Short Communication

Obesity screening for young Japanese males and females using skin fold measurements: the classification revisited

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Anthropometric assessment is a simple, safe, and cost-efficient method to examine the health status of individuals. The Japanese obesity classification based on the sum of two skin folds (Σ2SF) was proposed nearly 40 years ago therefore its applicability to Japanese living today is unknown. The current study aimed to determine Σ2SF cut-off values that correspond to percent body fat (%BF) and BMI values using two datasets from young Japanese adults (233 males and 139 females). Using regression analysis, Σ2SF and height-corrected Σ2SF (HtΣ2SF) values that correspond to %BF of 20, 25, and 30% for males and 30, 35, and 40% for females were determined. In addition, cut-off values of both Σ2SF and HtΣ2SF that correspond to BMI values of 23 kg/m^2, 25 kg/m^2 and 30 kg/m^2 were determined. In comparison with the original Σ2SF values, the proposed values are smaller by about 10 mm at maximum. The proposed values show an improvement in sensitivity from about 25% to above 90% to identify individuals with ≥20% body fat in males and ≥30% body fat in females with high specificity of about 95% in both genders. The results indicate that the original Σ2SF cut-off values to screen obese individuals cannot be applied to young Japanese adults living today and modification is required. Application of the proposed values may assist screening in the clinical setting.

Key Words: anthropometry, Japanese, sum of skin folds, obesity, classification

INTRODUCTION

Anthropometry is a non-invasive, cost-efficient approach for health assessment. Percentage body fat (%BF) and skin fold values are highly correlated with criterion body composition assessment methods such as underwater weighing (UWW) and dual energy x-ray absorptiometry (DXA).[1-3] A major advantage of anthropometry is that individuals, including the overweight and obese, can be screened by clinicians in the field where resources may be limited.

In Japan, body composition estimation equations using anthropometry were first proposed by Nagamine and Suzuki.[4] Later, Nagamine proposed the classification of overweight and obesity using the sum of two skin fold thicknesses (Σ2SF: triceps and subscapular) in different age groups including adults (Table 1).[5] The classification is based on Nagamine and Suzuki's equations and also the assumption that the %BF values of 20 and 30% are appropriate cut-off points in the adult population.[6]

Recent screening protocols for obesity or the metabolic syndrome use the body mass index (BMI) or waist circumference (WC) however Σ2SF is still widely used for health assessment in Japan and included in the reference data for clinical use.[7] In part, this may be due to the fact that neither BMI nor WC is a measure of body composition per se and inconsistencies in classification and measurement protocols used in Japan[8,9] compared with the international consensus exist.[10,11] There is ongoing debate regarding the appropriateness of these measures.[12] However, the Σ2SF classification was proposed some decades ago and it is essential to confirm its usefulness to Japanese living today.

The aim of the current study was to examine the ability of Nagamine's Σ2SF classification to screen young Japanese adults today. By revising the classification, the study enables us to observe any changes in subcutaneous fat distribution pattern as well as relationships with %BF or BMI among Japanese adults in the last 40 years.

MATERIALS AND METHODS

Two datasets consisting of 233 Japanese males and 139

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Table 1. Classification of obesity for Japanese adults using the sum of two skin folds (triceps and subscapular)

	Light obese		Obese		Severe obese	
	Males	Females	Males	Females	Males	Females
%BF (%)	20	30	25	35	30	40
Σ2SF (mm)	35	45	45	55	55	60

(modified from Nagamine[5])

Japanese females respectively, aged between 18-40 years were used in this study. Among the 233 Japanese males, 145 were recruited and measured in Perth, Western Australia and 88 were from Himeji, Hyogo prefecture, Japan. All females were recruited and measured at Saitama prefecture, Japan. Data collection for the original studies was approved by the Human Research Ethics Committee of appropriate institutions and each participant provided their written informed consent prior to measurement sessions.

Anthropometric measurements such as stature, body mass and skin folds at triceps, subscapular, iliac crest, supraspinale and abdominal sites were conducted using the international standard proposed by the International Society for the Advancement of Kinanthropometry (ISAK).[13] Male data was collected by a level three (instructor) and three level one anthropometrists accredited by ISAK. Female data was collected by the level three and a level one anthropometrist. Technical error of measurements (TEM) were within the acceptable limits as recommended in the literature.[14] All landmarks were located by the level three anthropometrist. From the anthropometric measurements, the BMI (kg/m^2), Σ2SF, and height-corrected sum of two skin folds (HtΣ2SF: Σ2SF x [170.18/stature in cm]) were calculated using the "phantom" stature of 170.18 cm proposed elsewhere.[15]

Percentage body fat was calculated by first predicting body density (BD) using the gender-specific body density prediction equations proposed by Durnin and Womersley and then using Siri's equation.[16,17] The Durnin and Womersley prediction equation was selected based on previous studies that showed no significant differences in predicted %BF values with results obtained from DXA.[18,19]

All statistical analyses were completed using the SPSS statistical package for Windows (version 14.0, SPSS Inc., Chicago, IL, 2005). Stepwise multiple regression analysis was conducted using %BF as a dependent variable and Σ2SF, HtΣ2SF and age as independent variables. Similarly, relationships between BMI and Σ2SF as well as HtΣ2SF were examined using BMI as an independent variable. In order to normalize the results, Σ2SF, HtΣ2SF and BMI were all transformed using natural logarithm. Once cut-off values for Σ2SF equivalent to the Nagamine's classification were identified, differences in sensitivity (true positive/[true positive + false negative]) and specificity (true negative/[true negative + false positive]) were compared between the proposed and Nagamine's cut-off values. In all analyses, a significance level of 0.05 was applied.

RESULTS

The mean age, stature and body mass were 22.2 ± 3.6 years, 172.1 ± 5.3 cm, and 64.2 ± 8.8 kg for males, and 20.4 ± 1.3 years, 158.8 ± 5.0 cm, and 52.5 ± 6.1 kg for females. Average BMI and %BF were within the "normal" range in both males (BMI: 21.7 ± 2.7 kg/m^2; %BF: 16.5 ± 5.0%) and females (BMI: 20.8 ± 2.2 kg/m^2; %BF: 27.8 ± 4.6%).

Based on equations derived from multiple linear regression analysis (data not shown), Σ2SF and HtΣ2SF cut-off points at the %BF cut-off values adopted in the Nagamine classification as well as BMI values of 23 kg/m^2, 25 kg/m^2 and 30 kg/m^2 were calculated for each gender (Table 2). Based on the relationship with the %BF cut-off points used in the original classification, Σ2SF values of 25 and 35 mm were found to be appropriate as cut-off points to classify males and females as "light obese". Similarly, the BMI value of 23 kg/m^2 had comparable Σ2SF and HtΣ2SF values at %BF values for "light obese" and therefore may also be useful as a cut-off point. As shown in Table 3, the proposed cut-off values provide much higher sensitivity (90.2% for males and 90.7% for females) compared to the original cut-off values (27.5% for males and 23.3% for females) and maintained comparable levels of specificity (97.7% for males and 94.8% for females) to the original cut-off values (100% in both genders). The results indicate that the use of the original cut-off values in the current young Japanese population may misclassify those who may be at risk of obesity.

DISCUSSION

The current study examined the usefulness of the classification of obesity using the Σ2SF cut-off values proposed by Nagamine in the early 1970s.[5] The results indicate that

Table 2. Calculated skin fold cut-off values based on %BF and BMI

Classification	Light obese		Obese		Severe obese	
	Males	Females	Males	Females	Males	Females
%BF (%)	20	30	25	35	30	40
Σ2SF (mm)	24.8	34.6	34.5	48.5	48.1	68.1
HtΣ2SF (mm)	25.1	32.2	35.0	45.3	48.9	63.7
BMI (kg/m^2)	23	23	25	25	30	30
Σ2SF (mm)	22.6	37.6	27.0	45.2	39.6	67.8
HtΣ2SF (mm)	22.8	34.9	27.2	41.8	39.8	62.2

Table 3. Differences in sensitivity and specificity between the proposed Σ2SF cut-off values and the original cut-off values for "Light obese" classification by Nagamine (1972) in a) males, and b) females.

a) Males		
Classification	Specificity/Sensitivity tests*	
Proposed values	%BF	
Σ2SF	< 20%	≥ 20%
< 25 mm	177 (97.3)	5
≥ 25 mm	5	46 (90.2)
Nagamine's values	%BF	
Σ2SF	< 20%	≥ 20%
< 35 mm	182 (100.0)	37
≥ 35 mm	0	14 (27.5)
b) Females		
Classification	Specificity/Sensitivity tests*	
Proposed values	%BF	
Σ2SF	< 30%	≥ 30%
< 35 mm	91 (94.8)	4
≥ 35 mm	5	39 (90.7)
Nagamine's values	%BF	
Σ2SF	< 30%	≥ 30%
< 45 mm	96 (100.0)	33
≥ 45 mm	0	10 (23.3)

* Sensitivity and specificity are stated as % within the brackets.

the Σ2SF values proposed nearly 40 years ago do not provide precise screening outcomes for young Japanese adults today. The average stature and body mass of the participants were comparable to those reported in the Japanese Anthropometric Reference Data (JARD) collected in 2001.[7] Also, considering the comparable results with the national nutrition survey results (e.g. 2004 data for females),[20] it can be stated that the database is representative of the general population for this specific age group.

With consideration of the results of the height-adjusted relative term (HtΣ2SF), the Σ2SF cut-off values of 25, 35 and 50 mm for males and 35, 45 and 65 mm for females may be appropriate to screen obesity risk. Compared to Nagamine's classification, this is a reduction of about 10 mm for the "light obese" and "obese" cut-off values in both genders and about a 5 mm reduction in males and a 5 mm increase in females for the "severe obese" cut-off values. Assessment of sensitivity and specificity using the proposed "light obese" cut-off values found that while the Nagamine cut-off points can identify only about 1/4 of all individuals with high %BF, the proposed cut-off values can identify more than 90% of those who may require clinical intervention. The decrease in the Σ2SF cut-off values in young Japanese may be due to different measurement protocols, including the use of different skin fold calipers. However, the difference may also be attributed to a change in fat distribution pattern and its relationship with total adiposity. While the %BF of the current datasets were greater than the samples reported in Nagamine and Suzuki study,[4] quartile values of both triceps and subscapular skin folds were comparable in both genders (data not shown). This may indicate that young Japanese adults are now likely to have a smaller upper body subcutaneous fat accumulation relative to their total adiposity. In addition, quartile values for abdominal skin fold were greater in males but smaller in females compared with the results reported by Nagamine and Suzuki (data not shown).[4] While the study cannot identify the causes, the results may suggest a possible change in subcutaneous fat distribution pattern over 45 years in both genders.

In addition to the cut-off points based on %BF, the current study also used BMI to determine Σ2SF cut-off values. Although the values were slightly different, the datasets showed consistency in the Σ2SF cut-off values estimated based on a BMI value of 23 kg/m^2 and %BF of 20% in males and 30% in females. In addition, the proposed Σ2SF value for males at the BMI value of 23 kg/m^2 was comparable to the results of another study (males: 25 mm; females: 40 mm) using a larger sample size.[21] The proposed value for females was about 5 mm lower than the previous study, which may be attributed to a smaller sample size (139 vs 549) as well as narrower age range of females in the current study.

Results from the current study suggest that Σ2SF cut-off values used to screen for obesity in young Japanese adults may need to be modified by about 10 mm. While the validity of the revised Σ2SF cut-off values needs to be examined further, the current study indicated that the revised values will be useful in the clinical setting. However the reliability and accuracy of anthropometry largely depends on the skill of the technician and the consistent use of the chosen protocol. Therefore, it is fundamental that measurers and clinicians are well-trained and maintain adequate measurement skills to minimize measurement errors. Skin folds taken by trained measurers can provide reliable fat distribution patterns and level of adiposity. These findings may not be affected by calculation errors from prediction equations and hydration status of participants which influence BIA results. In addition, while the revised values are specific to young Japanese adults, the same approach may be useful to assess the health status of populations in other countries where resources are limited.

It is important to acknowledge the limitations of the present study. Percentage body fat was estimated from gender-specific body density prediction equations by Durnin and Womersley.[16] Although the equations had high correlations and small inter-method variability compared with the results obtained from DXA,[18,19] the application of prediction equations using anthropometric variables may involve bias in the estimation of %BF. In order to confirm the applicability of the proposed Σ2SF cut-off values, it is recommended that further studies be conducted to measure the body composition of participants using DXA or total body water assessed using the deuterium dilution technique. Further, it is also recommended that future studies include a larger sample size across a wider age range.

AUTHOR DISCLOSURES

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皮脂厚度測量用於日本年輕成人之肥胖篩檢：分級的重新檢視

體位測量是一個簡單、安全與經濟的檢測個人健康狀況的方法。日本以兩項皮脂厚度總和來做肥胖分級的方法，是在約 40 年前所提出，因此是否適用於現今的日本人是未知的。本篇研究的目的是使用兩個日本年輕成人資料庫(233 位男性及 139 位女性)，根據其體脂肪百分比及身體質量指數來檢視兩項皮脂厚度總和的肥胖切點。使用回歸分析，計算出了符合體脂肪百分比切點 (男性 20%、25%、30%；女性 30%、35%、40%)的兩項皮脂厚度總和及經身高校正的兩項皮脂厚度總和的切點值；此外，也計算出了符合身體質量指數切點 (23、25、30 kg/m^2)的皮脂厚度總和及經身高校正的皮脂厚度總和的切點值。與原始的兩項皮脂厚度總和切點值比較，本文建議值都較小，差距最多達 10 mm。建議值對於分辨男性≧20%體脂肪及女性≧30%體脂肪有較好的靈敏度(從 25%提昇至 90%)，在兩個性別都有較高的特異度(95%)。結果指出，以原始的兩項皮脂厚度總和切點來評估肥胖，並不適用於現今的日本年輕成人，修正是必要的。應用本文建議值可以幫助臨床上的評估。

關鍵字：體位測量、日本、皮脂厚度總和、肥胖、分級