to ethnicity, suggesting the need for an ethnic-based MetS definition.

1. Introduction

The metabolic syndrome (MetS) is a cluster of metabolic abnormalities, including insulin resistance, dyslipidemia, and systemic hypertension, in which visceral obesity is prominent [1]. First identified in late 1950s, this syndrome is considered today a source of controversy [2]. Nevertheless, it is well accepted that this syndrome has the ability to predict diabetes and cardiovascular diseases (CVDs) [3-7].

Given the importance of preventing diabetes and CVDs in Westernized as well as in developing countries, health organizations have developed various definitions of MetS (Table 1). Currently, there are several well-known definitions of the syndrome. The first was provided by the World Health Organization (WHO) in 1999; other definitions followed in attempts to improve the clinical utility of MetS designation [8-11]. However, few studies have compared and evaluated the agreement between these definitions especially in ethnic groups [6,12-14].

Another important debate in the literature related to the definition of the MetS is the selection of appropriate visceral obesity cutoff points. The health implications of visceral body fat vary by ethnic group, as evidenced by different cutoffs recommended for Asian populations [15,16]. Thus, the International Diabetes Federation (IDF) has developed a new definition of MetS with specific waist circumference (WC) cutoff values for ethnic groups for whom they had sufficient information. Specific anthropometric differences

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are also observed in other populations such as in the Inuit [17-19].

Thus, the purpose of this study was to compare different definitions of MetS, with a special focus on abdominal obesity, and to explore sex and ethnic differences in the prevalence and nature of this syndrome in 3 different ethnic groups residing in the Canadian province of Québec.

2. Methods

2.1. Sample and design

Data were collected in a series of 3 cross-sectional surveys, using the same study design, conducted in 1990, 1991, and 1992 by the Quebec Ministry of Health and Social Services among Quebecers from southern Québec, James Bay Crees, and the Nunavik Inuit. Information was collected in 2 distinct stages including face-to-face interviews at participants' home and clinical sessions within the community health care clinic. A trained research nurse performed all physiologic and anthropometric measurement during the clinical session. The 3 study samples involved adults (18-74 years old), including 1417 Quebecers, 817 Indian Crees, and 379 Inuit, who were selected by stratified probabilistic sampling of each population. The sampling strategy has been described elsewhere [13]. Each participant provided informed-written consent before recruitment. Studies were approved by the relevant ethical review committees, notably the Clinical Research Deontology Committee of Laval University or the Ethics Committee of Maisonneuve-Rosemont Hospital.

2.2. Laboratory methods

Lipid profiles were obtained in accordance with the Lipid Research Clinics [20]. Cholesterol and triglycerides concentrations were determined in plasma and in lipoprotein fractions. The high-density lipoprotein cholesterol (HDL-C) fraction was obtained after precipitation of low-density lipoprotein cholesterol (LDL-C) in the infranatant fluid with heparin and manganese chloride. Plasma glucose was measured enzymatically, and fasting insulin concentrations were measured with a commercial double-antibody radioimmunoassay as described by Dewailly et al [21] in 2001. The *homeostasis model assessment of insulin resistance* (HOMA-IR), defined as the product of fasting insulin and glucose concentration divided by 22.5, was calculated as an index of insulin resistance [22].

2.3. Anthropometric and physiologic measures

Height, weight, WC, hip girth, and blood pressure were measured during a clinical session, performed by a trained research nurse according to the same standard protocol in surveys as previously reported [23]. Body mass index (BMI) was also calculated. The above measures were used to obtain the prevalence of MetS according to the definitions presented in Table 1. However, because microalbuminuria was not available from our population sample, this biological parameter was not used in the determination of the prevalence of MetS according to the WHO definition. Because no cutoff for central obesity in aboriginal populations had yet been defined, the waist girth cut points for whites (≥94 cm in men and ≥88 cm in women) were used according to the IDF definition [8].

Table 1
Definition of the MetS according to WHO, EGIR, ATP-III, and IDF

WHO	EGIR	ATPIII	IDF
Diabetes or impaired glucose tolerance or insulin resistance	Insulin or hyperinsulinemia (only nondiabetic individuals)		Central obesity (varies according to ethnic origin)
Plus at least 2 of the following	Plus at least 2 of the following	At least 3 of the following	Plus at least 2 of the following
Obesity	Central obesity	Central obesity	
BMI >30 kg/m^2	WC ≥94 cm in male	WC >102 cm in male	
WHR >0.9 in male	WC ≥80 cm in female	WC >88 cm in female	
WHR >0.85 in female			
Dyslipidemia	Dyslipidemia	Hypertriglyceridemia	Hypertriglyceridemia
TG ≥1.7 mmol/L	TG ≥2.0 mmol/L	TG ≥1.7 mmol/L, treatment for elevated TG	TG ≥1.7 mmol/L
or	or	Low HDL-C	Low HDL-C
HDL-C <0.9 mmol/L in male	HDL-C <1.0 mmol/L	HDL-C <1.03 mmol/L in male	HDL-C <1.03 mmol/L in male
HDL-C <1.0 mmol/L in female		HDL-C <1.3 mmol/L in female or treatment of reduced HDL-C	HDL-C <1.29 mmol/L in female
Hypertension	Hypertension	Hypertension	Hypertension
Blood pressure ≥140/90 mm Hg or previously diagnosed hypertension	Blood pressure ≥140/90 mm Hg or previously diagnosed hypertension	Blood pressure ≥130/85 mm Hg or previously diagnosed hypertension	Blood pressure ≥130/85 mm Hg or previously diagnosed hypertension
Microalbuminuria			
Albumin excretion ≥20 μg/min	Fasting glucose ≥6.1 mmol/L	Fasting glucose ≥5.6 mmol/L or treatment of elevated glucose	Fasting glucose ≥5.6 mmol/L
Albumin-creatinine ratio ≥30 mg/g			

Adapted from Zimmet et al [8]. WHR indicates waist to hip ratio; TG, triglycerides.

Table 2
Specific risk factor characteristics of the population stratified by sex and ethnicity

	Inuit		Crees		Quebecers		P value
	Male (n = 167)	Female (n = 212)	Male (n = 382)	Female (n = 435)	Male (n = 699)	Female (n = 718)	
Age	35.1 ± 14.6	35.7 ± 12.5	35.5 ± 14.6	35.6 ± 14.4	40.8 ± 14.6	41.8 ± 14.9	<.001
*Insulin (pmol/L)	40.9 (35.9-46.5)	47.3 (42.9-52)	76.0 (71.4-80.0)	102.1 (96.5-108.0)	73.2 (70.9-75.6)	68.8 (66.8-70.7)	<.001
*Fasting glucose (mmol/L)	5.1 (4.9-5.3)	5.1 (4.9-5.2)	4.9 (4.9-5.0)	5.1 (4.8-4.9)	5.3 (5.3-5.4)	4.9 (4.9-5.0)	.15
BMI (kg/m^2)	26.3 ± 4.2	27.1 ± 4.9	28.6 ± 5.2	31.6 ± 6.1	25.5 ± 3.7	24.3 ± 4.8	<.001
WC (cm)	87.0 ± 12.4	84.7 ± 12.7	98.3 ± 14.5	99.1 ± 14.9	89.8 ± 10.8	76.8 ± 11.3	<.001
WHR	0.9 ± 0.1	0.8 ± 0.1	0.9 ± 0.1	0.9 ± 0.1	0.9 ± 0.1	0.8 ± 0.1	<.001
TG (mmol/L)	1.2 ± 1	1.1 ± 0.5	1.4 ± 0.9	1.3 ± 0.6	1.8 ± 1.1	1.4 ± 0.8	<.001
HDL-C (mmol/L)	1.4 ± 0.5	1.6 ± 0.5	1.2 ± 0.3	1.3 ± 0.3	1.2 ± 0.3	1.4 ± 0.3	<.001
LDL-C (mmol/L)	3.1 ± 1	3.0 ± 0.8	3.1 ± 0.8	2.8 ± 0.6	3.3 ± 0.9	3.2 ± 0.9	<.001
Systolic BP (mm Hg)	115 ± 13	110 ± 13	123 ± 14	120 ± 18	125 ± 14	118 ± 17	<.001
Diastolic BP (mm Hg)	76 ± 9	72 ± 8	77 ± 9	74 ± 10	78 ± 9	73 ± 9	.001

All the above values are mean ± SD, except for those with “*,” which are geometric means with IC95%. *P* value of ethnic difference adjusted for age and sex (except for age comparison only adjusted by sex). BP indicates blood pressure.

2.4. Statistical analysis

All statistics were obtained from weighted data to restore the equiprobability of an individual’s selection and to take into account the lack of responsiveness by age, sex, and geographic stratum. Accordingly, each respondent was given a value (weight) corresponding to the proportion of persons he or she represented in the Québec population [24]. Crude n values are presented for information only. Results are presented as means ± SDs or as geometric means with respective 95% interval confidence (IC95%) for skewed variables. Insulin and fasting glucose were skewed variables. Analysis of variance was used to determine the effect of ethnic group and sex. Multiple comparisons were obtained by the Scheffé method. The κ coefficient was used as a measure of agreement between MetS definitions [25]. Data were analyzed using SAS 9.1 version (SAS Institute, Cary, NC), and the statistical significance was set at $\alpha = .05$.

3. Results

Characteristics of the population are presented in Table 2. Ethnic differences in risk factor levels were observed (Table 2). In general, the Cree had a worse risk factor profile than the Inuit who, in turn, had a better risk factor profile than Quebecers. Quebecers were significantly older ($P < .001$). In age- and sex-adjusted analyses, Quebecers had lower BMI ($P < .001$), higher triglycerides, and higher levels of LDL-C than the 2 other groups and had higher systolic blood pressure than the Inuit ($P < .001$). Moreover, male Quebecers had higher fasting glucose levels than men from the 2 other groups; but there were no glucose differences for women.

Differences in the prevalence of the MetS were observed by ethnic group across all definitions used (Table 3). Depending on the definition used, Cree individuals had a 1.3- to 2.5-fold higher prevalence of MetS compared with southern Quebecers (all age-adjusted rate ratios were statistically significant). Compared with southern Quebecers, the Inuit nearly had half the prevalence of MetS (relative risk = 0.60; IC95%, 0.40-0.86) using the IDF definition. Similar results were encountered with other definitions, but it did not reach statistical significance. Among Quebecers, we observed a significant sex difference (age-adjusted) in the prevalence of MetS for all definitions except for the European Group for the study of Insulin Resistance (EGIR) definition. Sex differences appeared among Cree individuals, but only reached statistical significance when using the WHO definition.

The WHO and the EGIR definitions shared 50% of cases of MetS, whereas the WHO and the National Cholesterol Education Program–Adult Treatment Panel III (NCEP APT-III) definitions shared 72% of cases of MetS. The EGIR and NCEP ATP-III definitions shared 43% of cases of MetS. The IDF definition shared 63% of cases of MetS with the WHO definition, 38% with the EGIR definition, and 74% with the NCEP APT-III definition. These results were supported by

Table 3
Prevalence of MetS according to definition and ethnicity

	WHO			EGIR			NCEP ATP-III			IDF		
	Male	Female	Total	Male	Female	Total	Male	Female	Total	Male	Female	Total
Crees	22.3	38.5*	30.3	17.5	16.7	17.1	18.2	24.21	21.2	21.1	25.1	23.3
Inuit	7.6	8.1	7.8		4.3	5.4	5.7	9.9	7.7	7.40	11.5	9.29
Quebecers	16.0	9.01*	12.5	10.1	6.2*	8.1	14.5	10.55	12.5	20.6	15.0*	17.8

* Significantly different by sex with an age-adjusted *P* value ≤ .05.

the κ statistics that showed a moderate agreement between the WHO and EGIR definitions ($\kappa = .60$, $P \leq .0001$). There was a moderate and a slight agreement with the NCEP APT-III definition and 2 other definitions, respectively (WHO: $\kappa = 0.59$, $P \leq .0001$; EGIR: $\kappa = 0.42$, $P \leq .0001$). However, the IDF definition presented a good agreement with the NCEP APT-III definition ($\kappa = 0.79$, $P \leq .0001$) but showed moderate and poor agreement with 2 other definitions, respectively (WHO: $\kappa= 0.57$, $P \leq .0001$; EGIR: $\kappa = 0.41$, $P \leq .0001$).

Fig. 1 illustrates the relationship between WC and HOMA-IR adjusted for age, stratified by sex, ethnicity, and presence of MetS using the IDF definition. For both sexes and each ethnic group, in individuals without MetS, we observed a similar increase in insulin resistance for each centimeter of increment of WC (Fig. 1). However, comparing people with MetS, the Inuit have lower HOMA-IR than Crees and Quebecers. This was significantly observed in both sexes, except for Inuit men in the highest quartile of WC (Fig. 1). However, the sample size of Inuit men with highest

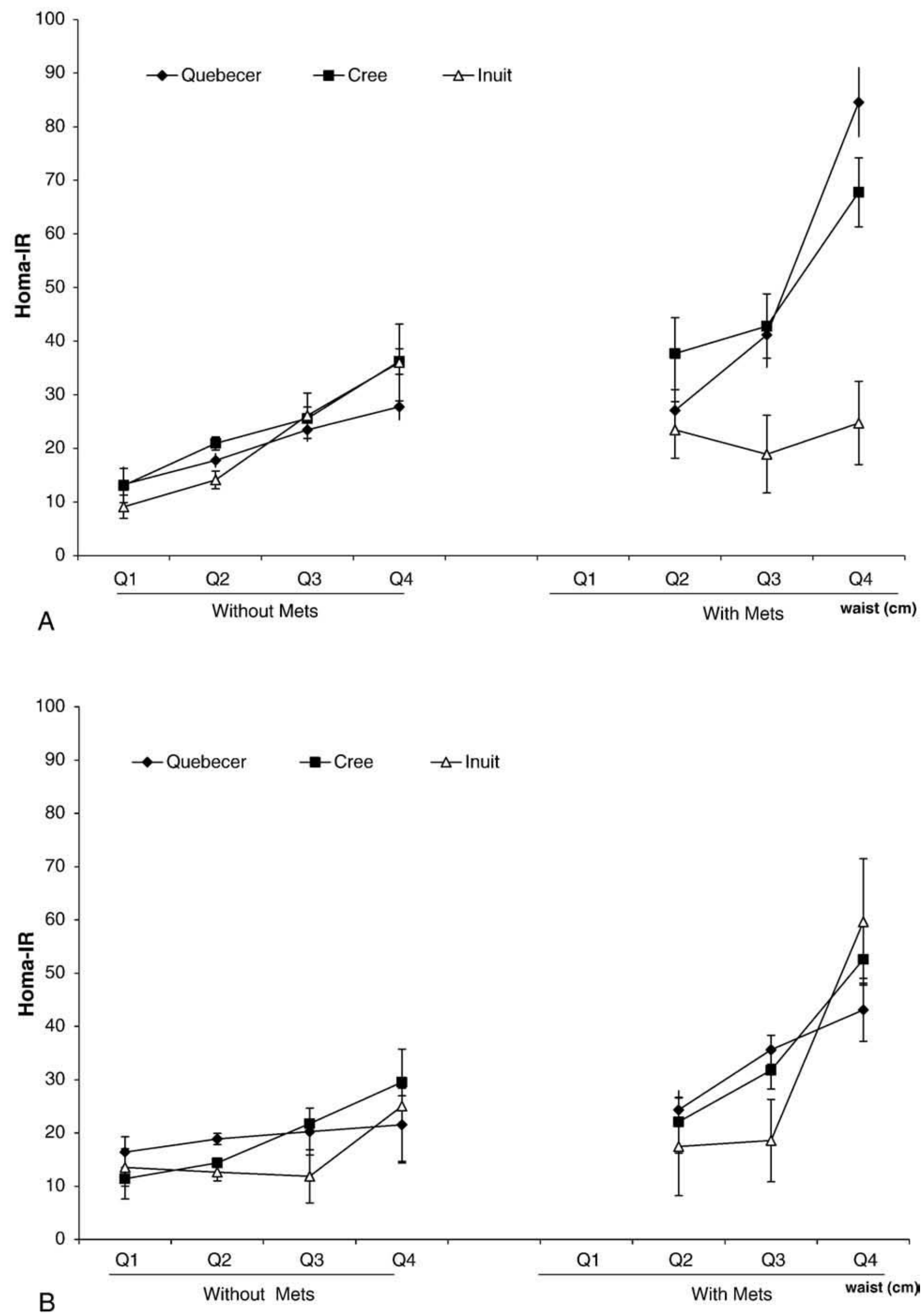

Fig. 1. Relationship between HOMA-IR and quartiles of WC by sex, ethnic group, and MetS status (A) in women and (B) in men.

Table 4
Average waist girth according to number of metabolic abnormalities adjusted for age and sex

	Inuit	Crees	Quebecers	*P* value
No. of metabolic abnormalities				
0	81.55	91.03	77.46	<.0001
1	89.70	102.76	82.22	<.0001
2	94.61	107.40	88.47	<.001
3	102.37	111.16	95.7	<.05
4	103.98	107.20	102.05	NS

NS indicates not significant.

waist was low. Moreover, examining the relationship between number of metabolic abnormalities (0-4) and average waist girth adjusted for sex and age, we observed that, for the same number of metabolic abnormalities, Quebecers have lower WCs than the Crees and Inuit (Table 4). These comparisons were highly significant except for individuals with 4 metabolic abnormalities. Furthermore, we noticed that Cree and Inuit women without metabolic abnormalities had average waist girth higher than the IDF waist cutoff for central obesity (waist $\text{girth}_{\text{Cree}}$: 92.00 [0.9], waist $\text{girth}_{\text{Inuit}}$: 80.1 [1.0] vs IDF cutoff waist girth: 80 cm). However, the same observation was not seen in men.

Finally, we compared the metabolic profile of individuals detected with MetS using the IDF definition. We observed 11 possible metabolic profiles; all of them were observed in Quebecers and Crees, and 10 of 11 profiles were observed in the Inuit group. In the Inuit, neither men nor women had a profile corresponding to elevated triglycerides and elevated blood pressure with elevated WC. Regardless of ethnic origin, the most frequent profile in women (25%) was characterized by the association of high WC, elevated triglycerides, and low HDL-C. In men, the predominant profile (20%) also included the same triad observed in women with the addition of high blood pressure. Other metabolic profiles are mostly ethnodependent and vary across ethnic group. Generally, in both men and women, the second most prevalent profile accounts for less than 20% and subsequent profiles account for less than 15% of MetS.

4. Discussion

Results of this cross-sectional population-based study on the prevalence of the MetS showed that the prevalence varies widely according to the definition applied, the ethnic population considered, and the sex. Moreover, findings highlight an obvious difference in the impact of the increased abdominal obesity, based on waist girth, on metabolic parameters across ethnic groups.

There are several studies comparing definitions of the MetS [12,14,26-29]. Nevertheless, as observed in all other previous studies, there is a moderate agreement (60%) between the NCEP APT-III and WHO definitions [14,26,27]. In our study, the lowest agreement was observed between the EGIR and IDF definitions (~40%); and the best agreement was observed between the NCEP APT-III and IDF definitions (~79%), as reported by others [29]. The difference between EGIR prevalence and those obtained from other definitions is related to the fact that EGIR did not take into account the presence of diabetes. In our study, MetS prevalence using WHO criterion is probably underestimated because we lack microalbuminuria in our data set. Furthermore, the lack of agreement observed between different definitions relies on addition of restrictive criteria from one definition to another. The modification of obesity criteria is a perfect example of this improvement to the definition. Around 40% of all individuals were identified as having MetS by all definitions. However, the remaining 60% of individuals were classified differently according to the definition being used. As an example, the weak agreement between the IDF definition and other definitions was related to the fact that the IDF definition excluded all people without abdominal obesity. Therefore, comparing research results based upon different definitions is highly problematic because the profile of those with MetS varies widely between definitions. This is probably one source of inconsistency between prospective studies that tested the ability of MetS to predict cardiovascular events [29].

In parallel, regardless of the definition used, we found that the prevalence of the MetS varies largely between ethnic groups. These findings confirm the heterogeneity of MetS [12,14,26,30,31]. The prevalence obtained in this study varies in a similar fashion as was recently observed in another Canadian province [14,32]. Crees presented with the highest prevalence, Inuit individuals presented with the lowest prevalence, and the nonaboriginal population had a prevalence in between [14,33]. However, the Inuit from Nunavik had a prevalence that was 2 times lower than that observed among Greenlandic Inuit [26]. This underlines the fact that there are probably different underlying risk factors, such as genetic predisposition, physical activity levels, extent of reliance upon a traditional diet, and environmental factors, that play a role in the prevalence of the MetS in specific ethnic groups.

Consistent with previous results [14,26,33-35], aboriginal women tend to show a higher prevalence of MetS than men; and this sex difference tends to be reversed in nonaboriginal populations. Sex differences were reported in Greenlandic Inuit, where the metabolic profile depends on the level of Westernization (ie, level of education, traditional activities, smoking and alcohol habits) and the implication of Westernization was different by sex [34]. Similar to the Greenlandic study, our results showed that metabolic profile differed between men and women. Men mainly (20%) present with the “deadly quartet” and women (25%) with a “triad” characterized by the concomitant presence of high WC, elevated triglycerides, and low HDL-C. All of these observations on sex differences should be carefully analyzed in a prospective study to better understand this phenomenon in terms of prediction of diabetes and CVD.

In fact, the question of WC and abdominal fat distribution is a concern due to its distribution that differed from one ethnic group to another. Debate on this question may be settled by the integration of specific WC cutoffs applied for white and for Asian individuals [8]. The Crees and Inuit also have some anthropometric differences that can bias the estimation of the true prevalence of the MetS. Our findings suggested that, considering the IDF criteria for abdominal obesity, 77% of the Crees and 41% of the Inuit are abdominally obese. Nevertheless, the metabolic impact of abdominal obesity differs widely; the profile of the Inuit population was better than that of the Crees and Quebecers, especially for HOMA-IR or triglycerides (data not shown) and for each level of WC, compatible with the results of a recent Inuit study [36]. Furthermore, Quebecers presented with more metabolic abnormalities than both aboriginal populations at similar WC.

These latest results support the need to adapt obesity cutoffs to both of these aboriginal populations to better assess the risk. These results are consistent with the report of Razak and colleagues [37], who compared Canadian aboriginals to Canadian Europeans and suggested to decrease BMI cut points to define obesity in aboriginals. In addition, in Crees, an increased risk of gestational diabetes mellitus for every level of obesity compared with non-aboriginals was observed [38]. However, our results suggest heterogeneity between the Inuit and Cree populations regarding the impact of WC on some metabolic parameters. Moreover, as in Pima Indians [39] or in Canadian aboriginals, we observed that despite higher BMI and WC, the Inuit have lower systolic and diastolic blood pressure than Quebecers.

Recently, a new concept named the *hypertriglyceridemic waist* was suggested as a more practical measure of “at risk obesity” for clinicians [40]. This phenotype was proposed as a predictor of atherogenic abnormalities, and it has been shown that people with this phenotype developed CVD 5 years earlier than others [7]. In our study, we observed that nearly 40% of people with MetS have the hypertriglyceridemic waist profile. Interestingly, this profile, which was of similar proportion in each ethnic group, seems generally more prevalent in men and lower in Inuit women. However, it could be interesting to test if the predictive value of the hypertriglyceridemic waist is similar in different ethnic groups and if its predictive value is better than that of MetS, which was determined to be low by Nilson and coworkers [29].

In conclusion, findings from the 3 population-based samples nourish the current debate on the utility of a universal definition of MetS, providing different prevalence across definition, ethnic group, and sex. For comparison between study populations, overall results support a definition of MetS that is ethnic and sex specific [12,41], as earlier proposed. However, adapted cutoffs for central obesity should be based on prospective study realized on the Cree and Inuit populations to evaluate the ability of MetS, in each population, to predict cardiovascular events or type 2 diabetes mellitus. Finally, regardless of the definition used or the ethnic group studied, we observed a striking variation in the prevalence of the MetS by sex, which should be explored in detail.

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