墨爾本華裔澳洲人的人體測量指標

Anthropometric indices among adult Melbourne Chinese Australians

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Anthropometric indices of adult Chinese living in Melbourne, Australia, were studied. 540 (271 men and 269 women) adult Melbourne Chinese were recruited for a study of food habits and cardiovascular risk factor prevalence; all had stature, body weight and waist and hip circumferences measured. Body mass index and waist-to-hip ratio were estimated, along with fat-free mass, total body fat and the percentage body fat, using established or published formulae. Stature was negatively associated with age and positively related to education level. The Australian-born Chinese had the greatest anthropometric indices; those born in China and Hong Kong had a similar anthropometric profile; the anthropometric profile of Vietnamese Chinese was similar to that of their Australian born counterparts and was significantly greater than that of their counterparts born in China and Hong Kong. Our study suggests that a favourable environment can promote full genetic potential in growth, as evident in the Australian-born Chinese. Those born in Vietnam appeared to have taken full advantage of the Australian environment and showed an elevation of body composition.

Introduction

In a study of food habits and cardiovascular risk factor prevalence in adult ethnic Chinese, we found that Melbourne Chinese had a low prevalence of overweight, in spite of a somewhat elevated waist-to-hip ratio, compared to their Australian counterparts[1]. The prevalence of overweight in Melbourne Chinese was, however, greater than their counterparts living in Guangdong province of Southern China[2]. Other studies have also shown a greater body mass index (BMI) and prevalence of obesity in Japanese migrants compared to their counterparts in Japan[3].

The various waves of migration in Chinese Australians showed that Chinese migrated to Australia via various routes; many involved a secondary migration from south east Asian nations[4]. Chinese Australians may appear homogeneous in heritage and tradition; in fact, they are heterogeneous in that they have been brought up under the socio-cultural influence of respective birthplace. It has been shown that malnutrition before the age of 2 years may produce long-term effects on growth[5]. The anthropometric profile of Chinese Australians thus may depend upon environmental exposure and/or opportunity for genetic potential prior to migration. In this study, anthropometric indices of an adult population of Chinese living in Melbourne, Australia, will be reported, aiming to compare anthropometric indices among those born overseas and in Australia and to identify factors associated with anthropometric indices.

Methods

Ethics approval for this study was granted by Monash University, and a consent form was signed by all participants. Participants were of Chinese ethnicity, permanent residents of Australia, and aged 25 years and over. Subjects were recruited from households, using a sampling method developed for this study[6].

Body weight, stature, waist and hip circumferences, were twice measured and recorded. The average of two readings was then used to obtain BMI, waist-to-hip circumference ratio, fat-free mass, total body fat and the percentage body fat (body composition measurements).

A non-stretch measuring tape was used to measure stature and abdominal circumferences, and a digital scale was used to measure body weight. Stature (in centimetres) and body weight (in kilograms) were measured using the 1983 NHF survey procedures[7]. The 'waist' girth was measured at the level of umbilicus and the 'hip' girth was measured at the level of maximum gluteal protrusion, with light clothes on and subjects standing in an up-right position[8,9]. Both were measured to the nearest millimetre.

The BMI, an indicator of total fatness, was calculated as body weight in kilograms divided by stature squared in metres. The Australian National Health and Medical Research Council (NH&MRC) recommended classification for underweight (BMI<20), acceptable weight (20<= BMI<=25), overweight (25<BMI<=30) or obese (BMI>30) was used to estimate the prevalence of overweight or

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obese[10,11]. The waist-to-hip circumference ratio (WHR), an indicator of abdominal fatness, was calculated as the circumference at the level of umbilicus divided by the maximum hip circumference.

The fat-free mass (FFM) was estimated using an equation developed by Deurenberg and colleagues[12]: FFM=0.282 • stature + 0.395 • body weight + 8.4 • sex – 0.144 • age – 23.6; where body weight is in kilograms; stature is in centimetres; age is in years; for female sex=0 and for men sex=1. Total body fat mass (TBF) was calculated by subtracting FFM from body weight. The percentage body fat (%BF) was then obtained, dividing TBF by body weight. Pregnant women were excluded from all analyses.

All statistical tests were performed, using the statistical analysing system (SAS) for the personal computer[13,14]. The significance level was set at 5%. Mean and standard deviation were reported for anthropometric indices, and other continuous variables. Pearson's correlation was used to examine relationships of anthropometric indices with age, age at arrival, length of stay in Australia, and education level. The partial correlations were performed to adjust for confounding factors, such as age, age at arrival, the length of stay in Australia or education level. The analysis of covariance was performed to obtain the adjusted means and compare them between population groups.

Results

A total of 540 ethnic Melbourne Chinese (271 men, 269 women) were studied. About 95% of Melbourne Chinese were born overseas, with China (24%), Hong Kong (12%), Malaysia/Singapore (25%), and Vietnam (25%) being the major donors (Table 1). Those who were born in China were older (mean age: 53.9 ± 14.5 years for men and 52.4 ± 13.9 years for women) and arrived in Australia at a later age (40.4 ± 15.8 years for men and 43.7 ± 15.6 years for women). They were also less educated (average less than 10 years of schooling for men and less than nine years for women). The latest Chinese migrant group to Australia were those born in Vietnam, with an average length of stay in Australia being 8.4 (sd 2.7) years for men and 8 (sd 3.4) years for women. Those born in Malaysia/Singapore had a relatively long length of stay in Australia (14.6 ± 8.3 years for men and 10.8 ± 7.7 years for women), and were more educated than their overseas born counterparts (Table 1).

The prevalence of obesity is low in men (2.7% for those born in Malaysia/Singapore and zero for other groups) and women (11.1% the highest value, being for the Australian–born). The prevalence of underweight was low in Australian-born for both men (8.3%) and women (11.1%), and men born in Vietnam (10.8%). In men, the prevalence of overweight among those born in Australia (41.7%), Hong Kong (23.3%), Vietnam (27.7%) or elsewhere (20%) was twice than those born in China (9.2%), Malaysia/Singapore (9.5%). In women, a much higher prevalence of overweight was found in the Australian born (33.3%). The prevalence of acceptable weight was comparable among all groups, in the vicinity of 50% (Table 2).

The unadjusted mean and standard deviation for anthropometric indices are shown in Table 3 for men and women, and by birthplace. The stature of those born in China (166.9 cm for men and 155 cm for women) and Vietnam (165.2 cm for men and 153.9 cm for women) was below the population average (167.3 cm for men and 156.2 cm for women). Additionally, men born in Vietnam had a body weight (63.5 kg) and BMI (23.3) above the population average (body weight: 63.2 kg; BMI: 22.6). All anthropometric indices of Australian-born men and women exceeded the population means. For those born in Hong Kong, there existed an identical anthropometric profile between sex that the average body weight, BMI, waist and hip circumferences, waist-to-hip (W/HR), TBF and %BF was lower than those of the entire population, and that the average stature and FFM exceeded the population average. The same anthropometric profile was

Table 1. Demographic characteristics of the study population, by gender and birthplace (data collected in 1988–89 from the Melbourne Metropolitan area, Australia).

	Australia	China	Hong Kong	Malaysia/ Singapore	Vietnam	Others	Total
MEN							
n	12	65	30	74	65	25	271
Age (years)	41.8 ± 13.8^{a}	53.9 ± 14.5^{a,b,c,d,e}	41.0 ±10.0^{b}	43.2 ± 9.4^{c}	39.8 ± 8.6^{d}	43.8 ± 13.8^{e}	44.7 ± 12.5
Age at arrival (years)#	0.0 ± 0.0	40.4 ± 15.8^{a,b,c,d}	27.6 ± 10.1^{a,e}	28.6 ± 10.4^{b,f}	31.4 ± 9.1^{c}	34.5 ± 15.1^{d,e,f}	31.2 ± 14.4
Length of stay in Australia (years)#	39.5 ± 14.0	13.5 ± 12.2^{a,b}	13.5 ± 10.7^{c}	14.6 ± 8.3^{d,e}	8.4 ± 2.7^{a,c,d}	9.3 ± 5.9^{b,e}	13.3 ± 10.8
Education level (mean)@	4.4 ± 0.8^{a,b,c}	3.5 ± 1.2^{a,d,e}	4.3 ± 1.0^{d,f,g,h}	4.7 ± 0.6^{e,f,i,j}	3.6 ± 0.9^{b,g,i}	3.5 ± 1.2^{c,h,j}	4.0 ± 1.1
0 – 6 years (%)	0	26	10	0	11	24	12
7 – 9 years (%)	17	26	10	11	37	28	23
10–12 years (%)	25	15	23	12	31	20	20
13+ years (%)	58	32	57	77	22	28	45
WOMEN							
n	9	65	37	57	73	28	269
Age (years)	48.7 ± 17.7^{a,b,c}	52.4 ± 13.9^{d,e,f,g}	37.4 ± 9.1^{a,d}	40.1 ± 9.0^{b,e}	38.4 ± 9.1^{c,f}	41.4 ± 13.9^{g}	42.4 ± 12.6
Age at arrival (years)#	0.0 ± 0.0	43.7 ± 15.6^{a,b,c,d}	28.1 ± 10.2^{a,e}	29.3 ± 8.7^{b,f}	30.4 ± 10.6^{c}	35.1 ± 14.2^{d,e,f}	32.3 ± 14.4
Length of stay in Australia (years)#	41.6 ± 17.6	8.7 ± 6.3	9.3 ± 6.0	10.8 ± 7.7^{a,b}	8.0 ± 3.4^{a}	6.3 ± 3.6^{b}	9.9 ± 8.7
Education level (mean)@	4.4 ± 0.7^{a,b,c}	3.0 ± 1.2^{a,d,e}	3.7 ± 1.1^{d,f,g}	4.3 ± 0.9^{e,f,h,i}	3.2 ± 1.1^{b,g,h}	3.3 ± 1.2^{c,i}	3.5 ± 1.2
0–6 years (%)	0	52	19	3	32	40	29
7–9 years (%)	11	6	19	16	28	20	18
10–12 years (%)	33	29	32	30	26	20	28
13+ years (%)	56	12	30	51	14	20	26

#Multiple comparisons apply to overseas–born only.
@Education level: 2 = 0–6 years; 3 = 7–9 years; 4 = 10–12 years; 5 = 13+ years.
a,b,c,d,e,f,g,h,i,j: Identical superscripts indicate significant differences between birthplaces.

Table 2. Mean and standard deviation of anthropometric indices, by birthplace and sex.

	Australia	China	Hong Kong	Malaysia/ Singapore	Vietnam	Others	Total
MEN							
Weight (kg)	70.0 ± 8.2	61.2 ± 8.3	62.5 ± 9.3	64.2 ± 10.2	63.5 ± 8.9	62.0 ± 9.6	63.2 ± 9.3
Stature (cm)	169.9 ± 4.8	166.9 ± 6.1	168.6 ± 6.1	168.6 ± 5.6	165.2 ± 5.9	166.8 ± 7.2	167.3 ± 6.1
BMI (kg/m^2)	24.3 ± 2.9	22.0 ± 2.6	22.0 ± 3.3	22.5 ± 3.0	23.3 ± 2.9	22.2 ± 3.1	22.6 ± 3.0
Waist circ. (cm)	87.6 ± 10.8	82.9 ± 8.3	80.6 ± 9.0	83.4 ± 8.2	84.4 ± 7.9	81.8 ± 8.7	83.2 ± 8.5
Hip circ. (cm)	96.5 ± 6.6	90.6 ± 5.0	90.9 ± 5.4	91.9 ± 5.7	91.8 ± 5.2	90.9 ± 5.4	91.6 ± 5.5
W/HR	0.91 ± 0.062	0.91 ± 0.060	0.88 ± 0.059	0.91 ± 0.050	0.92 ± 0.048	0.90 ± 0.053	0.91 ± 0.054
FFM (kg)	54.4 ± 4.1	48.3 ± 5.1	51.1 ± 4.7	51.6 ± 5.5	50.8 ± 4.8	50.0 ± 5.9	50.5 ± 5.3
TBF (kg)	15.6 ± 6.0	12.9 ± 5.1	11.4 ± 6.0	12.9 ± 5.4	12.8 ± 5.1	12.0 ± 5.5	12.7 ± 5.4
%BF	21.8 ± 6.7	20.6 ± 6.4	17.3 ± 7.6	19.4 ± 5.0	19.5 ± 5.9	18.5 ± 7.3	19.5 ± 6.2
WOMEN							
Weight (kg)	57.7 ± 8.7	53.1 ± 8.1	52.0 ± 8.4	52.7 ± 6.3	53.1 ± 9.6	55.7 ± 10.1	53.3 ± 8.5
Stature (cm)	156.7 ± 4.6	155.0 ± 5.8	157.4 ± 4.9	158.0 ± 5.8	153.9 ± 5.1	159.7 ± 5.9	156.2 ± 5.8
BMI (kg/m^2)	23.6 ± 3.8	22.1 ± 3.0	20.9 ± 3.0	21.1 ± 2.5	22.4 ± 3.7	21.8 ± 3.5	21.8 ± 3.2
Waist circ. (cm)	81.7 ± 14.3	84.8 ± 9.9	77.2 ± 9.4	79.6 ± 8.3	81.7 ± 11.4	81.9 ± 10.2	81.4 ± 10.4
Hip circ. (cm)	96.5 ± 7.8	91.6 ± 5.7	91.3 ± 6.1	91.8 ± 4.9	92.5 ± 8.1	92.9 ± 6.8	92.1 ± 6.5
W/HR	0.84 ± 0.11	0.93 ± 0.083	0.84 ± 0.057	0.87 ± 0.068	0.88 ± 0.068	0.88 ± 0.076	0.88 ± 0.077
FFM (kg)	36.4 ± 3.2	33.5 ± 5.1	35.9 ± 4.0	36.0 ± 3.4	35.2 ± 4.6	37.5 ± 5.5	35.4 ± 4.6
TBF (kg)	21.3 ± 7.3	19.6 ± 5.0	16.0 ± 5.3	16.7 ± 4.4	17.9 ± 5.8	18.2 ± 6.2	17.9 ± 5.5
%BF	36.2 ± 7.2	36.6 ± 6.4	30.2 ± 5.9	31.3 ± 5.4	32.9 ± 5.8	32.1 ± 6.6	33.1 ± 6.4

Table 3. Prevalence of overweight and obesity, by birthplace and sex.

	Australia	China	Hong Kong	Malaysia/ Singapore	Vietnam	Others
MEN						
Underweight	8.3	21.5	26.7	14.9	10.8	24.0
Acceptable weight	50.0	69.2	50.0	73.0	61.5	56.0
Overweight	41.7	9.2	23.3	9.5	27.7	20.0
Obese	0	0	0	2.7	0	0
WOMEN						
Underweight	11.1	24.6	43.2	35.1	27.4	39.3
Acceptable weight	44.4	58.5	43.2	54.4	50.7	53.5
Overweight	33.3	16.9	13.5	10.5	17.8	0
Obese	11.1	0	0	0	4.1	7.1

Table 4. Relationships (Pearson's *r*) between anthropometric indices, age, length of stay in Australia and education level, by gender.

	MEN (n = 271)				WOMEN (n = 276)			
Variable	Age	Age at arrival	Length of stay in Australia	Education Level	Age	Age at arrival	Length of stay in Australia	Education Level
Body weight (kg)	-0.08	-0.13*	0.06	0.09	0.14*	0.06	0.07	-0.15*
Height (cm)	-0.28****	-0.22***	-0.03	0.19**	-0.26****	-0.21***	-0.03	0.25****
BMI (kg/m^2)	0.06	-0.02	0.09	-0.0006	0.28****	0.16**	0.10	-0.29****
Waist circ. (cm)	0.19**	0.08	0.10	-0.03	0.47****	0.36****	0.04	-0.35****
Hip circ. (cm)	-0.006	-0.11	0.14*	0.06	0.14*	0.05	0.07	-0.18**
W/HR	0.34****	0.26****	0.04	-0.12	0.57****	0.49****	0.005	-0.37****
FFM (kg)	-0.49****	-0.39****	-0.05	0.21***	-0.38****	-0.33****	-0.01	0.13*
TBF (kg)	0.33****	0.16**	-0.04	0.54****	0.36****	0.12*	-0.35****	
%BF	0.53****	0.31****	0.19**	-0.11	0.78****	0.57****	0.13*	-0.44****

*P<0.05; **P<0.01; ***P<0.001; ****P<0.0001

also found in women born in Malaysia/Singapore.

Factors associated with anthropometric indices were age, age at arrival and education. The correlations were more pronounced in women than men (Table 4). Stature was negatively related to age or age at arrival, and was positively related to education level, in men and women.

Partial correlations of anthropometric indices with age, the length of stay in Australia, and education level are shown in Table 5. The stature adjusted associations of anthropometric indices with age were consistent with those without adjustment (Table 4), for both gender. There were significant relationships of anthropometric indices with the length of stay in Australia, after adjusting for stature and age at arrival, particularly in women. Further, in both sexes only FFM was found to be negatively related to the length of stay in Australia. In men, the relationship of body weight with age (r=0.04) or the length of stay in Australia (0.08) was not significant, while it is in women (age: r=0.27, P<0.0001; the length of stay in Australia: r=0.21, P<0.001). Similarly, BMI of men was not related to age or the length of stay in Australia, but BMI of women was. The relationships of anthropometric indices to education level were significant and negative for women, while no significant relationships were found in men.

Differences in anthropometric indices, adjusted for stature, age at arrival, length of stay in Australia, and education level, were mainly found in men (Table 6). Men born in Australia had a significantly higher body weight (68.1 vs 60.7 kg), waist (87.9 vs 81.0 cm) and hip (95 vs 90 cm) circumferences, FFM (52.1 vs 49.5 kg), TBF (16.2 vs 11.2 kg) and %BF (23.6 vs 17.8%) than men born in China. All anthropometric indices in men born in Vietnam were significantly higher than men born in China and Hong Kong. Men born in Australia had a significantly higher waist (87.9 vs 81.0 cm) and hip (95.0 vs 90.7 cm) circumferences, TBF (16.2 vs 11.8 kg) and %BF (23.5 vs 18.4%) than men born in Hong Kong. Men born in Malaysia/Singapore had a higher %BF than men born in China.

Women born in Vietnam had a higher body weight (55.1 vs 52.1 kg), BMI (22.5 vs 21.4), hip circumference (92.2 vs 90.6 cm) and FFM (36.2 vs 34.9 kg) than their counterparts born in China. Women born in Vietnam also had a significantly higher umbilical circumference (83.3 vs 79.0 cm), W/HR (0.89 vs 0.86) and FFM (36.2 vs 35.0 kg) than those born in Hong Kong. The W/HR for women born in Hong Kong (0.86) was significantly lower than those born in China (0.89). Women born in Australia had a higher hip circumference (97.2 cm) than women born in China (90.6 cm), and a higher %BF (37.2 per cent) than women born in China (32.6%), Hong Kong (32.3%) and Malaysia/Singapore (33.0%).

Discussion

Methodological issues

The use of anthropometric assessment in a population study has several limitations. It is a relatively insensitive method and cannot detect specific nutrient deficiencies of individual or short-term disturbance in nutritional status[15–17]. The anthropometric indices examined here, however, may be used as an indicator of past long-term nutritional history, particularly in relation to genetic potentials during growth[18,19] where the influence of socio-economic status and other environmental factors on stature is likely to have been established in early childhood[20–27]. The other usefulness of anthropometric measurements is in relation to the assessment of persistent positive energy balance or an accumulation of adipose tissue, an opposite to the familiar interest in the assessment of chronic protein-energy malnutrition (PEM)[28–32].

The assessment of adiposity is a key issue in studies of cardiovascular disease risk factors, such as ours. Body fatness, total and abdominal and/or body composition has been associated with major cardiovascular risk factors[33–40], glucose intolerance or non-insulin-dependent diabetes mellitus[41–46]. In apparently healthy individuals, body composition may be directly measured using a bioelectrical impedance analyser[47], ultrasound[48] or computerized tomography[49]. In this study, we undertook to measure body weight, stature, waist and hip circumferences. Body composition measurements were estimated from body weight, stature, age and gender[12].

Table 5. Relationships (Pearson's *r*) between anthropometric indices, age, length of stay in Australia and education level, with adjustment of confounding factors[a], by sex.

Variable	MEN ($n = 271$) Age	MEN Length of stay in Australia	MEN Education Level	WOMEN ($n = 276$) Age	WOMEN Length of stay in Australia	WOMEN Education level
Body weight (kg)	0.04	0.08	0.03	0.27****	0.21***	-0.20***
BMI (kg/m^2)	0.04	0.08	-0.03	0.27****	0.21***	-0.20***
Waist circ. (cm)	0.23***	0.20**	-0.003	0.48****	0.30****	-0.23****
Hip circ. (cm)	0.10	0.16**	0.02	0.22***	0.16**	-0.20**
W/HR	0.31****	0.19**	-0.02	0.55****	0.32****	-0.17**
FFM (kg)	-0.44****	-0.30****	0.03	-0.29****	-0.15*	-0.20***
TBF (kg)	0.36****	0.32****	0.03	0.55****	0.40****	-0.20***
%BF	0.51****	0.43****	0.02	0.77****	0.59****	-0.18**

[a], For age, adjusting for stature; For length of stay in Australia, adjusting for stature and age at arrival; For education level, adjusting for stature and age; *P<0.05; **P<0.01; ***P<0.001; ****P<0.0001.

Table 6. Mean and standard error of anthropometric indices, adjusted for stature, age at arrival, length of stay in Australia and education, by birthplace and gender.

	Australia	China	Hong Kong	Malaysia/ Singapore	Vietnam	Others
MEN						
n	12	65	30	74	65	25
Body weight (kg)	68.1 ± 2.9^{a}	60.7 ± 1.1^{a,b}	61.8 ± 1.5^{c}	63.3 ± 1.0	65.6 ± 1.1^{b,c}	62.5 ± 1.7
BMI (kg/m^2)	24.3 ± 1.0^{a}	21.7 ± 0.4^{a,b}	22.1 ± 0.5^{c}	22.6 ± 0.4	23.5 ± 0.4b,c	22.3 ± 0.6
Waist circ. (cm)	87.9 ± 2.9a,b	81.0 ± 1.1a,c	81.0 ± 1.5b,d	83.4 ± 1.0	86.0 ± 1.1c,d,e	82.1 ± 1.7e
Hip circ. (cm)	95.0 ± 1.8a,b	90.0 ± 0.7a,c	90.7 ± 0.9b,d	91.5 ± 0.6	93.1 ± 0.7c,d	91.3 ± 1.0
W/HR	0.92 ± 0.018	0.90 ± 0.069a	0.89 ± 0.0093b	0.91 ± 0.0063	0.92 ± 0.0068a,b,c	0.90 ± 0.010c
FFM (kg)	52.1 ± 1.1a	49.5 ± 0.4a,b	50.0 ± 0.6c	50.6 ± 0.4	51.5 ± 0.4b,c	50.2 ± 0.7
TBF (kg)	16.2 ± 1.8a,b	11.2 ± 0.7a,c	11.8 ± 0.9b,d	12.9 ± 0.6	14.1 ± 0.7c,d	12.2 ± 1.0
%BF	23.5 ± 1.8a,b,c	17.8 ± 0.7a,d,e	18.4 ± 1.0b,f	19.8 ± 0.6d	21.0 ± 0.7e,f	18.8 ± 1.1c
WOMEN						
n	9	65	37	57	73	28
Body weight (kg)	56.5 ± 3.4	52.1 ± 1.0^{a}	52.1 ± 1.2	52.8 ± 1.0	55.1 ± 0.9^{a}	53.0 ± 1.5
BMI (kg/m^2)	23.2 ± 1.4	21.4 ± 0.4^{a}	21.3 ± 0.5	21.7 ± 0.4	22.5 ± 0.4^{a}	21.7 ± 0.6
Waist circ. (cm)	81.8 ± 4.1	81.0 ± 1.2	79.0 ± 1.5^{a}	81.3 ± 1.3	83.3 ± 1.1^{a}	80.7 ± 1.8
Hip circ. (cm)	97.2 ± 2.7^{a}	90.6 ± 0.8^{a,b}	91.5 ± 1.0	92.2 ± 0.8	93.4 ± 0.8^{b}	91.2 ± 1.2
W/HR	0.84 ± 0.029	0.89 ± 0.0086^{a}	0.86 ± 0.010^{a,b}	0.88 ± 0.0088	0.89 ± 0.0079^{b}	0.88 ± 0.012
FFM (kg)	35.1 ± 1.3	34.9 ± 0.4a	35.0 ± 0.5^{b}	35.1 ± 0.4	36.2 ± 0.4^{a,b}	35.3 ± 0.6
TBF (kg)	21.4 ± 2.1	17.2 ± 0.6	17.2 ± 0.8	17.6 ± 0.6	18.9 ± 0.6	17.7 ± 0.9
%BF	37.2 ± 1.8^{a,b,c,d}	32.6 ± 0.5^{a}	32.3 ± 0.5^{b}	33.0 ± 0.5^{c}	33.7 ± 0.5	32.9 ± 0.8^{d}

[abcdef]: Identical superscripts indicate significant differences between birthplaces.

The use of anthropometric indices in a population setting is subject to measurement errors and the use of unsubstantiated assumptions in the derivation of body composition from anthropometric data can affect accuracy[50]. In this study, body composition variables are estimated using a formula developed from predominantly Caucasians which includes age[12]. The formula has since been validated against other methods in premenopausal Chinese women[51]. The body composition measurements (eg FFM, TBF and %BF) presented in this paper, though indirect, are valid and appropriate for comparisons within population groups. The inclusion of age in the formula, however, may complicate the interpretation of data in relation to associations of body compositional indices with age. Age represents a person's chronological years. Age of a migrant group however may be broken down to (1) years prior to migration, estimated by age at arrival, and (2) years resided in the host country, namely the length of stay in Australia. Thus, differences in body composition may reflect age-related differences attributable to age per se, the length of stay in Australia or the years resided at birthplace prior to migration.

Melbourne Chinese are predominantly born overseas, with a majority born in Asian countries, eg China, Hong Kong, Malaysia/Singapore and Vietnam. Differences in age, age at arrival or the length of stay in Australia, and education level among the birthplace sub-groups of Melbourne Chinese indicate a demographic heterogeneity of the study population and may limit the interpretation of data in relation to differences by birthplace. Any differences in anthropometric indices may reflect cohort effects associated with the various waves of migration to Australia among the Melbourne Chinese.

Stature and, where appropriate, age, age at arrival or the length of stay in Australia, and education level were considered in the covariate analyses to remove the potential effect of secular trends on observed differences by birthplace. By means of covariate analyses, the effect of confounding factors may be minimized, but cannot be adequately removed. This is evident from the fact that the adjusted differences in anthropometric indices by birthplace are more complex in men than women (Table 6). This may or may not be explained by the observation that age or the length of stay in Australia of men was not related to body weight and BMI (Table 5). The identification of education level as a confounding factor of anthropometric indices in women, but not men, suggests that factors other than age, age at arrival, or the length of stay in Australia may operate in men.

Differences by birthplace

Although a small group, Australian-born Chinese had the greatest values in virtually all anthropometric measurements studied, except for waist-to-hip ratio, compared to their overseas born counterparts, independent of stature, age-related factors or education level. Further, these anthropometric indices of Australian-born Chinese were within the range and no greater than Australian-at-large, with the exception of W/HR in men[1]. These observations suggest that anthropometrically there exists a greater environmental advantage of early life, and indeed adulthood, in Chinese born and raised in Australia and that the genetic potential of Chinese may in general be less prominent than for Caucasians. Further investigation of the optimal effect of anthropometric profile, particularly total and percentage body fat, on health outcomes such as cardiovascular risk factors in Australian-born Chinese is warranted.

In contrast to their counterparts born in Australia, Chinese born in China and Hong Kong had the lowest values for virtually all anthropometric indices studied. The two groups were similar in anthropometric profile in spite of dissimilarity in age or age at arrival in Australia and education level. The geographic proximity from which these two groups of Melbourne Chinese originated, suggests comparable environmental exposure pre- and post-migration and perhaps affinity in food culture and tradition, offers a conceivable explanation for the observation. The fact that the two groups had the lowest value of anthropometric indices, significantly lower than their counterparts born in Vietnam, is intriguing.

Chinese born in Vietnam represented the latest Chinese immigrants to Melbourne with an average length of stay of eight years, mostly having arrived in Australia around 1980, as Vietnam War refugees. As a group, they had the highest values in anthropometric measurements among those born overseas; the values were less than, but similar to, the Australian born. We do not know whether or not Chinese born in Vietnam would have undergone greater changes in body weight or body composition compared to their overseas born counterparts. The possible effects of war on nutritional status has been reported in south east Asian refugee children relocated in the United States[52]. Following the Gulf War, Iraqi infants and children under five years of age were found to have a somewhat high prevalence of stunting, but not wasting, suggesting a possible survivor bias[53]. Proos and colleagues[26,54] reported that Indian children adopted by families in Sweden had an anthropometric status similar to average children in India at arrival and with a marked catch-up in growth in the first two years of life in Sweden to Swedish children. If indeed Vietnamese Chinese were deprived of food during the war or prior to relocation, then it is conceivable that related changes in body composition may occur immediately after settlement.

One way to summarize the anthropometric indices of Malaysian/Singaporean Chinese would be that they represent what one might expect of an average Melbourne Chinese, though they were the most educated group among those born overseas. Malaysian/Singaporean Chinese did not differ from any of their counterparts born overseas for any anthropometric indices studied. They (men and women), however, had a percentage body fat significantly lower than their Australian-born counterparts.

Conclusion

Melbourne Chinese represented an apparently healthy adult migrant population, with a majority being born and raised overseas. Their years of life in Australia typified the changing dietary exposure and lifestyle commonly reported in migrant studies[55–65]. Their cardiovascular risk profile, particularly in men, is no longer low[1]. In this study, we found that the anthropometric profile of Melbourne Chinese differed by birthplace and that this cannot be fully explained by age or the length of stay in Australia, age at arrival, or education level. The greatest, and yet acceptable, anthropometric indices among the Australian born is indicative of an environmental advantage for growth in favour of improved economic development. The greater values among those born in Vietnam however suggests nutritional status of Vietnamese Chinese may have changed significantly from a previously war-time deprived state to a level that is comparable to their Australian-born counterparts and surpasses those of their counterparts born in China and Hong Kong. With all the differences that we have found, it remains to be answered as to why there is similarity between those born in China and Hong Kong, aside from their low anthropometric indices. Whether or not differences in anthropometric profile by birthplace are of importance in relation to health consequences of Melbourne Chinese needs to be unveiled.

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