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Health behaviours associated with healthy body composition among Aboriginal adolescents in Australia in the 'Next Generation: Youth Well-being study'

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ABSTRACT

This study described the distribution of healthy body composition among Aboriginal adolescents in Australia aged 10–24 years and examined associations with health behaviours and self-rated health. Data were cross-sectional from the 'Next Generation: Youth Well-being study' baseline (N = 1294). We used robust Poisson regression to quantify associations of self-reported health behaviours (physical activity, screen time, sleep, consumption of vegetables, fruit, soft drinks and fast food, and tobacco smoking and alcohol) and self-rated health to healthy body mass index (BMI) and waist/height ratio (WHtR). Overall, 48% of participants had healthy BMI and 64% healthy WHtR, with healthy body composition more common among younger adolescents. Higher physical activity was associated with healthy body composition (5–7 days last week vs none; adjusted prevalence ratio (aPR) healthy BMI 1.31 [95% CI 1.05–1.64], and healthy WHtR 1.30 [1.10–1.54]), as was recommended sleep duration (vs not; aPR healthy BMI 1.56 [1.19–2.05], and healthy WHtR 1.37 [1.13–1.67]). There was a trend for higher proportion of healthy body composition with more frequent fast food consumption. Healthy body composition was also associated with higher self-rated health ('very good/excellent' vs 'poor/fair'; aPR healthy BMI 1.87 [1.45–2.42], and healthy WHtR 1.71 [1.40–2.10]). Culturally appropriate community health interventions with a focus on physical activity and sleep may hold promise for improving body composition among Aboriginal adolescents.

1. Introduction

Aboriginal cultures in Australia are among the oldest in the world, continuing to thrive despite the ongoing impacts of British colonisation, though the Aboriginal population experiences substantial health and social inequities as a result (Australian Government Department of Health, 2021; Australian Institute of Health and Welfare, 2022). Aboriginal people make up about 4% of the Australian population, most living in urban areas, and have a younger age profile, with a median age of 24 years compared to 38 for the non-Aboriginal population (Australian Bureau of Statistics, 2022a, 2022b). Adolescence, defined here as 10–24 years of age (Sawyer et al., 2018), appears to be an important life

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phase to focus on improving health outcomes for the Aboriginal population, with 54% of those aged 10–14 years in the 'normal' range for body mass index (BMI), dropping to 34% among those aged 18–24 years (Australian Institute of Health and Welfare, 2018). Abdominal adiposity has also been shown to be prevalent among Aboriginal adolescents (O'Bryan et al., 2023), with a northern Australian study finding it was common even among those with normal BMI (Sellers et al., 2008). Both elevated BMI and waist circumference are associated with increased cardio-metabolic risk among Aboriginal adolescents (Juonala et al., 2016; McKay et al., 2022). Therefore, there is great potential to reduce obesity-related chronic disease risk in the next generation of adults, and reduce health inequities for Aboriginal people, through improvements in body composition during adolescence.

While there is substantial evidence of a disparity in obesity prevalence between Aboriginal and non-Aboriginal children and adolescents (Hardy et al., 2019), there has been little research within Aboriginal populations into the health behaviours that are associated with maintaining a healthy body composition (McKay et al., 2022). This is concerning because such data could inform more effective, culturally specific, and age-appropriate health policies and programs (Sherriff et al., 2019). Considering Aboriginal adolescent body composition through a bioecological model of health, health behaviours like physical activity and diet are considered proximal determinants, yet can be influenced by distal factors, including social, cultural and environmental determinants (Bronfenbrenner and Morris, 2007; Sawyer et al., 2012; Willows et al., 2012). Evidence about health behaviours and body composition would not only guide health interventions but also provide a foundation for further investigation of the wider determinants of health that drive health inequities for Aboriginal adolescents. In addition, an understanding of how body composition relates to adolescents' own perceptions of health could provide insight into the potential benefits of healthy body composition to broader wellbeing.

This study aimed to quantify the distribution of healthy body composition among Aboriginal adolescents from the 'Next Generation: Youth Well-being study' (NextGen) and investigate associations with health behaviours and self-rated health.

2. Methods

2.1. Study participants

Data were cross-sectional from the baseline recruitment of NextGen. Details of the study design and methods have been reported previously (Gubhaju et al., 2019). Briefly, participants were eligible if they self-identified as Aboriginal and/or Torres Strait Islander, were aged between 10 and 24 years, and resided in the states of Western Australia (WA), New South Wales (NSW), or the Central Australia (CA) region of the Northern Territory. There were no exclusion criteria. Between March 2018 and March 2020, Aboriginal-led community research officer teams from the three study regions recruited in community settings via personal and community networks, across a mix of urban, regional and remote areas. This approach is consistent with accepted working criteria for confirming Aboriginality in Australia of self-identification and acceptance as Aboriginal by the community (Australian Institute of Aboriginal and Torres Strait Islander Studies, 2022). Recruitment methods were pragmatic and regionally tailored to enhance engagement with a hard-to-reach population group, including personal communication through community organisations and youth programs, attendance at large community events, employment of youth peer recruiters, word-of-mouth, and social media. Participants completed a health and wellbeing survey (youth survey) and a clinical health assessment, and parents/carers of participants were invited to complete a survey (caregiver survey). There were two versions of the youth survey, designed according to the age of the participant (10–15 or 16–24 years).

Following exclusions (n = 17), 1294 youth participants were included in this study. Exclusion reasons included being pregnant, having an eating disorder, or a congenital condition that could influence body composition, or not identifying as male or female (as we analysed and presented data by gender, the small number of participants identifying as a gender other than female or male were excluded to preserve privacy and confidentiality). Data from 465 caregivers were included.

2.2. Ethical compliance

Ethics approvals have been granted by the Central Australian Aboriginal Human Research Ethics Committee (16–398), Western Australian Aboriginal Health Ethics Committee (719), Aboriginal Health and Medical Research Council of NSW Ethics Committee (1255–17), and the University of Melbourne Medicine and Dentistry Human Ethics Sub-Committee (1851155). Participants under 16 years of age required signed consent from a caregiver as well as their own consent. Participants aged 16 years and over consented for themselves.

2.3. Measures

2.3.1. Outcomes

BMI and waist/height ratio (WHtR) were calculated from height, weight, and waist circumference (WC). Weight and height were measured using a digital floor scale and stadiometer (Seca, Hamburg, Germany), and waist with a tape measure, on a firm surface or board. WC was measured twice at the point midway between the iliac crest and the costal margin and if there was a variation >0.5 cm a third measure was taken. Average WC was calculated. Anthropometric measures were checked for implausible values and data errors (supplementary File S1). For participants aged 18 years and over, BMI was categorised using the World Health Organization (WHO) classifications (WHO Consultation on Obesity, 2000). Younger participants were classified using the International Obesity Task Force (IOTF) age- and sex-specific cut-offs, which were designed to align with the WHO categories at 18 years of age (Cole et al., 2000; Cole et al., 2007). 'Healthy BMI' was defined as the 'normal' range of these respective classifications. WHtR was dichotomised at 0.5, with 'healthy WHtR' defined as WHtR <0.5 (Brambilla et al., 2013; Browning et al., 2010; Khoury et al., 2013). Participants and caregivers were provided with feedback from the clinical health assessment, including advice to follow up with their local health service if underweight or obese.

2.3.2. Exposures

All remaining variables were derived from survey responses (supplementary File S2). Survey questions were sourced from existing questionnaires that have been used with Aboriginal participants (45 and Up Study Collaborators, 2008; Australian Institute of Health and Welfare, 2020; Buysse et al., 1989; Centre for Epidemiology and Evidence, 2017; The Search Investigators, 2010). Exposure variables included age group (10–15; 16–19; 20–24 years), gender (female; male), self-rated health (fair/poor; good; very good/excellent), number of days participant engaged in physical activity in the last week (none; 1–2; 3–4; 5–7), usual number of hours of screen time on a weekday (0–2, 3 or more), sleep quality during the past month (very bad/fairly bad; fairly good/very good), any problems falling asleep (yes; no), meets recommended dietary guidelines for vegetables and fruit (at least 2 serves of fruit and 5 serves of vegetables on a usual day: neither for vegetables nor fruit; meets one of the guidelines; meets both), usual frequency of soft drink and fast food consumption (never or rarely; about 1–6 times a week; about once a day or more), ever tried smoking (no; yes), and ever had a full serve of alcohol (no; yes). The 16–24 years survey included additional questions not reported by 10–15-year-olds, which were used to define recommended sleep duration most nights (no; yes), current smoker (no; yes), and frequency of alcohol consumption (never/no longer drink; less than weekly; 1 or more days a week). Fruit and vegetable consumption, screen time, and sleep duration categories accord with Australian and international guidelines (Australian

Table 1
Socio-demographic characteristics, health behaviours and self-rated health of Australian Aboriginal adolescents aged 10–24 years from the 'Next Generation: Youth Well-being study' 2018–2020.

	Total [a]		10–15 years		16–24 years	
	%	(n)	%	(n)	%	(n)
Total, row % (n)	**100.0**	**(1294)**	**59.0**	**(763)**	**41.0**	**(531)**
Gender						
Female	56.8	(735)	52.6	(401)	62.9	(334)
Male	43.2	(559)	47.4	(362)	37.1	(197)
Recruitment region						
Western Australia	63.6	(823)	67.2	(513)	58.4	(310)
New South Wales	28.5	(369)	26.9	(205)	30.9	(164)
Central Australia	7.9	(102)	5.9	(1)	10.7	(57)
Physical activity (days last week)						
None	18.4	(178)	11.1	(66)	30.2	(112)
1–2 days	27.9	(270)	29.3	(175)	25.6	(95)
3–4 days	28.9	(280)	30.3	(181)	26.7	(99)
5–7 days	24.8	(240)	29.3	(175)	17.5	(65)
Screen time (weekday)						
0–2 h	43.5	(439)	50.6	(312)	32.4	(127)
3 or more hours	56.5	(570)	49.4	(305)	67.6	(265)
Sleep quality (past month)						
Very good/fairly good	84.5	(978)	90.4	(624)	75.6	(354)
Fairly bad/very bad	15.5	(180)	9.6	(66)	24.4	(114)
Problems falling asleep						
No	66.2	(751)	68.4	(456)	63.2	(295)
Yes	33.8	(383)	31.6	(211)	36.8	(172)
Recommended sleep duration [b]						
No	52.7	(226)	–	–	52.7	(226)
Yes	47.3	(203)	–	–	47.3	(203)
Meets dietary guidelines for vegetables & fruit						
Neither for vegetables nor fruit	22.8	(245)	17.2	(111)	31.1	(134)
Meets one of the guidelines	65.0	(699)	73.0	(470)	53.1	(229)
Meets both	12.2	(131)	9.8	(63)	15.8	(68)
Soft drinks (usual frequency)						
Never or rarely	17.9	(190)	11.8	(75)	26.7	(115)
About 1–6 times a week	58.1	(618)	59.1	(374)	56.7	(244)
About once a day or more	24.0	(255)	29.1	(184)	16.5	(71)
Fast food (usual frequency)						
Never or rarely	29.1	(309)	21.8	(138)	39.9	(171)
About 1–6 times a week	61.4	(652)	65.4	(414)	55.5	(238)
About once a day or more	9.5	(101)	12.8	(81)	4.7	(20)
Ever tried smoking						
No	72.3	(825)	89.9	(612)	46.3	(213)
Yes	27.7	(316)	10.1	(69)	53.7	(247)
Current smoker [b]						
No	68.3	(310)	–	–	68.3	(310)
Yes	31.7	(144)	–	–	31.7	(144)
Ever had full serve of alcohol						
No	71.6	(796)	91.7	(616)	40.9	(180)
Yes	28.4	(316)	8.3	(56)	59.1	(260)
Frequency of alcohol consumption (last 12 months) [b]						
Never/no longer drink	44.5	(187)	–	–	44.5	(187)
Less than weekly	38.6	(162)	–	–	38.6	(162)
1 or more days a week	16.9	(71)	–	–	16.9	(71)
Self-rated health						
Excellent/very good	49.3	(554)	56.6	(374)	39.0	(180)
Good	33.8	(380)	32.2	(213)	36.1	(167)
Fair/poor	16.8	(189)	11.2	(74)	24.9	(115)
Government income support						
Yes	77.2	(781)	88.0	(493)	63.7	(288)
No	22.8	(231)	12.0	(67)	36.3	(164)

[a] Category frequencies may not sum to sample total due to missing data, percentages represent the category proportions among those with data for that variable; [b] measured in the 16–24 years survey only.

Government Department of Health, 2019; Hirshkowitz et al., 2015; National Health and Medical Research Council, 2013a). The physical activity question was not directly comparable with Australian guidelines, so categories were chosen to assess increasing levels of activity against no activity. Category cut-offs for the soft drink and fast food exposures were chosen based on response options common to both the 10–15- and 16–24-years surveys.

2.3.3. Covariables

In addition to age and gender, covariables included recruitment region (WA; NSW; CA), and receiving government income support (yes; no). Government income support was used as a measure of socioeconomic status (SES) in sensitivity analyses. As eligibility for these payments during the study period required an assessment of income and assets (including caregiver income and assets for people under 22 years) (Services Australia, 2021), income support is an indicator of individual and/or household income and economic position. Participants aged 16–24 years and caregivers of participants aged 10–15 years were asked whether they currently received government income support payments (including unemployment support, study support, family tax benefits,

carer or parenting payments, disability support, or another type of government pension). A positive response to any form of allowance or benefit was defined as receiving government support.

2.4. Statistical analysis

Frequencies and proportions of outcomes and exposures were calculated. A strengths-based positive outcome approach was used to identify factors associated with healthy BMI and WHtR (Thurber et al., 2020). The primary regression analyses were restricted to participants with outcome data. Underweight participants ($n = 88$) were excluded from the BMI analyses to focus on healthy BMI as compared with overweight/obese. Missing exposure and covariable data were imputed (see supplementary File S3 for imputation method) (Rubin, 1987; White et al., 2011). Prevalence ratios (PRs) were calculated using robust Poisson regression (Cummings, 2009). To account for clustering within families, a generalised estimating equations framework with an exchangeable correlation structure was used (Hubbard et al., 2010; Liang and Zeger, 1986). Separate analysis models were used for each exposure variable, adjusted for major potential confounders: age group, gender, and recruitment region. Subgroup analyses were conducted by survey age group (10–15 and 16–24 years) to examine associations during early and late adolescence. Sensitivity analyses included a complete-records analysis, and adjustment for additional potential confounding variables (including government income support and other health behaviours) following a causal diagrams approach (supplementary File S4) (Greenland et al., 1999). Unlike for BMI, there are no established classifications about what values of WHtR indicate 'underweight'. In a sensitivity analysis, participants with WHtR <0.4 ($n = 125$) were excluded from the healthy WHtR category, following a previous definition of low WHtR (Sjöholm et al., 2020). Analyses were conducted in Stata 16.0.

3. Results

3.1. Participant characteristics

There were 1294 eligible participants aged 10–24 years: 57% were female; 59% were aged 10–15 years; and 63% were recruited in WA (Table 1). Comparing the early (10–15 years) and late (16–24 years) adolescence groups, there were higher levels of physical activity, very good/fairly good sleep, fast food and soft drink consumption for the younger group, and lower levels of screen time, ever tried smoking, and ever had a full serve of alcohol.

3.2. Outcome distribution

BMI data was available for 1047 participants (median 22 kg/m^2, interquartile range 19–27 kg/m^2) and 48% had healthy BMI, with 8% underweight, 24% overweight, and 20% obese (Table 2). Twenty-seven participants (2.6% of total) had BMI ≥40 kg/m^2 (data not shown), which is considered very severe obesity. For WHtR, 1039 participants had data (median 0.47, interquartile range 0.42–0.53) and 64% were in the healthy WHtR range. Healthy BMI and WHtR were more common in early adolescence and decreased with increasing age (Fig. 1). This trend remained after adjusting for gender (Figs. 2 and 3). Healthy body composition levels were similar among females and males. However, when stratified by age subgroup, healthy body composition was more common among males in the older age group compared to females (supplementary File S5).

3.3. Correlation of outcomes within-family

The 959 participants included in the primary analyses for healthy BMI (complete BMI data and not underweight) were from 652 families, with an intraclass correlation of 0.35 (95% CI 0.22–0.50) for healthy BMI among family groups. For healthy WHtR (1039 participants from 686 families), there was an intraclass correlation of 0.28 (0.16–0.43).

3.4. Association with health behaviours

Healthy body composition was more common with increasing level of physical activity (Figs. 2 and 3). For participants reporting 5–7 days of physical activity in the previous week, healthy BMI was 31% more prevalent (adjusted PR (aPR) 1.31 [95% CI 1.05–1.64]) and healthy WHtR was 30% more prevalent (aPR 1.30 [1.10–1.54]), compared to those reporting none. For those with recommended sleep duration, healthy body composition was more common than for those with usual sleep duration outside that range (healthy BMI 53% v 35%, aPR 1.56 [1.19–2.05]; healthy WHtR 64% v 47%, aPR 1.37 [1.13–1.67]). There was also a higher proportion of healthy body composition for those consuming fast food 'about once a day or more' compared to 'never or rarely' (healthy BMI 66% v 46%, aPR 1.26 [1.02–1.55]; healthy WHtR 73% v 58%, aPR 1.15 [0.98–1.36]). No clear trends were observed for other health behaviours.

3.5. Association with self-rated health

Compared to those with 'fair/poor' self-rated health, healthy body composition was more common among those reporting 'good' health

Table 2
Crude frequencies and proportions within body mass index (BMI) and waist/height ratio (WHtR) categories among Australian Aboriginal adolescents from the Next Generation study (2018–2020), by age, gender, and region.

	BMI ($N = 1047$)								WHtR ($N = 1039$)			
	Underweight		Healthy		Overweight		Obese		Healthy (<0.5)		Elevated (≥0.5)	
	%	(n)	%	(n)	%	(n)	%	(n)	%	(n)	%	(n)
Total	8.4	(88)	47.7	(499)	23.6	(247)	20.3	(213)	64.2	(667)	35.8	(372)
Age group												
10–15 years	8.0	(51)	52.6	(336)	23.3	(149)	16.1	(103)	69.4	(444)	30.6	(196)
16–19 years	10.8	(28)	43.6	(113)	23.2	(60)	22.4	(58)	61.1	(154)	38.9	(98)
20–24 years	6.0	(9)	33.6	(50)	25.5	(38)	34.9	(52)	46.9	(69)	53.1	(78)
Gender												
Female	9.6	(57)	45.6	(270)	22.6	(134)	22.1	(131)	63.2	(367)	36.8	(214)
Male	6.8	(31)	50.3	(229)	24.8	(113)	18.0	(82)	65.5	(300)	34.5	(158)
Recruitment region												
Western Australia	6.7	(43)	50.3	(324)	24.2	(156)	18.8	(121)	65.9	(425)	34.1	(220)
New South Wales	12.1	(39)	43.3	(139)	21.5	(69)	23.1	(74)	60.1	(191)	39.9	(127)
Central Australia	7.3	(6)	43.9	(36)	26.8	(22)	22.0	(18)	67.1	(51)	32.9	(25)

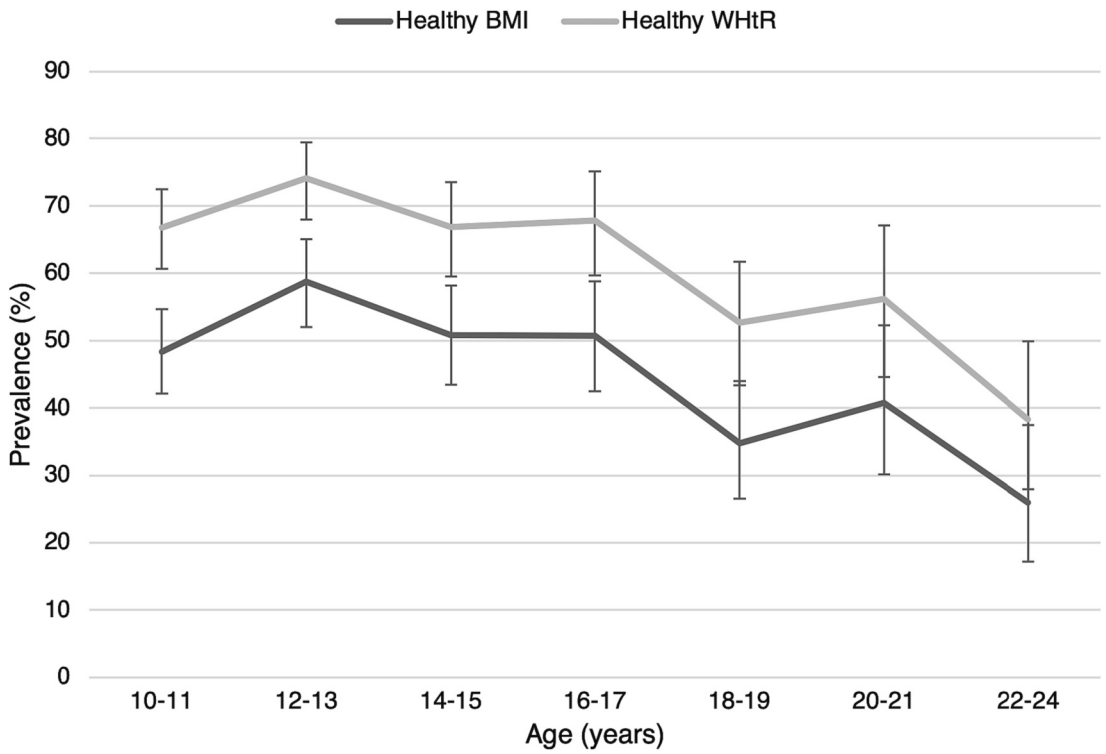


Fig. 1. Crude prevalence (%) of healthy body mass index (BMI)* and healthy waist/height ratio (WHtR)# by age among Australian Aboriginal adolescents aged 10–24 years from the Next Generation study (2018–2020), with 95% confidence intervals.
* Healthy BMI excludes participants with 'underweight' BMI.
# Healthy WHtR includes all participants with WHtR < 0.5.

(healthy BMI 51% v 30%, aPR 1.59 [1.21–2.07]; healthy WHtR 64% v 40%, aPR 1.54 [1.25–1.90]), and 'very good/excellent' health (healthy BMI 61%, aPR 1.87 [1.45–2.42]; healthy WHtR 73%, aPR 1.71 [1.40–2.10]).

3.6. Age subgroup analyses

Results from subgroup analyses were generally consistent with those from the primary analysis (supplementary File S5). However, for participants who met fruit and vegetable guidelines compared to those who did not, the association with healthy WHtR was in an opposite direction for younger adolescents (lower prevalence, aPR 0.76) to that of older adolescents (higher prevalence, aPR 1.21). For the older age group, there was a trend for higher proportion of healthy BMI among those with better sleep quality and no problems falling asleep.

3.7. Sensitivity analyses

The estimates from the complete-records analyses and other sensitivity analyses were consistent with those of the primary analyses (supplementary File S6). In the sensitivity analysis excluding participants with low WHtR, a stronger association was observed between soft drink consumption 'about once a day or more' (vs 'never or rarely') and healthy WHtR (aPR 1.26 [1.03–1.54]).

4. Discussion

4.1. Key findings

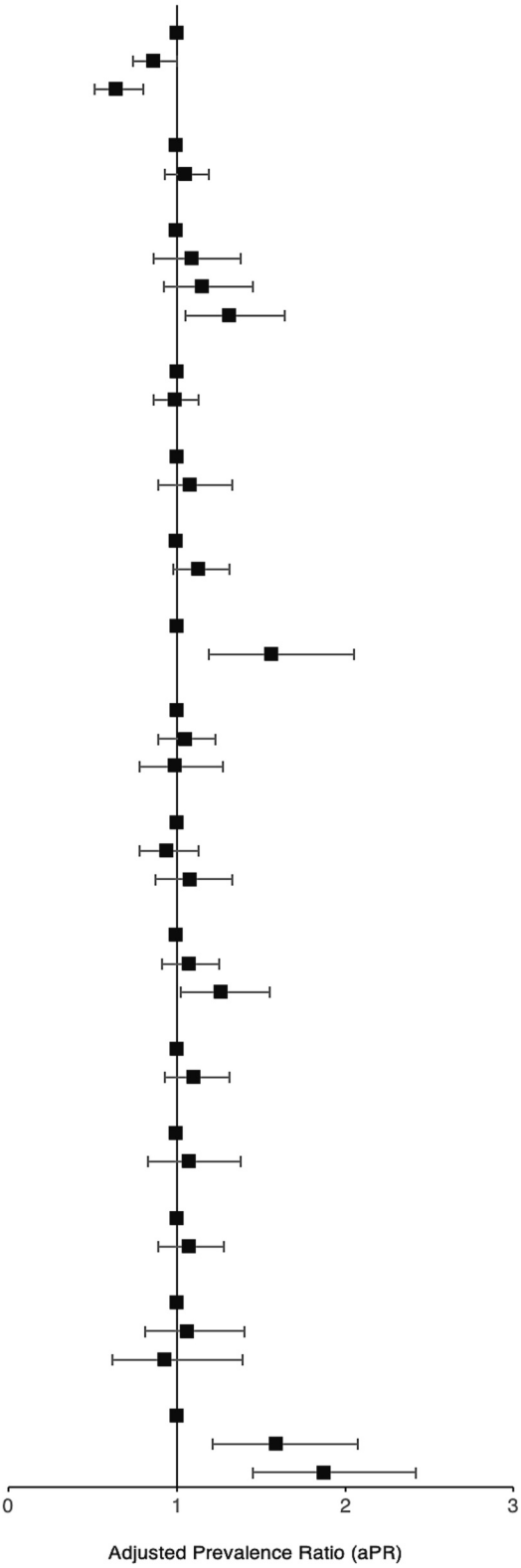
This is the first study to examine body composition and its relationship with health behaviours among Aboriginal adolescents across the entire adolescent age range of 10 to 24 years. Our findings suggest healthy BMI and WHtR are more common at the earliest ages of adolescence than the latest years. The health behaviours most clearly associated with healthy body composition among Aboriginal adolescents were physical activity and recommended sleep duration, while associations with self-reported diet measures were counterintuitive. Healthy body composition was also strongly associated with higher self-rated health, suggesting it is an important component of broader wellbeing.

4.2. Interpretation of results

The distribution of healthy body composition among NextGen participants was consistent with national data and other Aboriginal studies (Australian Institute of Health and Welfare, 2018; Dyer et al., 2017), as was the gender difference among older adolescents (Sjöholm et al., 2020). Females may require further support to maintain healthy body composition in late adolescence. A small proportion of the cohort had severe obesity, which may require intensive specialist intervention, highlighting the importance of regular health checks for Aboriginal adolescents and access to culturally safe primary care (Australian Government Department of Health, 2021; National Aboriginal Community Controlled Health Organisation and The Royal Australian College of General Practitioners, 2018; National Health and Medical Research Council, 2013b).

Higher levels of physical activity were associated with healthier body composition among Aboriginal adolescents. As the proportion of older adolescents reporting no physical activity in the previous week was substantially higher than younger adolescents (30% vs 11%), physical activity may play a role in the age-related decline in healthy body composition. Our findings are consistent with another cross-sectional study in the Torres Strait Islands (Valery et al., 2012). International studies have reported longitudinal associations, though these were often found to be bidirectional, with young people with a healthier body composition more likely to engage in physical activity (Cairney and

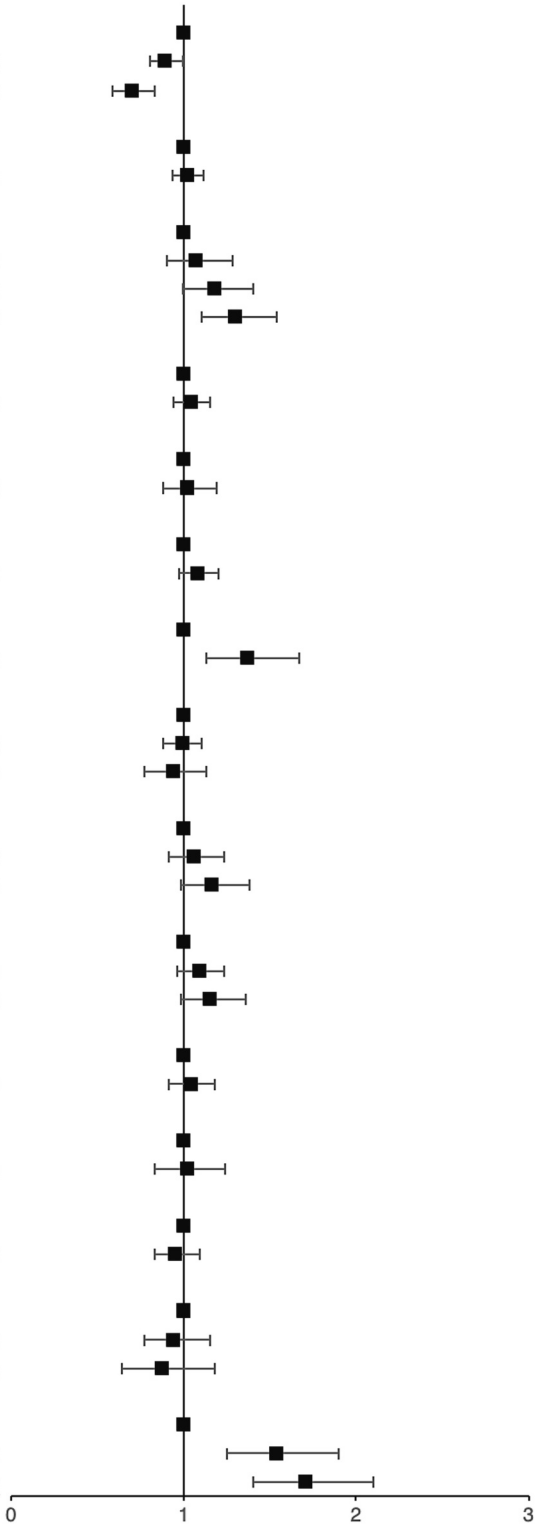
	Category total (n/958)	Healthy BMI %	aPR	(95% CI)
Age group				
10-15 years	588	57.1	Ref	
16-19 years	231	48.9	0.86	(0.74-1.00)
20-24 years	140	35.7	0.64	(0.51-0.80)
Gender				
Female	535	50.5	Ref	
Male	424	54.0	1.05	(0.93-1.19)
Physical activity (days last week)				
None	184	42.4	Ref	
1-2 days	260	50.1	1.09	(0.86-1.38)
3-4 days	272	52.7	1.15	(0.92-1.45)
5-7 days	243	60.7	1.31	(1.05-1.64)
Screen time (weekday)				
3 or more hours	529	51.8	Ref	
0-2 hours	430	52.4	0.99	(0.86-1.13)
Sleep quality (past month)				
Very bad/fairly bad	139	44.5	Ref	
Fairly good/very good	820	53.3	1.08	(0.89-1.33)
Problems falling asleep				
Yes	301	46.5	Ref	
No	658	54.6	1.13	(0.98-1.31)
Recommended sleep duration ^				
No	185	34.8	Ref	
Yes	186	53.0	1.56	(1.19-2.05)
Meets vegetable & fruit guidelines				
Neither for vegetables nor fruit	234	48.9	Ref	
Meets one of the guidelines	610	53.9	1.05	(0.89-1.23)
Meets both	115	48.5	0.99	(0.78-1.27)
Soft drinks (usual frequency)				
Never or rarely	170	48.2	Ref	
About 1-6 times a week	542	49.6	0.94	(0.78-1.13)
About once a day or more	247	60.0	1.08	(0.87-1.33)
Fast food (usual frequency)				
Never or rarely	281	46.2	Ref	
About 1-6 times a week	580	52.5	1.07	(0.91-1.25)
About once a day or more	97	66.4	1.26	(1.02-1.55)
Ever tried smoking				
No	708	53.4	Ref	
Yes	251	48.3	1.10	(0.93-1.31)
Current smoker ^				
No	252	44.1	Ref	
Yes	119	43.7	1.07	(0.83-1.38)
Ever had full serve of alcohol				
No	688	54.1	Ref	
Yes	271	46.7	1.07	(0.89-1.28)
Frequency of alcohol consumption ^				
Never/no longer drink	165	45.8	Ref	
Less than weekly	147	44.0	1.06	(0.81-1.40)
1 or more days a week	59	38.6	0.93	(0.62-1.39)
Self-rated health				
Poor/fair	165	29.5	Ref	
Good	333	51.3	1.59	(1.21-2.07)
Excellent/very good	461	60.7	1.87	(1.45-2.42)



^ only measured in 16-24 years survey

Fig. 2. Crude prevalence (%) and adjusted prevalence ratio (aPR)* of healthy body mass index (BMI) by socio-demographic characteristics, health behaviours and self-rated health, among Australian Aboriginal adolescents aged 10–24 years from the Next Generation study (2018–2020), calculated using multiply imputed data. * Regression models were adjusted for age group, gender, and recruitment region (except age group was only adjusted for gender, and gender only adjusted for age group). Age groups used for the exposures only measured in the 16–24 years survey were 16–17, 18–19, 20–21, and 22–24 years.

	Category total (n/1039)	Healthy WHtR %	aPR	(95% CI)
Age group				
10-15 years	640	69.4	Ref	
16-19 years	252	61.1	0.89	(0.80-0.99)
20-24 years	147	46.9	0.70	(0.58-0.83)
Gender				
Female	581	63.2	Ref	
Male	458	65.5	1.02	(0.93-1.11)
Physical activity (days last week)				
None	201	54.1	Ref	
1-2 days	287	60.4	1.07	(0.90-1.28)
3-4 days	288	66.4	1.18	(0.99-1.40)
5-7 days	264	73.6	1.30	(1.10-1.54)
Screen time (weekday)				
3 or more hours	581	62.4	Ref	
0-2 hours	458	66.5	1.04	(0.94-1.15)
Sleep quality (past month)				
Very bad/fairly bad	153	59.3	Ref	
Fairly good/very good	886	65.0	1.02	(0.88-1.19)
Problems falling asleep				
Yes	334	60.2	Ref	
No	705	66.1	1.08	(0.97-1.20)
Recommended sleep duration ^				
No	199	47.4	Ref	
Yes	200	64.3	1.37	(1.13-1.67)
Meets vegetable & fruit guidelines				
Neither for vegetables nor fruit	244	62.8	Ref	
Meets one of the guidelines	677	65.5	0.99	(0.88-1.10)
Meets both	118	59.4	0.94	(0.77-1.13)
Soft drinks (usual frequency)				
Never or rarely	178	56.7	Ref	
About 1-6 times a week	593	63.2	1.06	(0.91-1.23)
About once a day or more	269	71.4	1.16	(0.98-1.38)
Fast food (usual frequency)				
Never or rarely	297	57.6	Ref	
About 1-6 times a week	637	65.8	1.09	(0.96-1.23)
About once a day or more	105	73.1	1.15	(0.98-1.36)
Ever tried smoking				
No	760	66.1	Ref	
Yes	279	59.1	1.04	(0.91-1.18)
Current smoker ^				
No	265	56.9	Ref	
Yes	134	54.0	1.02	(0.83-1.24)
Ever had full serve of alcohol				
No	751	67.4	Ref	
Yes	288	55.8	0.95	(0.83-1.09)
Frequency of alcohol consumption ^				
Never/no longer drink	183	60.2	Ref	
Less than weekly	151	53.2	0.94	(0.77-1.15)
1 or more days a week	64	49.8	0.87	(0.64-1.18)
Self-rated health				
Poor/fair	177	39.6	Ref	
Good	352	64.3	1.54	(1.25-1.90)
Excellent/very good	510	72.6	1.71	(1.40-2.10)



^ only measured in 16-24 years survey

Fig. 3. Crude prevalence (%) and adjusted prevalence ratio (aPR)* of healthy waist/height ratio (WHtR) by socio-demographic characteristics, health behaviours and self-rated health, among Australian Aboriginal adolescents aged 10–24 years from the Next Generation study (2018–2020), calculated using multiply imputed data.

* Regression models were adjusted for age group, gender, and recruitment region (except age group was only adjusted for gender, and gender only adjusted for age group). Age groups used for the exposures only measured in the 16–24 years survey were 16–17, 18–19, 20–21, and 22–24 years.

Veldhuizen, 2017; Richmond et al., 2014; Schwarzfischer et al., 2018; Sprengeler et al., 2021). A systematic review of the effects of physical activity, diet and behavioural interventions on obesity among adolescents found they reduced BMI and weight measures on average, though evidence quality was low to moderate (Al-Khudairy et al., 2017). Our findings suggest interventions promoting higher physical activity among Aboriginal adolescents would likely deliver body composition benefits, though considering the potential for bidirectional associations, they may be more effective if combined with other weight control measures. Further support for Aboriginal-designed and led interventions should be considered to overcome low engagement in mainstream programs (Sherriff et al., 2019), and to ensure social, economic and cultural barriers are considered (Burgess et al., 2009; Macniven et al., 2017; Macniven et al., 2023; May et al., 2020).

Recommended sleep duration was associated with healthy body composition, a relationship that has not been previously reported in this age group. While sleep duration was only measured among the older adolescents in our study, the results are consistent with findings from the Longitudinal Study of Indigenous Children (Deacon-Crouch et al., 2018; Fatima et al., 2020). A systematic review of international longitudinal studies involving children and adolescents concluded short sleep duration is associated with future obesity (Fatima et al., 2015). However, there is also evidence higher body mass can precede sleep problems in adolescents and young adults (Sokol et al., 2020; Wang et al., 2023); obesity can predispose to obstructive sleep apnoea, for example (Drager et al., 2013). This may indicate associations are bidirectional, though the biological mechanisms remain uncertain (Felső et al., 2017; Garfield, 2019). Interventions aimed at improving sleep quality and duration among Aboriginal children and adolescents have not been widely explored, yet our results and the broader evidence indicate they hold promise for improving body composition outcomes. Sleep is likely to be influenced considerably by home environments, including poor housing quality and overcrowding, which Aboriginal people are disproportionately impacted by as a result of ongoing policy failures (Australian Institute of Health and Welfare and National Indigenous Australians Agency, 2020; National Aboriginal Community Controlled Health Organisation and The Royal Australian College of General Practitioners, 2018). As Aboriginal children are more likely to experience short sleep duration than non-Indigenous children (Blunden et al., 2021), the contribution of these factors to adolescent health disparities requires further investigation.

The results for dietary factors were surprising and counterintuitive yet are not without precedent. In the Longitudinal Study of Australian Children, longitudinal associations between diet and body composition were not clearly evident in either direction (Gasser et al., 2019). Though, there was a weak association between higher BMI at baseline and better quality diet (based on parent or child questionnaire responses) at 2-year follow-up. As the data used in our study are cross-sectional, reverse causation may be an issue, where those who are overweight may have reduced their consumption of fast food due to weight concerns, and those with healthier body composition may be less concerned about consuming fast food. Alternatively, higher fast food consumption may be a proxy for food insecurity, with frequent consumption of cheaper fast foods and insufficient access to nutritious foods and regular meals (Sherriff et al., 2022; Thorpe et al., 2012), which may be associated with leaner body composition. This issue deserves further investigation as Aboriginal communities have identified food insecurity as a major problem they continue to experience, linked to the ongoing impacts of colonisation (Sherriff et al., 2022). In addition, a potential major issue is measurement error in self-reported exposures, which when combined with the cross-sectional nature of the data, can give rise to both differential (dependent on the outcome) and non-differential measurement error. Misreporting of dietary exposures is widely reported to be influenced by body composition, with under-reporting of energy intake more common among study participants with higher BMI and vice versa, and additional measurement challenges for adolescents (Forrestal, 2011; Livingstone and Robson, 2000; Rangan et al., 2011). This type of bias can result in a null association or even an inverse of the true association being observed (Börnhorst et al., 2013), which might explain our results. Our findings and those of others may indicate short dietary questionnaires, commonly used in epidemiological studies, are of limited use in understanding the association between diet and body composition (Gasser et al., 2019). If so, there appears to be a need for more accurate dietary tools feasible for use with children and adolescents in large-scale studies (Gasser et al., 2019; Livingstone and Robson, 2000).

4.3. Future directions

A follow-up study of the NextGen cohort has been funded and will provide much needed longitudinal data. These data will help answer questions about the nature of associations between body composition and physical activity, sleep, and diet, as well as other cardio-metabolic health measures. Australia's first National Obesity Strategy was released only last year, which set a target of 5% reduction in adolescent obesity by 2032 (Commonwealth of Australia, 2022). Importantly, a guiding principle of the strategy is that disparity in obesity prevalence between Aboriginal and non-Aboriginal populations must be addressed. Public health interventions will need to be urgently funded and implemented to achieve the target, with additional focus on Aboriginal adolescents to address the disparity, and these should be designed such that they provide high quality data about effectiveness. The ongoing relationships between NextGen investigators and the communities involved in the study will ensure our findings can directly inform the design of community health initiatives for adolescents in those communities.

4.4. Study strengths and limitations

NextGen is a large, Aboriginal-led study including Aboriginal adolescents from urban, rural, and remote areas, with collection of a wide range of health and well-being information. The community-based researchers and peer recruiters established trust with communities and facilitated recruitment among a hard-to-reach population group. The geographic diversity of participants means our findings are likely to be more broadly relevant. Cross-sectional data were used, so associations reported in this study may not reflect causal relationships and may result from reverse causation or bidirectional relationships. All exposure variables were self-reported and, as noted for the dietary measures, are prone to measurement error. Physical activity and sleep duration are commonly over-reported relative to objective measures, with some evidence of more exaggerated over-reporting of physical activity among obese individuals, which has been shown to attenuate associations (Cespedes et al., 2016; Gupta et al., 2018; Slootmaker et al., 2009; Warner et al., 2012; Watkinson et al., 2010). As a result, the associations of physical activity and sleep duration to body composition reported in this study could be underestimates. We did not have data on time spent in physical activity on days participants were active, which would have allowed us to construct a more accurate exposure variable that aligns with physical activity guidelines. Although anthropometric measures followed a standard protocol to reduce bias, some aspects were not standardised such as when participants had consumed their last meal. Missing data created the potential for selection bias, though this was mitigated using multiple imputation methods. Results from primary analyses were consistent with those from the models adjusted for additional potential confounders, suggesting residual confounding bias was minimal. However, the lack of a consistently measured indicator of SES is a potential source of unmeasured confounding that may not be fully accounted for by the government support variable.

5. Conclusion

Healthy body composition is common in early adolescence but declines substantially in older adolescence. Culturally appropriate health interventions incorporating a focus on physical activity and sleep duration may hold promise for improving body composition among Aboriginal adolescents.

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Consent for publication

Consent forms advised participants that de-identified data may be published.

Code availability

Analysis code is available upon reasonable request.

CRediT authorship contribution statement

Christopher D. McKay: Conceptualization, Methodology, Investigation, Formal analysis, Writing – original draft, Writing – review & editing. **Lina Gubhaju:** Conceptualization, Methodology, Writing – review & editing, Funding acquisition, Supervision. **Alison J. Gibberd:** Conceptualization, Methodology, Writing – review & editing, Supervision. **Bridgette J. McNamara:** Conceptualization, Methodology, Writing – review & editing, Funding acquisition, Supervision. **Rona Macniven:** Writing – review & editing. **Grace Joshy:** Writing – review & editing. **Robert Roseby:** Writing – review & editing, Funding acquisition. **Robyn Williams:** Investigation, Writing – review & editing. **Aryati Yashadhana:** Investigation. **Ted Fields:** Investigation, Writing – review & editing. **Bobby Porykali:** Investigation, Writing – review & editing. **Peter Azzopardi:** Writing – review & editing, Funding acquisition. **Emily Banks:** Writing – review & editing, Funding acquisition. **Sandra J. Eades:** Conceptualization, Methodology, Writing – review & editing, Funding acquisition, Supervision.

Declaration of Competing Interest

The authors have no relevant financial or non-financial interests to disclose.

Data availability

The datasets analysed during the current study are available upon reasonable request, subject to ethics approval.

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Appendix A. Supplementary data

Supplementary data to this article can be found online at https://doi.org/10.1016/j.ypmed.2023.107715.

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