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Metabolic syndrome and cardiometabolic risk factors among indigenous Malaysians

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ABSTRACT

Objectives: This study was undertaken to investigate the occurrence of metabolic syndrome (MetS) and cardiovascular disease (CVD) risk in Orang Asli (OA), the indigenous people of Peninsular Malaysia. OA consist of Negrito, Proto-Malay, and Senoi groups who collectively comprise only 0.76% of the population of Peninsular Malaysia. Owing to the challenges in accessing their remote villages, these groups are often excluded in larger government health surveys. Although tropical diseases were scourges in the past, with rapid national development, many OA communities have been gradually urbanized. We believe an epidemiological transition is occurring and non-communicable diseases are on the rise.

Study design: A retrospective cross-sectional study.

Methods: Indigenous Malaysians ($n = 629$) from three major groups (Negrito, Proto-Malay, and Senoi) were recruited, after ethics approval and informed consent. Body mass index (BMI), body weight, height, waist circumference, and systolic and diastolic blood pressure were measured, and participants were examined for acanthosis nigricans. Venous blood samples were used for measurements of fasting blood sugar, triglycerides (TG), total cholesterol (TC), high-density lipoprotein cholesterol (HDL-C) and low-density lipoprotein cholesterol (LDL-C). Insulin resistance was estimated using a surrogate measurement TG/HDL-C. The ratios of TC to HDL-C, and of LDL-C to HDL-C were determined. MetS was accessed according to the Joint Interim Statement of the IDF Tsak Force on Epidemiology and Prevention.

Results: MetS affected 29.57% of the OA population investigated and was significantly more prevalent ($P < 0.05$) in women than in men (35.25% vs 21.95%, $P < 0.001$). MetS prevalence was the highest among the Proto-Malays (39.56%), followed by Negritos (26.35%) and Senois (11.26%). The most prevalent risk factor among the Negritos with MetS was low HDL-C (95.35%), whereas central obesity was the most common risk factor among the Proto-Malays (82.91%). In contrast, hypertension was the commonest risk factor among the

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Senois with MetS (94.44%). Elevated TG/HDL-C ratios resulted in the highest risk for MetS among the OA population (relative risk [RR] = 7.01, 95% confidence interval [CI] = 3.58–13.72). The risk was almost four-fold among those with high TG (RR = 3.89, 95% CI = 3.08–4.91) and three-fold among those with BMI obesity (RR = 3.37, 95% CI = 2.61–4.36) and central obesity (RR = 2.99, 95% CI = 2.48–3.61).

Conclusions: This may well be the first comprehensive report about MetS in OA indigenous communities in Malaysia. We have shown that rapidly urbanized OA communities had significant prevalence of MetS and associated cardiometabolic risk factors. Major contributory factors may include changes from previous hunter-gatherer lifestyles and subsistence diets to more urbanized lifestyles and easier access to high calorie foods.

Introduction

Metabolic syndrome (MetS) is a cluster of cardiometabolic risk factors such as central obesity, hypertension, elevated blood glucose, dyslipidemia, and insulin resistance (IR), which are associated with an increased risk of type 2 diabetes (T2D) and cardiovascular disease (CVD). In 2006, the International Diabetes Federation (IDF) estimated that up to 25% of the global population had MetS. Reaven proposed IR to be the underlying risk factor connecting the traits of MetS, referred as syndrome X.[1] The tendency of cardiometabolic risk factors to cluster together led to MetS definition as a 'constellation of risk factors which increase the risk of CVD and T2D'.[2] IR was highlighted by the European Group for the Study of Insulin Resistance (EGIR), the National Cholesterol Education Program (NCEP), and the American Association of Clinical Endocrinologists (AACE), which referred to MetS as an IR syndrome.

Studies within the Asia-Pacific region showed diversity and rise in MetS prevalence. MetS prevalence among adult Malaysians have been shown to be between 25% and 40%.[3–6] It has been reported that ethnicity and socio-economic factors such as urbanization, unemployment, and education level are influential in MetS prevalence among Malaysians.[3] For the indigenous Malaysians, studies reported 17%–40% of prevalence in indigenous populations. However, MetS showed significant variation among different indigenous communities and generally affected women more than men.[3,4]

Indigenous people of Peninsular Malaysia, also known as Orang Asli (OA) (which means 'original people' in the Malay language), comprise approximately 0.76% of the Peninsular Malaysia population.[7] OAs are categorized into three main groups, namely Negrito, Senoi, and Proto-Malay, based on physical characteristics, cultural practices, and linguistics.[8,9] Negritos are Austroasiatic (AA) speakers who inhabit in northern parts of Peninsular Malaysia. Traditionally, they were mainly hunter-gatherers and practiced egalitarianism. Senois speak a different dialect within the AA language family. They live in central areas of Peninsular Malaysia. Unlike Negritos, they practice swiddening and are more hierarchical. Genetic studies also indicate differences between Negritos and Senois.[10] Proto-Malays speak Aslian-Malay dialects of the Austronesian language family. They inhabit in southern parts of Malaysia; their traditional lifestyles involve farming and rainforest harvesting. Their social hierarchies are most highly defined among all OA groups. Each OA large group is subdivided into six subgroups to make up a total of 18 subgroups (Table 1).

From 1966, the Malaysian government implemented a series of five-year economic development programs called 'The Malaysia Plans' to improve economic livelihoods of Malaysians. For the OAs, these programs mainly focus on alleviation of poverty by structured resettlements to provide better education and health, thus 'enhancing' their socio-economic standards.[7,11] Over the years, many incentives were provided to encourage OA communities to migrate from their forest and rural habitats to resettlement villages closer to urban areas and modern amenities. However, the response to these resettlement programs varied among OA communities. Although many communities resettled in new villages, some communities preferred to remain in their original habitats. These demographic changes precipitated epidemiological transitions and a rise in non-communicable diseases.[12]

To our knowledge, there have been very few investigations of MetS in OA communities. Studies to date provide limited information, as sample sizes have been low with insufficient representation from the various groups. This was the impetus that prompted us to undertake the current investigation. We believe that this is the largest and most comprehensive study that includes nearly 630 individuals representing seven groups throughout Peninsular Malaysia.

Methods

This retrospective cross-sectional study was conducted between 2010 and 2016. The study was approved by the Department of Aboriginal Development (JAKOA), Ministry of Health (MOH), Monash University, and University Institute Technology MARA. Only adult OAs, above 18 years old, who consented were recruited for this study. A total of 629 individuals were recruited from three major OA groups. The Negritos, i.e., Bateq, Jehai, Mendriq, and Kintak, were recruited from Perak and Kelantan; Proto-Malays, i.e., Jakun, Kanak, and Seletar, were recruited from Pahang and Johor; and Senois, i.e., Mahmeri, Semai, and Temiar, were recruited from Selangor and Perak (Fig. 1 and Table 1). Interviews were performed in Bahasa Malaysia. However, for participants who could not

Table 1 – Characteristics of OA groups in Malaysia.

Tribe	Subtribe	Region	Location	Lifestyle[b]	Language	Population[a] (2010)
Negrito	**Jehai**	**Northern Malaysia**	**North Perak (North Malaysia) (North Malaysia)**	**Hunter-gathering**	**Austroasiatic**	**2326**
	Bateq		**Kelantan**	**Hunter-gathering**	**Austroasiatic**	**1359**
	Kintak		**North Perak**	**Hunter-gathering**	**Austroasiatic**	**234**
	Mendriq		**Kelantan**	**Hunter-gathering; swiddening**	**Austroasiatic**	**253**
	Kensiu		Kedah	Hunter-Gathering	Austroasiatic	280
	Lanoh		Perak	Hunter-gathering; swiddening	Austroasiatic	390
Senoi	**Mah Meri**	**Central Malaysia**	**Selangor**	**Swiddening/fishing**	**Austroasiatic**	**2120**
	Semai		**South Perak**	**Swiddening**	**Austroasiatic**	**49,697**
	Temiar		**South Perak**	**Swiddening**	**Austroasiatic**	**30,118**
	Che Wong		Pahang	Hunter-gathering; swiddening	Austroasiatic	818
	Jah Hut		Pahang	Swiddening	Austroasiatic	4191
	Semoq Beri		Terengganu Pahang	Hunter-gathering; swiddening	Austroasiatic	3413
Proto-Malay	**Jakun**	**Southern Malaysia**	**Pahang**	**Agriculture**	**Austronesian**	**31,577**
	Kanak		**Johor**	**Agriculture**	**Austronesian**	**238**
	Seletar		**Johor**	**Fishing**	**Austronesian**	**1042**
	Temuan		Selangor, N. Sembilan	Agriculture	Austronesian	19,343
	Semelai		Pahang	Swiddening	Austroasiatic	9228
	Orang Kuala		Johor	Agriculture	Austronesian	3761

OA: Orang Asli.
[a] Population size of each OA subgroups adapted from Endicott et al. (2015).
[b] Swiddening is a system of agriculture in which temporarily plots of land are prepared by slash-and-burn of their natural vegetation for crop cultivation.

communicate in Bahasa Malaysia relevant JAKOA staff and interpreters were recruited to assist in communications. Participants were reimbursed with RM 20, which represents a day's wage for taking time off to participate in these studies. Those in very remote areas such as Upper Perak river tributaries with no road access requested the basics such as rice, sugar, and salt which they require but are unable to buy easily.

Physical examinations were conducted on the participants. Body weight, height, and waist circumference (WC) were measured. Body mass index (BMI) was calculated from weight and height. An Omron digital sphygmomanometer was used to measure blood pressure (BP). BP was measured after 5 min of rest; the participant was seated with their arms at level with their heart. BP was measured on the left and right arms twice, and the measurements from the arm with the highest readings were used to calculate average systolic and diastolic BP. If there was a significant variation between the first and second readings or pulse rate was greater than 80 bpm, participants were requested to relax before repeating measurements. Participants were also examined for the presence of acanthosis negricans, a sign for possible underlying problems such as IR, diabetes, or abnormal hormone levels.

Venous blood samples were taken and subjected to biochemical testing. Initially, the OGTT protocol was conducted to derive IR readings. However, it was discontinued as most participants did not respond well to the glucose solution. Fasting blood sugar (FBS), triglycerides (TG), total cholesterol (TC), high density lipoprotein cholesterol (HDL-C), and low-density lipoprotein cholesterol (LDL-C) levels were measured. Biochemical parameters were measured with a Selectra XL chemistry analyzer (Vital Scientific, Netherlands). Reagents used were from Randox Laboratories Ltd., United Kingdom.

DSL-10-1600 Active 1 Insulin ELISA kits (Diagnostic System Laboratories Inc., USA) were used to measure plasma insulin levels. IR was estimated using a surrogate measurement TG/HDL-C. The ratios of TC to HDL-C and of LDL-C to HDL-C were determined.

MetS assessed as per the Joint Interim Statement (JIS) definition[13] which requires three out of five of the following risk factors:

1. Central obesity per population-specific cutoffs (WC $\geq$ 90 cm for men and $\geq$80 cm for women in Asians).[14]
2. Hypertension ($\geq$130 mm Hg for systolic BP or $\geq$85 mm Hg for diastolic BP) or on hypertensive medication.
3. Raised FBS ($\geq$5.6 mmol/L) or on diabetic medication.
4. Raised fasting TG ($\geq$1.7 mmol/L).
5. Low HDL-C (<1.0 mmol/L for men, <1.3 mmol/L for women).

Statistical analysis was performed with Microsoft Excel's Analysis Toolpak software. Percentages and confidence intervals (CIs) were used to describe the MetS prevalence based on group, subgroup, and gender. Categorical variables were compared using the Chi-squared test. The Pearson correlation test among risk factors was performed for different OA groups. Relative risk (RR) calculation was performed, and Chi-squared test was used to test significance of RR values.[15]

Fig. 1 – A map of the Orang Asli tribes that participated in this study.

BMI obesity was defined as >27.5 kg/m^2,[16] high glycated hemoglobin (HbA1c) levels as >6.0%,[12] high uric acid (UA) as >350 μmol/L,[17] high insulin levels as >179.38 pmol/L,[18] high TC/HDL-C as >5.0 for men and >4.5 for women, high LDL-C/HDL-C as >3.5 for men and >3.0 for women, and high TG/HDL-C as >3.0.[19]

Results

In general, MetS affected 29.57% of the OA population investigated (Table 2) and was significantly more prevalent ($P < 0.05$) in women than in men OA (35.25% vs 21.95%,

Table 2 – Prevalence of MetS in the Orang Asli, overall, and for each group.

Tribe	Prevalence of MetS [% (95% CI)]			P
	Overall (n = 629)	Male (n = 366)	Female (n = 263)	(Chi-squared)
Orang Asli	29.57 (26.00–33.14)	21.67 (16.69–26.65)	35.25 (30.35–40.14)	<0.001**
Negrito	26.35 (19.63–33.07)	21.05 (11.83–30.28)	30.77 (21.23–40.30)	0.206
Bateq	23.40 (11.30–35.51)	11.76 (0.93–22.59)	53.85 (26.75–80.95)	0.002*
Jehai	31.15 (19.53–42.77)	32.26 (15.80–48.71)	30.00 (13.60–46.40)	0.849
Kintak	21.05 (2.72–39.38)	NA	21.05 (2.72–39.38)	NA
Mendriq	28.95 (14.53–43.37)	20.00 (−4.79–44.79)	32.14 (14.84–49.44)	0.468
Proto-Malay	39.56 (34.16–44.96)	29.91 (21.23–38.58)	44.50 (37.74–51.25)	0.012*
Jakun	24.24 (13.90–34.58)	31.58 (10.68–52.48)	21.28 (9.58–32.98)	0.377
Kanak	61.54 (35.09–87.99)	NA	61.54 (35.09–87.99)	NA
Seletar	42.49 (36.14–48.84)	29.07 (19.47–38.67)	50.34 (42.46–58.42)	0.002*
Senoi	11.26 (6.18–16.33)	11.11 (4.27–17.96)	11.43 (3.87–18.99)	0.932
Mah Meri	12.50 (1.04–23.96)	20.00 (−0.24–40.24)	5.88 (−5.30–17.07)	0.228
Semai	12.96 (4.00–21.92)	11.11 (0.84–21.38)	16.67 (−0.55–33.88)	0.567
Temiar	9.52 (2.28–16.77)	6.67 (−2.26–15.59)	12.12 (0.99–23.36)	0.462

MetS: metabolic syndrome; NA: not available.
Chi-square test was used for comparison between male and female.
*Significant at $P < 0.05$.
**Significant at $P < 0.001$.

$P < 0.001$). MetS prevalence was the highest among the Proto-Malays (39.56%), followed by Negritos (26.35%) and Senois (11.26%).

Among the OA with MetS, hypertension comprised the most prevalent risk factor (73.8%) (Table 3). It was also the most prevalent risk factor among male OAs with MetS compared with the female OAs (85.9% vs 68.5%, $P < 0.05$). In contrast, central obesity was the most prevalent risk factor among female OAs with MetS (78.9% vs 58.9%, $P < 0.05$).

The prevalence of cardiometabolic risk factors were also differed as per the groups (Table 3). The most prevalent risk factor among the Negritos with Mets was low HDL-C (95.3%), whereas central obesity (82.9%) and hypertension (94.4%) were the most common risk factors among the Proto-Malays, and Senois, respectively.

Among the OA, HDL-C was correlated with the highest number of risk factors (Supplementary Table 1); of which, the strongest correlation was found with TC/HDL-C ($r = 0.59$, $P < 0.05$). BMI had a strong positive correlation with WC ($r = 0.73$, $P < 0.05$). HbA1c was strongly correlated to FBS ($r = 0.62$, $P < 0.001$). TG/HDL-C ratio showed the strongest correlation with TG ($r = 0.98$, $P < 0.001$). In Negritos, TG/HDL-C was correlated with the highest number of risk factors; of which, the strongest correlations were found with TG ($r = 0.95$, $P < 0.001$) and TC/HDL-C ratio ($r = 0.53$, $P < 0.001$). BMI and TC/HDL-C ratio were correlated with the highest number of risk

Table 3 – Cardiometabolic risk factors among the OA with MetS.

Cardiometabolic risk factor[a]	Percentage among MetS individuals [% (95% CI)]			
	OA (n = 629)	Negrito (n = 165)	Proto-Malay (n = 315)	Senoi (n = 149)
Central obesity	72.6 (66.1–79.2)	40.9 (26.4–55.4)	82.9 (76.1–89.7)	83.3 (66.1–100.5)
BMI obesity	52.1 (44.9–59.3)	18.2 (6.8–29.6)	62.9 (50.9–74.8)	61.11 (38.6–83.6)
High FBS	68.0 (61.1–74.9)	45.4 (31.6–61.4)	77.9 (70.5–85.4)	53.85 (26.7–80.9)
High HbA1c	21.3 (15.4–27.2)	NA[b]	28.9 (20.8–37.0)	22.2 (3.0–41.4)
High insulin	32.2 (24.8–39.7)	43.7 (25.5–60.9)	29.9 (21.6–38.2)	NA[b]
High TG	64.7 (57.9–71.6)	65.9 (51.9–79.9)	62.4 (53.9–70.9)	77.8 (57.6–97.0)
Low HDL-C	59.7 (52.6–66.7)	95.3 (89.0–101.6)	48.8 (40.0–57.7)	50.0 (26.9–73.1)
High TC/HDL-C	50.6 (43.1–58.0)	70.6 (55.3–85.9)	46.7 (37.9–55.6)	38.9 (16.4–61.4)
High LDL/HDL-C	45.1 (37.8–52.5)	61.8 (45.4–78.1)	41.5 (32.8–50.2)	38.9 (16.4–61.4)
High TG/HDL-C	16.6 (11.1–22.1)	35.3 (19.2–51.4)	9.8 (4.5–15.0)	27.8 (11.5–67.0)
Hypertension	73.8 (67.5–80.1)	79.5 (67.6–91.7)	68.8 (60.7–76.9)	94.4 (83.9–105.0)
High UA	34.6 (27.1–42.1)	52.6 (55.3–85.9)	34.1 (25.8–42.5)	14.3 (4.0–32.6)

BMI: body mass index; FBS: fasting blood sugar; HbA1c, glycated hemoglobin; HDL-C: high density lipoprotein cholesterol; LDL-C: low-density lipoprotein cholesterol; MetS: metabolic syndrome; NA: not available; OA: Orang Asli; TG: triglycerides; UA: uric acid.
[a] Central obesity (WC ≥ 90 cm for men and ≥80 cm for women), BMI obesity was defined as >27.5 kg/m2, FBS (≥5.6 mmol/L), high HbA1c levels as >6.0, high insulin levels as >179.38 pmol/L, high TC/HDL-C as >5.0 for men and >4.5 for women, high LDL-C/HDL-C as >3.5 for men and >3.0 for women, high TG/HDL-C as >3.0, and high UA as >350 μmol/L.
[b] We could not obtain comprehensive HbA1C and insulin measurement for these groups.

factors in Proto-Malays. Among the Senois, diastolic BP was correlated with the highest number of risk factors. Diastolic BP was strongly correlated to systolic BP ($r = 0.80$, $P < 0.001$).

Elevated TG/HDL-C ratios resulted in the highest risk for MetS among the OA population (RR = 7.01, 95% CI = 3.58–13.72) (Table 4). The risk was almost four-fold among those with high TG (RR = 3.89, 95% CI = 3.08–4.91) and three-fold among those with BMI obesity (RR = 3.37, 95% CI = 2.61–4.36) and central obesity (RR = 2.99, 95% CI = 2.48–3.61).

The clinical risk factors differed when subgroup analysis was performed based on the major groups. High TG/HDL-C ratio resulted in the highest risk for MetS among Negritos (RR = 15.41, 95% CI = 4.61–51.56) and Senois (RR = 19.17, 95% CI = 4.01–91.63). In contrast, high TG was the highest risk for Mets among Proto-Malays (RR = 5.13, 95% CI = 3.41–7.70).

Discussion

Changes in diet and transition to a sedentary urban lifestyle have been associated with an increase in metabolic abnormalities in indigenous populations. There are reports of native American populations who had transitioned from traditional to urban sedentary lifestyle. This resulted in development of MetS with prevalence between 49.9% and 66.1%.[20–23] The prevalence of MetS among OAs in our study was 29.57%, with a higher prevalence among women. This figure is higher than the prevalence reported for the Malays (26.4%) and Chinese (26.2%) in Malaysia, although lower than that of ethnic Indians (35.6%).[4] MetS is higher in women of Malaysian major ethnic groups and indigenous communities.[4,5] The most prevalent components of MetS in OA were hypertension (73.80%) and central obesity (72.63%). The prevalence of MetS in our study is comparable with that reported for the indigenous groups in Sabah, Malaysia (31.4%)[5] but higher than prevalence previously reported by Ashari et al. for OA communities (20.5%).[24] These observed differences may be attributed to variation of OA groups investigated or MetS assessment criteria (JIS vs IDF).

There was wide variation in prevalence of MetS amongst different OA groups. The prevalence of MetS was the highest in Proto-Malays (39.56%) but lowest in Senois (11.26%). The highest MetS prevalence was observed among the Proto-Malays, who inhabit urbanized fringe areas. Our findings are in line with other reports of elevated MetS in the suburban groups of OA.[24]

The OA with MetS in our study exhibited higher percentages of cardiometabolic risk factors such as hypertension, high FBS, and raised TG but lower prevalence of high IR than major ethnic groups in Malaysia, and indigenous Borneans.[5] Prevalence of high TG/HDL-C ratios (as surrogate marker for IR) was comparatively low, affecting only 16.57% of the OA with MetS. Proto-Malays displayed the highest prevalence of MetS but the lowest percentage of raised TG/HDL-C ratios at 9.76%. A large-scale study in the United States showed that TG/HDL-C ratios and fasting serum insulin were correlated in non-Hispanic whites, non-Hispanic blacks, and Mexican-Americans.[25] However, we did not find any correlations between TG/HDL-C and insulin in the OA. This may suggest that hyperinsulinemia may not be associated with IR in the OA.

Among Negritos, the correlation between BMI and insulin was stronger ($r = 0.32$, $P < 0.001$) than that between WC and insulin ($r = 0.24$, $P < 0.05$). In Proto-Malays, WC was more strongly correlated with BP, whereas BMI was more strongly correlated with glycemic factors. In Senois, BMI was significantly correlated to TC/HDL-C and TG/HDL-C, whereas WC was more significantly correlated to FBS and HbA1c levels. This may indicate a stronger link between WC and diabetes and between BMI and CV risk and IR. This is contrary to previous studies which indicate that central obesity is more strongly associated with IR.[26,27]

Table 4 – Relative risk (RR) of cardiometabolic risk factors for individuals with MetS. Chi-square test was used for significance for RR.

Cardiometabolic risk factor	Relative risk (95% CI)			
	Orang Asli	Negrito	Proto-Malay	Senoi
	MetS (n = 187) non-MetS (n = 442)	MetS (n = 44) non-MetS (n = 121)	MetS (n = 125) non-MetS (n = 190)	MetS (n = 18) non-MetS (n = 131)
Central obesity	2.99* (2.48–3.61)	6.29* (4.26–9.28)	2.35* (1.90–2.90)	3.31* (2.31–4.74)
BMI obesity	3.37* (2.61–4.36)	7.45*(2.07–26.85)	2.44* (1.85–3.22)	5.08* (2.82–9.16)
High FBS	3.34* (2.69–4.14)	2.66* (1.60–4.42)	2.79* (2.17–3.58)	3.64* (1.72–7.72)
High HbA1c	3.11* (2.00–4.82)	NA	3.37* (1.98–5.64)	2.59 (0.94–7.19)
High insulin	1.62* (1.19–2.20)	1.89* (1.14–3.13)	1.62* (1.09–2.42)	NA
High TG	3.89* (3.08–4.91)	5.07* (3.06–8.39)	5.13* (3.41–7.70)	2.96* (2.03–4.31)
Low HDL-C	1.70* (1.43–2.02)	1.36 (1.19–1.56)	1.87* (1.39–2.53)	3.17* (1.73–5.81)
High TC/HDL-C	2.02* (1.63–2.50)	1.78* (1.31–2.41)	2.31* (1.65–3.23)	2.12* (1.08–2.17)
High LDL/HDL-C	1.47* (1.19–1.82)	1.16 (0.81–1.65)	2.21* (1.54–3.16)	1.48 (0.78–2.82)
High TG/HDL-C	7.01* (3.58–13.72)	15.41* (4.61–51.56)	3.19* (1.23–8.27)	19.17* (4.01–91.63)
Hypertension	2.11* (1.84–2.43)	1.69* (1.11–2.56)	2.65* (2.03–3.47)	2.60* (2.02–3.34)
High UA	1.48* (1.12–1.97)	1.18 (0.71–1.97)	1.63* (1.14–2.35)	0.92 (0.24–3.55)

BMI: body mass index; FBS: fasting blood sugar; HbA1c, glycated hemoglobin; HDL-C: high density lipoprotein cholesterol; LDL-C: low-density lipoprotein cholesterol; MetS: metabolic syndrome; NA: not available; TG: triglycerides; UA: uric acid.
*Significant at $P < 0.05$.

Different groups had distinct metabolic profiles. Negritos with MetS had the highest prevalence of high TG/HDL-C (35.29%). The association of TG/HDL-C with WC and BMI in Negritos ($r = 0.30$, $P < 0.05$) indicates that IR was an underlying factor in MetS and linked to obesity among Negritos. However, TG/HDL-C was not associated with WC in other groups. Coupled with the higher rates of obesity relative to IR, this contradicts the consensus that IR is linked to central obesity in Proto-Malays and Senois. However, the high number of correlations of BMI and TC/HDL-C in Proto-Malays and Senois highlights the significance of obesity and dyslipidemia and a stronger association with CV risk.

Among OA, Negritos and Senois, the highest RR for MetS was for TG/HDL-C >3.0, highlighting the power of TG/HDL-C as a discriminatory tool. However, high TG/HDL-C was among the least prevalent risk factors in MetS individuals, appearing in only 16.57% of OA with MetS. This inconsistency shows that although TG/HDL-C is associated with MetS, IR may not be a predominant factor in MetS in these indigenous communities. This contrasts with the general consensus from the study of other ethnic groups that IR is the main underlying factor of MetS.[2] Our findings have been corroborated by a previous study on non-Hispanic whites, non-Hispanic blacks, and Mexican-Americans which showed that a significant proportion of MetS individuals did not have IR, and a significant proportion of IR individuals did not have MetS.[28] Our results indicate that although IR may be predictive of chronic metabolic profile, it is not sensitive to less severe profiles. It is possible that high TG/HDL-C may point at a genetic tendency in some certain OA groups to develop MetS, as lipid-related genes have been linked to IR in genome-wide association studies.[29]

Overall, there is a variation in MetS profiles belonging to different indigenous groups, suggesting that the pathology of MetS is complex and a result of interplay of several underlying factors.

Limitations

The euglycemic clamp procedure is generally considered the gold standard in measuring insulin sensitivity. However, this protocol was not used because of limitations in the study environment, such as a lack of a controlled hospital environment and remoteness of the location where the participants were surveyed. Many participants vomited when administered with glucose in the oral glucose tolerance test. Triglyceride and HDL-C measurements were available in more individuals compared with those of FBS and insulin levels. Owing to these limitations, TG/HDL-C ratios were used as a surrogate marker for IR instead of the more conventional HOMA (Homeostatic Model Assessment)-IR. TG/HDL-C has been shown to have higher discriminatory power in detecting MetS than HOMA-IR in obese Chinese children[30] and has been found to be a surrogate marker for IR in obese Malaysian children[31] and Chinese participants.[32] It remains a challenge to work with indigenous communities because of low education levels, cultural differences, and the absence of written language and mathematical knowledge. Parameters that are self-reported in the absence of official documents such as age, smoking habits, family disease, and so on, which may present as confounders in health studies, often cannot be verified.

Conclusions

We have determined the overall prevalence of MetS in the OA to be 29.57%, with the Negritos, Proto-Malays, and Senois at 26.35%, 39.56%, and 11.26%, respectively. Proto-Malays who have the most urbanized lifestyle have a higher MetS prevalence, whereas the Senois have the lowest MetS prevalence. RR values show that TG/HDL-C is generally the most specific risk factor in differentiating individuals with and without MetS. There is no single underlying risk factor for MetS among the OA because they seem to differ for each group. The most prevalent risk factor among the Negritos with MetS was low HDL-C (95.35%), whereas central obesity was significant among the Proto-Malays (82.91%).

MetS and cardiovascular risks are to a great extent preventable. Affected individuals can benefit from better health education, changes in diet, and more healthy lifestyles. We believe our findings shed light on indigenous communities undergoing rapid epidemiological transition. OA communities are now receiving secondary education and appear to be more receptive to health-care intervention. We hope that health departments and other agencies will use our findings to initiate preventive health programs.

Author statements

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Ethical approval

All the relevant ethics approvals were obtained from the Malaysian Research Ethics Committee, Ministry of Health Malaysia, Monash University and Department of Aboriginal Development (JKOA), Malaysia.

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Competing interests

None declared.

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Appendix A. Supplementary data

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