Canadian global village reality

Anthropometric surrogate cutoffs and metabolic abnormalities among Canadians of East Asian, South Asian, and European descent

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ABSTRACT

OBJECTIVE To test the appropriateness of body mass index (BMI) and waist circumference (WC) cutoff points derived in largely white populations (ie, those of European descent) for detecting obesity-related metabolic abnormalities among East Asian and South Asian Canadians.

DESIGN Cross-sectional survey.

SETTING Primary care and community settings in Ontario.

PARTICIPANTS Canadians of East Asian (n = 130), South Asian (n = 113), and European (n = 111) descent.

MAIN OUTCOME MEASURES Variables for metabolic syndromes, including BMI, WC, body fat percentage, blood pressure, lipid profile, and fasting blood glucose and insulin levels, were measured. Receiver operating characteristics curve analysis was used to generate BMI and WC cutoff points based on various criteria for metabolic syndromes.

RESULTS Adjusting for sex and age, East Asian Canadians had a significantly lower mean BMI (23.2 kg/m^2) and mean WC (79.6 cm) than did those of South Asian (26.1 kg/m^2 and 90.3 cm) and European (26.5 kg/m^2 and 89.3 cm) descent ($P < .05$). The BMI cutoffs for an increased risk of metabolic abnormalities ranged from 23.1 to 24.4 kg/m^2 in East Asian Canadians; 26.6 to 26.8 kg/m^2 in South Asian Canadians; and 26.3 to 28.2 kg/m^2 in European Canadians. Waist circumference cutoffs for increased risk of metabolic abnormalities were relatively low in East Asian men (83.3 to 85.2 cm) and women (74.1 to 76.7 cm), compared with South Asian men (98.8 cm) and women (90.1 to 93.5 cm), as well as European men (91.6 to 95.2 cm) and women (82.8 to 88.3 cm).

CONCLUSION The BMI and WC cutoffs used for defining risk of metabolic abnormalities should be lowered for East Asian Canadians but not for South Asian Canadians. The World Health Organization ethnic-specific BMI and WC cutoffs should be used with caution, particularly with Asian migrants who have resided in Canada for a long period of time.

EDITOR'S KEY POINTS

- The Canadian Guidelines for Body Weight Classification in Adults recommend generic criteria for all Canadians: body mass index (BMI) of ≥ 25 and ≥ 30 kg/m^2 for classification of overweight and obese, respectively, and waist circumference (WC) of greater than 102 cm for men and 88 cm for women for defining adults at increased risk of metabolic abnormalities. Because Canada is a multiethnic country, the appropriateness of these cutoff values for all Canadians is questionable.
- Results of this study indicate a need to use lower BMI and WC cutoff points for East Asian Canadians, but not for South Asian Canadians, in defining their risk of metabolic abnormalities; they also suggest a need to consider both ethnic differences and ethnic-environment interactions that influence optimal anthropometric surrogate cutoffs for detecting metabolic abnormalities.

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Le Canada, véritable village global

Normes anthropométriques particulières et anomalies métaboliques pour les Canadiens originaires d'Asie de l'Est, d'Asie du Sud ou d'Europe

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RÉSUMÉ

OBJECTIF Déterminer si les valeurs d'indice de masse corporelle (IMC) et de circonférence de la taille (CT) dérivées d'une population majoritairement caucasienne (c.-à-d. d'origine européenne) sont appropriées pour détecter les anomalies métaboliques liées à l'obésité chez les Canadiens originaires d'Asie de l'Est et d'Asie du Sud.

TYPE D'ÉTUDE Enquête transversale.

CONTEXTE Soins primaires et milieux communautaires de l'Ontario.

PARTICIPANTS Canadiens originaires d'Asie de l'Est (n = 130), d'Asie du Sud (n = 113) et d'Europe (n = 111).

PRINCIPAUX PARAMÈTRES À L'ÉTUDE Variables pour les syndromes métaboliques, incluant l'IMC, la CT, le pourcentage de graisse corporelle, la tension artérielle, le profil lipidique, et la glycémie et l'insulinémie à jeun. On s'est servi de la courbe d'analyse des caractéristiques de fonctionnement du récepteur pour établir des valeurs limites d'IMC et de CT à partir de divers critères pour les syndromes métaboliques.

RÉSULTATS Après ajustement pour l'âge et le sexe, les Canadiens originaires d'Asie de l'Est avaient un IMC moyen (23,2 kg/m^2) et une CT moyenne (79,6 cm) inférieurs à ceux d'Asie du Sud (26,1 kg/m^2 et 90,3 cm) et à ceux d'Europe (26,5 kg/m^2 et 89,3 cm) ($P < ,05$). Le niveau d'alarme de l'IMC pour un risque accru d'anomalie métabolique était de 21,1 à 24,4 kg/m^2 chez les Canadiens d'Asie de l'Est; de 26,6 à 26,8 kg/m^2 chez ceux d'Asie du Sud; et de 26,3 à 28,2 kg/m^2 chez ceux d'Europe. Les valeurs de CT à partir desquelles le risque d'anomalies métaboliques augmente étaient relativement basses chez les hommes (83,3 à 85,2 cm) et les femmes (74,1 à 76,7 cm) d'Asie de l'Est, par rapport aux hommes (98,8 cm) et aux femmes (90,1 à 93,5 cm) d'Asie du Sud et aux hommes (91,6 à 95,2 cm) et aux femmes d'Europe (82,8 à 88,3 cm).

CONCLUSION Les valeurs d'IMC et de CT utilisées pour prédire le risque d'anomalies métaboliques devraient être plus basses pour les Canadiens originaires d'Asie de l'Est, mais non pour ceux d'Asie du Sud. Les valeurs spécifiques aux ethnies de l'Organisation mondiale de la Santé devraient être utilisées avec discernement, particulièrement pour les immigrants d'Asie qui résident au Canada depuis longtemps.

POINTS DE REPÈRE DU RÉDACTEUR

- Les lignes directrices canadiennes pour la classification du poids corporel chez l'adulte recommandent des critères uniformes pour tous les Canadiens : un indice de masse corporelle (IMC) ≤ 25 pour un surpoids et ≤ 30 kg/m^2 pour une obésité, et un tour de taille > 102 cm pour les hommes et > 88 pour les femmes, cela afin d'identifier les sujets présentant un risque accru d'anomalies métaboliques. Le Canada étant un pays multiethnique, on peut se demander si ces valeurs normatives s'appliquent à tous les Canadiens.
- Les résultats de cette étude indiquent qu'on doit utiliser des valeurs plus basses pour les Canadiens venant d'Asie de l'Est, mais non d'Asie du Sud, lorsqu'on détermine leur risque d'anomalies métaboliques; ils suggèrent aussi qu'on doit tenir compte des différences ethniques et des interactions ethno-environnementales qui influencent les normes anthropométriques optimales utilisées pour détecter les anomalies métaboliques.

Cet article a fait l'objet d'une révision par des pairs.
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Overweight and obesity are serious public health concerns in both developed and developing countries.[1,2] The prevalence of overweight and obesity hinges on their definitions. Recognizing that there are ethnic differences in the relationship between body build and health risks among diverse populations, the World Health Organization (WHO) recommended ethnic-specific body mass index (BMI) and waist circumference (WC) cutoff values for defining overweight and obesity for Asians living in their home countries.[3] The Canadian Guidelines for Body Weight Classification in Adults, however, recommend a generic set of criteria for all Canadians: BMI of 25 or greater and 30 or greater for classifying overweight and obesity, respectively, and WC of 102 cm for men and 88 cm for women for defining adults at increased risk of metabolic abnormalities.[4] Because Canada is a multiethnic country, the appropriateness of these cutoff values to all Canadians is questionable.

Some ethnic groups differ in their body fat content, body fat distribution patterns, and the degree of health risk associated with a given BMI. For instance, Chinese adults have more body fat compared with white adults with the same BMIs.[5-7] Thus, the BMI cutoff values of 25 and 30 might underestimate the prevalence of overweight and obesity among Chinese adults. South Asians (eg, Indians) have more central body fat and also tend to have a higher health risk compared with white adults with similar BMIs.[8] As a result, applying generic BMI and WC criteria might hinder the diagnosis of adiposity-related health aliments in these ethnic groups in Canada. The guideline, however, acknowledges the fact that "research in the area of race/ethnicity and body weight, body fat distribution and related health risks is in its early stages, particularly in Canada."[4] The purpose of this study is to begin to address this deficiency.

We hypothesized that ethnic differences existed in the relationships among BMI, body fat content, fat distribution pattern, hypertension, and metabolic parameters among Canadians. A cross-sectional study was conducted in Ontario to compare these relationships among those of East Asian, South Asian, and European descent who had resided in Canada for 3 years or longer.

METHODS

The study was conducted between 2003 and 2006 in London, Toronto, and Cambridge, Ont. The study protocol was approved by the Research Ethics Board at the University of Western Ontario in London. Written informed consent was obtained from subjects before data collection.

Study subjects

Three cohorts were studied: East Asian Canadians (eg, Chinese, Vietnamese, Japanese, Koreans), South Asian Canadians (eg, Indians), and European Canadians. In order to be included in the study, potential participants had to have resided in Canada for 3 or more years (based on the general principle, "a person may apply for Canadian citizenship provided he/she is a permanent resident of Canada for more than three years"[9]); be older than 20 years of age; not be taking any medication that might influence the study parameters, such as cortisol, cortisone, insulin, hypoglycemic agents, and medication for schizophrenia; and not have diagnosed medical conditions such as diabetes, hyperlipidemia, or hypertension. Because the primary objective of this study was to test the appropriateness of BMI and WC cutoff points derived largely from white populations for detecting obesity-related metabolic abnormalities among East Asian and South Asian Canadians, sample size was estimated based on receiver operating characteristics (ROC) curve analysis. It was estimated that 64 metabolically normal (negative group) and 64 metabolically abnormal subjects (positive group) were needed to test an area under the curve of 0.7 to be significantly different from the null hypothesis value of 0.5 (ie, no discriminating power), with a type I error of .05 and a power of 80%.[10] The final sample size was set at 128 subjects in each ethnic group.

Data collection

Subjects were recruited from both primary health care and community settings in London, Toronto, and Cambridge through posters, flyers, and word of mouth. Data collection by a trained research assistant took place in physicians' offices or a mobile examination station in community settings. Body weight and height were measured and BMI was calculated. Four sites of skinfold thickness (biceps, triceps, subscapular, and suprailiac) were measured, and body fat percentage was calculated using the Durnin-Womersley equation.[11] Body fat distribution patterns were determined by measuring waist and hip circumference. Seated resting blood pressure was measured on the right arm with a standard mercury sphygmomanometer. Three overnight fasting blood samples were taken in 5-minute intervals within a 15-minute period. Blood samples were processed by the central laboratory at the Robarts Institute at the University of Western Ontario. Total plasma cholesterol, high-density lipoprotein cholesterol, and plasma triglyceride (TG) concentrations were determined using enzymatic methods. Plasma glucose was measured using enzymatic reagents, and plasma insulin was measured using an enzyme immunoassay for biologically active insulin. Homeostasis model assessment–insulin resistance (HOMA-IR) was calculated with the following formula[12,13]:

$$\frac{\text{fasting plasma insulin } (\mu U/mL) \times \text{fasting plasma glucose } (mg/dL)}{405}$$

A short demographic questionnaire was administered to obtain information such as age, sex, ethnicity, years living in Canada, and socioeconomic status.

Data analysis

All analyses were conducted using SPSS version 15 (SPSS Inc, Chicago, Ill). Descriptive statistics were calculated for ethnic groups. Anthropometric and metabolic characteristics were compared among the 3 ethnic groups using ANOVA (analysis of variance), adjusted for age and sex. Post-hoc multiple comparisons were performed using Bonferroni tests. Prevalence of metabolic abnormalities was compared among the 3 ethnic groups using χ^2 testing with a P value of .025, instead of .05, for statistical significance to account for family-wise error rates (P value of .05 divided by the total number of tests performed within the comparison groups—2 in this case: $P = .05 \div 2 = .025$). We used ROC curve analysis to determine the sensitivity and specificity of BMI and WC in predicting the risk of metabolic abnormalities. Accordingly, optimal cutoffs to distinguish between subjects with or without metabolic abnormalities by ethnic group were generated. Cutoff values were not identified when the area under the curve was close to 0.5 (ie, no apparent distributional difference between the 2 groups of the test values).[14] Metabolic abnormalities included hypertension (systolic blood pressure >130 mm Hg or diastolic blood pressure >85 mm Hg); elevated TG level (TG >1.7 mmol/L); and glucose intolerance (fasting glucose >5.6 mmol/L).[15] In addition, the cutoff values to define and screen for insulin resistance were established at the upper quartile of HOMA-IR for each ethnic group[12,16,17] (ie, East Asians >1.89, South Asians >2.39, and Europeans >2.21). Metabolic syndrome (MetS) was defined according to the WHO criteria,[18] the revised National Cholesterol Education Program–Adult Treatment Panel III (ATP III),[19] and the International Diabetes Federation (IDF) worldwide definition of MetS[20] (**Table 1**).

RESULTS

In total, 130 East Asian Canadians, 113 South Asian Canadians, and 111 Canadians of European descent participated in the study.

Demographic profiles were generally comparable among the 3 ethnic groups; however, more of the East Asian Canadians had lived for shorter periods of time in Canada and were more likely to follow traditional dietary practices than white participants (**Table 2**). In addition, a higher proportion of the South Asian Canadian cohort was in the upper age range (ie, older than 50 years of age). More Canadians of European descent were in the upper income category than their Asians counterparts (**Table 2**).

After adjusting for age and sex, anthropometric profiles differed among the ethnic groups. Compared with

Table 1. Criteria for metabolic syndromes

CLINICAL MEASURES	WHO CRITERIA,[18] 1998	REVISED ATP III CRITERIA,[19] 2005	IDF CRITERIA,[20] 2005
Insulin resistance	IGT, IFG, T2DM, or lowered insulin sensitivity* plus meeting the criteria for any 2 of the other clinical measures	None, but any 3 of the criteria for the other clinical measures	None
Anthropometrics	BMI >30 kg/m^2 or waist-to-hip ratio >0.90 (men), >0.85 (women)	WC >102 cm (men), >88 cm (women)†	Increased WC: Europids >94 cm (men), >80 cm (women); Asians >90 (men), >80 (women); and any 2 of the criteria for the other clinical measures
Lipid profile	TG >1.7 mmol/L or HDL-C <0.9 mmol/L (men), <1.0 mmol/L (women)	TG >1.7 mmol/L or HDL-C <1.0 mmol/L (men), <1.3 mmol/L (women)	TG >1.7 mmol/L; HDL-C <1.0 mmol/L (men), <1.3 mmol/L (women); or medication for HDL or TG
Blood pressure	>140/90 mm Hg	>130/85 mm Hg	>130 mm Hg systolic, >85 mm Hg diastolic, or taking medication for hypertension
Glucose	IGT, IFG, or T2DM	>5.6 mmol/L (includes diabetes)	>5.6 mmol/L (includes diabetes)

ATP—Adult Treatment Panel, BMI—body mass index, HDL-C—high-density lipoprotein cholesterol, IDF—International Diabetes Federation, IFG—impaired fasting glucose, IGT—impaired glucose tolerance, T2DM—type 2 diabetes mellitus, TG—triglyceride, WC—waist circumference, WHO—World Health Organization.

*Insulin sensitivity measured under hyperinsulinemic euglycemic conditions; glucose uptake below lowest quartile for background population under investigation.

†Some American adults of non-Asian origin (eg, white, black, Hispanic) with marginally increased WC (eg, 94–101 cm in men and 80–87 cm in women) might have a strong genetic contribution to insulin resistance and should benefit from lifestyle changes, similar to men with categorical increases in WC. Lower WC cutoffs (eg, 90 cm in men and 80 cm in women) appear to be appropriate for Asian Americans.

Table 2. Demographic characteristics of study subjects by ethnic group

CHARACTERISTICS	PROPORTION (95% CI)		
	EAST ASIAN DESCENT* (N = 130)	SOUTH ASIAN DESCENT† (N = 113)	EUROPEAN DESCENT‡ (N = 111)
Male	49 (40.4 to 57.6)	43 (33.9 to 52.1)	49 (39.7 to 58.3)
Age, y			
• 20-29	22 (14.9 to 29.1)	8 (3.0 to 13.0)	33 (24.3 to 41.7)
• 30-39	31 (23.0 to 39.0)	9 (3.7 to 14.3)	29 (20.6 to 37.4)
• 40-49	45 (36.4 to 53.6)	26 (17.9 to 34.1)	36 (27.1 to 44.9)
• ≥ 50	2 (-0.4 to 4.4)	58 (48.9 to 67.1)	2 (-0.6 to 4.6)
Education level			
• Less than grade 8	10 (4.8 to 15.2)	7 (2.3 to 11.7)	5 (0.9 to 9.1)
• Some high school or completed high school	18 (11.4 to 24.6)	15 (8.4 to 21.6)	21 (13.4 to 28.6)
• Some college or university	14 (8.0 to 20.0)	19 (11.8 to 26.2)	32 (23.3 to 40.7)
• Completed university	58 (49.5 to 66.5)	58 (48.9 to 67.1)	43 (33.8 to 52.2)
Employment status			
• Full-time	52 (43.4 to 60.6)	58 (48.9 to 67.1)	67 (58.3 to 75.7)
• Part-time	6 (1.9 to 10.1)	8 (3.0 to 13.0)	9 (3.7 to 14.3)
• Student	23 (15.8 to 30.2)	6 (1.6 to 10.4)	18 (10.9 to 25.1)
• Stay at home	2 (-0.4 to 4.4)	16 (9.2 to 22.8)	3 (-0.2 to 6.2)
• Other	10 (4.8 to 15.2)	12 (6.0 to 18.0)	10 (4.4 to 15.6)
Family income, $			
• < 23 000	31 (23.0 to 39.0)	24 (16.1 to 31.9)	11 (5.2 to 16.8)
• 23 100-39 000	26 (18.5 to 33.5)	25 (17.0 to 33.0)	20 (12.6 to 27.4)
• 39 100-55 000	14 (8.0 to 20.0)	12 (6.0 to 18.0)	23 (15.2 to 30.8)
• > 55 000	29 (21.2 to 36.8)	40 (31.0 to 49.0)	47 (37.7 to 56.3)
Duration of residence in Canada, y			
• 3-5	32 (24.0 to 40.0)	17 (10.1 to 23.9)	1 (-0.9 to 2.9)
• 6-10	19 (12.3 to 25.7)	8 (3.0 to 13.0)	0
• 11-15	14 (8.0 to 20.0)	7 (2.3 to 11.7)	2 (-0.6 to 4.6)
• 16-20	6 (1.9 to 10.1)	21 (13.5 to 28.5)	5 (0.9 to 9.1)
• > 20	29 (21.2 to 36.8)	48 (38.8 to 57.2)	92 (87.0 to 97.0)
Keeping traditional dietary habits			
• Not at all	16.2 (9.9 to 22.5)	2.8 (-0.2 to 5.8)	7.2 (2.4 to 12.0)
• A little	6.2 (2.1 to 10.3)	14.7 (8.2 to 21.2)	9.9 (4.3 to 15.5)
• Somewhat	17.7 (11.1 to 24.3)	37.6 (28.7 to 46.5)	40.5 (31.4 to 49.6)
• Very much	60.0 (51.6 to 68.4)	45.0 (35.8 to 54.2)	21.6 (13.9 to 29.3)
• Not applicable	0	0	20.7 (13.2 to 28.2)

CI—confidence interval.
*Represented ethnicities included Cambodian (n = 2), Chinese (n = 86), Japanese (n = 1), Korean (n = 1), Nepalese (n = 2), and Vietnamese (n = 9); not all participants' ethnicities were identified.
†Represented ethnicities included Indian (n = 100); not all participants' ethnicities were identified.
‡Represented ethnicities included Brazilian (n = 2), Canadian (n = 85), German (n = 1), Greek (n = 7), Polish (n = 1), and Portuguese (n = 5); not all participants' ethnicities were identified.

Canadians of European descent, East Asian Canadians had lower values for BMI, waist and hip circumference, and waist-to-hip ratio, and had a slightly lower percentage of body fat (**Table 3**), while South Asian Canadians had a higher waist-to-hip ratio and a higher percentage of body fat. South Asian Canadians had statistically higher values in all anthropometric parameters than East Asian Canadians did.

After adjusting for age and sex, metabolic profiles were comparable between Canadians of East Asian

and European descent, except that East Asians had lower systolic blood pressure as well as lower total and low-density lipoprotein cholesterol compared with Canadians of European descent (**Table 3**). South Asian Canadians had lower diastolic blood pressure, lower total cholesterol, and lower fasting glucose (**Table 3**). The prevalence of metabolic abnormalities was comparable among the 3 ethnic groups; however, East Asian Canadians had the lowest rate of MetS as defined by APT III or IDF criteria (**Table 4**[18-20]).

The optimal BMI cutoffs for detecting metabolic abnormalities by ethnicity are presented in **Table 5**.[18-20] In East Asian Canadians, optimal BMI cutoffs ranged from 23.1 to 24.4 kg/m^2. A BMI cutoff of 24.4 kg/m^2 had the highest sensitivity and specificity in detecting MetS as defined by the new worldwide definition of the IDF.[20] A BMI of 26.8 kg/m^2 was found to be the cutoff value for detecting increased risks of all metabolic abnormalities in South Asian Canadians. For Canadians of European descent, optimal BMI

Table 3. Anthropometric and metabolic profiles of study subjects by ethnic group: *ANOVA adjusted for age and sex.*

ANTHROPOMETRIC AND METABOLIC PARAMETERS	ADJUSTED MEAN* (STANDARD ERROR OF MEAN)		
	EAST ASIAN DESCENT (N = 130)	SOUTH ASIAN DESCENT (N = 113)	EUROPEAN DESCENT (N = 111)
BMI, kg/m^2	23.2 (0.4)[a]	26.1 (0.4)[b]	26.5 (0.4) [b]
Waist circumference, cm			
• Combined sex	79.6 (0.9)[a]	90.3 (1.1)[b]	89.3 (1.0)[b]
• Male	84.2 (1.2)[a]	96.5 (1.6)[b]	97.0 (1.4)[b]
• Female	75.5 (1.4)[a]	85.7 (1.6)[b]	82.5 (1.6)[b]
Hip circumference, cm	95.0 (0.7)[a]	103.3 (0.9)[b]	104.4 (0.8)[b]
Waist-to-hip ratio	0.84 (0.01)[a]	0.87 (0.01)[b]	0.85 (0.01)[a]
Body fat by skinfold, %	28.1 (0.5)[a]	34.1 (0.4)[b]	29.1 (0.4)[c]
Blood pressure, mm Hg			
• Systolic	112.3 (1.2)[a]	116.4 (1.5)[b]	118.7 (1.4)[b]
• Diastolic	77.3 (0.8)[a]	72.1 (1.0)[b]	78.4 (0.9)[a]
Total TG, mmol/L	1.4 (0.1)[a]	1.3 (0.1)[a]	1.3 (0.1)[a]
Total cholesterol, mmol/L	4.7 (0.1)[a]	4.7 (0.1)[a]	5.1 (0.1)[b]
HDL cholesterol, mmol/L	1.4 (0.3)[a]	1.3 (0.4)[b]	1.4 (0.4)[a]
LDL cholesterol, mmol/L	2.7 (0.1)[a]	2.8 (0.1)[ab]	3.0 (0.1)[bc]
Average fasting plasma glucose level, mmol/L	5.0 (0.1)[a]	4.7 (0.1)[b]	5.0 (0.1)[a]
Average fasting insulin level, µU/mL	6.8 (0.6)[a]	10.8 (0.7)[b]	7.7 (0.7)[ab]
HOMA-IR	1.5 (0.2)[a]	2.4 (0.2)[b]	1.8 (0.7)[a]

ANOVA—analysis of variance, HDL—high-density lipoprotein, HOMA-IR—homeostatic model assessment of insulin resistance, LDL—low-density lipoprotein, TG—triglyceride.

*Adjusted means with different letters were significantly different ($P < .05$) by post-hoc multiple comparison using Bonferroni tests.

Table 4. Prevalence of metabolic disorders by ethnic group

METABOLIC ABNORMALITIES	PROPORTION (95% CI)			*P* VALUE*
	EAST ASIAN DESCENT (N = 130)	SOUTH ASIAN DESCENT (N = 113)	EUROPEAN DESCENT (N = 111)	
Hypertension (BP > 130/85 mm Hg)	20.0 (13.1-26.9)	20.4 (13.0-27.8)	28.8 (20.4-37.2)	> .05
Elevated TG level (TG > 1.7 mmol/L)	26.9 (19.3-34.5)	25.7 (17.6-33.8)	20.7 (13.2-28.2)	> .05
Impaired fasting glucose (> 5.6 mmol/L)	10.0 (4.8-15.2)	13.3 (7.0-19.6)	12.6 (6.4-18.8)	> .05
HOMA-IR	23.8 (16.5-31.1)	25.7 (17.6-33.8)	24.3 (16.3-32.3)	> .05
MetS by WHO criteria[18]	17.7 (11.1-24.3)	17.7 (10.7-24.7)	18.9 (11.6-26.2)	> .05
MetS by ATP III criteria[19]	19.2 (12.4-25.9)[a]	26.5 (18.4-34.6)[ab]	36.0 (27.1-44.9)[b]	< .01
MetS by IDF criteria[20]	6.5 (2.3-10.7)[a]	17.7 (10.7-24.7)[b]	15.3 (8.6-22.0)[b]	< .05

ATP—Adult Treatment Panel, BP—blood pressure, CI—confidence interval, HOMA-IR—homeostatic model assessment of insulin resistance, IDF—International Diabetes Federation, MetS—metabolic syndrome, TG—triglyceride, WHO—World Health Organization.

*Comparison among 3 ethnic groups by χ^2 test; percentages with different letters are significantly different by pair-wise χ^2 tests with *P* values less than .025 to account for family-wise error rate.

cutoff points for detecting MetS or insulin resistance ranged from 26.3 to 28.2 kg/m^2, and 27.4 kg/m^2 was the most sensitive and specific cutoff for detecting MetS as defined by IDF.[20]

Optimal WC cutoff values for detecting metabolic abnormalities by ethnic group ranged from 83.3 to 85.2 cm for East Asian men and 74.1 to 76.7 cm for East Asian women (**Table 6**). Waist circumference cutoff values were 98.8 cm and 90.1 to 93.5 cm for South Asian men and women, respectively. For South Asian women, WC seems to be a poor indicator of insulin resistance, as it had a relatively low value for area under the ROC curve (0.47). Among European Canadians, WC cutoff values ranged from 91.6 to 95.2 cm for men and 82.8 to 88.3 cm for women (**Table 6**).

DISCUSSION

Results from this study indicate a need to use lower BMI and WC cutoff points for East Asian Canadians, but not for South Asian Canadians, for defining their risks of metabolic abnormalities; they also suggest the need to consider both ethnic differences and ethnic-environmental interactions influencing optimal anthropometric surrogate cutoff values in detecting metabolic abnormalities.

Research in East Asian countries consistently demonstrates a need for a lower BMI cutoff point (ie, <25 kg/m^2) for estimating risk of metabolic abnormalities.[21-24] The WHO has set ethnic-specific BMI and WC cutoff values for East Asians and South Asians living in Asia.[3]

Table 5. Area under the ROC curve, sensitivity, and specificity of optimal BMI cutoffs for detecting metabolic abnormalities

	EAST ASIAN (N = 130)				SOUTH ASIANS (N = 113)				EUROPEAN DESCENDANTS (N = 111)			
METABOLIC ABNORMALITIES	BMI CUTOFF	SENSITIVITY	SPECIFICITY	AUC	BMI CUTOFF	SENSITIVITY	SPECIFICITY	AUC	BMI CUTOFF	SENSITIVITY	SPECIFICITY	AUC
Hypertension	23.1	0.65	0.59	0.60	26.8	0.65	0.52	0.56	26.3	0.87	0.84	0.81
Elevated TG level	23.1	0.83	0.67	0.77	26.6	0.83	0.57	0.64	26.3	0.68	0.74	0.67
GI	23.4	0.62	0.58	0.61	26.8	0.60	0.50	0.53	28.2	0.73	0.71	0.74
IR	23.2	0.65	0.62	0.70	26.8	0.55	0.50	0.54	28.2	0.79	0.82	0.82
MetS by WHO criteria[18]	23.2	0.74	0.62	0.70	26.8	0.70	0.55	0.61	26.5	0.71	0.68	0.73
MetS by ATP III criteria[19]	23.1	0.71	0.6	0.65	26.8	0.70	0.55	0.61	26.9	0.79	0.88	0.88
MetS by IDF criteria[20]	24.4	0.91	0.77	0.90	26.8	0.82	0.56	0.67	27.4	0.96	0.83	0.91

ATP—Adult Treatment Panel, AUC—area under the curve, BMI—body mass index, GI—glucose intolerance, IDF— International Diabetes Federation, IR—insulin resistance, MetS—metabolic syndrome, ROC—receiver operating characteristic, TG—triglyceride, WHO—World Health Organization.

Table 6. Area under the ROC curve, sensitivity, and specificity of optimal WC cutoffs for detecting metabolic abnormalities by sex and ethnic group

	EAST ASIANS (N = 130)				SOUTH ASIANS (N = 113)				EUROPEAN DESCENDANTS (N = 111)			
METABOLIC ABNORMALITIES	WC CUTOFF	SENSITIVITY	SPECIFICITY	AUC	WC CUTOFF	SENSITIVITY	SPECIFICITY	AUC	WC CUTOFF	SENSITIVITY	SPECIFICITY	AUC
Men												
• Hypertension	NI*	NI*	NI*	0.57	NI*	NI*	NI*	0.56	95.2	0.83	0.70	0.84
• Elevated TG level	83.3	0.88	0.70	0.79	98.8	0.71	0.59	0.64	95.2	0.81	0.66	0.82
• GI	85.2	0.80	0.65	0.61	98.8	0.89	0.59	0.66	91.6	0.72	0.63	0.71
• IR	84.8	0.94	0.72	0.83	98.8	0.68	0.58	0.69	95.2	0.83	0.70	0.84
Women												
• Hypertension	74.3	0.80	0.63	0.68	92.0	0.67	0.53	0.67	88.3	0.86	0.86	0.93
• Elevated TG level	74.3	0.73	0.62	0.78	90.1	0.73	0.52	0.60	NI*	NI*	NI*	0.54
• GI	76.7	0.67	0.68	0.64	93.5	0.67	0.64	0.60	88.3	0.67	0.79	0.66
• IR	74.1	0.71	0.60	0.71	NI*	NI*	NI*	0.47	82.8	0.67	0.74	0.76

AUC—area under the curve, GI—glucose intolerance, IR—insulin resistance, NI—not identified, ROC—receiver operating characteristic, TG—triglyceride, WC—waist circumference.
*Area under the curve was very close to 0.5; therefore, cutoff values were not identified.

According to those criteria, a person with a BMI between 23.0 and 24.9 kg/m^2 is considered to be overweight, and a person with a BMI of 25.0 kg/m^2 or greater is considered to be obese; a WC greater than 90 cm for men and 80 cm for women was set as a marker of increased risk of metabolic abnormalities.[3] The appropriateness of the WHO ethnic-specific cutoffs for Asian immigrants in Western countries is uncertain. If both genetics and environmental interactions play a role in determining risk, the ethnic-specific cutoff points might not apply to Asian immigrants in Western countries.

Our study supports a lower BMI cutoff point (ie, <25 kg/m^2) for estimating risk of metabolic abnormalities among recent East Asian immigrants in Canada. Our study showed that a BMI of 23.1 kg/m^2 for East Asian Canadians, as compared with 27.4 kg/m^2 for European Canadians, had acceptable sensitivity and specificity for the detection of metabolic abnormalities in this study sample. Furthermore, these results indicate that the WHO ethnic-specific WC cutoffs are still too high for East Asian Canadians. For WC, our results based on ROC curve analysis show a cutoff of 83.3 cm and 74.1 cm for East Asian men and women, respectively, compared with 91.7 cm and 82.8 cm in men and women, respectively, of European descent. Such findings are consistent with research in Western countries that supported the concept of lowering BMI and WC cutoff values for Asian immigrants.[25-27] The WHO ethnic-specific BMI and WC cutoff points appear unsuitable for those South Asian immigrants who have resided in Canada for a long period of time. A BMI of 26.8 kg/m^2 was the cutoff point for the detection of metabolic abnormalities in this study sample for South Asians, compared with the cutoff of 27.4 kg/m^2 for European Canadians. Waist circumference cutoff points for South Asians were 98.8 cm for men and 90.1 cm for women, as compared with WC of 91.7 cm in men and 82.8 cm in women of European descent.

The South Asian cohort in this study had resided in Canada much longer than the East Asian cohort; 48% of the South Asians lived in Canada for more than 20 years. Acculturation, including lifestyle changes, might have occurred to a greater extent among the South Asian cohort than the East Asian cohort in this study. Although a recent Canadian study showed lower BMI cutoff values were needed for the detection of impaired fasting glucose and other metabolic risk factors among South Asians, the proportion of recent immigrants in the study sample was unknown.[25] A study in the United Kingdom found that anthropometric cutoffs developed among native Asian Indians for detecting risk of diabetes had a much higher sensitivity but less specificity when applied to their migrant cohort in England. The authors suggested that cutoffs developed and tested even within one ethnic group cannot be generalized to individuals of the same ethnic group living in different cultural settings where the distribution of risk factors for diabetes or MetS is different.[28] Future research is needed to compare the differences between recent East Asian migrants and those who have resided in Canada for a long period of time.

Strengths and limitations

One of the strengths of this study was that we recruited "healthy" subjects who had never been diagnosed with metabolic abnormalities, as some forms of metabolic abnormalities (eg, diabetes) can affect BMI; however, there are a number of limitations associated with this study. First, we used a convenience sample, not a random sample, which might limit the generalizability of our study findings. Second, this was a cross-sectional survey, which does not determine causal relationships. Third, although we made every effort to recruit a sample with an even age distribution, more subjects in the South Asian cohort were, in fact, in the older age range compared with the East Asian cohort. Finally, the sample size was somewhat limited. Although the total number for each ethnic group was close to the target sample size, the distribution of normal (negative group) versus abnormal subjects (positive group) was not equal as required. This might compromise the accuracy of BMI and WC cutoff points determined using ROC curve analysis.

Conclusion

Our results support lowering the BMI and WC cutoffs for East Asian Canadians, but not for South Asian Canadians, for defining risks of metabolic abnormalities. The WHO ethnic-specific BMI and WC cutoffs should be used with caution, particularly for Asian Canadians residing in Canada for a long period of time.

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Contributors

Dr He contributed to conception and design of the study, sought funding, and oversaw data collection; was responsible for data analysis and interpretation; wrote the first draft of the article; and approved the final version of the manuscript. **Dr Li** contributed to conception and design of the study, sought funding, participated in interpretation of the data, reviewed and revised the article, and approved the final version of the manuscript. **Drs Harris, Huff,** and **Anderson** contributed to conception and design of the study, participated in interpretation

of the data, reviewed and revised the article, and approved the final version of the manuscript. **Dr Yau** contributed to development of the study concept, facilitated subject recruitment and data acquisition, and reviewed and approved the final version of the manuscript.

Competing interests
None declared

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