Original Article

Accuracy of body mass index (BMI) thresholds for predicting excess body fat in girls from five ethnicities

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The association between body mass index (BMI) and body fat in young people differs among ethnic groups. Consequently, BMI thresholds for defining childhood overweight may not represent an equivalent level of adiposity in multiethnic populations. The objectives of this study were to characterise the relationships between BMI and percentage body fat (%BF) and to determine the appropriateness of universal BMI standards for predicting excess fatness in girls from five ethnic groups. The BMI and %BF of 1,676 European, Maori, Pacific Island, East Asian, and South Asian girls aged 5-16 years were determined using anthropometric and bioimpedance measurements. Receiver operating characteristic (ROC) curves were prepared to assess the sensitivity and specificity of the International Obesity Taskforce (IOTF) and Centers for Disease Control and Prevention (CDC) BMI thresholds for detecting %BF >85th percentile. Compared with European girls, South and East Asians averaged 4.2% and 1.3% more %BF at a fixed BMI and age, whereas Pacific Islanders averaged 1.8% less %BF. Areas under the ROC curves ranged from 89.9% to 92.4%, suggesting that BMI is an acceptable screening tool for identifying excess adiposity. However, the IOTF and CDC thresholds showed low sensitivity for predicting excess %BF in South and East Asian girls, with low specificity in Pacific Island and Maori girls. The development of an ethnic-specific definition of overweight improved diagnostic performance. We conclude that BMI can be an acceptable proxy measure of excess fatness in girls from diverse ethnicities, especially when ethnic-specific BMI reference points are implemented.

Key Words: epidemiology, ethnicity, child, adolescent, obesity

INTRODUCTION

Body mass index (BMI), a simple anthropometric measure of weight divided by squared height, is the most widely used screening tool for overweight and obesity. While evidence suggests that BMI can provide an acceptable proxy measure of body fatness in young people,[1, 2] the natural increases in BMI that occur with age necessitate the use of age-specific thresholds. The US Centers for Disease Control and Prevention (CDC) growth charts are routinely applied to identify children and adolescents with a BMI greater than the 85th or 95th percentile.[3] However, the appropriateness of an American dataset for defining overweight in young people from other populations is questionable. As an alternative, the International Obesity Task Force (IOTF) developed age-specific BMI curves that pass through the adult standards for overweight and obesity at age 18 y (25 kg/m² and 30 kg/m², respectively).[4] The latter thresholds are now the most frequently used classification for childhood overweight and obesity in public health research.

Key to the international applicability of the IOTF reference values was their development from a multi-country dataset. However, averaging values from different countries does not ensure the suitability of a single set of BMI standards in all populations. Much like the age and sex-specific variation observed in the association between BMI and body fat, differences also exist across ethnic groups. For example, young people of East Asian,[5]

South Asian,[6] and Hispanic[7, 8] descent tend to have more body fat than Europeans at an equivalent BMI. Conversely, Polynesian[9] and African-American[10] children and adolescents average less body fat than their European counterparts for the same BMI. These findings suggest that a universal BMI classification system for childhood overweight may not correspond to a comparable level of body fatness in all populations. The identification and management of excess body fatness may be confounded in certain individuals, while BMI-based prevalence estimates may not accurately characterise the population groups most at risk of health disadvantages.

To date, research assessing the diagnostic accuracy of the IOTF BMI standards has been based on individual ethnic groups with relatively small age ranges.[11-14] All studies reported less than optimal sensitivity, with values ranging from 22% in Swedish girls aged 17 y to 72% in UK girls aged 7 y,[12] and 46% in UK boys aged 7 y,[12] to 83% in Chinese boys aged 6-11 y.[11] Low sensitivity in

these populations reflects an inability to accurately detect individuals with high body fat, resulting in excessive misclassification of overweight young people as normal weight. The only study to compare the IOTF and CDC criteria concluded that the CDC reference values were superior for detecting overweight in Swiss children.[14] However, there is a clear need to investigate the performance of both methods in a multiethnic sample. The objectives of the present study were to: [1] compare body fatness at a given BMI in girls from five diverse ethnic groups (European, Maori, Pacific Island, East Asian, and South Asian), [2] investigate the sensitivity and specificity of the CDC and IOTF reference values for detecting excess body fat in a multiethnic sample, and [3] examine the appropriateness of ethnic-specific BMI cut-off points for predicting body fatness in girls.

MATERIAL AND METHODS

Subjects

A total of 1,676 participants aged 5-16 y (school years 1-10) were randomly selected from 39 primary, intermediate, and secondary schools in Auckland, New Zealand. The age and ethnicity of each child was determined from the information provided by the parents upon enrollment in the school. The ethnic composition of this sample was 680 European (40.6%), 355 Pacific Island (21.2%), 216 Maori (12.9%), 243 East Asian (14.5%), and 182 South Asian (10.9%). The East Asian ethnic grouping composed of: Chinese (53.5%), Korean (25.5%), Filipino (10.7%), Thai (4.5%), and 'other' East Asian (5.8%) girls; and the South Asian grouping was composed of: Indian (93.4%), Sri Lankan (5.5%), and 'other' South Asian (1.1%) girls. Ethical approval for this study was obtained from the Auckland University of Technology Ethics Committee. Written informed consent was provided by each participant and her legal guardian.

Body composition analyses

The height of each participant was measured to the nearest mm with a portable stadiometer (Design No. 1013522, Surgical and Medical Products, Seven Hills, Australia). Weight in light clothing without shoes was measured to the nearest 0.1 kg on a digital scale (Model Seca 770, Seca, Hamburg, Germany). Body mass index was then calculated as weight (kg) divided by squared height (m²). Body fat measurements were obtained using hand-to-foot bioelectrical impedance analysis (BIA). While previous research in New Zealand children indicates that BIA is not sufficiently precise for individual diagnoses (CV = 5.4-8.0%), the absence of significant bias when compared with isotope dilution warrants its use in population research.[9,15] Resistance (R) was measured at 50 kHz using a bioimpedance analyzer (Model BIM4, Impedimed, Capalaba, Australia) with a tetrapolar arrangement of self-adhesive electrodes (Red Dot 2330, 3M Healthcare, St Paul, MN, USA). After swabbing the skin on the right hand and foot with alcohol, source electrodes were placed on the dorsal surface of the foot over the distal portion of the second metatarsal, and on the hand on the distal portion of the second metacarpal. Sensing electrodes were placed at the anterior ankle between the tibial and the fibular malleoli, and at the posterior wrist between the

styloid processes of the radius and ulna. Testing was initiated after the participants emptied their bladder, and had been lying supine with their arms and legs abducted for at least 5 min. Testing was completed when repeated measurements of R were within 1 Ω of each other. Fat-free mass (FFM) was calculated from R, height, and weight using two separate ethnic-specific equations previously validated with deuterium dilution in New Zealand children: one specifically for Maori, Pacific Island, and European children[9] and another for East and South Asian children.[15] The procedures used in this study, including the BIA instrument, were identical to those used to develop the aforementioned FFM prediction equations. Fat mass (FM) was derived as the difference between FFM and body weight, and percentage body fat (%BF) was calculated as 100 × FM/weight.

The BMI status of each participant was determined using the reference values for overweight proposed by the CDC[3] and the IOTF.[4] However, the ideal criterion for the identification of excess %BF has yet to be established. While some researchers have recommended the use of a single %BF value that is directly related to increased health risk in children,[16-19] subsequent research suggests that %BF in children is strongly age-dependent, and that a series of age-specific cut-offs are required to avoid an underestimate of excess adiposity in younger children.[20] Adjustment for ethnicity is also necessary in multiethnic populations to allow for potential variation in body fat profiles. In the present sample, the 85th age- and ethnic-specific percentiles of %BF were used to define overweight. This statistical definition of overweight, although arbitrary, is consistent with current practice in pediatric research.[21] The sample was consolidated into three age groups (5-8, 9-12, and 13-15 years) to enable accurate estimation of the age-adjusted 85th percentile.

Statistical analyses

Data were analyzed using SPSS version 12.0.1 for Windows (SPSS Inc., Chicago, IL). Differences in physical characteristics (age, height, weight, BMI, %BF) among ethnicities were compared using analyses of covariance with Bonferroni post hoc tests where applicable. Sensitivity of the IOTF reference values was defined as the percentage of overweight children (%BF ≥85th percentile) correctly classified, while specificity was defined as the percentage of non-overweight children (%BF <85th percentile) correctly classified. Differences in sensitivity and specificity among ethnic groups were assessed using Bonferroni-adjusted chi-squared tests. Receiver operating characteristic (ROC) curves were used to evaluate the ability of BMI to accurately predict overweight. The age-dependency of the BMI distribution was negated by using BMI z-scores adjusted for age. As there are currently no BMI reference values that account for all five ethnic groups in this study, BMI z-scores were generated with data from the present sample. The ROC curves for each ethnic group were constructed by calculating the sensitivity and specificity of a series of ethnic-specific BMI z-score percentiles (1-100) for predicting overweight (%BF < 85th percentile). The area under the curve (AUC) was then calculated as an indicator of the overall predictive ability of BMI in each ethnic group.

RESULTS

Table 1 shows the characteristics of the study population according to ethnicity. The only significant difference in age was that East Asian girls were older than European and South Asian girls (p <0.001). Pacific Island girls were heavier than all other groups (p <0.001), and taller than all groups except Maori (p <0.005). In addition, Maori girls averaged higher body weights than the remaining three ethnicities (p <0.001). BMI varied significantly across ethnicity (p <0.001): Pacific Islanders were larger than all other groups (p <0.001); followed by Maori, who were larger than European, East Asian, and South Asian girls (p <0.001). Significant differences in %BF were also observed: Pacific Island and South Asian girls had more body fat than European and East Asian girls (p <0.001), and Maori girls had more body fat than European girls (p <0.001). Table 2 shows the variation in the age- and ethnic-specific 85th percentiles used to define overweight in this study.

Figure 1 compares the mean (± 95% CI) %BF of European, Maori, Pacific Island, East Asian, and South Asian girls after adjustment for differences in age and BMI (ANCOVA). Significant differences in %BF were observed across the five ethnic groups (p <0.001). In particular, Asian and Pacific Island girls showed contrasting %BF characteristics. South Asian girls had the highest %BF at a given BMI and age (31.0 ± 0.6%), which was significantly greater than the four remaining ethnicities (p <0.001). East Asian girls had the next highest %BF (28.1 ± 0.5%), which was significantly greater than that of European, Maori, and Pacific Island girls (p <0.001). At the other extreme, Pacific Island girls had the lowest %BF at a given age and BMI (25.0 ± 0.4%), which was significantly different than all other ethnic groups (p <0.01). The level of %BF at a given BMI and age was similar between Maori (26.2 ± 0.5%) and European (26.8 ± 0.3%) girls (p = 0.392).

Figure 2 shows the ROC curves of BMI z-score per-

Table 1. Physical characteristics of the study population.[†]

	European (n = 680)	Maori (n = 216)	Pacific Island (n = 355)	East Asian (n = 243)	South Asian (n = 182)
Age (y)	11.4 ± 2.9	11.5 ± 2.6	11.9 ± 2.9	12.1 ± 2.6	11.3 ± 2.5
Height (m)	1.47 ± 0.17	1.50 ± 0.16	1.52 ± 0.17	1.47 ± 0.15	1.45 ± 0.15
Weight (kg)	44.1 ± 16.0	51.5 ± 20.1	58.6 ± 22.2	42.9 ± 13.2	41.2 ± 14.6
BMI (kg/m^2)	19.6 ± 4.0	22.1 ± 5.5	24.2 ± 6.0	19.2 ± 3.4	19.0 ± 4.2
Body fat (%)	25.5 ± 6.6	27.6 ± 7.2	28.8 ± 6.9	26.4 ± 4.4	29.0 ± 5.2

[†]All values are $\bar{x}$ ± SD.

Table 2. Eighty-fifth percentiles of %BF for each age and ethnic group

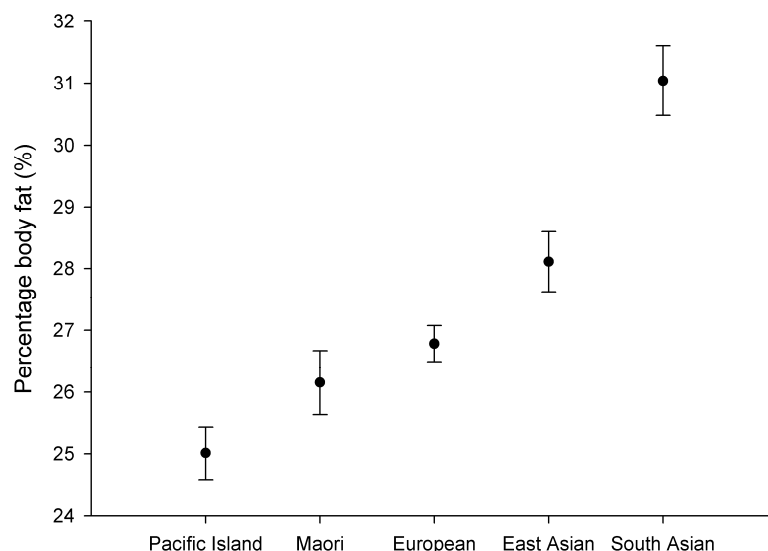| Age Group	European	Maori	Pacific Island	East Asian	South Asian
5-8 years	27.8%	29.7%	26.9%	27.9%	33.7%
9-12 years	32.7%	36.1%	34.4%	29.8%	33.3%
13-15 years	33.9%	33.9%	37.8%	31.8%	36.1%

Figure 1. Percentage body fat ($\bar{x}$ ± 95% CI) in European, Maori, Pacific Island, East Asian, and South Asian females when corrected for differences in age and BMI (ANCOVA).
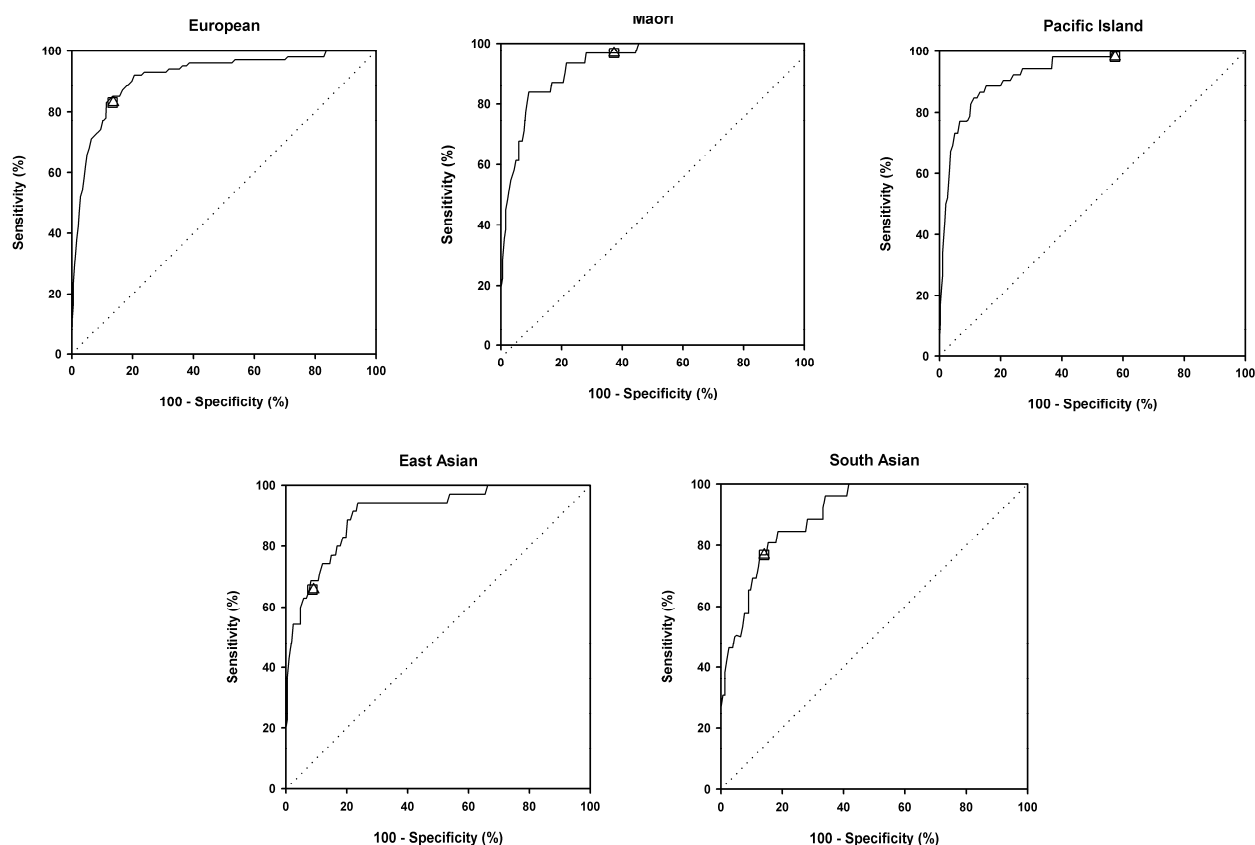
Figure 2. Receiver operating characteristic (ROC) curves of body mass index z-score percentiles 100-1 (left to right) for the prediction of overweight (%BF > 85th percentile) in European, Maori, Pacific Island, East Asian, and South Asian girls. The sensitivity and specificity of the Centers for Disease Control and Prevention (CDC; □) and International Obesity Task Force (IOTF; Δ) BMI reference standards for overweight are given for each ethnic group.

Table 3. Area under the receiver operating characteristic curves (AUC) of BMI z-score percentiles (1-100) and the optimum BMI z-score percentiles

Ethnicity	AUC ± SE	Optimum BMI z-score Percentile[†]	Sensitivity[‡] (%)	Specificity[‡] (%)
European	0.907 ± 0.020	70th	90	80.3
Maori	0.922 ± 0.034	69th	90.3	78.9
Pacific Island	0.924 ± 0.026	69th	90.4	79.2
East Asian	0.899 ± 0.036	68th	91.4	77.9
South Asian	0.899 ± 0.041	58th	92.3	66.7

[†]First percentile where the sensitivity is ≥ 90.
[‡]Criterion = 85th percentile of body fat for each age and ethnic group.

centiles for prediction of overweight in each ethnicity in addition to the CDC and IOTF positions for overweight. The sensitivity of both thresholds was lowest among East and South Asian girls, whereas the corresponding values for specificity were high among these groups. Conversely, sensitivity was high and specificity relatively low in Maori and Pacific Island girls. In European girls, sensitivity and specificity values were similar. Chi-squared analyses revealed significant differences in the sensitivity and specificity (p <0.001 for both) of the CDC/IOTF thresholds for overweight across the different ethnic groups.

Table 3 gives the area under the ROC curves for the different ethnic groups and the optimum BMI z-score percentiles (first percentile where sensitivity ≥90) for predicting the 85th percentile of %BF. No significant differences were observed among AUC values. Although the sensitivity of these thresholds was similar among ethnicities ($\chi^2 = 5.62$, $p = 0.229$), specificity showed significant ethnic variation ($\chi^2 = 20.8$, p <0.001). The use of alternative criteria for defining the optimum percentile for predicting high body fat (maximum sum of sensitivity and specificity; the left-most point in the ROC curve) produced equivalent results. When compared to the CDC/IOTF cut-off points, the use of ethnic-specific percentiles offered significant improvements in sensitivity for East Asian girls ($\chi^2 = 6.87$, $p = 0.009$), but not for European ($\chi^2 = 2.10$, $p = 0.147$), Maori ($\chi^2 = 5.44$, $p = 0.076$), Pacific Island ($\chi^2 = 2.83$, $p = 0.093$), or South Asian ($\chi^2 = 2.36$, $p = 0.124$) girls. While significant improve-
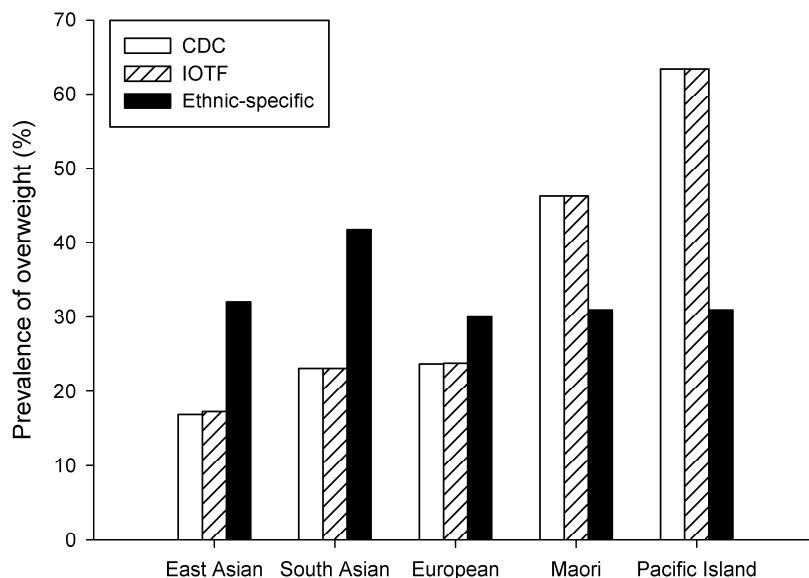
Figure 3. Prevalence of overweight in European, Maori, Pacific Island, East Asian, and South Asian females as defined by the Centers for Disease Control and Prevention (CDC), the International Obesity Task Force (IOTF), and ethnic-specific thresholds developed in the present study (first percentile where sensitivity ≥ 90).

ments in specificity were observed for Maori ($\chi^2 = 11.8$, $p = 0.001$) and Pacific Island ($\chi^2 = 85.4$, $p < 0.001$) girls, specificity decreased in European ($\chi^2 = 8.58$, $p = 0.003$), East Asian ($\chi^2 = 13.3$, $p < 0.001$), and South Asian ($\chi^2 = 15.9$, $p < 0.001$) girls.

The prevalence of overweight in the study sample for the ethnic-specific BMI thresholds and the CDC/IOTF criteria is presented in Figure 3. Compared with CDC/IOTF estimates, ethnic-specific percentiles resulted in a significant increase in the prevalence of overweight in East Asian ($\chi^2 = 14.3$, $p = 0.006$) and South Asian ($\chi^2 = 14.5$, $p = 0.006$) girls, and a significant decrease in Maori ($\chi^2 = 10.6$, $p = 0.031$) and Pacific Island ($\chi^2 = 74.7$, $p < 0.001$) girls. The minor increase observed in European girls was not statistically significant ($\chi^2 = 6.59$, $p = 0.159$).

DISCUSSION

Despite the widespread use of BMI as a screening tool for overweight and obesity in children, there is evidence that it is not a consistent predictor of %BF across all ethnicities.[5-10] This ethnic variation has the potential to confound the identification of those at risk of negative health outcomes related to excess adiposity. Our results suggest that South Asian girls, in particular, have significantly higher body fat levels at a fixed BMI and age than other ethnic groups. The propensity for South Asians to accumulate higher levels of body fat despite their relatively small body size has been demonstrated formerly in both adolescents[6] and adults,[22] and is a concern for the future health status of this ethnic group. Although less pronounced, the %BF/BMI ratio in East Asian girls was also greater than European, Maori, and Pacific Island girls. These trends are consistent with previous investigations in Asian populations,[5, 6, 23] and point to a body composition profile dis-

tinctive to Asian ethnicities. It has been suggested that the characteristic Asian body build (high slenderness, low muscularity) may contribute to the variation in relative fat accretion.[24] In contrast, Pacific Island peoples tend to have greater muscle mass and bone mineral density than other ethnic groups,[25,26] evident in the present study as the lowest %BF for a given BMI of all five ethnicities.

It is clear from the preceding findings that a universal BMI-based classification scale for overweight will correspond to markedly different %BF levels in girls from diverse ethnic backgrounds. Not surprisingly, the sensitivity and specificity of both the CDC and IOTF criteria were dependent on ethnic group, with East Asian girls showing the lowest sensitivity (65.7%) and Pacific Island girls the lowest specificity (42.6%). In other words, greater than a third of East Asian girls with excess body fatness were not identified as overweight, whereas over half of Pacific Island girls with normal levels of body fat were incorrectly categorized as overweight. This highlights the potential inconsistencies when applying reference norms that are independent of ethnicity to a multiethnic population.

We also noted that the predictive abilities of the CDC and IOTF BMI thresholds were almost identical in all ethnic groups. This differs from previous research in Swiss children suggesting that the 85th percentile of the CDC data is preferable to the IOTF cut-off points for overweight when predicting excess adiposity (%BF <85th percentile) from multisite skinfold thicknesses.[14] Comparisons of overweight classification criteria from the IOTF, World Health Organization, and a Swedish national survey also revealed performance disparities when estimating the %BF status of Swedish adolescents using air-displacement plethysmography.[13] While the factors responsible for the discrepancies among studies are un-

clear, our data indicate that the ethnic variation in sensitivity and specificity associated with any universal BMI classification system is of greater importance than the differences between specific criteria.

While the disadvantages of using non-specific BMI reference values for predicting fat status in multiethnic populations are evident, the high AUC values obtained in the present study indicate that BMI can still provide an acceptable proxy measure of %BF if cut-off points are tailored to each ethnic group. The optimum BMI z-scores for predicting the 85th percentile of %BF ranged from the 70th percentile in European girls to the 58th percentile in South Asian girls. Application of these ethnic-specific BMI thresholds corrected both the low sensitivity in European, South Asian, and East Asian girls (although only the latter was statistically significant) and the low specificity in Maori and Pacific Island girls. However, as with any threshold adjustment to an imperfect screening instrument, an increase in sensitivity is accompanied by a subsequent decrease in specificity (and vice versa). For instance, raising the sensitivity in East Asian girls from 65.7% (IOTF) to 91.4% (ethnic-specific) resulted in a decrease in specificity from 90.9% to 77.9%. This raises the question of which parameter is considered the most important. If minimizing incorrect classifications of overweight is the top priority to avoid unnecessary psychological distress, then a high specificity is desirable. Alternatively, if it is essential that those with excess adiposity are not overlooked by lifestyle interventions or clinicians, greater emphasis should be placed on achieving high sensitivity. Naturally, these preferences will vary depending on the purpose of the study, and will require resolution before the most appropriate BMI criteria can be established.

To better understand the implications of the ethnic-specific adjustments described in this study, the effects on the prevalence of overweight in the study sample were estimated. Compared with the CDC/IOTF criteria, the use of the ethnic-specific thresholds resulted in significant increases in the number of East and South Asian girls classified as overweight, as well as considerably fewer Maori and Pacific Island girls classified as overweight. Thus, applying ethnic-specific classification systems for young people in national and international surveys will likely initiate major changes to the monitoring and surveillance of 'high risk' groups. For example, Maori and Pacific Island children in New Zealand are viewed as the priority groups for obesity prevention in government strategies, while Asian children are often overlooked.[27] Our findings suggest that South and East Asian girls should be included within this priority grouping.

Another point for discussion is the practicality of applying ethnic-specific cut-offs in real world settings. Introducing multiple cut-off points may make classification too complex for users thereby limiting their acceptance. The publication of thresholds for only the major ethnic groupings would limit complexity but would also reduce diagnostic accuracy. Alternatively, one reference dataset (such as the CDC growth charts) could be used as the template with different ethnic cut-off points corresponding to different BMI percentiles from the same dataset. However, it is uncertain whether growth charts generated overseas accurately reflect the change in BMI within other populations. We suggest that it would be preferable to use data from the existing population to develop BMI thresholds for overweight.

A limitation of the present study is that only female participants were assessed. It is possible that the relationship between BMI and %BF in boys may not follow the same ethnic variation observed in girls. Rush et al[9] found that %BF at a fixed BMI varied among European, Maori, and Pacific Island girls but not among their male counterparts. This suggests that a universal BMI criterion may be adequate for predicting overweight in boys from these three ethnic groups. In contrast, the significant difference in relative %BF levels reported in European and Asian boys supports the use of ethnic-specific thresholds for these populations.[5,6] Although gender differences in the performance of universal BMI criteria have been reported in individual ethnic groups,[11-14] further research is required to elucidate the role of gender on diagnostic accuracy in a multiethnic sample.

In addition, subsuming a number of Asian ethnicities into the wider groupings of 'East Asian' and 'South Asian' may have masked differences between individual Asian groups (e.g., between Chinese and Korean girls). While there is evidence of variation in body composition between certain Asian populations,[5] the number of Asian participants in the present study permitted only two ethnic groupings (East Asian and South Asian) to be assessed with sufficient statistical power. It may be beneficial to develop a more detailed understanding of ethnic disparity by targeting specific Asian populations in future studies. However, it is unlikely that the differences within East Asian or South Asian children will surpass the observed variation between these wider ethnic groups.

The definition of overweight used in this study was based on the 85th percentile of %BF after adjustment for age and ethnicity. Previous research in European children has shown that this threshold yields a similar proportion of overweight individuals as the IOTF BMI cut-off points.[21] However, we know little about the ethnic variation in health risk across a range of %BF values. It is possible that girls from diverse ethnic groups begin to experience health complications at markedly different levels of adiposity. This brings into question the selection of a generic %BF threshold to represent an equivalent degree of health risk in a multiethnic population. Clearly, there is an immediate need for information describing the dose-response relationship between %BF and health risk in young people. The delayed onset of numerous health complications related to overweight during childhood makes this a difficult undertaking.

In summary, this study represents the first multiethnic investigation of the predictive ability of universal BMI criteria for childhood overweight. Our results show that the CDC and IOTF reference values provide an equivalent degree of sensitivity and specificity that varies substantially among girls from different ethnic groups. The relatively high %BF for a given BMI in South and East Asian girls corresponded to a low sensitivity and a high specificity, whereas girls of Pacific Island descent experienced the opposite trend. Adjusting the BMI threshold parameters to the optimum diagnostic profile in each eth-

nic group resulted in significant improvements to sensitivity and specificity in East Asian and Pacific Island girls (respectively), with positive but non-significant effects on sensitivity in South Asian girls. These findings indicate that ethnic-specific BMI cut-off points can provide an acceptable screening tool for overweight in girls from ethnically diverse populations.

AUTHOR DISCLOSURES

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Original Article

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可準確預測五種族女孩過多體脂肪的身體質量指數（BMI）切點

在不同種族的年輕族群中，身體質量指數(BMI)與體脂肪相關性也有所不同。因此，在不同種族人口中，定義兒童過重的 BMI 切點可能與肥胖程度不符。本篇研究目的在找出五種族女孩中，BMI 與體脂肪比例(BF%)之關係，並探討以 BMI 通用標準預測過度肥胖的適當性。共有 1,676 位含歐洲裔、毛利族、太平洋島嶼族、東亞和南亞族裔的 5-16 歲女孩，接受體位測量及生物電阻法測量體脂肪。使用接受器操作特性(ROC)曲線評估國際肥胖工作小組(IOTF)及疾病控制和預防中心(CDC)的 BMI 切點對於偵測體脂肪高於 85 百分位的靈敏度及特異度。結果發現在同一 BMI 及年齡下，與歐裔女孩相比，南亞裔及東亞裔平均%BF 高出 4.2%及 1.3%，但太平洋島裔女孩平均低 1.8%BF。ROC 曲線下面積從 89.9%至 92.4%，因此 BMI 可作為過度肥胖之篩選工具。然而 IOTF 及 CDC 訂定的切點，在預測南亞及東亞裔女孩過高體脂肪時，敏感度較低；而預測太平洋島裔和毛利族女孩時，特異度較低。依種族特異訂出的肥胖標準，診斷的功能較佳。結論，依種族特異性訂定出 BMI 參考點，在不同種族女孩中，BMI 可作為過度肥胖之替代測量。

關鍵字：流行病學、種族、兒童、青少年、肥胖