Original Article

# Is the BMI cut-off level for Japanese females for obesity set too high? – A consideration from a body composition perspective

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The aim of the study was to determine the sensitivity and specificity of the BMI cut-off points that have been applied in the National Nutritional Survey in Japan (NNS-J) for young Japanese females. The relationship between the body mass index (BMI) and percentage body fat (%BF) of 139 young Japanese females (aged 18-27 years old) was examined using dual energy x-ray absorptiometry (DXA) and anthropometry. The sensitivity and specificity of the BMI cut-off point that has been in use in Japan was compared with the cut-off point proposed for Asia-Pacific population (the WPRO classification). The regression equation calculated for the relationship between the BMI and %BF using the DXA scan data was %BF = -15.152+2.058*BMI; $R^2$ = 0.612, SEE = 3.66. From this equation the BMI value that corresponded with %BF of 30% was calculated to be 21.9kg/m$^2$ (95%CI: 16.9-28.6). From the sensitivity and specificity analysis, it was found that more than 90% of Japanese females with %BF >30% were misclassified as "not obese" when the BMI value of 25kg/m$^2$ was used to identify obese individuals. The misclassification reduced to 60% when the BMI value of 23kg/m$^2$ was used as a cut-off point. The results indicate that the current classification used in the NNS-J may not precisely reflect the obesity status of young Japanese females and a considerable proportion of females with a large fat deposition would be misclassified as not obese. The current study shows the importance of including detailed body composition assessments to determine obesity level of individuals.

**Key Words: Body Mass Index, body fat, BMI cut-off points, Japanese, females**

## Introduction

Obesity is a well known risk factor of a number of health problems including hypertension, diabetes, high blood glucose and cholesterol levels and cardiovascular diseases. The World Health Organization (WHO) has proposed using body mass index (BMI: body mass (kg)/stature(m)$^2$) as a simple screening tool of obesity with the value of 25kg/m$^2$ as a cut-off point of "pre-obese".[1] While its application to individuals may be problematic[2,3] BMI has been shown to have a high correlation with these obesity-related health problems in epidemiological studies.[4,5] Previous studies have suggested that Asians have a higher percent body fat (%BF) than Caucasians at the same BMI value and they are likely to develop health problems at lower BMI values than Caucasians.[6-11] This may be associated with ethnic differences in body proportion (i.e proportion of limb or trunk lengths in relation to stature).[12] Considering ethnic differences in the BMI and risk of developing obesity-related health problems, the Regional Office for the Western Pacific Region of WHO, together with the International Association for the Study of Obesity (IASO) and the International Obesity Task Force (IOTF) proposed BMI cut-off points that are suitable for populations living in the Asia-Pacific region (the WPRO classification).[13] In 2004, WHO proposed additional BMI cut-off points of 23kg/m$^2$, 27.5kg/m$^2$, 32.5kg/m$^2$ and 37.5kg/m$^2$ as levels to provide appropriate health advice, depend on ethnic background of the target population.[14]

The National Nutrition Survey in Japan (NNS-J) has shown that obesity has been more prevalent among males than females. Only 7% of the females aged 20-29 years old in the 2002 survey were classified as "obese".[15] The NNS-J classified obesity using the BMI classification defined by the Japan Society for the Study of Obesity (JASSO),[16] which used the same BMI cut-off points for "underweight" as the WHO classification (ie, 18.5kg/m$^2$) but classified individuals with the BMI value of 25kg/m$^2$ as "obese" instead of "pre-obese".

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Accepted 30th April 2006

**Table 1.** Physical characteristics of Japanese females obtained from anthropometry and whole-body DXA scan

| | Japanese females ($N$ = 139) mean ± standard deviation |
|---|---|
| Age (years) | 20.4 ± 1.3 |
| Stature (cm) | 158.8 ± 5.0 |
| Body mass (kg) | 52.5 ± 6.1 |
| BMI (kg/m$^2$) | 20.8 ± 2.2 |
| Percent body fat using DXA (%) | 27.6 ± 5.9 |
| BMD (g/cm$^2$) | 1.14 ± 0.07 |
| BMC (g) | 2351.6 ± 266.5 |
| Sum of skinfolds (mm) | 124.5 ± 35.5 |
| Height-corrected sum of skinfolds (mm) | 133.5 ± 38.3 |

Individuals who had their BMI ≥25kg/m$^2$ are advised to undergo further assessment on their waist circumference in order to examine abdominal fat distribution. However, the JASSO classification was not proposed with consideration of the actual relationship between BMI and body fat deposition (BMI-%BF relationship) of Japanese population. As the BMI itself does not reflect the actual amount of body fat of individuals and also because of ethnic differences in the BMI-%BF relationship, it is possible that the JASSO classification may underestimate the proportion of Japanese females with a considerable amount of body fat. Several Japanese studies have described obese individuals who were misclassified as "normal" using the WHO or the JASSO classifications as "masked obese".[17-19] It is possible that misclassifications reported in previous studies are because of the application of inappropriate BMI cut-off points that do not reflect their actual body fatness.

The aim of the current study was to determine sensitivity and specificity of the JASSO classification in young Japanese females by assessing the BMI-%BF relationship of the group based on the body composition results obtained from whole-body dual energy x-ray absorptiometry (DXA) and anthropometry.

## Method

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.[20] In the current study 139 healthy Japanese females volunteers aged 18-27years old were recruited. Each subject 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. Participants were asked if they were pregnant prior to undergo body composition assessment.

*Dual energy x-ray absorptiometry (DXA)*

Body composition of subjects was assessed using dual energy x-ray absorptiometry (DXA; Lunar® DPX-LIQ). This method is based on multi-compartment model and considered as one of the methods that provide relatively valid estimation of %BF.[21-23] A whole-body DXA scan provides information on bone mineral density (BMD), bone mineral content (BMC), fat mass, lean mass, and %BF of the entire body and different body sections (eg., head, trunk and limbs). Every subject was asked to remove all accessories and metallic items before their body composition measurements. The DXA measurements were completed in approximately 10 min and all measurements were conducted by an accredited technician.

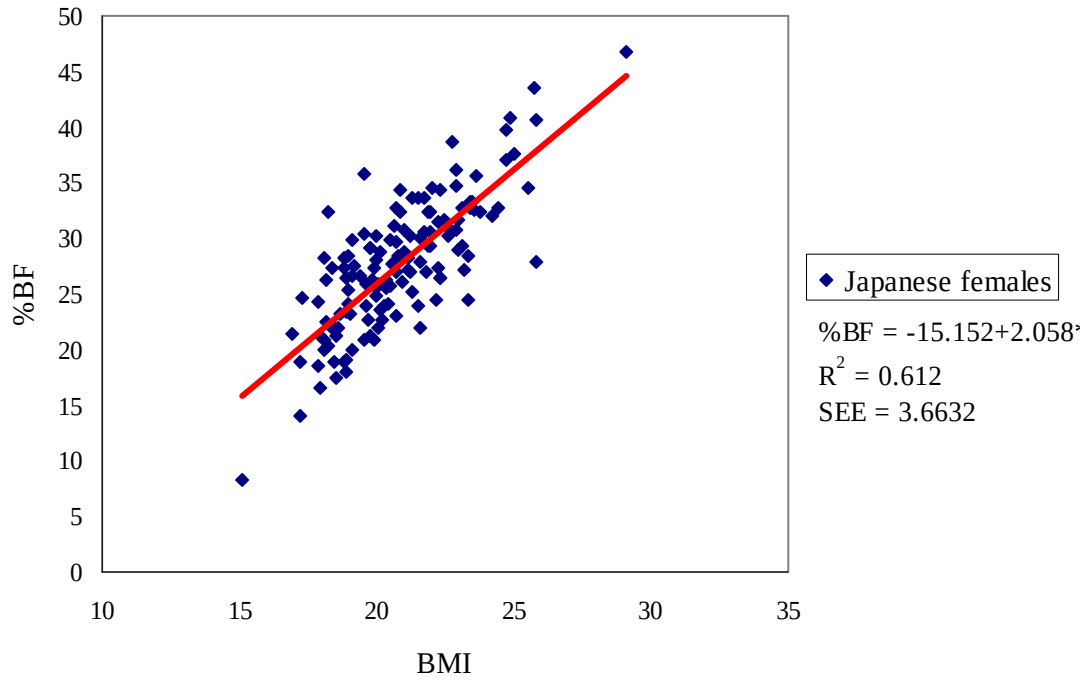


**Figure 1.** The BMI-%BF relationship of Japanese females

**Table 2.** A comparison of specificity and sensitivity of the JASSO and the WPRO BMI cut-off points for obesity and overweight (at risk) in relation to estimated %BF using a whole-body DXA scan

| The JASSO classification (%)[1] | | |
|---|---|---|
| | %BF < 30% | %BF ≥ 30% |
| BMI < 25kg/m$^2$ | 98.9 | 91.1 |
| BMI ≥ 25kg/m$^2$ | 1.1 | 8.9 |
| **The WPRO classification (%)[2]** | | |
| | %BF < 30% | %BF ≥ 30% |
| BMI < 23kg/m$^2$ | 94.7 | 60.0 |
| BMI ≥ 23kg/m$^2$ | 5.3 | 40.0 |

[1] The BMI classification proposed by the Japanese Society for the Study of Obesity.

[2] The BMI classification proposed by the Regional Office for the Western Pacific Region of WHO, together with the International Association for the Study of Obesity (IASO) and the International Obesity Task Force (IOTF).

*Anthropometry*

Anthropometry measurements include stature, body mass, eight skinfolds measurements (triceps, subscapular, biceps, iliac crest, supraspinale, abdominal, front thigh and medial calf), five girths measurements (relaxed arm, flexed and tensed arm, waist, gluteal and maximum calf), and four bone breadths 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).[24] The measurements were conducted by a Level 3 and a Level 1 anthropometrists who were accredited by ISAK and their technical error of measurements (TEM) were within the acceptable limits proposed elsewhere.[25] All measurement sites for each subject were located by the Level 3 anthropometrist prior to the measurements. From the measurements BMI, sum of eight skinfolds and height-corrected sum of eight skin-folds (sum of skinfolds*(170.18/stature)) were calculated.

All statistical analyses were conducted using the SPSS® (version 10.05, 1999, Chicago) statistical package. A stepwise regression analysis was conducted to develop the regression equation using %BF results from DXA scan as a dependent variable and BMI and age as independent variables. In addition, cross-tabulation was also used to assess specificity and sensitivity of different BMI classifications. Based on previous recommendations[26,27] %BF of 30% was used as a cut-off point of obesity for Japanese females. The sensitivity and specificity results obtained from the JASSO classification was compared with the results using the WPRO cut-off point.

## Results

Results of body composition assessments using DXA and anthropometry are shown in Table 1. Figure 1 shows the relationship between BMI and %BF obtained from DXA scan. The BMI-%BF relationship of Japanese young females was determined by a stepwise regression analysis using %BF as the dependent variable. While age was initially considered as an independent variable, it was excluded from the final model. The final equation was %BF = -15.152+2.058*BMI with $R^2$=0.612 and SEE = 3.6632. Using this equation, the BMI value at which the corresponding %BF was 30% was calculated to be 21.9 (95%CI: 16.9kg/m$^2$-28.6kg/m$^2$). The results indicate a possible misclassification of Japanese females who have a considerable amount of body fat even though their BMI's are below 25, which the JASSO classification used as a cut-off point of obesity.

Differences in magnitudes of misclassification between the JASSO and the WPRO classifications were compared using sensitivity and specificity analysis (Table 2). While the BMI value of 25kg/m$^2$ has been used as a cut-off point of "overweight" for the WHO classification and "obese" for the JASSO classification, the current study showed that 91% of Japanese females who had a %BF or more than 30% were classified as not overweight or obese using this value as a cut-off point. In comparison, a proportion of misclassified individuals reduced to 60% when the BMI value of 23kg/m$^2$, the cut-off point of "overweight (at risk)" in the WPRO classification, was used.

## Discussion

Results from the current study showed that young Japanese females are likely to have a large amount of fat deposition in relation to their BMI values. This is similar to the pattern observed in young Japanese males[28] and supports previous findings that Asians have high %BF at lower BMI values when compared to Caucasian subjects.[12,29] The stature and body mass of Japanese females who participated in the current study were comparable to the 20 years old age category of the 2002 NNS-J.[15] This suggests that the current sample is typical of young Japanese women and the current findings may represent the normative trend of the BMI %BF relationship of young Japanese females.

The current results showed that young Japanese females could have a considerable level of %BF at a relatively low BMI. Based on the JASSO classification, the NNS-J conducted in 2002 reported only 7% of young Japanese females as "obese". However the current findings suggest that it is highly likely that there will be a higher proportion of young Japanese females who should be classified as "obese" and reported in the NNS-J. The results obtained in the current study was consistent to the result using Japanese males living in Australia[30], suggesting that young Japanese are likely to be misclassified if the BMI value of 25kg/m$^2$ was used as a cut-off point of obesity.

The BMI value of 23kg/m$^2$ that has been proposed as the cut-off point of "overweight (at risk)" in the WPRO classification[13] and recently proposed as a one of the cut-off points to recommend public health action by WHO.[14] From the results obtained from the current study it appears that the BMI value of 23kg/m$^2$ reflects actual body fat level of young Japanese females better than the BMI value of 25kg/m$^2$ and therefore maximizes effectiveness of the BMI as a screening tool for the obesity for this specific population.

By saying that, still 60% of young Japanese females were misclassified as "not obese" using the BMI value of 23kg/m$^2$ as the cut-off point. This result illustrates a proportion of body fat deposition among young Japanese females in relation to their body size and weight. Although the current study was unable to clarify the causes of the observed results, it is possible that strong preoccupation toward thinness and dieting behaviours without regular physical exercise are associating to the results. There are Japanese studies that have focused on an issue of "masked obesity", which defined as a condition which one has considerable amount of body fat without having high BMI that classify the individual as "overweight" or "obese".[31] Although a phenomenon of "masked obesity" could derived from inappropriate BMI cut-off points as in the current study, some studies have suggested that an attempt to lose body mass without regular physical exercise has been suggested as one of the causes for "masked obesity"[32] and a greater proportion of females compared to males are "masked obese".[31] These previous results may indicate a reliance of diet restriction as their weight-loss method among young Japanese females and also a possibility of depletion of muscle mass and increase in fat mass by experiencing repeated reduction and regaining of their body mass. As more than 50% of subjects with an excessive level of body fat were misclassified, it is possible that relatively large proportion of young Japanese females may develop health problems at their later stage of life.

Recently a Japanese committee that consists of members from eight medical societies, which include the JASSO and the Japanese Society of Internal Medicine (JSIM), has proposed a screening guideline for a metabolic syndrome.[33] The new guideline proposed using waist circumference measured at the umbilical level with cut-off points of 85cm for males and 90cm for females as the standard criteria and individuals were classified as at risk of metabolic syndrome if they have high waist circumference with any combination of high triglyceride or cholesterol levels, hypertension, or high blood glucose levels. The effectiveness of waist circumference as an index of cardiovascular disease risk has been suggested in several studies[34-36] and the proposed waist circumference values in Japan were based on the study using 1,193 subjects (418 women) that equate with a visceral fat area of 100cm$^2$, the value that considered as a cut-off point of developing coronary heart disease in Japanese.[37] However, it is important to acknowledge that the females participated in the study were mainly middle-aged (mean age: 55 ± 12 years) and it is unlikely for young Japanese females to have a waist circumference of 90cm. The average waist circumference value in the current study was 66.3 ± 4.9cm and the range was 57.3-82.3cm. Although the definition of waist measurement site was not exactly the same, none of the subjects who had excessive level of body fat in the current study had waist values ≥90cm. Therefore it may be appropriate to determine waist circumference level specifically for young Japanese females and its application together with the appropriate BMI cut-off point (i.e BMI value of 23kg/m$^2$) in order to improve detection of young Japanese females who require improvement in their lifestyle to reduce their health risks later in their life.

The current study found that a considerable proportion of young Japanese females with an excessive amount of body fat are likely to being misclassified as not obese using the current classification used in the NNS-J. Future research should be conducted on children and adolescents to examine if the current classification is appropriate to detect individuals with childhood obesity in Japan. In addition, the current study showed a wide 95% CI that ranged from 16.9kg/m$^2$ to 28.6kg/m$^2$. In order to increase the precision of the BMI %BF relationship as well as sensitivity and specificity using different BMI cut-off points, further studies using greater sample size may be required.

## Conclusion

This study aimed to assess sensitivity and specificity of the BMI cut-off points that have been applied in the National Nutritional Survey in Japan (NNS-J) for young Japanese females based on the relationship between the BMI and %BF. While the NNS-J reports a proportion of obese individuals based on the BMI classification using the value of 25kg/m$^2$ as a cut-off point of "obese", the NNS-J report may misclassify young Japanese females who are in fact obese. The current study suggests an application of lower BMI cut-off point would improve screening ability of the BMI. The study also recommends inclusion of body composition and fat distribution assessments in a screening procedure to obtain precise information of body fatness of individuals.

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# Is the BMI cut-off level for Japanese females for obesity set too high? – A consideration from a body composition perspective

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## 日本女性肥胖的標準的身體質量指數切點是否訂太高了?-從體組成的觀點來思考

本研究的主旨為評估已經被運用在日本國民營養調查(NNS-J)中的身體質量指數(BMI)切點，在年輕日本女性的敏感度跟特異度。使用雙能量 X 光吸收儀(DXA)及體位測量評估 139 名年輕日本女性(18-27 歲)的 BMI 與體脂肪率(%BF)的相關。比較目前日本使用的 BMI 切點的敏感度跟特異度與建議使用於亞太族群的切點(WPRO 分類)。使用 DXA 掃描結果的數據去計算 BMI 與體脂肪率的相關，得到的迴歸方程式為%BF=-15.152+2.058*BMI；$R^2$=0.612，SEE=3.66。依照這個方程式，當體脂肪率為 30%時所對應的 BMI 為 21.9 kg/m$^2$ (95% CI=16.9-28.6)。敏感度跟特異度分析發現，以 BMI 值為 25 kg/m$^2$ 當作肥胖的切點時，有超過 90%體脂肪率>30%的日本女性被錯誤分類為非肥胖。當 BMI 值以 23 kg/m$^2$ 為切點時，錯誤分組降低到 60%。此結果指出在 NNS-J 使用目前的分組可能無法確實反映出年輕的日本女性的肥胖狀態，有一大部分身體囤積大量脂肪的女性將被錯誤分組當為非肥胖者。本研究指出在裁定個體肥胖的程度時涵蓋詳細的體組成測量的重要性。

關鍵字：身體質量指數、體脂肪、BMI 切點、日本人、女性。