Original Article

Migrant Asian Indians in New Zealand; prediction of metabolic syndrome using body weights and measures

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The aim of this study of Asian Indian migrants in New Zealand was to determine cut-off points for body mass index, waist circumference, waist-to-hip ratio, and waist-to-height ratio that best discriminate for increased risk of type 2 diabetes and cardiovascular disease. One hundred and seventy-five (90F, 85M) Asian Indian volunteers (aged >50 y) were recruited from urban Auckland, New Zealand. Body weight, height and waist and hip circumferences were measured using standard techniques. Waist-to-hip ratio, waist-to-height ratio and body mass index were derived. Total and percent body fat by dual energy X-ray absorptiometry, and fasting glucose, insulin and lipids were measured. Three measures of metabolic risk were determined: the homeostasis model assessment of insulin resistance, the McAuley score for insulin sensitivity and metabolic syndrome by International Diabetes Federation criteria. Body mass index, percent body fat and anthropometric measurements of central adiposity generally did not perform well as indicators of metabolic risk in this high risk population of Asian Indian migrants. Our data support the use of lower ethnic specific body mass index and waist circumference for Asian Indian women and men. The discriminatory power of waist-to-height ratio was similar to that of body mass index. Hence, waist-to-height ratio could be used as a simple screening tool. A recommendation, of a waist-to- height ratio of less than 0.5 that would underpin the simple public health message of "your waist circumference should be less than half your height".

Key Words: Asian Indians, New Zealand, metabolic syndrome, type 2 diabetes mellitus, waist-to-height ratio

INTRODUCTION

The prevalence of type 2 diabetes in New Zealand is increasing[1] and mostly affects people of Maori, Pacific and Asian origins.[1,2] Asian populations are the fastest growing ethnic group in New Zealand.[3] By 2021 Asians are expected to make up 15% of New Zealand total population.[4] In New Zealand, Chinese represent 42% and Asian Indians 25% of all Asian people.[5]

Asian Indians who migrated to Western countries have higher prevalence of type 2 diabetes than their counterparts in India.[6,7] Among Asian Indians in New Zealand, the prevalence of self-reported type 2 diabetes is 9.4% and it is three times higher than for the total population.[2] Recent studies report that Asian Indians are more insulin resistant than their matched Caucasian counterparts, and are more susceptible to developing upper body obesity, rather than general obesity, that might account for their propensity to insulin resistance.[6,8] There is evidence that an excess of visceral fat is a strong determinant of insulin resistance and is a major risk factor for the development of type 2 diabetes, cardiovascular disease (CVD), hypertension, and premature death but determination of abdominal obesity should be ethnic-specific.[9]

Body mass index (BMI) thresholds are used to identify populations with higher risk of some obesity-related diseases. BMI, however, does not provide information about body fat distribution, whereas waist circumference (WC), waist-to-hip ratio (WHR) and waist-to-height ratio (WHtR) may more reliably reflect central fat deposition. Current targets for BMI and WC have been based on data derived from Caucasians.[10] However, there is increasing evidence that Asian populations have an increased risk of developing type 2 diabetes and CVD at lower BMI and WC than European population, even with a "normal" BMI, individuals with an elevated WC can have two-to-three-fold increase in type 2 diabetes risk, CVD, and premature death.[11] Risk factors associated with visceral and general obesity, include elevated fasting glucose, increased insulin resistance, elevated diastolic and/or systolic blood pressures, increased blood lipid levels and decreased high density lipoprotein.[12]

Behavioural and environmental changes associated with westernisation of Asian Indian countries and migration of Asian Indians to developed countries is associated with an alarming increase in the prevalence of type 2 diabetes and CVD.[13,14] Furthermore, the interaction of genes with environmental factors may induce intergenerational metabolic programming in this susceptible population.[13] In New Zealand, Asian Indian men and women aged 35 to 75 years have a two to four times greater burden of

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diabetes than European[15] and in Auckland, where a high proportion Asian Indian people reside, the incidence of gestational diabetes is four times that of European (16% vs. 4%).[16] In migrant Asian Indian populations including those in New Zealand, there is an urgent need for better ways of screening for and informing the public of the high metabolic risk for Asian Indians.[17]

The aims of the current study were to determine for Asian Indians in New Zealand cut-off points for BMI, WC, WHR, and WHtR that best discriminate metabolic risk for type 2 diabetes and cardiovascular disease. It was hypothesised that a higher metabolic risk for Asian Indians would be associated with a higher proportion of body fat content for the same BMI and WC of Europeans.

METHODS

Subjects

The present analysis is based on the measurements of 175 (90 women and 85 men) participants aged between 20 and 75 years from two studies of body composition in Asian Indian.[18,19] Participants for these two studies were recruited by personal contact from community organisations (unrepresentative convenience sample) and selected to achieve similar numbers in both men and women for each decade of age between 20 and 70 years. Inclusion criteria for this analysis were measurement of fasting glucose and lipids, and blood pressure in addition to anthropometry and total and percent body fat measured by dual energy X-ray absorptiometry. Exclusion criteria for the studies were living in New Zealand for less than three years, pregnancy, significant medical conditions (such as diabetes or cancer), and medication which could affect body composition such as oral steroids. Study participants had both parents who identified as Asian Indian (76.1% Indian, 17.6% Fijian Indian, 3.4% Sri Lankan, 1.1% Pakistani, 1.1% Bangladesh); nine were born in New Zealand and 94% of the participants were resident in urban New Zealand for more than five years.

Protocols

Volunteers visited the Department of Surgery Body Composition Laboratory in the morning after an overnight fast. Body weight, height and waist and hip circumferences were measured using standard techniques. After lying for at least 15 mins, blood pressure was measured twice using a mercury sphygmomanometer and a stethoscope; and a fasting blood sample was obtained. Body composition was determined from a whole-body dual-energy X-ray absorptiometry (DXA) scan.

Anthropometry

Height (±0.1 cm) and weight (±0.1 kg) were measured in duplicate using a platform beam scale (Avery, Birmingham, United Kingdom) with volunteers wearing light clothing or standard hospital gown and no shoes. An estimated clothing weight was subtracted. Standing waist at the lateral mid-point between the lower rib and the iliac crest (±0.5 cm) and hip at the level of maximum protrusion of the gluteal muscles (±0.5 cm) were measured with a non-stretch tape measure (Figure finder tape measure, Novel products line, Rockton, IL, USA) with a device to ensure that constant tension was applied to within 0.5 cm, All measurements were made by trained observers and were repeated if not within the required precision. WHR, WHtR and BMI (kg/m^2) were derived.

Dual-energy X-ray absorptiometry

Body composition (total body fat, fat-free soft tissue and bone mineral content) was measured using a single DXA machine (GE-Lunar Model DPX+ with software version 3.6y, Lunar Radiation Corp., Madison, WI). Quality assurance checks were carried prior to scanning each subject. Fat-free mass (FFM) was calculated as the sum of fat-free soft tissue and bone mineral content. Percent body fat (%BF) was calculated as 100 x fat mass/ (fat mass + FFM).

Blood chemistry

Blood serum and plasma were stored at -85ºC and analysed in batches. Diagnostic Medlab Laboratories assayed lipids: triglycerides, HDL, LDL, total cholesterol by standard Roche-Hitachi methodology and HDL was by direct assay. Glucose was determined by the Roche-Hitachi glucose oxidase method. All assays were within target limits specified by the RCPA Quality Assurance Program. Plasma samples were assayed for insulin by LabPlus of Auckland City Hospital using the Abbot Imx Insulin assay (list No2A10, Abbot Laboratories, Japan). The HOMAIR[20] and McAuley[21] scores were calculated as measures of insulin resistance.

Criteria for selected cut-offs

The discriminatory power of selected cut-off points anthropometric measures of general and central adiposity: BMI (kg/m^2), and WC, WHR and WHtR, to correctly classify the presence or absence of risk for insulin resistance[22], insulin sensitivity[21], and metabolic syndrome[12] in Asian Indian migrants, was examined. The rationale for cut-offs and the definitions of risk applied are described below.

In 2004 the World Health Organisation (WHO) defined BMI≥23 as the public health action point or ethnic specific cut-off for Asian populations, while BMI cut-offs ≥25 and ≥27 were defined as increased risk, and ≥30 was defined as high risk.[23] Waist circumference cut-off values defined by the International Diabetes Federation[12] (IDF) for men ≥90 cm, and women ≥80 cm were selected. WHO values[24] for WHR of 0.90 and 0.80 for men and women respectively were also selected. Further values of WHR≥0.7 and ≥1.0 were also tested to cover the range of WHR in this sample.

A WHtR≥0.5 and ≤0.6 has been defined as a “take care” value, while a WHtR≥0.6 is considered a “take action” value equivalent to high metabolic risk.[25]

Arbitrary percent body fat (%BF) of ≥20%, ≥30%, and ≥40% cut-off points were sequentially examined to cover the range of body fatness in men and women.

Insulin resistance was defined as having an HOMA-IR (homeostasis model assessment of insulin resistance) value ≥2.27, and was calculated according to Matthew’s et al, (1985).[22] Insulin sensitivity was estimated by using the McAuley score. The McAuley score ≤6.3 identified low insulin sensitivity.

The most recently updated IDF criteria were used to define an Asian Indian as having metabolic syndrome.[12] The presence of metabolic syndrome was defined as having central obesity (defined as waist circumference (WC) ≥80 cm for South Indian women and ≥90 cm for South Indian men) and any two of the following four factors: elevated triglycerides (>1.7 mmol/L), reduced HDL cholesterol (≤1.1 mmol/L in women, ≤0.9 mmol/L in men), raised blood pressure (systolic blood pressure ≥130 mmHg or diastolic blood pressure ≥85 mmHg), and raised fasting plasma glucose (FPG) (≥5.6 mmol/L).

Statistical analysis

Statistical analyses were performed by PASW Statistics 18.0 (SPSS Inc, IL). Normality of continuous data was tested for skewness and z-values checked for statistical significance of the skewness. Skewed variables triglycerides, fasting glucose, fasting insulin, and HOMA; these variables were log transformed before analysis. Means (±SD or 95% CI) and frequencies (percentages) were used to describe the physical and metabolic characteristics of women and men separately. Geometric means and 95% confidence intervals were calculated for the four skewed variables. Differences between women and men for continuous variables were determined by unpaired t-tests. Chi square test was used to test difference in prevalence by gender. Separately by gender sensitivity, specificity, positive predictive value, and negative predictive value of anthropometric variables of the presence or not of insulin resistance, insulin sensitivity, and metabolic syndrome were determined. Receiver operating characteristic (ROC) curves were plotted and the areas under the curves compared to explore the discriminatory ability of anthropometric variables for assessing insulin resistance, insulin sensitivity and metabolic syndrome. A $p<0.05$ was considered statistically significant.

RESULTS

Asian Indian women were of similar age to men but were shorter and weighed less but BMI was not different between genders (Table 1). On average Asian Indian women's BF% was 10% higher (43% compared with 31%) than men. Women had a lower WHR than men but WHtR was not different. In general, Asian Indian women and men had similar total cholesterol (~5.3 mmol/L), while men had higher triglyceride and fasting glucose concentrations than women. The McAuley score was higher in women than men, while HOMA-IR was not different.

Three quarters of the participants had a BMI of more than 23 kg/m^2 (men 77%, women 79%) (Table 2) and for over half of women and men the BMI exceeded 25 kg/m^2. Almost all women and 54% of men had %BF that exceeded 30%; 70% of women and 11% of men had %BF greater than 40%.

A WHR ≥0.8 was present in more men than women, 98% and 71%, respectively, while WHR≥0.9 was also more present in 75% of men and 17% of women. Only eight of the eighty-five men had a WHR≥1.0. One sixth of women and men had a WHtR that exceeded 0.6. Insulin resistance was present in 57% of Asian Indian men, and in 50% of women, respectively; about 58% of men had a McAuley score ≤6.3. The prevalence of metabolic syndrome was significantly higher in men (31%) than women (22%).

A BMI cut-off of 23 kg/m^2 correctly classified over 84% of women and men with insulin resistance, lowered insulin sensitivity and ≥3 risk factors for metabolic syndrome (Table 3) using the Asian Indian cut-offs for waist according to IDF ethnic-group specific criteria.[12] Increasing BMI cut-offs to over 25, 27, and 30 kg/m^2, fewer participants were correctly identified with metabolic syndrome, but slightly more (61% to 64%) were correctly

Table 1. Characteristics of the study population

	Women (n=90)	Men (n=85)	*p* value*
Age (y)	43.5±12.8	45.1±12.9	0.396
Height (cm)	157±5.7	170±7.9	0.001
Weight (kg)	64.7±10.6	73.0±12.7	<0.001
BMI (kg/m^2)	26.4±4.6	25.4±3.7	0.118
Total body fat (%)†	42.8±6.5	31.3±7.6	<0.001
Waist circumference (cm)	85.8±9.7	92.6±10.3	<0.001
Waist-to-hip ratio (WHR)	0.84±0.07	0.94±0.07	<0.001‡
Waist-to-height ratio (WHtR)	0.55±0.07	0.55±0.06	0.907
Total cholesterol (mmol/L)	5.3±1.0	5.4±0.9	0.456
HDL cholesterol (mmol/L)	1.3±0.3	1.1±0.3	<0.001‡
LDL cholesterol (mmol/L)	3.3±0.9	3.5±1.0	0.194
Log triglycerides (mmol/L)	0.78±0.21	0.88±0.22	0.000‡
Triglycerides (mmol/L)§	1.3 (1.2,1.4)	1.7 (1.5,1.9)	0.000‡
Systolic blood pressure (mmHg)	115±19.9	120±18.9	0.059
Diastolic blood pressure (mmHg)	72.6±8.9	75.9±9.0	0.019‡
Fasting insulin (mlU/mL)§	10.0 (9.0,11.0)	10.3 (9.1,11.7)	0.000
Fasting insulin (pmol)	79.7±39.8	86.4±48.9	0.320
Fasting glucose (mmol/L) §	5.1 (5.0,5.2)	5.3 (5.2,5.4)	0.010‡
McAuley score	6.9±1.6	6.4±1.8	0.030‡
HOMA-IR§	2.3 (2.0,2.5)	2.4 (2.1,2.8)	0.000

Mean (SD). †Measured by whole body dual X-ray absorptiometry. §Geometric mean and 95% CI of mean from back transform of log transformed variables.

BMI: Body mass index; HOMA-IR: homeostasis model assessment of insulin resistance.

The differences between each gender were analysed by independent t test.

‡Men significantly different from women. *p* value <0.05, *independent t test.

classified with metabolic syndrome. A BMI cut-off of ≥30 kg/m^2 correctly identified 75% of women with and without insulin resistance, and metabolic syndrome. Three quarters of the insulin resistant men were correctly identified at a BMI of ≥25 kg/m^2.

A BF% of ≥40% correctly identified 78% of women with metabolic syndrome but did not perform well for other measures of risk. WC was not a good predictor of risk in women. It correctly identified <60% of women for all indices of risk. WC cut-off ≥90 cm correctly identified 70% of men with metabolic syndrome.

A WHR cut-off of ≥0.7 correctly classified 27% of Asian Indian women and 47% of men with metabolic syndrome respectively. Rising WHR cut-off to ≥0.8 correctly classified 47% of women and 53% of Asian Indian men with metabolic syndrome respectively, while percentage of women and men with insulin resistance and low insulin sensitivity increased in both genders. WHR of ≥0.9 showed that 72% of Asian Indian women and 61% of men were correctly classified with metabolic syndrome; 65% of women were less insulin sensitive, while 60% of men were correctly classified with insulin resistance.

A WHtR cut-off of ≥0.5 correctly classified over 60% of Asian Indian men with insulin resistance, lower insulin sensitivity, and metabolic syndrome. About 54% of Asian Indian women were correctly classified with insulin resistance and low insulin sensitivity, while 48% of women had metabolic syndrome, although with high sensitivity and low specificity. Raising the WHtR cut-off to ≥0.6 correctly classified 75% of women with low insulin sensitivity and metabolic syndrome, while over 50% of Asian Indian men were correctly classified in relation to three health indexes of health risk. Asian Indian men were more insulin resistant, while women were less insulin sensitive than men.

The area under ROC curves show the ability of each anthropometric measure to correctly discriminate between those with and without insulin resistance and lowered insulin sensitivity, and metabolic syndrome at all possible cut-offs of the screening measures (Figure 1). Generally, all measurements, for both women and men had lower than desired (area under curve >0.80) ability to discriminate between those with or without metabolic risk and discriminatory ability was not different. WC, WHtR and BMI appear to perform similarly with areas under the curve ranging from 0.57 (WHtR for women) to 0.79 (BMI and WC for men). WHR had the worst performance, only discriminating correctly from 44% to 60% of the time.

DISCUSSION

In this high risk convenience sample more than half the participants had high risk of metabolic disease. Predetermined anthropometric cut-offs for risk of insulin resistance, insulin sensitivity, or metabolic syndrome did not perform well. Our evidence supports the use of lower ethnic specific BMI and WC targets for the New Zealand Asian Indian population.[8,26,27] Due to lack of specificity of anthropometric cut-offs and the high prevalence of risk, in multiethnic population Asian Indian ethnicity alone is justified as a risk factor.[28]

Women had smaller body weight (~20%), higher body fatness (10%), less central adiposity and less insulin sensitivity than men. One other study of young adults living in Kolkata, India has examined measures of fatness in relation to blood pressure.[29] After controlling for BMI and waist circumference there was no difference in blood pressure between genders but within gender waist circumference was the best, positive, predictor of blood pressure. In Pune, India a study has reported that men, compared with women, have markedly higher (1.8x) homocysteine, a risk factor for metabolic disease, concentrations, when compared with gender differences for homocysteine for other ethnic groups. The higher insulin resistance of men in the present study may be related to increased central adiposity.[30]

Due to the relatively lean appearance and lower mean body mass index in this population, visceral obesity may not be clinically observed yet our objective measure of excess of body fat reinforces the previous findings of under-recognition of obesity in Asian Indians, when defined by BMI alone.[31,32]

The anthropometric cut-off of central obesity, WHtR, of ≥0.5 correctly classified 54% of women and 64% of men with metabolic syndrome respectively, with high sensitivity (>95%) and low specificity (~30%) for both genders. In contrast to the observation by Ashwell et al,[33] that WHtR has significantly greater discriminatory power over BMI and WC, in the present study the discrimina-

Table 2. Proportion (%) of participants above selected cut-offs for anthropometric and metabolic measures[†]

Selected cut-offs		Women (n=90)	Men (n=85)
Body mass index	≥23 kg/m^2	78.9	76.5
	≥25 kg/m^2	55.6	51.8
	≥27 kg/m^2	34.4	25.9
	≥30 kg/m^2	17.8	10.6
Total body fat	≥20%	100	94.1
	≥30%	97.8	54.1
	≥40%	70.0	10.6
Waist circumference			
	≥80 cm in women; ≥90 cm in men	74.4	63.5
Waist-to-hip ratio	≥0.7	97.8	100
	≥0.8	71.1	97.6
	≥0.9	16.7	75.3
	≥1.0	0.9	9.4
Waist-to-height ratio	≥0.5	76.7	81.2
	≥0.6	17.8	16.5
Insulin resistance (HOMA-IR ≥2.27)		50.0	56.5
Lowered insulin sensitivity (McAuley score ≤6.3)		33.3	57.6
Metabolic syndrome[‡]		22.2	30.6

[†]HOMA-IR: homeostasis model assessment of insulin resistance. The differences between genders were analysed by chi-square test.
[‡]According to the International Diabetes Federation (IDF definition, a person to be identified as having metabolic syndrome they must have central obesity (female waist circumference ≥80 cm, male waist circumference ≥90 cm) plus any two of the following four factors reduced HDL cholesterol (<1.1 mmol/L in females and <0.9 mmol/L in males), raised triglycerides level (≥1.7 mmol/L), raised blood pressure (systolic blood pressure ≥130 mmHg or diastolic blood pressure ≥85 mmHg), and raised fasting plasma blood glucose (≥5.6 mmol/L).

Table 3. Sensitivity and specificity of BMI, waist circumference, and waist-to-height ratio in relation to indexes of health risk in Asian Indian women and men[†]

Selected cut offs	Women (n=90)					Men (n=85)				
	Sensitivity	Specificity	PPV[††]	NPV[‡‡]	Correctly classified	Sensitivity	Specificity	PPV[††]	NPV[‡‡]	Correctly classified
Insulin resistance (HOMA-IR)[‡]	%	%	%	%	%	%	%	%	%	%
Body mass index ≥23 kg/m^2	86.7	28.9	54.9	68.4	57.8	91.7	40.5	66.7	79.0	69.4
≥25 kg m^2	66.7	55.6	60.0	62.5	61.1	72.9	78.8	79.6	68.3	74.1
≥27 kg/m^2	48.9	80.0	70.8	61.0	64.4	37.5	89.2	81.8	52.4	60.0
≥30 kg/m^2	31.1	95.6	87.5	58.1	63.3	18.8	100	100	48.7	54.1
Total body fat ≥20%	100	0	54.7	100	50.0	100	13.5	60.0	100	62.4
≥30%	100	4.44	51.1	100	52.2	68.8	64.9	71.7	61.5	67.1
≥40%	77.8	37.8	55.6	63.0	57.8	16.7	97.3	88.9	47.4	51.8
Waist cut-off ≥80 cm in women; ≥90 cm in men	84.4	35.6	56.7	69.6	60.0	77.1	54.1	68.5	64.5	67.1
Waist-to-hip ratio ≥0.7	95.6	0	48.7	0	47.8	97.9	0	56.0	0	55.3
≥0.8	71.1	28.9	50.0	50.0	50.0	100	5.41	57.8	66.7	58.8
≥0.9	8.89	75.6	26.7	45.3	42.2	81.3	32.4	60.9	57.1	60.0
Waist-to-height ratio ≥0.5	80.0	26.7	52.8	57.1	53.3	91.7	32.4	63.8	75.0	65.9
≥0.6	22.2	86.7	62.5	52.7	54.4	27.1	97.3	92.9	50.7	57.7
Insulin sensitivity (McAuley score)[§]										
Body mass index ≥23 kg/m^2	96.7	30.0	40.9	94.7	52.2	87.8	36.1	65.2	68.4	65.9
≥25 kg m^2	80.0	56.7	58.1	79.7	64.4	65.3	66.7	72.7	58.5	65.9
≥27 kg/m^2	60.0	78.3	58.1	79.7	72.2	32.7	83.3	72.7	47.6	54.1
≥30 kg/m^2	40.0	93.3	75.0	75.7	75.6	14.3	94.4	77.8	44.7	48.2
Total body fat ≥20%	100	0	33.3	0	33.3	100	13.9	61.3	100	63.5
≥30%	100	3.33	34.1	100	35.6	63.3	58.3	67.4	53.9	61.2
≥40%	80.0	35.0	38.1	77.8	50.0	14.3	94.4	77.8	44.7	48.2
Waist cut-off ≥80 cm in women; ≥90 cm in men	96.7	36.7	43.3	95.6	56.7	75.5	52.8	68.5	61.3	65.9
Waist-to-hip ratio ≥0.7	96.7	1.67	33.0	50.0	33.3	98.0	0	57.1	0	56.5
≥0.8	83.3	35.0	39.1	80.8	51.1	98.0	2.78	57.8	50.0	57.7
≥0.9	23.3	86.7	46.7	69.3	65.6	81.6	33.3	62.5	57.1	61.2
Waist-to-height ratio ≥ 0.5	96.7	33.3	42.0	95.2	54.4	89.8	30.6	63.8	68.8	64.7
≥ 0.6	40.0	93.3	75.0	75.7	75.6	22.5	91.7	78.6	46.5	51.8

[†]BMI: Body mass index; HOMA-IR: homeostasis model assessment of insulin resistance.
[‡]HOMA-IR≥2.27.
[§]McAuley score ≤6.3.
[¶]According to the International Diabetes Federation (IDF definition, a person to be identified as having metabolic syndrome they must have central obesity (female waist circumference ≥80 cm, male waist circumference ≥90 cm) plus any two of the following four factors reduced HDL cholesterol (<1.1 mmol/L in females and <0.9 mmol/L in males), raised triglycerides level (≥1.7 mmol/L), raised blood pressure (systolic blood pressure ≥130 mmHg or diastolic blood pressure ≥85 mmHg), and raised fasting plasma blood glucose (≥5.6 mmol/L).
[††]PPV: Positive predictive value (%).
[‡‡]NPV: Negative predictive value (%).

Table 3. Sensitivity and specificity of BMI, waist circumference, and waist-to-height ratio in relation to indexes of health risk in Asian Indian women and men† (cont.)

Selected cut offs		Women (n=90)					Men (n=85)				
		Sensitivity	Specificity	PPV††	NPV‡‡	Correctly classified	Sensitivity	Specificity	PPV††	NPV‡‡	Correctly classified
Metabolic syndrome¶											
Body mass index	≥23 kg/m^2	100	27.1	28.2	100	22.0	100	32.2	39.4	100	30.6
	≥25 kg m^2	85.0	52.9	34.0	92.5	18.9	84.6	62.7	50.0	90.2	23.9
	≥27 kg/m^2	65.0	72.9	40.6	87.9	14.4	50.0	84.8	59.1	79.4	15.3
	≥30kg/m^2	40.0	88.6	50.0	83.8	8.89	26.9	96.6	77.8	75.0	8.26
Total body fat	≥20%	100	100	22.2	0	22.2	100	8.47	32.5	100	30.6
	≥30%	100	2.86	22.7	100	22.2	73.1	54.2	41.3	82.1	22.4
	≥40%	80.0	32.9	25.4	85.2	17.8	19.2	93.2	55.6	72.4	5.89
Waist cut-off	≥80 cm in women; ≥90 cm in men	100	32.9	29.9	100	22.2	100	52.5	48.2	100	30.6
Waist-to-hip ratio	≥0.7	0	85.7	0	77.5	0	7.69	100	100	71.1	2.35
	≥0.8	0	0	0	77.8	0	0	0	0	69.4	0
	≥0.9	0	0	0	77.8	0	0	0	0	68.4	0
Waist-to-height ratio	≥0.5	100	24.3	27.4	100	22.2	100	23.7	36.6	100	30.6
	≥0.6	45.0	84.3	45.0	84.3	10.0	42.3	93.2	73.3	78.6	12.9

†BMI: Body mass index; HOMA-IR: homeostasis model assessment of insulin resistance.
‡HOMA-IR≥2.27.
§McAuley score ≤6.3.
¶According to the International Diabetes Federation (IDF definition, a person to be identified as having metabolic syndrome they must have central obesity (female waist circumference ≥80 cm, male waist circumference ≥90 cm) plus any two of the following four factors reduced HDL cholesterol (<1.1 mmol/L in females and < 0.9 mmol/L in males), raised triglycerides level (≥1.7 mmol/L), raised blood pressure (systolic blood pressure ≥130 mmHg or diastolic blood pressure ≥85 mmHg), and raised fasting plasma blood glucose (≥5.6 mmol/L).
††PPV: Positive predictive value (%).
‡‡NPV: Negative predictive value (%).

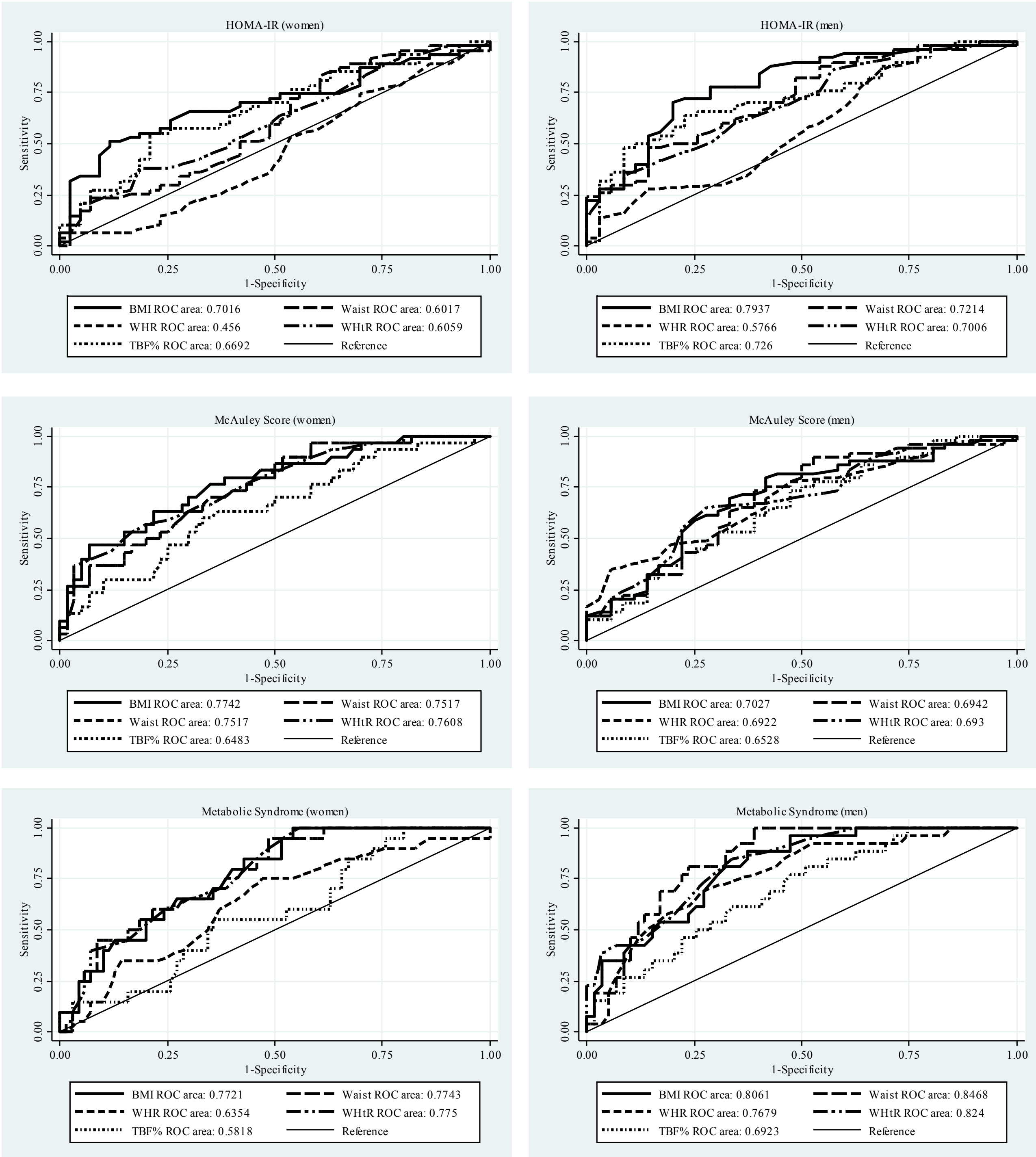

Figure 1. Receiver operating characteristic curves for body mass index, waist circumference, waist-to-hip ratio, total body fat % and waist-to-height ratio in relation to insulin resistance (HOMA-IR), insulin sensitivity (McAuley score), and metabolic syndrome.

tory power of WHtR was similar to BMI.

The present study was small, was confined to a sample of older Indian men and women living in New Zealand and the findings are not generalizable to the population. Some evidence is provided of the lack of utility of anthropometric measures for the identification of individuals at risk of metabolic syndrome and lends support to the current recommendation for further screening of Indian men aged over 35 years and women aged over 45 years for metabolic risk.[28] In the present study, data for the menopausal status of Asian Indian a woman over 45 years of age were not provided and is a limitation. Menopause is associated with an increase in fat mass and redistribution of fat to the abdominal area, although the Study of Women's Health across the Nation (SWAN)[34] showed no independent effect of menopause on fat distribution.

New Zealand guidelines however do not have ethnic specific BMI or WC criteria for Asian Indian despite the recognition of higher risk for diabetes and cardiovascular disease.[2,28] The clustering of cardiovascular risk factors in New Zealand Indian and European people is different; Indian have more than twice the prevalence of type 2 diabetes yet relatively lower blood pressure and prevalence of smoking. Indian people are also over represented in areas with higher deprivation.[15]

While no anthropometric measure performed well in the present study, a boundary value of WHtR of 0.5 is age and gender independent, and may indicate increased risk in people of different ethnic groups.[25] In a multi-ethnic population, such as in New Zealand, WHtR may be easier for the primary health provider to measure and calculate than BMI, while in public health the message to aim for a waist that is half your height is more likely to be understood.

In conclusion, in these Asian Indian people living in New Zealand, metabolic abnormalities associated with type 2 diabetes and CVD are present at lower BMI and WC cut-offs than other ethnic groups.[35] There is an urgent need for public health measures targeted across the life course for this high risk group.

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Original Article

Migrant Asian Indians in New Zealand; prediction of metabolic syndrome using body weights and measures

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用体重及相关测量指标预测新西兰亚洲印度裔移民的代谢综合症

本研究目的在于确定新西兰亚洲印度裔移民人群的体重指数（BMI），腰围（WC），腰臀比（WHR），和腰围身高比（WHtR）的最佳诊断界值，以甄别该人群中 2 型糖尿病和心血管疾病的高危人群。本研究从新西兰奥克兰市区征集了 170 名亚洲印度裔移民志愿者（90 名女性，85 名男性；年龄>50 岁）。体重、身高、腰围和臀围均由标准方法测量。腰臀比、腰围身高比和体重指数由以上原始数据计算得出。采用双能 X 线吸收法测量了全身体脂总含量和体脂百分比，同时还测量了空腹血糖、胰岛素和血脂。本研究确定了三个代谢风险诊断标准：用动态平衡模型评估胰岛素抵抗，McAuley 评分评估胰岛素敏感性和国际糖尿病联合会的标准诊断代谢综合症。作为诊断亚洲印度裔移民代谢综合症高危人群的指标，体重指数、体脂百分比和中心肥胖人体测量值的总体应用价值表现并不好。我们的数据支持对亚洲印度裔的女性和男性使用低民族特殊性的体重指数和腰围。WHtR 表现出同 BMI 相当的甄别能力。因此，WHtR 可以作为一个简单的筛选工具。“腰围身高比低于 0.5”这一建议支持简明的公共健康信息：“你的腰围应当小于你身高的一半”。

关键词：亚洲印度裔、新西兰、代谢综合症、2 型糖尿病、腰围身高比