Original Article

Body composition and anthropometry in Japanese and Australian Caucasian males and Japanese females

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The total amount and location of fat deposition are important factors in the development of obesity and the metabolic syndrome. To date there have been no reported studies of ethnic and gender differences in body composition and fat distribution patterns in Japanese and Australian young adults. The aim of this study was to assess body composition of young Japanese and Australian Caucasian adults using whole-body dual energy x-ray absorptiometry (DXA) and anthropometry to examine body fat deposition patterns. Body composition of 45 Japanese males and 42 Australian Caucasian males living in Australia (aged 18-40 years) and 139 Japanese females living in Japan (aged 18-27 years) were measured using whole-body DXA scanning and anthropometry. Differences in relationships between BMI and waist circumference (WC), sum of skinfolds (ΣSF) and %BF obtained from DXA were assessed using multivariate analyses. Distinct gender and ethnic differences ($p<0.05$) in bone density and waist circumference were observed but no gender differences in BMI and bone mineral content and no ethnic differences in sum of skinfolds and %BF. Both Japanese males and females showed a greater %BF at given BMI, WC and ΣSF values ($p<0.05$). The results indicate differences in relationships between %BF and anthropometric measures in young Japanese compared to Caucasians and the importance of population-specific cut-off points for these indices. These findings also have implications for the development of chronic disease and further research, including studies in other Asian countries, is recommended.

Key Words: body composition, DXA, anthropometry, Japanese, Australians

Introduction

Overweight and obesity are major, and increasing, public health concerns in all parts of the globe. Obesity increases the risk of chronic health consequences including hypertension, hypercholesteroaemia, hyperglycaemia, type II diabetes and cardiovascular diseases. In Australia, 19% of adult males and 22% of adult females are considered obese and the direct health care costs of obesity are estimated at approximately $830 million annually.[1]

To relate obesity directly to health risks, assessment of both total body fat deposition and distribution as subcutaneous or visceral fat are important. Methods frequently used to determine overall body fatness include Body Mass Index (BMI; body mass (kg)/stature $(m)^2$) and percentage body fat (%BF). However, a number of studies have shown that it is not appropriate to use a single BMI cut-off point to detect obesity as different BMI-%BF relationships have been observed in different ethnic groups.[2,3] Using anthropometry, a previous study found that the BMI value of 23kg/m^2 for young Japanese adults equates with a BMI value of 25kg/m^2 for Australian Caucasians. [4] Similarly, while waist circumference has been accepted as a useful tool to determine abdominal fat deposition and obesity-related health problems [5-7], there has been an inconsistency in methodology.[8] For example, a large epidemiological study of 11,247 Australian adults measured waist circumference defined as 'the halfway point between the lower border of the ribs and the iliac crest' [6] whereas a Japanese study (n = 1,193) used to propose the Japanese classification of waist circumference to detect metabolic syndrome, measured their waist circumference 'at the level of umbilicus'.[9] Application of different measurement protocols makes comparison between studies difficult.

To date, there have been a small number of studies that have reported anthropometric characteristics of Japanese and Caucasians[10,11] and studies that have compared fat distribution patterns are limited.[12] The aim of the current study was to analyse two datasets of 1) young Japanese and Caucasian males and 2) Japanese females to compare body composition and subcutaneous fat distribution pattern in young Japanese and Australian young adults using dual energy x-ray absorptiometry (DXA) and anthropometry.

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In the current study ethnic and gender differences in the BMI-%BF relationship were determined and at the same time, appropriate anthropometric cut-off points for waist circumference and sum of skinfolds were estimated.

Methods

The study was approved by the Human Research Ethics Committees of Curtin University of Technology and Kagawa Nutrition University. The study adhered to the principles of medical research established by the National Health and Medical Research Council.[13] The body composition data of 45 Japanese and 42 Australian Caucasian males aged 18-40 years obtained in Perth, Australia and the data of 139 Japanese females aged 18-27 years obtained in Japan were used in this analysis. Participants were healthy volunteers who were mostly students at the time of body composition assessments. Japanese participants were those who recognised themselves as of Asian ethnic background with Japanese citizenship and Australian Caucasian males were Australian citizens who perceived themselves as 'Caucasian' background. Each participant was provided with a written informed consent form in which the purpose of the study and the radiation exposure involved in the study were explained. The confidentiality of the results was guaranteed. Female participants were asked if they were pregnant prior to undergoing body composition assessment using DXA.

Dual energy x-ray absorptiometry (DXA)

A whole-body DXA scanning was conducted to obtain body composition of the participants. The scanners used in the study were a Hologic® QDR-2000 (version 5.73) in Australia and a Lunar® DPX-LIQ (version 4.7c) in Japan. Body composition obtained from this method is based on a three-compartment model differentiating bone, lean and soft tissues and is considered as one of the more reliable methods of estimating %BF.[14-17] The DXA measurements were completed in approximately 10 minutes and were conducted by accredited technicians. It needs to be acknowledged that use of different DXA machines makes comparison of results difficult. However, assuming comparable prediction errors exist in different DXA machines, it may be sufficient to observe a trend in relationships between %BF and anthropometric measures.

Anthropometry

Anthropometric measurements include stature, body mass, eight skinfold measurements (triceps, subscapular, biceps, iliac crest, supraspinale, abdominal, front thigh and medial calf), five girth measurements (relaxed arm, flexed and tensed arm, waist, gluteal and maximum calf), and four bone breadth measurements (biacromial, biiliocristal, biepicondylar humerus and biepicondylar femur). All sites were measured using the protocol of the International Society for the Advancement of Kinanthropometry (ISAK).[18] Participants in Australia and Japan were measured by the same Level 3 anthropometrist accredited by ISAK and in Japan assistance was provided by a Level 1 anthropometrist. The technical error of measurements (TEM) for both anthropometrists were within the acceptable limits proposed elsewhere.[19] All measurement sites for each participant were located by the Level 3 anthropometrist prior to the measurements. From the anthropometric measurements, BMI, sum of eight skinfolds (ΣSF) and height-corrected sum of eight skinfolds (HtΣSF; sum of skinfolds*(170.18/stature)) were calculated.

All statistical analyses were conducted using the SPSS® (version 14.0.0, 2005, Chicago) statistical package. Subcutaneous fat distribution was compared between the study groups using HtΣSF. Using this approach it is possible to compare anthropometric characteristics by controlling body size differences between the study groups. Relationships between %BF estimated from DXA and anthropometric measures such as BMI, waist circumference (WC) and ΣSF were determined using regression analysis. BMI was transformed by natural logarithm (LnBMI) to normalize the data. Initially age was also included as independent variable but was excluded from the

Table 1. Physical characteristics of 45 Japanese males, 42 Australian Caucasian males and 139 Japanese females

	Japanese males (n = 45) Mean ± SD	Australian Caucasian males (n = 42) Mean ± SD	Japanese females (n = 139) Mean ± SD
Age (years)	24.3 ± 5.5	22.6 ± 5.3	20.4 ± 1.3†, ‡
Stature (cm)	172 ± 5.8*	180 ± 7.9	159 ± 5.0†, ‡
Body mass (kg)	62.6 ± 7.1*	74.5 ± 9.6	52.5 ± 6.1†, ‡
BMI (kg/m^2)	21.3 ± 2.3*	23.0 ± 2.5	20.8 ± 2.2†
Percent body fat (%)	15.7 ± 6.2	15.9 ± 6.2	27.6 ± 5.9†, ‡
Bone mineral density (g/cm^2)	1.10 ± 0.08*	1.17 ± 0.09	1.14 ± 0.07†, ‡
Bone mineral content (g)	2450 ± 310*	2890 ± 392	2350 ± 267†
Waist circumference (cm)	73.5 ± 5.2*	79.3 ± 6.0	66.3 ± 4.9†, ‡
Sum of skinfolds (mm)	73.5 ± 28.2	83.1 ± 34.5	125 ± 35.5†, ‡
Height-corrected sum of skinfolds (mm)	73.2 ± 28.7	78.5 ± 32.8	134 ± 38.3†, ‡

* Significant difference between Japanese males and Australian males at the 0.05 level. † Significant difference between Japanese females and Australian males at the 0.05 level. ‡ Significant difference between Japanese females and Japanese males at the 0.05 level.

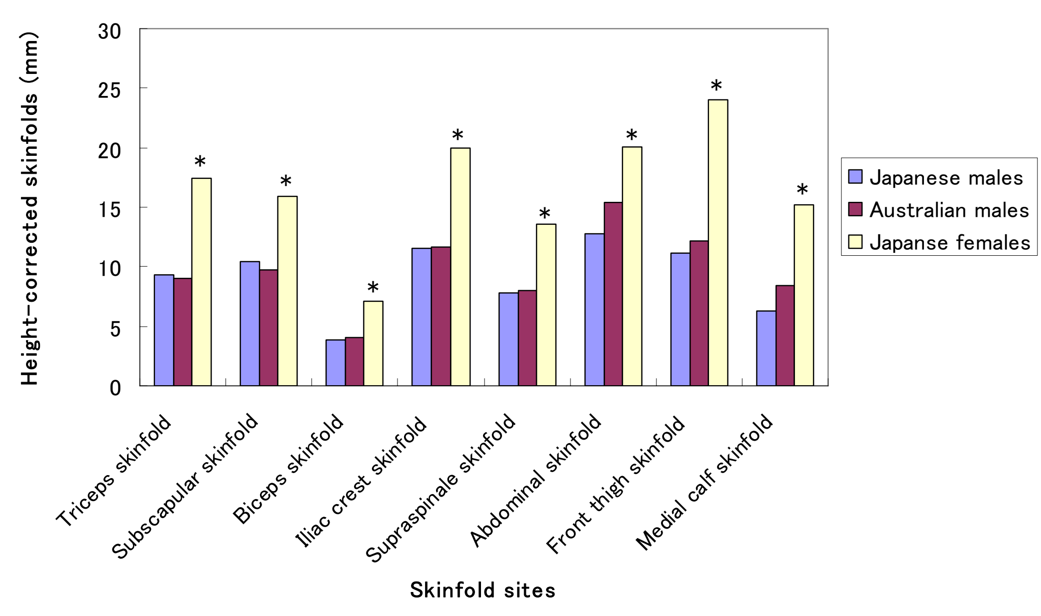


Figure 1. Ethnic and gender differences in subcutaneous fat distribution. Subcutaneous fat distribution pattern was illustrated using height-corrected skinfolds. When the body size (ie, stature) of participants was corrected, no ethnic differences in subcutaneous fat distribution pattern were observed. In comparison, females had significantly greater subcutaneous fat accumulation at all skinfold sites (p<0.05). * Significantly different with Japanese and Australian males at the 0.05 levels.

Table 2. Equations used in the analysis and predicted anthropometric cut-off points

Independent variable		Regression equations	R^2	SEE
LnBMI	Males#	%BF = -100.435 + 2.63*(Ethnicity) + 37.186*(LnBMI)	0.45	4.40
	Japanese females	%BF = -104.279 + 43.553*(LnBMI)	0.61	3.65
Waist circumference	Males#	%BF = -38.859 + 3.771*(Ethnicity) + 0.691*(WC)	0.44	4.46
	Japanese females	%BF = -29.852 + 0.868*(WC)	0.53	4.05
Sum of skinfolds*	Males#	%BF = 2.277 + 1.393*(Ethnicity) + 0.164*(ΣSF)	0.76	2.93
	Japanese females	%BF = 8.848 + 0.151*(ΣSF)	0.84	2.38

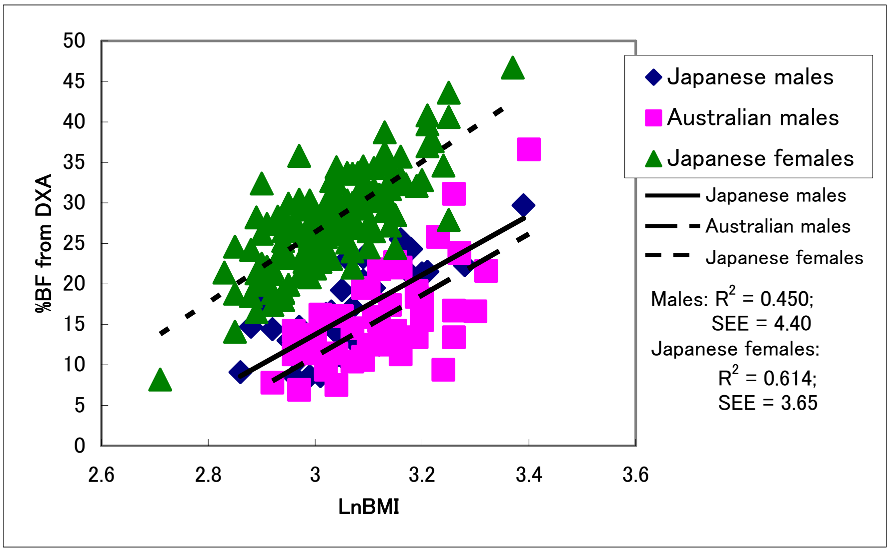
Ethnicity: 0 = Australian males; 1 = Japanese males. * Sum of skinfolds = Σ(triceps, subscapular, biceps, iliac crest, supraspinale, front thigh, medial calf skinfolds) in mm

final equation.

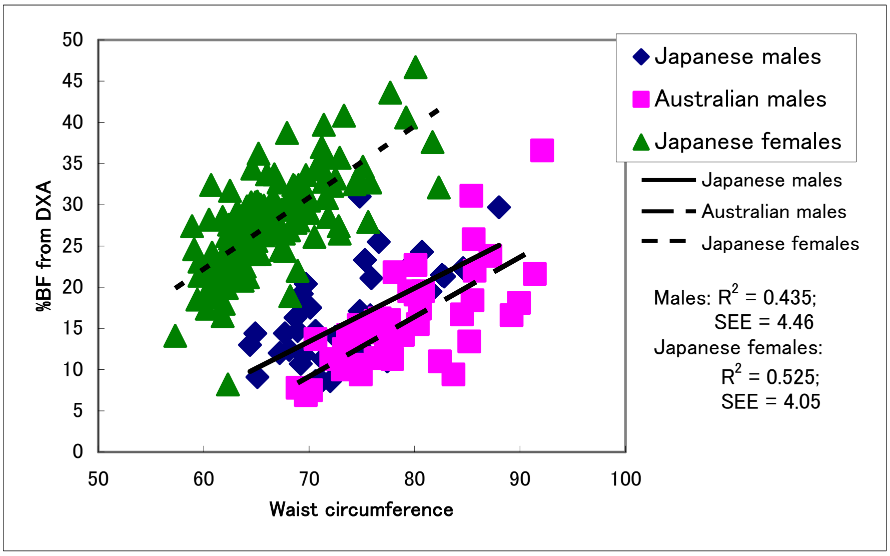
Results

Results of body composition assessments using DXA and anthropometry are shown in Table 1. Australian Caucasian males were significantly greater in stature, body mass, BMI as well as bone mineral density and contents than Japanese males (p<0.05). However measured sum of skinfolds and estimated %BF did not differ between Japanese and Australian males in the current study. In comparison with male groups, Japanese females were smaller in physique but greater in %BF and total subcutaneous fat deposition. Figure 1 shows the relative differences in subcutaneous fat distribution between the study groups. The results showed there is no significant difference in subcutaneous fat distribution pattern between Japanese and Australian Caucasian males but a distinct difference was evident between genders.

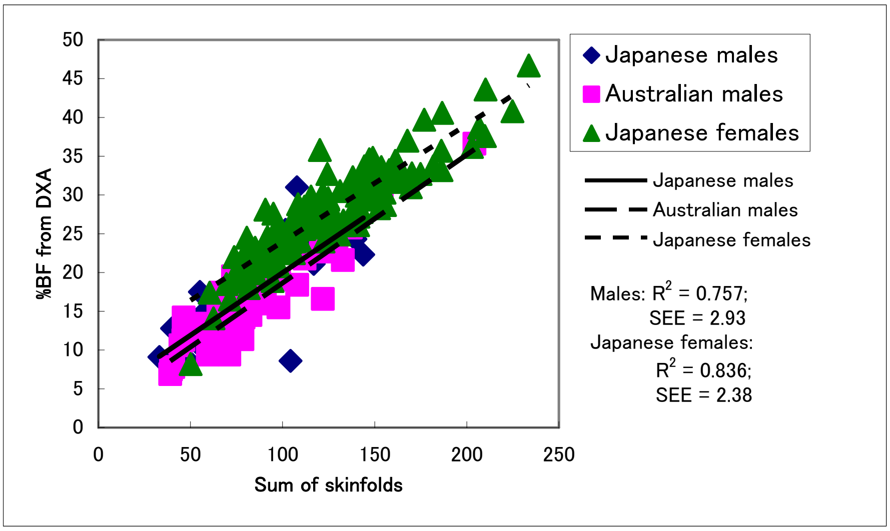
Figure 2 shows relationships between %BF values estimated from DXA scans and a) BMI, b) waist circumference, and c) sum of skinfolds of the study groups. Ethnicity significantly contributed in all relationships and Japanese males had significantly higher %BF at given values of each anthropometric parameter compared to Australian Caucasian males. Japanese females had greater body fat accumulation than male counterparts at the given level of anthropometric indices. The figures show that the slopes of each relationship were almost parallel between genders, suggesting the only difference in relationships between genders is the magnitude of %BF deposition at given an-



a) %BF-BMI relationships



b) % BF-Waist circumference relationships



c) %BF-Sum of skinfolds relationships

Figure 2. Relationships between %BF and anthropometric indices in Japanese and Australian Caucasian males and Japanese females. The relationships between %BF estimated from DXA and a) BMI, b) waist circumference, and c) sum of skinfolds for each study group were plotted. Significant ethnic differences in the regression lines between Japanese and Australian males in all relationships and similarly significant gender differences were observed in Japanese groups.

thropometric values. Table 2 lists the equations established from the regression analyses. It was calculated that Australians have a %BF of 19.3% at a BMI of 25kg/m^2 however the BMI value for Japanese males with the same %BF was about 23kg/m^2. Using a BMI of 23kg/m^2, %BF for Japanese females was calculated to be 32.3%. Using the calculated %BF values, cut-off points for other anthropometric parameters were estimated. The estimated values for Australian males, Japanese males and Japanese females were 84.2cm, 78.7cm, 71.6cm for waist circumferences and 103.8mm, 95.3mm and 155.3mm for ΣSF, respectively.

Discussion

In the current study Japanese males have a smaller body size (ie, stature and body mass) than Australian Caucasian males but have greater body fat deposition at the same anthropometric status. Calculated cut-off points for BMI, waist circumference and sum of skinfolds for Japanese males are therefore lower than their Australian counterparts and this confirms the importance of population-specific cut-off points when screening for obesity. The observed ethnic differences in relationships between %BF-BMI have been suggested to be due to ethnic differences in body proportion and frame size.[20] The ethnic differences in the relationships may be attributed to an as yet unspecified number of factors, including genetic, hormonal or environmental variables. While the current study was unable to identify these potential variables, total body size (ie, stature) was suggested to be an additional structural variable that may contribute to the relationship between %BF and anthropometric indices, in addition to body proportion and frame size. A previous meta-analysis concluded that Japanese have greater visceral fat deposition in relation to the amount of subcutaneous fat.[12] In the current study, however, no ethnic differences in subcutaneous fat deposition were observed after adjusted for the total body size (ie, stature). Considering no ethnic differences in %BF between Japanese and Australian males and no relative subcutaneous fat distribution pattern, there may be no ethnic 'relative' differences in subcutaneous and visceral fat distribution patterns in young adults. Further studies on the influence of body size may allow establishment of height-corrected anthropometric indices that could be used in both Asian and Caucasian young adults.

From the established regression equations anthropometric cut-off points for each study group were calculated. While further research is essential to derive more reliable cut-off points, the values calculated from the equations may assist in health assessments for obesity. To date, cut-off points for waist circumference have been proposed for different ethnic groups and many have been assessed in relation to blood assay and visceral fat accumulation using CT scans that contribute development of metabolic syndrome.[8] In this study waist circumference was determined in relation to %BF obtained from DXA. We found that the study groups have a considerable amount of body fat at much lower waist circumference values than the existing waist circumference cut-off values (Europid males: ≥94cm; Japanese males: ≥85cm; Japanese females: ≥90cm).

Because of the inconsistent definitions of 'waist circumference' used in previous studies and the small sample size of the current study, it is difficult to draw definitive conclusions and a sensible interpretation of the cut-off value differences is required. However it is also important to highlight that, particularly for Japanese cut-off points, values were derived from a sample of mainly middle-aged individuals and hence may not always be useful for young populations. Also Japanese waist cut-off points were proposed in order to diagnose individuals with metabolic syndrome for treatment and therefore not to identify individuals at risk of obesity and related health risks (ie, not for a primary prevention purpose). The current findings were comparable to the findings by Misra et al. [21], which examined appropriate waist circumference cut-off points to improve the health status (an action level) using 2,050 Asian Indians (883 males and 1,167 females aged above 18 years old). While further research is recommended to determine the sensitivity/specificity of existing waist circumference classifications for young adults, it may be important to propose lower waist cut-off points for young population in order to improve its screening capability and also to improve health promotion strategies.

The current study also indicated cut-off points for sum of skinfolds that may reflect obesity risks in both Japanese and Australian young populations. While accuracy and precision of skinfold measurements largely relates to the expertise of the anthropometrist, it is cheap, non-invasive, portable and a convenient method [22,23] and readily available in many countries. This is the first study that determined sum of skinfolds in relation to actual body composition in Japanese and Australian populations and further validation of the calculated cut-off points may be required. However, these values may provide useful for a screening purpose in these populations.

The current study has a number of limitations. Because of the small sample size of males and no Australian female data, it is important to conduct further research using a larger sample size including Australian Caucasian females. Furthermore, the current study was also hampered by the difficulty in comparing results obtained from two different DXA machines (ie, Hologic and Lunar). The current study showed a significant difference in bone mineral density between Japanese males and females. However, the gender differences obtained may simply be due to differences in analysis algorithms of the machines used. To avoid these complications in comparisons across datasets it is necessary to confirm the current findings using the same DXA machine in future studies.

Conclusion

The current study showed ethnic and gender differences in relationships between %BF and anthropometric measures such as BMI, waist circumference and sum of skinfolds using Japanese and Australian Caucasians. These findings underline the importance of population-specific classifications in order to use these indices as useful screening tools for obesity and related health risks. The study results also indicated a possible influence of body size to the observed ethnic differences in the %BF and anthropometric measure relationships. Future studies to confirm this finding may lead to the establishment of body size-corrected indices that can be applied in both ethnic groups.

Acknowledgements

The current study was supported by staff of the Gairdner Bone Densitometry Services, Department of Endocrinology and Diabetes, Sir Charles Gairdner Hospital, Perth, Australia. The research team would like to express their appreciation for the assistance of staff in body composition assessments using DXA. The authors would also like to express their gratitude to Associate Professor Kazuhiro Uenishi and Ms Miki Mori from Kagawa Nutrition University and Miss Chiharu Kuroiwa from Koriyama Institute of Health Science for their assistance in recruitment and data collection in Japan.

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