Ethnic differences in body composition and anthropometric characteristics in Australian Caucasian and urban Indigenous children

Kagawa, Masaharu; Byrne, Nuala M.; King, Neil A.; Pal, Sebely; Hills, Andrew P.

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Authors:

Masaharu Kagawa[1, 2]; **Nuala M. Byrne**[1, 2]; **Neil A. King**[1, 2]; **Sebely Pal**[3]; **Andrew P. Hills**[1, 2]

Institution:

[1] ATN Centre for Metabolic Fitness, School of Human Movement Studies, Queensland University of Technology, Brisbane, QLD.

[2] Institute of Health and Biomedical Innovation, Queensland University of Technology.

[3] School of Public Health, Curtin University of Technology, Perth, WA.

Correspondence and reprint requests should be addressed to:

Dr. Masaharu Kagawa

Postdoctoral Research Fellow

ATN Centre for Metabolic Fitness, School of Human Movement Studies, Institute of Health and Biomedical Innovation, Queensland University of Technology, 60 Musk Avenue, Kelvin Grove, Qld 4059, Australia

Phone: +61-7-3138-6091; Fax: +61-7-3138-6030, E-mail: m.kagawa@qut.edu.au

Running head:

Ethnic differences in body composition

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Children; ethnicity; body composition; anthropometry.

Abstract

Objective: To compare ethnic differences in anthropometry, including size, proportions and fat distribution, and body composition in a cohort of 70 Caucasian (44 males, 26 females) and 74 urban Indigenous (36 males, 38 females) children (9-15 years of age). ***Methods:*** Anthropometric measures (stature, body mass, eight skinfolds, 13 girths, six bone lengths and five bone breadths) and body composition assessment using dual energy x-ray absorptiometry (DXA: Lunar Prodigy) were conducted. Body composition variables including total body fat percentage (%BF) and percentage abdominal fat (%AF) were determined and together with anthropometric indices including body mass index (BMI: kg/m^2), abdominal-to-height ratio (AHtR) and sum of skinfolds, ethnic differences were compared for each gender. ***Results:*** After adjustment for age, Indigenous girls showed significantly (p<0.05) greater trunk circumferences and proportion of overweight/obesity than their Caucasian counterparts. In addition, Indigenous children had a significantly greater proportion (p<0.05) of trunk fat. The best model for total and android fat prediction included sum of skinfolds and age in both genders (>93% of variation). Ethnicity was only important in girls where abdominal circumference and AHtR were included and Indigenous girls showed significantly (p<0.05) smaller total/android fat deposition than Caucasian girls at the given abdominal circumference or AHtR values. ***Conclusion:*** Differences in anthropometric and fat distribution patterns in Caucasian and Indigenous children may justify the need for more appropriate screening criteria for obesity in Australian children relevant to ethnic origin.

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INTRODUCTION

Indigenous Australians have a higher risk of developing obesity-related health conditions [1, 2]. A recent study reported that the average age of Aboriginal and Torres Strait Islanders diagnosed with type 2 diabetes mellitus (T2DM) decreased by about two years in the period from 1999 to 2005 [3]. Considering the increasing financial burden for the Australian community from obesity and related health problems [4], early screening and prevention strategies for the Indigenous population have been recommended.

To apply effective strategies, a better understanding of morphology and its relationships with body composition and metabolic markers in each ethnic group is essential. In adults, anthropometric indices such as the BMI and waist circumference (WC) have been used as indicators of cardiovascular disease risk [5]. Indigenous Australian adults have a different pattern of fat distribution compared to non-Indigenous Australians [6], and, as reported in different ethnic groups [7, 8], Aboriginal adults (aged 18 to 35) show different relationships between adiposity and fat distribution to BMI compared to their European counterparts [9].

Comprehensive assessments of the physical characteristics of Indigenous children and adolescents are few and dated [10], and it is important to clarify if screening using the same cut-off points for Caucasian and Indigenous children is appropriate. A lack of understanding of ethnic differences in body size, proportion and fat distribution patterns may lead to misuse or misinterpretation of results obtained from anthropometric indices. Today, the number of Indigenous people living a more traditional lifestyle is relatively small compared to the urban Indigenous population who have a more mixed racial background and commonly live in lower socioeconomic circumstances compared to most Australian Caucasians.

The aim of the current study was to characterize the anthropometry and body composition of Caucasian and Indigenous children and adolescents living in an urban setting. Previous studies have referenced ethnic differences in relationships between commonly used anthropometric indices, such as the BMI, and accumulated fat in adults [7, 8]. Due to the paucity of similar studies in children and adolescents [11, 12], the present study also examined relationships between fat mass and anthropometric indices in Caucasian and Indigenous children and adolescents.

METHODS

The study was approved by the Human Research Ethics Committee of Queensland University of Technology and adhered to the principles of medical research established by the National Health and Medical Research Council [13]. Participants were recruited from primary and secondary schools located in the Brisbane metropolitan area with the majority of Indigenous children recruited through the Aboriginal and Islander Independent Community School (Murri School). Participants were also recruited through flyers, local newspapers and magazines. All participants and their parents/caregivers were given information packages and consent forms were signed prior to participation.

The study included 70 Caucasian (44 male, 26 female) and 74 Indigenous (36 male, 38 female) children aged 9-15 years. The criteria for “Indigenous” were that a child had at least one parent of “Indigenous” ancestry or that the Indigenous community recognized the child as a member of that community. Selection criteria were similar to the definition of “Aboriginal” by Australian law outlined in a previous study [9], that is, 1) Aboriginal descent; 2) self-identification as an Australian Aboriginal; and 3) being accepted as such by the community in which he or she lives or has lived. Children with chronic health problems or taking medication that may have influenced their physical status were excluded from the study.

Anthropometry

Stature, body mass, eight skinfolds (triceps, subscapular, biceps, iliac crest, supraspinale, abdominal, front thigh, and medial calf), 13 girths (head, arm [relaxed], arm [flexed and tensed], forearm, wrist, chest, waist [narrowest point], abdominal [the level of umbilicus], gluteal, thigh, mid-thigh, calf [maximum] and ankle), six bone lengths (acromiale-radiale, radiale-stylion, midstylion-dactylion, trochanterion-tibiale laterale, tibiale-height and foot length) and five bone breadths (biacromial, biiliocristal, transverse chest, biepicondylar humerus and biepicondylar femur) of each participant were measured using the standard protocol by the International Society for the Advancement of Kinanthropometry (ISAK) [14]. All participants were asked to wear light clothing, such as shorts and T-shirt, and stature and body mass were measured without shoes and socks. All landmarks and measurements were conducted by a Level 3 (instructor) anthropometrist accredited by ISAK. Intra-tester technical error of measurement (TEM) was calculated for all measures using 20 randomly selected participants. The intra-tester TEM was no greater than 5.0% for all skinfold measurements and no greater than 1.0% for other measurements, within the acceptable limits of intra-tester TEM recommended by ISAK for a Level 3 anthropometrist [15].

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From the measurements, BMI (body mass (kg)/stature^2 (m)), abdominal-to-height ratio (AHtR: abdominal/stature), waist-to-hip ratio (WHR: waist/gluteal) were calculated. In addition, the sum of eight skinfolds (ΣSF; triceps + subscapular + biceps + supraspinale + iliac crest + abdominal + front thigh + medial calf) and sum of trunk skinfolds (ΣTrunkSF; supraspinale + iliac crest + abdominal) were calculated to determine subcutaneous fat distribution pattern. Arm and leg lengths relative to stature were calculated to observe ethnic differences in body proportion, and the physique of participants was determined by calculating a somatotype score [16]. Somatotype is a representation of one's physique and is a combination of endomorphy (relative plumpness), mesomorphy (relative muscularity) and ectomorphy (relative linearity) components. Each component was calculated using equations described in the literature [16].

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Body composition assessment

Body composition was assessed using DXA (Lunar Prodigy Advance, enCORE 2005 version 9.30.044, GE Healthcare, Madison, WI, USA). Each whole-body DXA scan was completed within approximately 6-10 minutes, depending on the size of the participant and information on bone mineral content (BMC: in kg), bone mineral density (BMD: in g/cm^2), fat tissue mass, lean tissue mass, total tissue mass (fat + lean tissue mass) of the whole body as well as android and gynoid regions of interest (ROI) were obtained. The android ROI is defined as the "Lower boundary at pelvis cut, upper boundary located at above pelvis cut by 20% of the distance between pelvis and neck cuts. Lateral boundaries are the arm cuts." The gynoid ROI is defined as "Upper boundary below the pelvis cut line by 1.5 times the height of the android ROI. Gynoid ROI height equal to 2 times the height of the android ROI. Lateral boundaries are the outer leg cuts". The DXA scan also provides ratios of fat mass, including: 1) total body fat percentage (%BF); 2) android fat percentage (%AF); 3) gynoid fat percentage (%GF); 4) trunk to total fat ratio; 5) legs to total fat ratio; 6) limbs to total fat ratio and 7) android to gynoid fat ratio. Further, the proportion of android fat relative to total fat mass ($P_{Android}$: android fat/total fat×100) was calculated to compare fat deposition in the abdominal region between the study groups.

All statistical analyses were conducted using SPSS software for Windows (version 14.0.0, 2005, Chicago). Ethnic differences in body size (ie. stature, body mass) and also ratios calculated from anthropometry (eg. BMI) and body composition measurements (eg. %BF) were determined using age-adjusted ANCOVA for each gender. In order to control for the influence of body size, other anthropometric and body composition variables, including ΣSF and total fat tissue mass, were analyzed using age- and stature-adjusted ANCOVA. Anthropometric and body composition variables were transformed to normalize the data prior to analysis wherever necessary using natural logarithm (LN). The effect size for variables that showed significant differences between ethnic groups was also calculated using Cohen's *d* using the equation (M_1 x M_2/SD_{pooled} where M = mean and SD = standard deviation and $SD_{pooled} = \sqrt{[(SD_1^2 + SD_2^2)/2]}$). Proportions of overweight and obesity were determined using age- and gender-specific Cole et al. criteria [17] and ethnic differences in prevalence of overweight/obesity were compared using the Chi-square test. Furthermore, ethnic differences in relationships between body fat variables from DXA and selected anthropometric indices were

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determined using the general linear model (GLM). Body fat variables used in the analysis were: 1) total fat tissue mass and, 2) abdominal fat tissue mass which was derived from android ROI and anthropometric variables used in this analysis included body mass, BMI, Σ SF, Σ TrunkSF, abdominal circumference and AHtR. Age and ethnicity (1 for Indigenous and 0 for Caucasians) were included as covariates to examine their influences on the relationships. Considering a previous suggestion that application of ratios may not be useful to define obesity [18], relationships were assessed using absolute mass instead of %BF or %AF. The equations were proposed with adjusted correlation coefficients (R_{ad}^2) and standard error of estimates (SEE).

RESULTS

Table 1 shows demographic information of the study groups. Caucasian girls were significantly (p<0.05) younger than their Indigenous counterparts however after controlling for age, no ethnic differences in mean stature, body mass, BMI and %BF were observed. After adjusting for age and stature, body composition variables obtained from DXA which included BMC, BMD and total and android fat tissues as well as Σ SF and Σ TrunkSF from anthropometry, were comparable between ethnic groups. However, using the Cole et al. (17) BMI criteria, a significantly greater proportion of Indigenous girls were classified as overweight (Caucasian: 7.7%; Indigenous: 39.5%) and obese (Caucasian: 0%; Indigenous: 23.7%). These differences were not evident in boys. The mean somatotype for Caucasian boys was balanced mesomorph and for Indigenous boys, endomorphic mesomorph, a physique with greater fat deposition in the latter group. In girls, both groups had a mean somatotype of mesomorphic endomorph, although Indigenous girls showed a greater endomorphy.

Insert Table 1 about here

Ethnic differences in subcutaneous fat distribution and other anthropometric variables after adjustment for age and stature are shown in Figure 1-3. Despite a tendency for higher skinfold measures in Indigenous children, the only significant difference was for subscapular skinfold thickness in girls (p<0.05) (Figure 1). Indigenous girls also showed significantly greater (p<0.05) trunk circumferences (Figure 2). Indigenous children also showed significantly greater (p<0.05) forearm lengths (radiale-stylon and midstylion-dactylion) (Figure 3). The larger frame size of Indigenous girls was confirmed by longer acromiale-radiale measures and wider biacromial and biiliocristal breadths (p<0.05). All significant variables in Indigenous girls showed medium to large effect sizes, between 0.56 (midstylion-dactylion length) and 0.83 (subscapular skinfold and waist circumference) using Cohen's d. In boys, the effect size was smaller (Cohen's d = 0.2).

Insert Figure 1-3 about here

Ethnic differences in anthropometric and body composition ratios are shown in Table 2. As seen in Figure 3, Indigenous children had longer arms relative to stature compared to Caucasian children (p<0.05; Cohen's d: boys = 1.0, girls = 0.63), and Indigenous girls had significantly (p<0.05) greater AHtR and WHR, suggesting greater abdominal fat accumulation. However the effect size from the WHR was smaller (Cohen's d = 0.22) compared that for the AHtR (0.82). This finding of greater fat deposition in the trunk was consistent with DXA results (trunk-total fat mass ratio: p<0.05; Cohen's d: boys = 0.67; girls = 0.99; limbs-trunk fat mass ratio: p<0.05; Cohen's d: boys = 0.83; girls = 0.93). After adjustment for age, fat accumulation in the android ROI relative to total fat reached significance in boys (Caucasian boys: 6.2%, Indigenous boys: 6.8%. p<0.05).

Insert Table 2 about here

The best predictive models (>93% of variation) for total and android fat in boys and girls were obtained from sum of skinfolds and age (Table 3). Other models which accounted for more than 70% of the variation included combinations of age, ethnicity (for girls not boys), AC, AHtR, body mass and BMI. The relationship between body composition variables and BMI was not influenced by age

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and tended to be weaker than ΣSF, AC or AHtR. Despite the lack of ethnic influence in boys in relationships involving total and android fat, relationships between abdominal circumference and android fat tissue were consistent regardless of ethnicity in Indigenous girls who tended to have a smaller amount of total fat tissue mass at a given abdominal circumference (Figure 4). Results also indicated that Indigenous girls were likely to have a smaller total or android fat tissue at a given AHtR calculated from the abdominal circumference.

Insert Table 3 and Figure 4 about here

DISCUSSION

To the best of our knowledge, this is the first study to undertake a comprehensive anthropometric and body composition assessment on Caucasian and Indigenous children and adolescents living in an urban Australian setting. The study confirmed a striking gender difference in body composition and anthropometric indices between ethnic groups.

After adjustment for age, we found that Indigenous and Caucasian children were similar in stature and body mass. However, these findings were inconsistent with previous studies that reported significantly smaller body mass and stature in Aboriginal children (10, 18) which may in part be attributed to a difference in geographical location of respective study cohorts. Previous studies used Aboriginal children living in rural areas where growth retardation is common [19, 20] due to both poor maternal nutrition [21] and food availability [22]. According to Barker's "fetal origin theory", children who are born undernourished have a greater risk of developing obesity and related health problems [23], considered one of the causes of poor health status in the Indigenous population. In the current study, a greater proportion of Indigenous children were overweight or obese, consistent with previous findings that children living in urban areas tend to be larger and have higher BMIs than those living in rural areas [24]. There is also a higher prevalence of obesity among Indigenous adults of high socioeconomic status [25] due to the nutrition transition experienced by the Indigenous

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population in urban areas.

The current study also confirmed that ethnic differences in anthropometry are more significant in girls than boys with Indigenous girls having greater relative trunk circumferences and indices including AHtR and WHR. The mean value for AHtR suggests that Indigenous girls have an abdominal circumference 10 cm greater than Caucasian girls for a given stature, indicative of a larger proportion of abdominal fat. Tendency for a greater subcutaneous fat deposition (as measured as skinfold thickness) among Indigenous children is also consistent with the higher deposition of abdominal fat subcutaneously than Caucasian children. Previous studies have reported that Caucasians and Asians are predisposed to greater visceral fat deposition than Africans [26-29], with current results indicative of similarity in the pattern of abdominal fat distribution in Indigenous and African populations. A significant ethnic difference in fat accumulation in the android ROI was only found in boys which may be due to the small number of Caucasian girls and also the possibility that Indigenous girls had greater fat deposition in both the abdomen and chest.

The study also revealed ethnic differences in fat distribution between the trunk and limbs with Caucasian children showing a lower proportion of fat in the trunk despite no ethnic differences in total tissue mass and %BF. Caucasian children also showed a greater fat deposition in their limbs relative to trunk although Indigenous children have longer arms and also comparable total tissue mass. Results also suggest that Indigenous children are likely to have a physique with leaner limbs and greater fat accumulation in the trunk than Caucasians at a given total tissue mass, consistent with results in previous studies [30, 31]. As effect size was calculated for ethnic differences in arm length and fat distribution ratio between the limbs and the trunk, results may suggest biologically significant physical differences.

In the current study, relationships between total and android fat tissue and commonly used anthropometric indices were also examined. Results indicate that ΣSF and abdominal circumference

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are useful measures of total or regional fat accumulation in both genders. These indices also showed an influence of age, indicative that maturation significantly influences the increased fat deposition in the study population. Caucasian and Indigenous girls had a comparable amount of android fat tissue at a given abdominal circumference however Indigenous girls were likely to have significantly less android fat when AHtR was calculated from measured abdominal circumference. It has been suggested that AHtR or waist-to-height ratio may be a useful screening index for abdominal obesity across age, gender and ethnicity [32-34], however, the ethnic difference in the current study (despite no difference in body size) suggests caution in the use of this index in Indigenous children. Further research on ethnic differences in AHtR and abdominal fat deposition/distribution pattern, along with associations with metabolic health risks is warranted. Apart from abdominal circumference and AHtR in girls, there were no ethnic differences in relationships between common anthropometric indices, including BMI, and body composition variables in this study. Despite ethnic differences in body fat distribution pattern it is possible to use the same cut-off points for anthropometric indices to determine metabolic health risks in both Caucasian and Indigenous children. These findings differ from an earlier study of adults [9] and another in which Caucasian, Maori and Pacific Islander children living in New Zealand were compared [12].

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The classification method used to identify ethnic background may also be an important factor to consider. In the current study, identification of both parents/guardians and community recognition was used to categorize the background of participants. The urban dwelling Indigenous population is a diverse mix of different ethnic backgrounds, including Aboriginals, Torres Strait Islanders, Caucasians, Asians and South Pacific Islanders. As a result, a major limitation of the current study, and possibly one of the reasons for minimal ethnic differences in the majority of anthropometric indices and body composition variables, may be the ‘similarities’ between groups. It is also important to stress that only a small proportion of the Indigenous population has maintained their traditional lifestyle. As the definition of “Aboriginal” used was consistent with that used by Australian law, we can be confident that the current results are reflective of differences in the physical characteristics between Caucasian and Indigenous children. In addition, the study provides confirmation of the applicability of the same anthropometric cut-off points for the metabolic screening of Indigenous children living in an urban setting.

Finally, this is the first study to provide comprehensive anthropometric and body composition information of Indigenous compared with Caucasian children living in urban Australia. The results confirmed the comparability of physical characteristics in boys and the presence of some distinct differences between girls of different ethnic backgrounds, including the proportion of overweight and obese. Results also indicated possible ethnic differences in fat distribution patterns including visceral-subcutaneous and trunk-extremities. However, relationships between anthropometric indices and selected body composition variables showed no ethnic influence in boys and minimal impact in girls. The findings, despite the relatively modest sample size, tentatively confirm the appropriateness of similar screening tools being used to prevent childhood obesity and children at-risk of future metabolic complications. Due to the small sample size of the study as well as lack of information about socioeconomic status and pubertal stages of the children, it is strongly recommended that future research should be conducted on a larger cohort with inclusion of both social and biological information.

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STATEMENT OF NO CONFLICTS

All co-authors have contributed in a preparation of the current manuscript. Dr. Kagawa contributed in the project design, data collection, data analysis and preparation of the manuscript. Dr. Byrne, Dr.

King and Dr. Pal contributed in preparation of the manuscript and Prof. Hills contributed as a supervisor and preparation of the manuscript. There were no conflicts of interest in this study between authors. The study was supported by the ATN Centre for Metabolic Fitness grant.

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Tables

Table 1. Physical characteristics of Caucasian and Indigenous children

Gender	Boys						Girls					
Ethnicity	Caucasian			Indigenous			Caucasian			Indigenous		
Sample size	44			36			26			38		
	Mean	SE	Range	Mean	SE	Range	Mean	SE	Range	Mean	SE	Range
Age (years)	12.1	0.2	10-15	12.1	0.3	9-15	11.4*	0.3	10-15	12.2	0.3	10-15
Stature (cm)	155.1	1.7	132.1-179.5	154.7	2.0	128.2-180.6	152.9	2.1	135.0-177.7	154.5	1.6	127.7-169.3
Body mass (kg)	49.2	2.1	27.1-103.8	50.7	2.7	26.2-91.7	47.0	1.9	32.4-66.5	56.7	2.9	25.6-88.1
Body Mass Index (kg/m^2)	20.1	0.6	13.7-32.2	20.9	0.9	14.9-34.9	20.0	0.5	16.1-25.7	23.3	0.9	14.5-34.0
Total body fat percentage (%)	22.2	1.5	5.8-45.7	23.4	1.9	5.3-46.1	29.2	1.6	12.6-43.0	33.2	1.7	13.6-48.2
Total tissue mass (kg)	47.1	2.1	25.7-100.1	48.4	2.6	24.8-87.9	44.4	1.9	28.6-63.6	54.2	2.8	24.2-84.7
Total fat tissue mass (kg)	11.6	1.2	1.6-35.3	12.7	1.6	3.0-38.6	14.0	1.1	5.1-28.3	20.3	1.9	5.1-39.8
Android fat tissue mass (kg)	0.8	0.1	0.07-2.9	0.9	0.1	0.2-3.5	1.0	0.1	0.2-2.5	1.6	0.2	0.3-3.7
Bone mineral content (kg)	1.8	0.1	1.2-3.3	1.9	0.1	0.9-3.4	1.8	0.1	1.1-2.9	2.0	0.1	0.8-3.4
Bone density (g/cm^2)	1.00	0.01	0.85-1.19	1.01	0.02	0.86-1.25	1.01	0.01	0.89-1.26	1.02	0.02	0.83-1.31
Sum of skinfolds (mm) †	108.5	9.2	29.8-270.2	115.9	11.8	43.4-275.6	153.7	10.7	56.7-237.0	181.8	12.1	62.1-293.7
Sum of trunk skinfolds (mm) †	14.4	1.5	3-38.0	16.7	1.9	4.8-38.0	19.2	1.6	5.6-8.2	25.0	1.8	7.6-42.4
Proportion of overweight (%)	25.0			30.6			7.7*			39.5		
Proportion of obese (%)	9.1			13.9			0.0*			23.7		
Somatotype	3.4-5.1-2.9			3.9-5.2-2.8			4.5-4.4-2.6			5.6-4.7-1.8		

* Significant ethnic differences between Caucasian and Indigenous groups at the 0.05 level after controlling for effects of age and stature.

[†] One Caucasian boy declined to have his iliac crest skinfold thickness measured, therefore the number of Caucasian boys included in sum of skinfolds and sum of trunk skinfolds was 43.

Table 2. Ethnic differences in anthropometric and body composition indices

	Boys				Girls			
	Caucasian		Indigenous		Caucasian		Indigenous	
Sample size	44		36		26		38	
	Mean	SE	Mean	SE	Mean	SE	Mean	SE
Arm lengths relative to stature	0.45*	0.002	0.46	0.002	0.45*	0.004	0.46	0.002
Leg lengths relative to stature	0.54	0.002	0.55	0.003	0.54	0.004	0.54	0.002
Abdominal-to-Height ratio	0.48	0.01	0.50	0.015	0.50*	0.01	0.56	0.01
Waist-to-Hip ratio	0.82	0.006	0.83	0.008	0.79*	0.008	0.80	0.008
Percentage android fat (%)	24.3	2.0	27.4	2.5	33.7	2.3	39.6	2.2
Percentage gynoid fat (%)	31.8	1.5	32.2	1.9	39.9	0.3	42.7	1.3
Android fat relative to total fat (%)	6.2*	0.2	6.8	0.2	6.8	0.3	7.5	0.2
Trunk – Total fat mass ratio	0.39*	0.009	0.43	0.01	0.43*	0.01	0.48	0.008
Legs – Total fat mass ratio	0.47*	0.009	0.43	0.008	0.43	0.01	0.40	0.008
Limbs – Trunk fat mass ratio	1.49*	0.06	1.21	0.05	1.26*	0.05	1.04	0.03
Android – Gynoid fat ratio	0.71	0.03	0.79	0.006	0.81	0.007	0.89	0.03

* Significant ethnic differences between Caucasian and Indigenous groups at the 0.05 level after controlling for the effect of age.

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Table 3. Prediction of total and android fat using selected anthropometric indices †,‡,§

Gender	Dependent variable	Anthropometric Index	Regression equations	R_{ad}^2	SEE
Boys	Ln Total fat (g)	ΣSF	3.025 + 1.194 × Ln(ΣSF) + 0.058 × Age	0.943	0.161
		AC	-7.510 + 4.068 × Ln(AC) – 0.072 × Age	0.901	0.213
		AHtR	11.111 + 4.101 × Ln(AHtR) + 0.085 × Age	0.831	0.278
		BMI	0.194 + 2.996 × Ln(BMI)	0.819	0.288
		BM	9.152 + 0.045 × BM – 0.181 × Age	0.707	0.367
	Ln Android fat (g)	ΣTSF	6.153 + 1.232 × Ln(ΣTSF)	0.947	0.197
		AC	-14.540 + 5.103 × Ln(AC) – 0.089 × Age	0.899	0.270
		AHtR	8.795 + 5.101 × Ln(AHtR) + 0.108 × Age	0.814	0.367
		BMI	-4.750 + 3.725 × Ln(BMI)	0.802	0.379
		BM	6.364 + 0.056 × BM – 0.226 × Age	0.706	0.462
Girls	Ln Total fat (g)	ΣSF	3.050 + 1.137 × Ln(ΣSF) + 0.079 ×Age	0.951	0.133
		AC	-5.115 + 3.366 × Ln(AC) – 0.131 × Ethnicity	0.951	0.132
		AHtR	10.928 + 3.592 × Ln(AHtR) + 0.091 × Age – 0.196 × Ethnicity	0.905	0.185
		BM	8.256 + 0.040 × BM – 0.061 × Age	0.878	0.210
		BMI	1.924 + 2.510 × Ln(BMI)	0.864	0.221
	Ln Android fat (g)	ΣTSF	5.317 + 1.233 × Ln(ΣTSF) + 0.067 × Age	0.934	0.194
		AC	-11.341 + 4.276 × Ln(AC) – 0.042 × Age	0.922	0.211
		AHtR	9.024 + 4.632 × Ln(AHtR) + 0.084 × Age – 0.196 × Ethnicity	0.884	0.258
		BMI	-2.452 + 3.074 × Ln(BMI)	0.813	0.327
		BM	5.515 + 0.05 × BM – 0.098 × Age	0.811	0.329

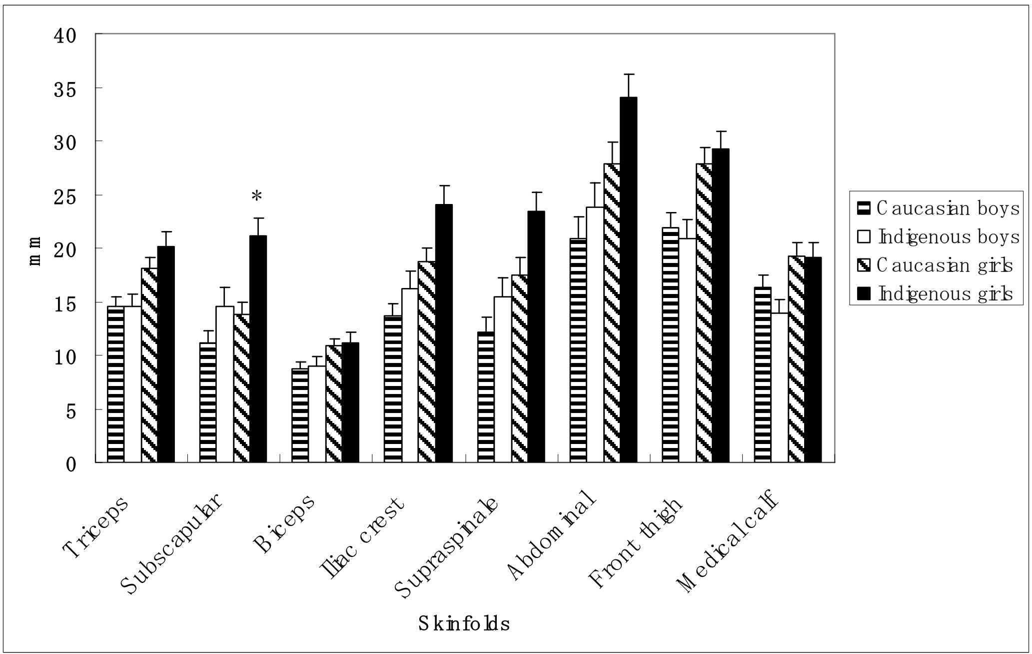
† One Caucasian boy declined to have his iliac crest skinfold thickness measured and therefore the number of Caucasian boys available for ΣSF and ΣTrunkSF was 43.

‡ Ethnicity 1 = Indigenous, 0 = Caucasian.

§ Independent variables: age, ethnicity, body mass (BM), body mass index (BMI), sum of eight skinfolds (ΣSF), sum of trunk skinfolds (ΣTrunkSF), abdominal circumference (AC) and abdominal-to-stature ratio (AHtR).

Figures

Figure 1. Ethnic differences in age- and stature-corrected skinfolds †, ‡

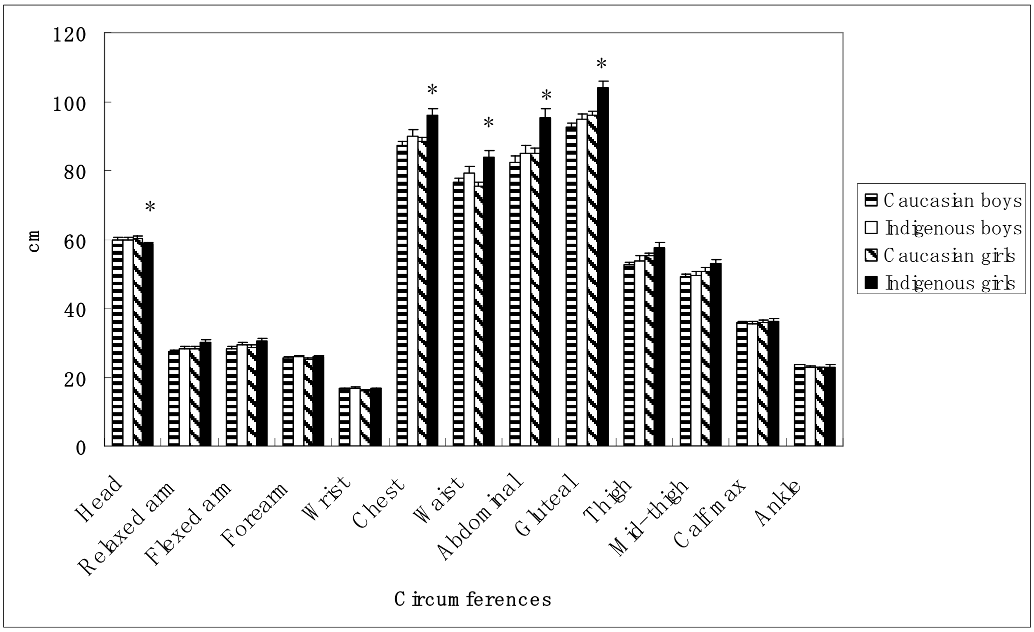


* Significant ethnic differences between Caucasian and Indigenous groups at the 0.05 level after controlling for the effect of age and stature.

† One Caucasian boy declined to have his iliac crest skinfold thickness measured and therefore the number of Caucasian boys for sum of skinfolds and sum of trunk skinfolds was 43.

‡ Error bars indicate standard error.

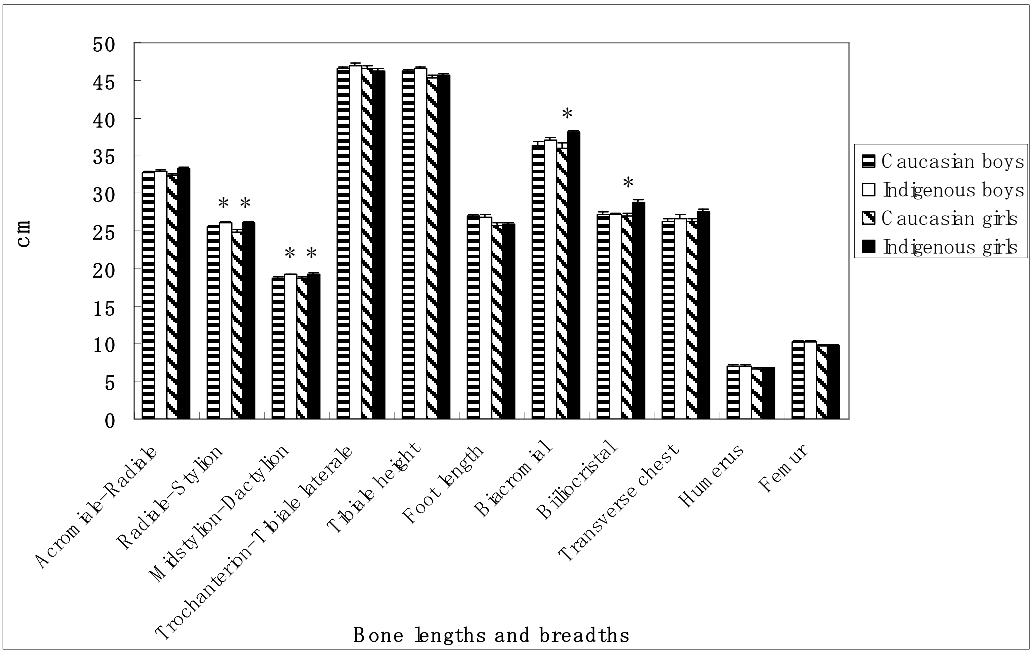
Figure 2. Ethnic differences in age- and stature-corrected circumferences †



* Significant ethnic differences between Caucasian and Indigenous groups at the 0.05 level after controlling for the effect of age and stature.

† Error bars indicate standard error.

Figure 3. Ethnic differences in age- and stature-corrected lengths and bone breadths †

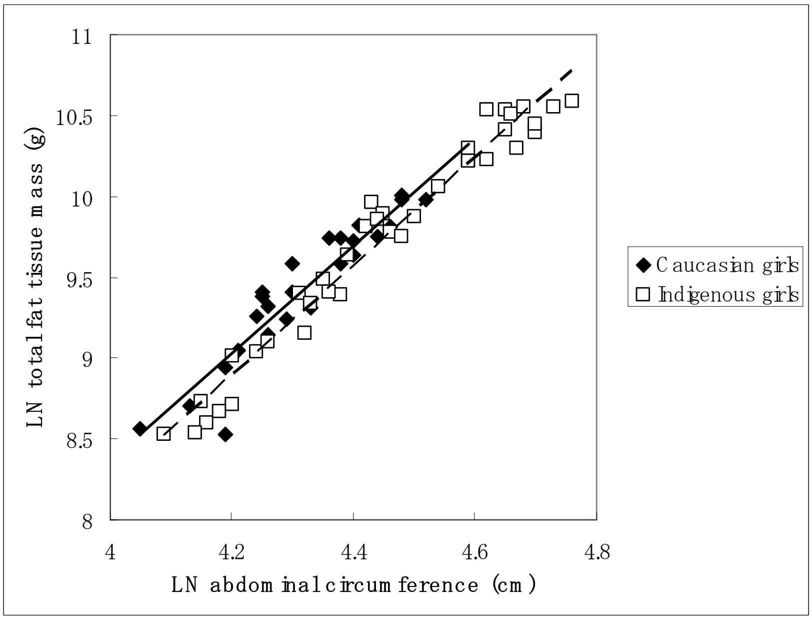


* Significant ethnic differences between Caucasian and Indigenous groups at the 0.05 level after controlling for the effect of age and stature.

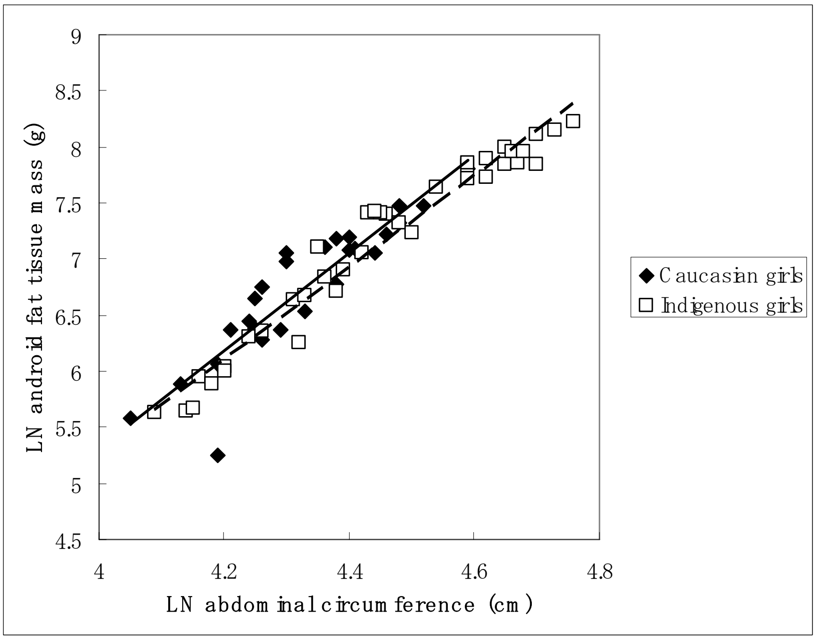
† Error bars indicate standard error.

Figure 4. Scatter plots of 1) abdominal circumference and 2) AHtR using a) total fat and b) android fat tissues in girls

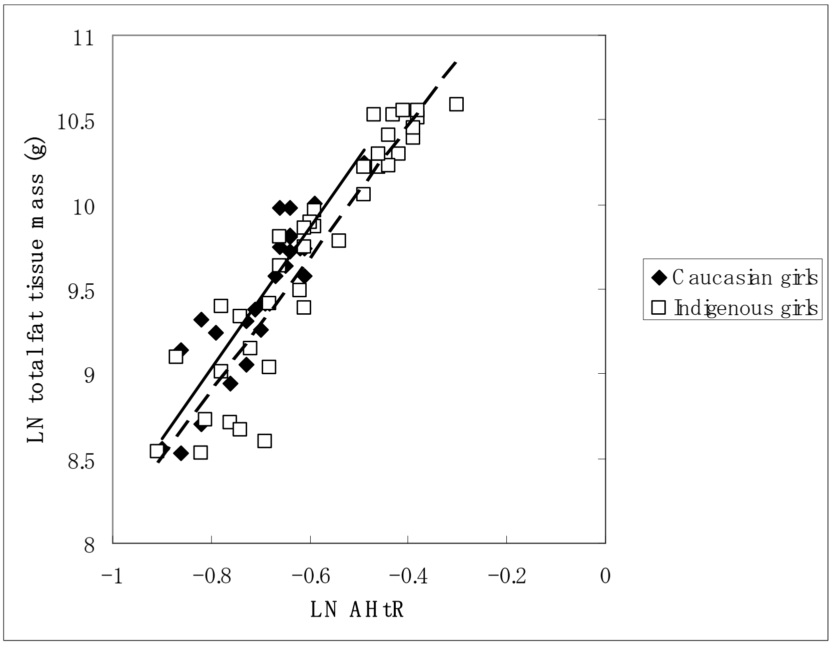
1a) Relationship between abdominal circumference and total fat tissue



1b) Relationship between abdominal circumference and android fat tissue



2a) Relationship between AHtR and total fat tissue



2b) Relationship between AHtR and android fat tissue

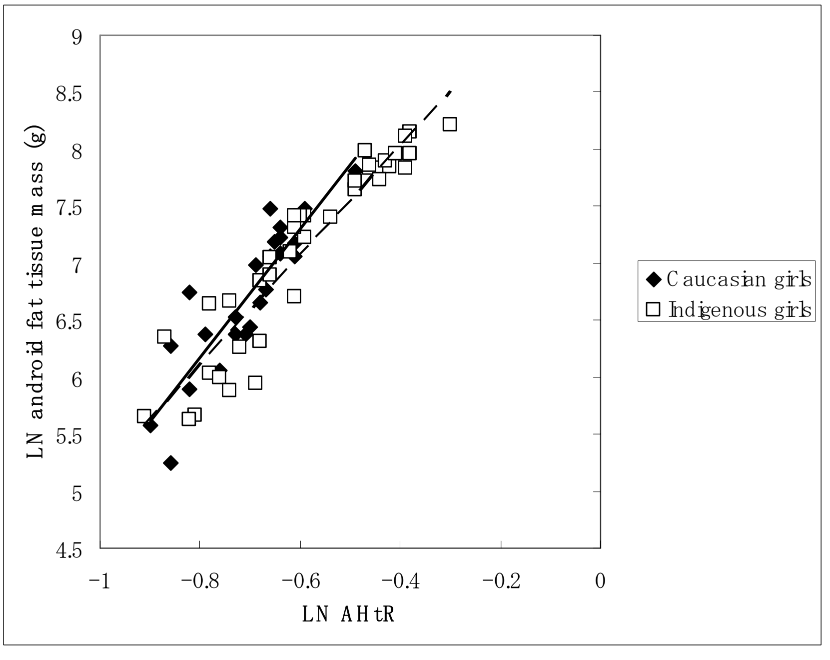


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Figure 1. Ethnic differences in age- and stature-corrected skinfolds

A significant ethnic difference was observed in subscapular skinfold thickness for girls.

Figure 2. Ethnic differences in age- and stature-corrected circumferences

Significant ethnic differences were observed in trunk circumferences, including chest, waist, abdominal and gluteal (hip). No ethnic differences were observed in boys.

Figure 3. Ethnic differences in age- and stature-corrected lengths and bone breadths

Indigenous children showed longer radiale-stylion and mid-stylion-dactylion bone lengths compared to Caucasians. In addition, Indigenous girls showed significantly longer acromiale-radiale length as well as biacromial and biiliocristal bone breadths than Caucasian girls.

Figure 4. Scatter plots of 1) abdominal circumference and 2) AHtR using a) total fat and b) android fat tissues in girls

While no ethnic difference in the relationship between abdominal circumference and android fat tissue was observed, Indigenous girls showed a smaller amount of total body fat at given abdominal circumference ($p<0.05$). Similarly, Indigenous girls showed a smaller amounts of both total and android fat tissues at the given AHtR compared to Caucasian girls ($p<0.05$).

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