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Metabolic Syndrome and Incident Coronary Heart Disease in Australian Indigenous Populations

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This report aims to compare the prediction of the metabolic syndrome (MetS) and its components for morbidity and mortality of coronary heart disease (CHD) in a cohort of Australian Aboriginal and Torres Strait Islander adults (TSIs). A total of 2,100 adults (1,283 Aborigines and 817 TSIs) was followed up for 6 years from 2000. Outcome measures were all CHD events (deaths and hospitalizations). Baseline anthropometric measurements, blood pressure (BP), fasting blood lipids and glucose were collected. Smoking and alcohol intake was self-reported. We found MetS was more prevalent in TSI (50.3%) compared to Aborigines (33.0%). Baseline MetS doubled the risk of a CHD event in Aborigines. Increased fasting triglycerides was stronger in predicting CHD (hazard ratio (HR): 2.8) compared with MetS after adjusted for age, sex, tobacco and alcohol consumption, and baseline diabetes and albuminuria for Aborigines but not among TSIs. MetS was not more powerful than its components in predicting CHD event. In Australian Aborigines, the "triglyceridemic waist" phenotype strongly predicts CHD event, whereas among TSI, baseline diabetes mediated the prediction of increased fasting glucose for CHD event.

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INTRODUCTION

Metabolic syndrome (MetS) is a clustering of several risk factors including hypertension, dyslipidemia, impaired glucose tolerance, and central adiposity. The clustering of those risk factors confers a higher risk of diabetes and cardiovascular disease (CVD). The most recent International Diabetes Federation (IDF) definition, similar to World Health Organization criteria, relies on an ordering of criteria as an abnormal waist circumference (WC) must be present to satisfy for MetS (1,2); whereas the Adult Treatment Panel III (ATPIII) of the National Cholesterol Education Program proposed the definition of MetS as an abnormality in any three of five criteria (3) (**Table 1**).

The prevalence of MetS in adult Australians was 28.6% in 1999–2000 in a nationally representative sample using the IDF definition (4). Indigenous Australians had higher rates where the ATPIII criteria classified 43% of Torres Strait Islander adults (TSIs) and 44% of Aborigines with MetS, compared to 32 and 28%, respectively, according to World Health Organization criteria, from a cross-sectional survey in North Queensland during 1993–1995 (5). No studies in the Australian population have been published to date to study the prediction of MetS for CVD, although a meta-analysis of a dozen prospective studies from United States and European countries indicated MetS independently conferred a modest risk (hazard ratio (HR): 1.3–1.7) of developing CVD, using both ATPIII of the National Cholesterol Education Program or World Health Organization criteria (6).

We have previously shown in this population that high baseline prevalence of diabetes and albuminuria better predict incident CHD than the "traditional" Framingham risk factors alone: BMI, blood pressure (BP), smoking, and dyslipidemia (7). The aim of this analysis is to compare the prevalence of MetS using IDF and ATPIII criteria, and to explore the independent prediction of components of MetS for developing CHD in two distinct Australian indigenous populations from North Queensland.

METHODS AND PROCEDURES

Participants

The Well Persons Health Check (WPHC), conducted between 1998 and 2000, offered screening and referral services for people in discrete indigenous communities in northern Queensland (8). A cohort of 2,100 indigenous people aged ≥15 without pre-existing heart conditions was included in this study. The study was approved by the Cairns Base Hospital Ethics Committee with support from relevant peak Aboriginal and Torres Strait Islander Health Councils.

Baseline measurements

Details of the methods used in the WPHC have been published elsewhere (8). WC was recorded to the nearest centimeter with the latter

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Table 1 Criteria for the definition of the metabolic syndrome (IDF, NCEP-ATPIII)

	IDF	NCEP-ATPIII
WC	≥94 cm (men), ≥80 cm (women)	≥102 cm (men), ≥88 cm (women)
Triglycerides	≥1.7 mmol/l or treatment	≥1.7 mmol/l or treatment
HDL	<1.03 mmol/l (men), <1.29 mmol/l (women)	<1.03 mmol/l (men), <1.29 mmol/l (women)
Blood pressure	≥135/86 mm Hg, or treatment of previously diagnosed hypertension	≥135/86 mm Hg, or treatment of previously diagnosed hypertension
Fasting glucose	≥5.6 mmol/l	≥5.6 mmol/l

According to the IDF 2005 definition, for a person to be defined as having MetS, one must have central obesity plus any two risk factors. NCEP-ATPIII is based on any three of the risk factors.
HDL, high-density lipoprotein; IDF, International Diabetes Federation; NCEP-ATPIII, National Cholesterol Education Program–Adult Treatment Panel III; WC, waist circumference.

measured by the same technician at the level of the umbilicus. Smoking and alcohol intake was assessed by self-report questionnaire (9). Total cholesterol, high-density lipoprotein (HDL), low-density lipoprotein (LDL), triglycerides, and glucose were measured from the blood of all participants after at least 8 hours fast. The blood was collected by a medical officer, registered nurse, or trained phlebotomist in the early morning. Blood glucose and blood lipids were measured using photometric enzyme end point assay with Cobas Integra 700/400 (Roche Diagnostics, Rotkreuz, Switzerland). Albumin:creatinine ratio (ACR) testing was performed routinely by immunoassay on all urine specimens that were collected in a sterile 50 ml container and refrigerated at 4–8 °C immediately following collection (8). BP was the average of three measurements taken in sitting position after 10 min rest.

Collection of hospitalization and death records

Hospitalization and death records for the WPHC participants were matched using deterministic linkage based on hospital record numbers and clinical record numbers. A manual search of the Queensland Health hospital records systems was conducted by a registered nurse having experience working in the hospital records department. As there is no universal unique patient identifiers within Queensland, a mapping table linking WPHC reference number, hospital facility code, and local unit record number was developed. This mapping process commenced in January 2006 and was subsequently applied to the Queensland Admitted Patient Data Collection, and hospitalization relevant to the match unit record, facility code tuples were extracted.

Death matching was performed manually at the Queensland Registry of Births, Deaths and Marriages.

Outcome determination

The census date for the study was determined as 1 January 2006, as this marked the commencement of the mapping of WPHC numbers to hospital unit record numbers. Any hospitalizations or deaths which occurred subsequent to this date were disregarded.

Hospitalizations were considered to be CHD related if they contained an ICD9-CM code commencing with 410, 411, 413, or 414 or an ICD9-CM procedure code between 3,600 and 3,699, inclusive. For hospitalizations coded to ICD10, the diagnosis code range I20–I25, and procedure code blocks 669–679, inclusive, were used.

Statistical analysis

All analyses were performed using STATA v10.1 (STATA, College Station, TX).

Diabetes was defined as clinical diagnosis verified by the participant's medical records, or a 2-h glucose tolerance test result (blood glucose level >11.1 mmol/l 2-h post glucose load), or fasting blood glucose level (>7 mmol/l (10)). Albuminuria was defined having an abnormal spot urine albumin:creatinine ratio ≥2.5 mg/mmol for males and ≥3.5 mg/mmol for females (4).

MetS were categorized using both the IDF and ATPIII criteria based on the available measurements of MetS components. The differences in baseline characteristics between the two indigenous groups were compared using t-tests or χ^2-tests. The prevalence of MetS and its components in the two subgroups were compared and the agreement κ was calculated.

CHD cumulative incidence was calculated using the Kaplan–Meier method for a range of population strata by MetS and its components.

HRs were calculated using a Cox proportional hazards model and adjusted for sex, age, smoking and drinking status, diabetes, and albuminuria to explore the independent predictive effect of MetS. The statistical significance level was set as $P < 0.05$.

Table 2 Baseline characteristics of the Aboriginal and TSIs from North Queensland

	Aborigines (*N* = 1283)	TSIs (*N* = 817)	*P* value
Age (years)	36.6 (0.4)	37.9 (0.5)	0.02
Men, *n* (%)	620 (48.3)	433 (53.0)	0.04
Waist, men (cm)	89.4 (0.6)	101.3 (0.7)	<0.01
Waist, women (cm)	92.1 (0.6)	103.0 (0.8)	<0.01
Systolic BP (mm Hg)	128.3 (0.5)	133.8 (0.7)	<0.01
Diastolic BP (mm Hg)	71.9 (0.4)	70.8 (0.5)	0.05
Glucose (mmol/l)	5.4 (0.1)	6.1 (0.1)	<0.01
Triglycerides (mmol/l)	1.9 (0.04)	1.7 (0.04)	0.01
LDL (mmol/l)	2.9 (0.03)	3.2 (0.03)	<0.01
HDL (mg/mmol)	1.18 (0.01)	1.11 (0.09)	<0.01
ACR	15.5 (1.7)	14.4 (1.7)	0.7
Smokers (%)	822 (64.8)	415 (50.9)	<0.01
Drinkers (%)	902 (72.3)	514 (64.1)	<0.01
IDF MetS (%)	421 (33.0)	410 (50.3)	<0.01

Values are means (standard error) or no. (%); *P* value from *t*-tests for means and χ^2-tests for percentage.
ACR, albumin:creatinine ratio; HDL, high-density lipoprotein; IDF, International Diabetes Federation; LDL, low-density lipoprotein; MetS, metabolic syndrome; TSIs, Torres Strait Islander adults.

RESULTS

The baseline health profile differs significantly between the two indigenous groups. TSIs had significantly higher WC, systolic BP, fasting blood glucose, LDL but lower triglycerides, HDL, albumin:creatinine ratio, and behavioral risks including smoking and drinking alcohol (Table 2).

The baseline prevalence of MetS and its components defined by IDF and ATPIII in the two ethnic groups are summarized

Table 3 Prevalence of metabolic syndrome and components (IDF, NCEP-ATPIII criteria) by ethnicity

	IDF	NCEP-ATPIII
Aborigines, *n*	1,277	1,283
Raised WC, *n* (%)	723 (56.6)	496 (38.8)
Raised BP, *n* (%)	570 (44.6)	570 (44.4)
Raised blood glucose, *n* (%)	240 (19.4)	240 (18.7)
Low HDL, *n* (%)	603 (51.9)	603 (47.0)
Raised triglycerides, *n* (%)	490 (39.5)	490 (38.2)
MetS, *n* (%)	421 (33.0)	400 (31.2)
TSIs, *n*	816	817
Raised WC, *n* (%)	652 (79.9)	522 (64.0)
Raised BP, *n* (%)	452 (55.5)	452 (55.3)
Raised blood glucose, *n* (%)	225 (28.2)	225 (27.5)
Low HDL, *n* (%)	457 (57.8)	457 (55.9)
Raised triglycerides, *n* (%)	281 (35.2)	281 (34.4)
MetS, *n* (%)	410 (50.3)	383 (46.9)

In Aborigines, agreement of MetS between the two definition was 90.9%, κ was 0.79, $P < 0.001$. In TSIs, agreement of MetS was 94.7%, κ was 0.89, $P < 0.001$.
BP, blood pressure; HDL, high-density lipoprotein; IDF, International Diabetes Federation; MetS, metabolic syndrome; NCEP-ATPIII, National Cholesterol Education Program–Adult Treatment Panel III; TSIs, Torres Strait Islander adults; WC Waist circumference.

in Table 3. Compared with ATPIII MetS criteria, the IDF definition classified the same prevalence of MetS (33% vs. 31% in Aborigines and 50.3% vs. 46.9% in TSIs) and its components. The percentage of agreement of the two definitions was 90.9% in Aborigines and 94.7% in TSIs and the κ statistic was 0.79 in Aborigines ($P < 0.001$) and 0.89 in TSIs ($P < 0.001$).

A total of 151 CHD events (deaths and hospitalizations) were identified during a mean of 6.0 years of follow-up among the 2,100 eligible subjects. A total crude CHD incidence rate was similar in the two groups: 11.9 cases/1,000 person years (py) (12.6 cases/1,000 py; 95% confidence interval: 10.3–15.3 for Aborigines compared with 10.9/1,000 py; 95% confidence interval: 8.3–14.3 in TSIs). Among Aborigines, the CHD incidence rate in those classified as having MetS was 20.0 cases/1,000 py compared with 8.9 cases/1,000 py in normal groups. Among TSIs, the incidence rate in MetS patients was 16.3 cases/1,000 py compared with 5.7 cases/1,000 py in normal subjects. The CHD incidence rates by MetS components in the two groups are summarized in Tables 4 and 5. Among the Aborigines, higher CHD incidence rate was associated with higher WC, hypertension, increased blood fasting glucose, triglycerides and combined hypertriglycerides and waist; whereas in TSIs, the significant MetS components predicting CHD were raised BP and raised fasting glucose. Baseline diabetes and albuminuria were strong predictors of CHD incidence in both groups (HR for diabetes 3.2, HR for albuminuria 3.4 $P < 0.001$ (7)).

After adjusting for age, sex, smoking and drinking status, baseline diabetes, and albuminuria, Aborigines with MetS were approximately twice as likely to develop CHD. Increased WC remained associated with CHD incidence. The predictive

Table 4 Incidence of CHD and its association with IDF MetS among Aborigines from North Queensland

	Incidence rate case/1,000 py (95% CI)	Crude HR (95% CI)	Adjusted HR[a] (95% CI)
MetS			
No	8.9 (6.7–11.8)	1.0	1.0
Yes	20.0 (15.2–26.4)	2.3 (1.5–3.4)	1.9 (1.1–3.3)
Raised waist			
No	9.6 (6.9–13.6)	1.0	1.0
Yes	14.7 (11.5–18.8)	1.5 (1.0–2.3)	1.8 (1.0–3.2)
Yes	16.0 (12.0–21.3)	1.5 (1.0–2.3)	1.8 (1.02–3.2)
Raised BP			
No	8.0 (5.7–11.1)	1.0	1.0
Yes	18.2 (14.2–23.4)	2.3 (1.5–3.5)	1.5 (0.8–2.6)
Raised blood glucose			
No	10 (7.7–12.8)	1.0	
Yes	23.4 (16.6–32.9)	2.4 (1.5–3.6)	1.3 (0.6–2.8)
Low HDL			
No	12.3 (9.0–16.7)	1.0	1.0
Yes	14.1 (10.7–18.6)	1.1 (0.7–1.7)	0.9 (0.5–1.5)
Raised triglycerides			
No	7.2 (5.1–10.1)	1.0	1.0
Yes	21.1 (16.4–27.1)	2.9 (1.9–4.5)	2.8 (1.6–4.8)
Raised triglycerides and waist			
None	7.3 (4.6–11.6)	1.0	1.0
Either	10.1 (7.1–14.4)	1.4 (0.8–2.5)	1.6 (0.7–3.8)
Both	21.9 (16.4–29.3)	3.0 (1.7–5.1)	3.6 (1.6–8.1)

CI, confidence interval; CHD, coronary heart disease; IDF, International Diabetes Federation; MetS, metabolic syndrome; HR, hazard ratio; py, person years.
[a]Adjusting for age, sex, smoking and drinking status, diabetes, and albuminuria.

effects of hypertension and increased blood glucose were attenuated to null after adjustment, however, those with raised triglycerides were 2.8 times more likely to develop CHD during the 6-year follow-up. The combined increased triglycerides and WC independently predicted CHD incidence in Aborigines (HR: 3.6, 95% confidence interval: 1.6–8.1), while those with increased triglycerides but normal waist or those with increased waist but normal triglycerides did not predict CHD morbidity and mortality (Table 4). In TSIs, after adjustment, neither MetS nor its components predicted CHD incidence.

DISCUSSION

We found in this population a high baseline prevalence of MetS, by both IDF and ATPIII criteria (31–33% in Aborigines and 47–50% in TSI) compared to the general Australian (28.6% (4)) and the US (32%) populations (11). The higher MetS prevalence among TSI was attributable mainly to higher WC and fasting glucose compared to Aborigines. Yet incidence of CHD was similar for both groups and there were no sex differences.

Table 5 Incidence of CHD and its association with IDF MetS among TSIs from North Queensland

	Incidence rate case/1,000 py (95% CI)	Crude HR (95% CI)	Adjusted HR[a] (95% CI)
MetS			
No	5.7 (3.4–9.6)	1.0	1.0
Yes	16.3 (11.9–22.3)	2.9 (1.6–5.3)	1.0 (0.5–2.3)
Raised waist			
No	4.9 (2.1–11.9)	1.0	1.0
Yes	12.5 (9.4–16.6)	1.6 (1.0–6.5)	1.5 (0.4–6.7)
Raised blood pressure			
No	6.9 (4.2–11.4)	1.0	1.0
Yes	14.2 (10.4–19.6)	2.1 (1.1–3.8)	0.7 (0.3–1.4)
Raised blood glucose			
No	6.6 (4.4–10.0)	1.0	1.0
Yes	21.8 (15.0–31.5)	3.3 (1.9–5.8)	0.6 (0.2–2.2)
Low HDL			
No	9.2 (5.8–14.6)	1.0	1.0
Yes	12.0 (8.5–16.9)	1.3 (0.7–2.3)	1.1 (0.6–2.1)
Raised triglycerides			
No	8.4 (5.7–12.4)	1.0	1.0
Yes	14.9 (10.1–22.1)	1.8 (1.0–3.1)	1.1 (0.6–2.1)

CI, confidence interval; CHD, coronary heart disease; IDF, International Diabetes Federation; MetS, metabolic syndrome; HR, hazard ratio; py, person years.
[a]Adjusting for age, sex, smoking and drinking status, diabetes, and albuminuria.

Ethnic-specific cut-offs for WC or other anthropometric measurements may be needed for these populations when assessing health risks. A study using receiver operating characteristic analysis to assess the discrimination power of BMI, WC, and waist/hip ratio for cardiometabolic risks among these populations showed neither BMI nor WC was better than waist/hip ratio (12).

MetS has been shown to strongly predict diabetes incidence in this population, with an adjusted HR of 2.7 in Aborigines and 2.9 in TSIs compared with absence of the MetS at baseline (13). MetS predicts CHD morbidity and mortality in US and European populations with varied HRs due to varied adjustment of other risk factors and different methods used to classify MetS (6). For example, the Framingham Offspring study showed that a cluster of any three out of six risk factors including the sex-specific lowest quintile HDL, highest quintile of BMI, systolic BP, triglycerides, glucose, and serum total cholesterol was associated with a 2.4 and 5.9 times increased risk of CHD in men and women, respectively (14). The European studies show adjusted hazard ratios for CHD mortality were 1.5 in men and 2.5 in women with the MetS (15).

The prediction of MetS components for CHD among the two indigenous groups also varied, although HDL in both groups did not significantly predict CHD morbidity and mortality. Among Aborigines, increased triglycerides was the strongest independent predictor (HR: 2.8) followed by increased waist (HR: 1.8). This result is consistent with that from a meta-analysis of 10,158 incident cases among 262,525 participants in 29 western prospective studies (16) and another meta-analysis among 96,224 individuals from 26 studies in Asia-Pacific region (17). Both studies reported the top tertile or quintile triglycerides conferred 1.6–1.8 times increased risk of CHD morbidity and mortality after adjustment for other known cardiovascular risk factors including fasting glucose, total and HDL cholesterol.

Other studies have analyzed the prevalence of the hypertriglyceridemic waist phenotype and its association with type 2 diabetes and CVDs, indicating it could be a simpler alternative to MetS for CHD risk identification, especially among young people, before other MetS components appear clinically (18,19).

Aboriginal and TSI people experience disadvantage across a range of socioeconomic indicators including education, employment, income and housing (20). In 2004–2005, half of the adult indigenous population were current daily smokers. The proportion of indigenous adults drinking alcohol at high risk levels increased from 12% in 2001 to 17% in 2004–2005 (20). More than half (57%) of indigenous people aged ≥15 years were overweight or obese. Between 1995 and 2004–2005, rates of overweight/obesity among indigenous people aged ≥15 years increased from 48% to 56% (20).

In summary, this study showed that MetS did not predict CHD as strongly as its components. In Aborigines, the combined increased triglycerides and WC better predicts incident CHD, whereas in TSIs, baseline diabetes and albuminuria could be used to detect those at risk. In both populations, greater attention is needed to alleviate risk behaviors and conditions, including improving the quality of the food supply.

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DISCLOSURE

The authors declared no conflict of interest.

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