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Normal-weight central obesity and cardiometabolic disorders among Aboriginal and Torres Strait Islander Australians

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Abstract

Background Cardiometabolic disorders are the leading cause of mortality and contribute substantially to the First Nations Health Gap in Australia. Central obesity is the major contributor to metabolic syndrome. We investigated factors associated with central obesity and how normal-weight central obesity is associated with cardiometabolic disorders among Aboriginal and Torres Strait Islander Australians (hereafter respectfully referred to as 'Indigenous Australians').

Methods This study used the 2018–2019 Australian Bureau of Statistics (ABS) National Aboriginal and Torres Strait Islander Health Survey dataset. A total of weighted 4864 Indigenous adults (18 + years) were included. Normal-weight central obesity refers to individuals with a normal body mass index (BMI) but with an elevated waist circumference (WC ≥ 102 cm for males and ≥ 88 cm for females). Main outcomes included self-reported type 2 diabetes, hypertension, high cholesterol and heart disease. Multi-level logistic regression models were used to examine the relationship between explanatory variables and outcomes.

Results The overall prevalence of central obesity was 46.2% (95% confidence interval [CI]: 42.8, 49.72) in males and 67.7% (95% CI: 64.90, 70.4) in females. Physical inactivity increased the risk of central obesity in males (odds ratio [OR] = 1.34; 95% CI: 1.09, 1.65), while daily consumption of soft drinks was associated with central obesity in females (OR = 1.35; 95% CI: 1.12, 1.62). Males living in very remote areas had a lower risk of central obesity, while females in very remote areas had a higher risk. Our findings also showed that females with normal-weight central obesity had a higher risk of hypertension (OR = 3.29; 95% CI: 1.95, 9.62) and higher total cholesterol (OR = 4.62; 95% CI: 2.22, 9.62). Similarly, males with normal-weight central obesity were associated with a higher risk of type 2 diabetes (OR = 4.13; 95% CI: 1.23, 13.94).

Conclusions This was the first study to report that approximately 12% of Indigenous Australians with normal BMI have central obesity. Relying solely on BMI to identify such high-risk individuals may be inadequate for early intervention. Public health initiatives targeting obesity should include individuals with a normal BMI and central obesity.

Keywords Central obesity, Cardiometabolic disorders, Indigenous population, Australia

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Background

Aboriginal and Torres Strait Islander Australians (hereafter, we use 'Indigenous Australians' as a collective term, respectfully acknowledging the diversity of language and culture of Aboriginal and Torres Strait Islander peoples, as the First People and custodians of Australia) have a life expectancy of 8.8 years fewer for males and 8.1 years fewer for females compared to other Australians [1]. Cardiometabolic disorders play a critical role in the persistence of this gap, primarily due to their strong link with premature death [2–4]. The higher prevalence of cardiometabolic disorders in Indigenous populations is influenced by a complex interplay of genetic, environmental and socioeconomic factors [5, 6]. Additionally, in Indigenous Australians, the onset of type 2 diabetes, hypertension and cardiovascular diseases happens earlier and at higher rates compared to non-Indigenous Australians [7].

Central obesity (excess body fat particularly around the abdomen) is the major contributor to cardiometabolic disorders [8]. Central obesity leads to the release of inflammatory cytokines and hormones that disrupt normal metabolic processes [3, 4]. These disruptions include insulin resistance, dyslipidaemia, elevated blood pressure and impaired glucose regulation [3, 4]. In Indigenous Australians, the prevalence of central obesity is higher compared to the general population [9]. This can be attributed to various factors including limited access to affordable healthy food options, higher rates of sedentary behaviours, genetics, and historical and ongoing socioeconomic disparities [10]. Consequently, the disparity in the burden of central obesity and cardiometabolic disorders further widens the gap in life expectancy between Indigenous and non-Indigenous Australians [11].

Body mass index (BMI) is widely used to assess body fat levels and predict cardiometabolic risks [12]. However, recent studies have highlighted the limitations of BMI in accurately determining body fat distribution and percentage [12–14]. For example, a study in the USA found that half of women with a high body fat percentage were not identified by BMI [14]. There is also evidence that individuals with a normal BMI, but larger waist circumference are at a higher risk of cardiovascular disorders and mortality than those who are overweight or obese [15, 16]. These can be potentially attributed to the accumulation of visceral fat in the abdominal area, which is not adequately captured by BMI measurements. Despite a range of studies existing in the literature, so far, none of the studies has examined the relationship between normal-weight central obesity and cardiometabolic disorders among Indigenous Australians.

Given the high rates of central obesity in Indigenous Australians, a considerable segment of the population may have normal-weight central obesity (e.g. normal BMI and elevated WC). Understanding the health risks associated with this group is essential from a clinical perspective and for the development of risk reduction initiatives. This study aimed to investigate the link between normal-weight central obesity and cardiometabolic disorders, as well as the risk factors contributing to central obesity in Indigenous Australians. Findings from this study will have policy implications in addressing the First Nations Gap [17].

Methods

Data sources

The study was based on the secondary analysis of the 2018–2019 National Aboriginal and Torres Strait Islander Health Survey (NATSIHS) data. The NATSIHS was designed to collect a wide range of information about the health of Indigenous Australians, including the prevalence of health conditions (e.g. type 2 diabetes, hypertension, heart diseases), the prevalence of health risk factors (such as smoking and vaping, alcohol consumption and physical activity) and social determinants of health. The NATSIHS was funded by the Australian Government Departments of Health and Prime Minister and Cabinet and implemented by the Australian Bureau of Statistics (ABS) [9]. This study followed the Strengthening the Reporting of Observational Studies in Epidemiology (STROBE) reporting guideline for cross-sectional studies.

Study setting and sampling

The NATSIHS was conducted between July 2018 and April 2019. Two samples were used: a community sample and a non-community sample. The community sample included a random selection of discrete Indigenous communities and associated outstations from the Dwelling Register for Aboriginal and Torres Strait Islander Communities. The non-community sample involved multistage area sampling of private dwellings outside Indigenous communities. Mesh blocks with Indigenous households from the 2016 census were identified. Dwellings in each mesh block were randomly selected. In non-remote areas, up to two adults aged 18 years or older were randomly selected from both the community and non-community samples, while in remote areas, up to one adult was randomly selected [9]. For this study, a total of weighted 4864 adult samples (18 years or older) were included.

Cardiometabolic disorders

The main outcome variables were type 2 diabetes, hypertension, high cholesterol and heart disease, measured

through self-reported questionnaires. Respondents indicated whether a doctor or nurse had ever diagnosed them with these conditions, and for those with chronic conditions, respondents were additionally asked if the condition was long-term, defined as present at the time of the survey and expected to last 6 months or more [18]. The classification of health conditions in the NATSIHS followed the International Classification of Diseases, 10th Revision (ICD-10) [18]. For this study, the condition of heart diseases included angina, heart attack, heart failure and other heart diseases, based on the ICD-10 criteria.

Anthropometric measurements

Physical measurements, including height, weight and waist circumference (WC), were obtained from respondents aged 2 years and above [18]. Pregnant women were excluded from measurements. Individuals aged 2 years and older were invited in the NATSIHS to voluntarily measure their waist using a tape measure with a maximum length of 150 cm [18]. For this study, central obesity was defined as a waist circumference [WC] of ≥ 102 cm for males and ≥ 88 cm for females [19]. Additionally, the NATSIHS recorded BMI using participants' voluntarily provided height and weight measurements [18]. BMI was categorised into three groups: normal weight (BMI: 18.5–24.9 kg/m^2), overweight (BMI: 25–29.9 kg/m^2) and obese (BMI ≥ 30.0 kg/m^2) [19].

The term 'normal weight' is widely used in the literature to describe BMI values between 18.5 and 24.9 kg/m^2. While we used for consistency with established definitions, it is important to note that these classifications may not fully account for the diversity in body composition across populations. For this study, normal-weight central obesity refers to individuals who fall within a typical healthy BMI range (18.5–24.9 kg/m^2) but with an elevated WC that meets the thresholds for central obesity.

Other study variables

Based on the review of the literature, we have also included other covariates broadly classified as sociodemographic factors, health risk factors and geographic factors. Sociodemographic factors included age (grouped as '18–29 years', '30–34 years' or '45 + years'), sex (grouped as 'male' or 'female'), highest educational attainment (grouped as 'did not complete year 12', 'completed year 12', 'trade certification or diploma' or 'tertiary education'), individual income (grouped as 'average or more income' or 'below average') and marital status ('married' or 'not married'). We used the 2021 census median individual weekly income (AUD$540) for Indigenous populations to dichotomise income to 'average or more' and 'below average'.

Health risk factors encompassed physical inactivity, low fruit and vegetable consumption, smoking, sugar/sweet drink intake and alcohol consumption. Physical inactivity was defined according to the Australian Department of Health 2014 Physical Activity and Sedentary Behaviour guidelines [20]. Physical activity in this survey was measured using self-reported Recent Physical Activity Questionnaire (RPAQ) [18]. Individuals aged 18–64 years were considered to have met the 2014 Guidelines if, in the past week, they engaged in activities such as walking, moderate or vigorous physical activity on at least 5 days, accumulated 150 min or more (with vigorous activity counted as double) and performed strength or toning exercises on at least 2 days, excluding workplace activity. For individuals aged 65 and over, meeting the guidelines required engaging in activities like walking, moderate or vigorous physical activity every day and accumulating at least 30 min of activity on at least 5 days [20].

Fruit and vegetable consumption was measured using a self-reported questionnaire. The classification of consumption was based on the 2013 Australian Dietary Guidelines developed by the National Health and Medical Research Council (NHMRC) [21]. The guidelines recommend a minimum daily intake of two servings of fruits and five servings of vegetables, with specific requirements varying by age and sex. Respondents reported their usual daily intake in servings, excluding all drinks, beverages and juices. Individuals aged 15 years and over were also asked about their regular use of tobacco products during the interview. Tobacco products included manufactured (packet) cigarettes, roll-your-own cigarettes, pipes, cigars or other tobacco products, but excluded chewing tobacco and the smoking of non-tobacco products such as marijuana [18]. In this study, a person's smoking status was categorised as a current daily smoker, defined as someone who reported regularly smoking one or more cigarettes, pipes, cigars or other tobacco products per day.

Excessive alcohol consumption was defined as exceeding the Australian Adult Alcohol Guidelines based on two criteria: component A: consuming more than 10 standard drinks in the past week and component B: consuming more than 4 standard drinks on at least 12 days in the past year [18]. For component A, weekly consumption was estimated using self-reported data on alcohol intake over the 3 most recent drinking days and the total number of drinking days in the prior week. The total alcohol consumed for each drink type was summed, averaged and scaled to reflect weekly consumption. For component B, respondents reported the number of occasions they drank 5 or more standard drinks in a single day over the past year. Excessive drinking was classified as consuming over 21 units (168 g or 213 ml) of alcohol weekly, based on criteria from Lancet Public Health [22].

Additionally, sugary drink consumption included soft drinks (including those in ready-to-drink alcoholic beverages), cordials, sports drinks and energy drinks, while excluding fruit juice, flavoured milk, sugar-free drinks and hot beverages.

Geographic factors included remoteness and area-level socioeconomic disadvantages. Remoteness was grouped as 'urban cities', 'outer regional', 'inner regional', 'remote' or 'very remote' areas. This classification was based on the Australian Statistical Geography Standard (ASGS). Socioeconomic disadvantage was calculated at the Statistical Area 1 (SA1) and categorised into quintiles from most to least disadvantaged.

Statistical analysis

All data were accessed in the ABS DataLab (https://new.datalab.abs.gov.au/) and analysed using the STATA software (version 18, Stata Corp, College Station, TX, USA).

The NATSIHS was designed to produce reliable estimates for the Aboriginal and Torres Strait Islander population, including by state, territory and remoteness area. Each person or household was assigned a weight reflecting the number of people or households represented in the entire population. This weight was based on their probability of selection in the sample. The 2018–2019 dataset included two weight variables: household weight (FINHHWT), used for estimating households, and person weight (FINPERWT), used for estimating the total population [18]. For this study, we used the person-level weight variable (FINGERWT), and the sample size was approximated by dividing the personal weight variable by 100.

Initial analyses involved describing sociodemographic, health risk and geographic factors using frequencies and percentages, all weighted using the personal weight variable. The prevalence of central obesity was calculated across explanatory variables. Subsequently, multilevel multivariable logistic regression models were used to investigate associations between sociodemographic factors, health risk factors and geographic factors with central obesity. Similarly, multilevel regression modelling was used to examine the relationship between normal-weight central obesity and cardiometabolic disorders, such as type 2 diabetes, hypertension, high cholesterol and heart diseases, after adjusting for sociodemographic, health risk and geographic factors.

Multilevel modelling was selected due to its advantages over classical single-level logistic regression models [23, 24]. Specifically, it accounts for the hierarchical nature of the data, recognising that individuals within the same neighbourhood may share similarities in their cardiometabolic risks. Failing to acknowledge these hierarchical structures can lead to an underestimation of standard errors of regression coefficients, potentially inflating the statistical significance of results. Odds ratios (ORs) with 95% confidence intervals (CIs) were calculated to measure the association between study factors and outcome variables.

Results

Study participants

This study included a total weighted sample of 4864 Indigenous (≥18 years), with a mean age of 42.8 (±16.3) years, and 52.0% of the participants were females. Approximately 43.6% did not complete year 12, and 50.9% earned below the average income. About 80.7% were physically inactive, and only 4.1% met the guideline for vegetable consumption. One in five adults (19.3%) resided in remote or very remote areas, while 53.6% were in areas with high socioeconomic disadvantages (Table 1).

Prevalence of central obesity

The overall prevalence of central obesity was 46.2% (95% CI: 42.8, 49.72) in males and 67.7% (95% CI: 64.90, 70.4) in females. The prevalence of central obesity among Indigenous adults with normal BMI was 11.6% (95% CI: 9.4, 14.3). Notably, the prevalence of normal-weight central obesity was substantially higher in females compared to males (20.9%; 95% CI: 16.8, 25.6 in females and 2.2%; 95% CI: 0.9, 5.1 in males). Older individuals (45 + years of age) had a higher prevalence of central obesity, compared to younger participants (70.4% vs 41.8%). Indigenous who were physically active had a lower prevalence of central obesity compared to those who were not physically active (46.4% vs 60.1%). Females who resided in very remote areas had a higher prevalence of central obesity, compared to males from very remote areas (72.4% vs 37.4%) (Table 2).

Factors associated with central obesity

Females who consumed sugar/sweet drinks daily were associated with a higher risk of central obesity (OR = 1.35; 95% CI: 1.12, 1.62). Females living in remote (OR = 1.51; 95% CI: 1.13, 2.03) and very remote (OR = 1.95; 95% CI: 1.46, 2.61) areas were associated with a higher risk of central obesity compared to those residing in urban cities. On the other hand, physically inactive males were more likely to have central obesity (OR = 1.34; 95% CI: 1.06, 1.65), whereas daily smokers showed a lower risk (OR = 0.50; 95% CI: 0.42, 0.59). Males residing in very remote areas were less likely to be centrally obese compared to urban cities (OR = 0.72; 95% CI: 0.53, 0.98) (Table 3).

Table 1 Study participants ($N = 4864$)

Variables	Males, *n* (%)	Females, *n* (%)	Total, *n* (%)
Age group			
18–29 years	859 (37.5)	856 (34.5)	1715 (36.0)
30–34 years	602 (26.3)	663 (26.7)	1264 (26.5)
45 + years	829 (36.2)	961 (38.8)	1789 (37.5)
Highest educational attainment			
Did not complete year 12	1025 (45.2)	1023 (42.1)	2048 (43.6)
Completed year 12	313 (13.8)	341 (14.0)	655 (13.9)
Trade certification or diploma	782 (34.5)	856 (35.2)	1638 (34.9)
Tertiary education	146 (6.4)	211 (8.7)	356 (7.6)
Marital status			
Married	923 (39.5)	996 (39.4)	1919 (39.4)
Not married	1412 (60.5)	1534 (60.6)	2946 (60.6)
Individual income**			
Average and above	1255 (53.8)	1310 (51.8)	2390 (49.1)
Below average	1080 (46.2)	1220 (48.2)	2475 (50.9)
Physical inactivity			
Met the guideline	499 (21.4)	439 (17.3)	938 (19.3)
Not met the guideline	1834 (78.6)	2091 (82.7)	3925 (80.7)
Smoking			
Not daily smoking	1356 (58.1)	1553 (61.4)	2909 (59.8)
Daily smoking	978 (41.9)	977 (38.6)	1956 (40.2)
Fruit consumption			
Met the guideline	789 (33.8)	1080 (42.7)	1869 (38.4)
Not met the guideline	1546 (66.2)	1449 (57.3)	2995 (61.6)
Vegetable consumption			
Met the guideline	42 (1.8)	160 (6.3)	202 (4.1)
Not met the guideline	2293 (98.2)	2370 (93.4)	4663 (95.9)
Sugar/sweet drink consumption			
Not daily drinking	1727 (74.0)	1969 (77.8)	3696 (76.0)
Daily drinking	608 (26.)	560 (22.2)	1168 (24.0)
Alcohol consumption			
Not excessive drinking	1857 (79.5)	2370 (96.7)	4227 (86.9)
Excessive drinking	477 (20.5)	160 (6.3)	637 (13.1)
Remoteness			
Urban cities	890 (38.1)	961 (38.0)	1851 (38.0)
Inner regional	539 (23.1)	574 (22.7)	1113 (22.9)
Outer regional	455 (19.5)	504 (19.9)	960 (19.7)
Remote	158 (6.7)	173 (6.8)	331 (6.8)
Very remote	293 (12.5)	317 (12.5)	610 (12.5)
Socioeconomic disadvantages			
Quintile 1 (most disadvantaged)	1206 (51.7)	1401 (55.4)	2608 (53.6)
Quintile 2	493 (21.1)	469 (18.5)	962 (19.8)
Quintile 3	327 (14.0)	352 (13.9)	679 (14.0)
Quintile 4	164 (7.0)	225 (8.9)	389 (8.0)
Quintile 5 (least disadvantaged)	144 (6.2)	83 (3.3)	227 (4.7)

** The median weekly income of $540 for Indigenous population from 2021 National Census was used to classify individual income as average and above, and below average.

Table 2 Prevalence of central obesity in Indigenous Australians ($N = 4864$)

Variables	Males, *n* (%)	Females, *n* (%)	Total, *n* (%)
Age group			
18–29 years	276 (32.2)	441 (51.5)	717 (41.8)
30–44 years	276 (45.8)	478 (72.2)	754 (59.6)
45 + years	498 (60.1)	761 (79.2)	1259 (70.4)
Highest educational attainment			
Did not complete year 12	490 (47.8)	721 (70.5)	1211 (59.1)
Completed year 12	1112 (35.6)	187 (54.8)	299 (45.6)
Trade certification or diploma	390 (49.9)	591 (69.1)	981 (59.9)
Tertiary education	61 (41.6)	146 (69.5)	207 (58.1)
Marital status			
Married	457 (49.5)	685 (68.7)	1142 (59.5)
Not married	622 (44.1)	1029 (67.1)	1651 (56.0)
Individual income**			
Average and above	622 (49.6)	809 (66.3)	1431 (57.8)
Below average	457 (42.3)	904 (69.0)	1361 (56.9)
Physical inactivity			
Met the guideline	175 (35.1)	260 (59.2)	435 (46.4)
Not met the guideline	904 (49.3)	1454 (69.5)	2357 (60.1)
Smoking			
Not daily smoking	699 (51.5)	1057 (68.1)	1756 (60.4)
Daily smoking	380 (38.8)	656 (67.2)	1036 (53.0)
Fruit consumption			
Met the guideline	352 (44.6)	702 (64.9)	1053 (56.3)
Not met the guideline	728 (47.1)	1012 (69.8)	1739 (58.1)
Vegetable consumption			
Met the guideline	22 (51.3)	125 (78.3)	147 (72.7)
Not met the guideline	1057 (46.1)	1588 (67.0)	2646 (56.7)
Sugar/sweet drink consumption			
Not daily drinking	736 (46.0)	1265 (67.7)	2001 (57.7)
Daily drinking	343 (46.7)	448 (67.8)	791 (56.7)
Alcohol consumption			
Not excessive drinking	873 (47.0)	1597 (67.4)	2470 (58.4)
Excessive drinking	206 (43.2)	116 (72.7)	322 (50.6)
Remoteness			
Urban cities	420 (47.2)	604 (62.9)	1024 (55.3)
Inner regional	280 (52.0)	400 (69.7)	680 (61.1)
Outer regional	200 (44.0)	356 (70.6)	556 (58.0)
Remote	69 (43.7)	123 (71.2)	192 (58.1)
Very remote	110 (37.4)	230 (72.4)	339 (55.6)
Socioeconomic disadvantages			
Quintile 1 (most disadvantaged)	554 (45.9)	988 (70.5)	1542 (59.2)
Quintile 2	233 (47.1)	326 (69.5)	558 (58.0)
Quintile 3	163 (49.8)	209 (59.5)	372 (54.8)
Quintile 4	66 (40.5)	145 (64.5)	212 (54.4)
Quintile 5 (least disadvantaged)	63 (43.9)	45 (54.2)	108 (47.6)

** The median weekly income of $540 for Indigenous population from 2021 National Census was used to classify individual income as average and above, and below average.

Table 3 Factors associated with central obesity in Indigenous Australians (*N* = 4864)

Variables	Males, *n* (%)	Females, *n* (%)
Age group		
18–29 years	1.00	1.00
30–44 years	1.65 (1.29, 2.10)	2.13 (1.76, 2.59)
45 + years	2.83 (2.26, 3.55)	3.69 (3.04, 4.47)
Highest educational attainment		
Did not complete year 12	1.00	1.00
Completed year 12	0.91 (0.68, 1.21)	0.93 (0.73, 1.19)
Trade certification or diploma	1.16 (0.95, 1.42)	1.20 (0.99, 1.49)
Tertiary education	0.88 (0.58, 1.33)	1.37 (0.99, 1.91)
Marital status		
Married	1.00	1.00
Not married	0.89 (0.74, 1.06)	1.07 (0.91, 1.26)
Individual income**		
Average and above	1.00	1.00
Below average	0.84 (0.70, 1.01)	0.96 (0.81, 1.13)
Physical inactivity		
Met the guideline	1.00	1.00
Not met the guideline	1.34 (1.09, 1.65)	1.24 (1.00, 1.53)
Smoking		
Not daily smoking	1.00	1.00
Daily smoking	0.51 (0.43, 0.61)	0.66 (0.56, 0.77)
Fruit consumption		
Met the guideline	1.00	1.00
Not met the guideline	0.93 (0.78, 1.12)	0.81 (0.69, 0.95)
Vegetable consumption		
Met the guideline	1.00	1.00
Not met the guideline	0.92 (0.52, 1.61)	1.37 (0.99, 1.90)
Sugar/sweet drink consumption		
Not daily drinking	1.00	1.00
Daily drinking	1.00 (0.83, 1.20)	1.35 (1.12, 1.62)
Alcohol consumption		
Not excessive drinking	1.00	1.00
Excessive drinking	1.01 (0.83, 1.21)	1.20 (0.87, 1.66)
Remoteness		
Urban cities	1.00	1.00
Inner regional	1.12 (0.86, 1.46)	1.23 (0.96, 1.67)
Outer regional	0.91 (0.69, 1.20)	1.07 (0.84, 1.37)
Remote	0.86 (0.63, 1.18)	1.51 (1.13, 2.03)
Very remote	0.72 (0.53, 0.98)	1.95 (1.46, 2.61)
Socioeconomic disadvantages		
Quintile 1 (most disadvantaged)	1.00	1.00
Quintile 2	1.03 (0.81, 1.30)	0.93 (0.75, 1.17)
Quintile 3	0.86 (0.65, 1.15)	0.86 (0.66, 1.19)
Quintile 4	0.84 (0.57, 1.24)	0.80 (0.57, 1.11)
Quintile 5 (least disadvantaged)	0.63 (0.37, 1.09)	1.07 (0.62, 1.83)

** The median weekly income of $540 for Indigenous population from 2021 National Census was used to classify individual income as average and above, and below average.

Normal-weight central obesity and cardiometabolic disorders

Females with normal-weight central obesity were more likely to have self-reported hypertension (OR = 3.29; 95% CI: 1.95, 9.62) and self-reported high cholesterol (OR = 4.62; 95% CI: 2.22, 9.62) compared to those without central obesity and with a normal BMI. However, there was no significant association between normal-weight central obesity and self-reported type 2 diabetes or heart diseases among females (Fig. 1). Similarly, males with normal-weight central obesity had a higher risk of self-reported type 2 diabetes compared to those with no central obesity and a normal BMI (OR = 4.13; 95% CI: 1.23, 13.94). Our results did not show a significant association between normal-weight central obesity and self-reported hypertension, high cholesterol or heart diseases (Fig. 2).

Discussion

In this cross-sectional study, we examined the link between normal-weight central obesity and cardiometabolic disorders, along with identifying risk factors for central obesity in adult Indigenous Australians. Our findings revealed that males with normal-weight central obesity had a higher risk of type 2 diabetes, whereas females with normal-weight central obesity were more likely to have hypertension and high cholesterol. Additionally, physical inactivity was associated with an increased risk of central obesity in males, while daily consumption of sugary drinks was associated with central obesity in females. Interestingly, males residing in very remote areas showed a lower risk of central obesity, whereas females in these regions had a higher risk.

Excess abdominal obesity is a modifiable precursor of cardiometabolic disorders [25]. Relying solely on the BMI as a measure of relative body weight is not adequate for accurately identifying obese individuals who are at higher cardiometabolic risks [12–14]. This is because fat depots in abdominal areas, directly linked to insulin resistance, creates an atherogenic pro-inflammatory environment, thereby posing substantial health risks and increasing the chance of type 2 diabetes and cardiovascular disorders [26]. Our findings support this assertion, revealing that in Indigenous individuals, those with elevated waist circumference but normal BMI had a greater risk of type 2 diabetes, hypertension and high cholesterol. This highlights the importance of targeting central obesity, rather than solely focusing on BMI, in addressing the gap in cardiometabolic disorders in Indigenous Australians. In addition, incorporating WC in routine clinical assessments by primary care physicians and other allied health professionals is imperative.

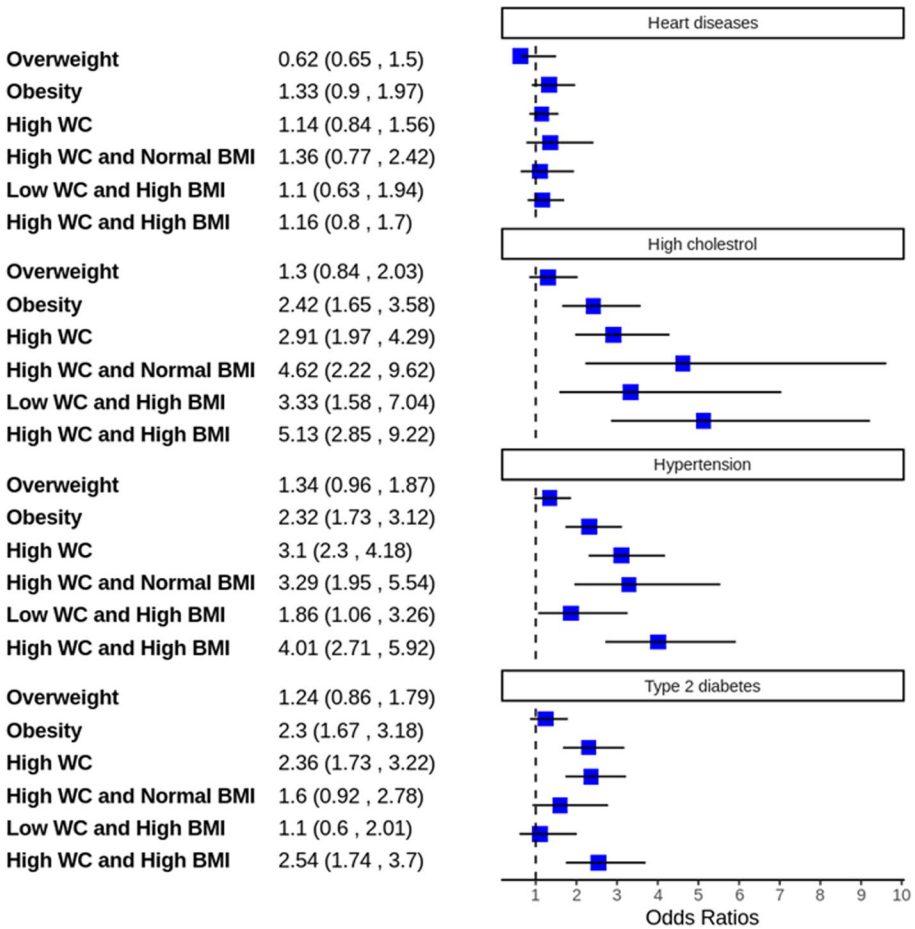

Fig. 1 Female obesity patterns and cardiometabolic risks in Indigenous Australians, 2018–2019. Note: Normal BMI was the reference for overweight and obesity results; low WC was the reference for the results of high WC; low WC and low BMI was the reference for the results of high WC and normal BMI, low WC and high BMI and high WC and high BMI

Lifestyle modifications, such as physical exercise and a healthy diet, are widely recommended for combating the global obesity epidemic [27–29]. Despite the extensive promotion of these lifestyle changes, obesity rates have continued to rise unabated [30]. This raise concerns on the effectiveness of current intervention approaches. Consistent with the global trend, the trend of obesity within Indigenous communities in Australia is also on the rise [31]. This can be attributed, in part, to the prevalence of major fast-food chains establishing outlets in low socioeconomic neighbourhoods. Additionally, socioeconomic disparities and limited access to affordable, nutritious foods in these communities further compound the challenges of adopting healthier lifestyles [32, 33].

Based on past literature [34, 35] and our findings, promoting lifestyle changes alone may not be sufficient to address cardiometabolic risks in Indigenous Australians. Tailored, community-driven nutritional interventions targeting Indigenous Australians in low socioeconomic areas, particularly those with a high density of fast-food outlets, should be prioritised. These community-based interventions should incorporate culturally appropriate strategies, engage local leaders and address barriers such as food insecurity and limited accessibility to healthy options. Furthermore, our results indicate that women in very remote areas are at greater risk of central obesity, highlighting the need for targeted lifestyle modification programs tailored to women in rural and remote areas.

Strengths and limitations of the study

Our findings benefit from a nationally representative sample and the implementation of sample weights, which enhance the reliability of the findings. This study also had certain limitations. Firstly, the use of cross-sectional data presents challenges in establishing a temporal relationship between explanatory variables and outcomes.

Secondly, this study acknowledges limitations related to the measurement of outcomes and the reliance on

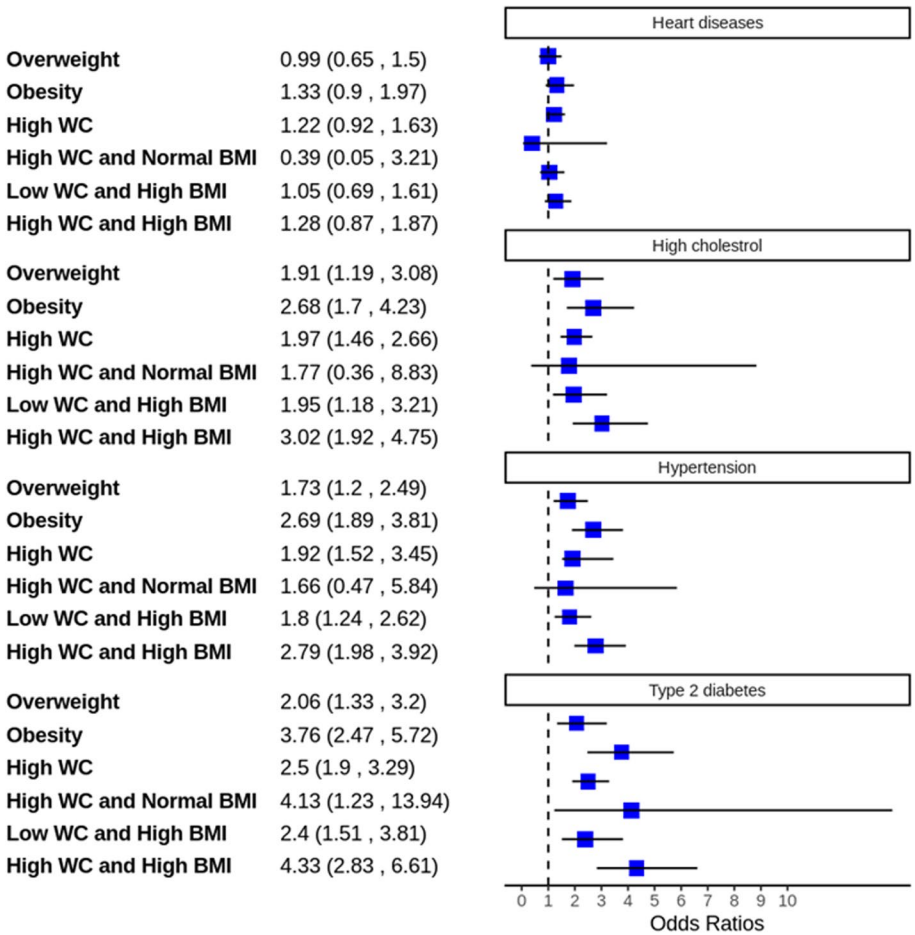

Fig. 2 Male obesity patterns and cardiometabolic risks in Indigenous Australians, 2018–2019. Note: Normal BMI was the reference for overweight and obesity results; low WC was the reference for the results of high WC; low WC and low BMI was the reference for the results of high WC and normal BMI, low WC and high BMI and high WC and high BMI

self-reported data. The use of self-reported measures for outcomes such as type 2 diabetes, hypertension, high cholesterol and heart disease introduces the potential for underreporting or underestimation of true prevalence. This may result from factors such as recall bias, misunderstanding of survey questions, social desirability bias, inaccessibility to healthcare or the unaffordability of medical care. Despite these limitations, our findings are derived from a nationally representative survey, which has been widely used and remains a robust source of data for understanding health outcomes at the population level in Australia. To enhance the accuracy of these estimates, we recommend that future national surveys incorporate objective clinical measures, such as blood tests and standardised diagnostic assessments, to validate and complement self-reported data.

Third, while the ABS data offer a comprehensive range of health indicators, their reliance on self-reported information also raises concerns about the accuracy of certain health risk behaviours. Self-reported data are particularly prone to underreporting behaviours that have negative social connotations, such as smoking, excessive alcohol consumption or physical inactivity. This underreporting can distort prevalence estimates and hinder a full understanding of health risk behaviours in the population. To address these limitations, future surveys could incorporate digital health technologies, such as wearable devices and mobile health applications, that could provide real-time, unbiased and accurate assessments of behaviours like physical activity and dietary habits.

Conclusions

In this cross-sectional study of 4864 Indigenous adults aged 18 years or older, we found that approximately 12% of individuals with a normal BMI also have central obesity. Relying solely on BMI to identify high-risk individuals may be insufficient for early intervention, as central

obesity, despite a normal BMI, is a significant predictor of cardiometabolic risk and could be overlooked when BMI is the only measure used. While current clinical and public health initiatives (e.g. a regular physical activity and a healthy diet) primarily focus on addressing general obesity, these efforts should be broadened to specifically target adults with a normal BMI who also have central obesity, as they remain at increased risk due to abdominal fat accumulation. Furthermore, future National Health Surveys in Australia should consider incorporating objective clinical measures and digital health technologies, such as blood tests, standardised diagnostic assessments and mobile applications, to validate self-reported data and enhance the accuracy of prevalence estimates.

Abbreviations

ABS	Australian Bureau of Statistics
ASGS	Australian Statistical Geography Standard
AUD	Australian dollar
BMI	Body mass index
CI	Confidence interval
ICD	International Classification of Diseases
NATSIHS	National Aboriginal and Torres Strait Islander Health Survey
NHMRC	National Health and Medical Research Council
OAMS	Orange Aboriginal Medical Services
OR	Odds ratio
REDI.E	Regional Enterprise Development Institute
RPAQ	Recent Physical Activity Questionnaire
SA1	Statistical Area 1
STROBE	Strengthening the Reporting of Observational Studies in Epidemiology
WC	Waist circumference

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Authors' contributions
KYA conceptualised the study idea, obtained and analysed the data, interpreted the results, drafted the original manuscript, and critically revised the manuscript. AGR contributed to the conception of the research idea and interpretation and critically revised the manuscript. AGR, MMH, ST, SBA, JN, UKM, SM, FHA, AEA, and PG critically revised the manuscript for intellectual content. KYA, ST and MMH had full access to all the data in the study and took responsibility for the integrity of the data and the accuracy of the data analysis. All authors read and approved the final manuscript.

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Data availability
Data sharing is at the discretion of the data custodians and will be considered upon request.

Declarations

Ethics approval and consent to participate
Ethical clearance was obtained from the Charles Sturt University Human Research Ethics Committee (H23808), and the ABS provided clearance to the data analysis output files. The involvement of Indigenous People in reviewing the study's concept, design and implementation was facilitated through Orange Aboriginal Medical Services (OAMS) and Regional Enterprise Development Institute (REDI.E), aligning with the National Health and Medical Research Council (NHMRC) guideline for conducting ethical research with Aboriginal and Torres Strait Islander peoples.

Consent for publication
Not applicable.

Competing interests
The authors declare no competing interests.

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