Lower BMI cut-off value to define obesity in Hong Kong Chinese: an analysis based on body fat assessment by bioelectrical impedance

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There is increasing evidence suggesting that the cut-off values for defining obesity used in the Western countries cannot be readily applied to Asians, who often have smaller body frames than Caucasians. We examined the BMI and body fat (BF) as measured by bioelectrical impedance in 5153 Hong Kong Chinese subjects. We aimed to assess the optimal BMI reflecting obesity as defined by abnormal BF in Hong Kong Chinese. Receiver operating characteristic curve (ROC) analysis was used to assess the optimal BMI predicting BF at different levels. The mean age and SD of the 5153 subjects (3734 women and 1419 men) was 51·5 (SD 16·3) years (range: 18·0–89·5 years, median: 50·7 years). Age-adjusted partial correlation (r) between BMI and BF in women and men were 0·899 (P<0·001) and 0·818 (P<0·001) respectively. Using ROC analysis, the BMI corresponding to the conventional upper limit of normal BF was 22·5–23·1 kg/m2, and the BMI corresponding to the 90 percentiles of BF was 25·4–26·1 kg/m2. Despite similar body fat contents, the BMI cut-off value used to define obesity in Hong Kong Chinese should be lower as compared to Caucasians. We suggest a BMI of 23 kg/m2 and 26 kg/m2 as the cut-off values to define overweight and obesity respectively in Hong Kong Chinese.

Obesity has become a major health problem due to its increasing prevalence and associated morbidity and mortality (Jousilahti et al. 1996; Seidell et al. 1996; WHO, 1998). Increasing BMI is associated with a higher risk of diabetes mellitus, hypertension, and other cardiovascular risk factors in both Caucasians and Asians, such as Hong Kong Chinese (Higgins et al. 1988; Srinivasan et al. 1996; Ko et al. 1998, 1999a). Obesity is characterised by an excess of body fat (BF), which is defined conventionally as BF > 25 % in males and > 35 % in females (young adults aged < 35 years; WHO, 1995; Lohman et al. 1997; Deurenberg et al. 1998). The BMI corresponding to these body fat contents is 30 kg/m2 in young Caucasians (WHO, 1995). Some Western workers also reported a relationship between a BMI cut-off value of 30 kg/m2 with morbidity and mortality. In accordance with this, WHO (1995) recommend a BMI cut-off value for obesity at 30 kg/m2. However, there is increasing evidence suggesting these cut-off levels cannot be readily applied to Hong Kong Chinese, who often have smaller body frames than Caucasians such as Americans (Ko et al. 1999a, b). In this study, we examined 5153 Hong Kong Chinese subjects on their BMI and BF measured by bioelectrical impedance. We aimed to assess the optimal BMI reflecting obesity as defined by abnormal BF in Hong Kong Chinese.

Methods

Subjects

From April 1996 to August 1997, subjects from the community of Hong Kong presented themselves voluntarily at the United Christian Nethersole Community Health Service Centers for primary health care check-up. The United Christian Nethersole Community Health Service is a self-funded non-profit-making organisation with the

Abbreviations: BF, body fat; ROC, receiver operating characteristic curve.

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objective of health promotion through primary health care and education. Interested citizens came from different districts all over Hong Kong. During the study period, 17 121 subjects were recruited. Due to the limitation of resources, BF measurements with bioelectrical impedance were randomly performed in 5153 of these 17 121 subjects (one in three). The BF measurements of these 5153 subjects were analysed in this study.

Demographic data were documented, and height and weight (measured to the nearest 0·1 kg) were measured with the subject in light clothing without shoes. BMI was calculated as the weight (kg) divided by the square of the height (m). Classification of BMI was based on the WHO criteria (1995). Overweight was defined as BMI ≥25 kg/m² and obesity ≥30 kg/m². Increased BF, high BF and very high BF were defined as BF ≥30 %, ≥35 % and ≥40 % in females, and ≥20 %, ≥25 % and ≥30 % in males respectively.

Bioelectrical impedance

All bioelectrical impedance measurements were performed with a bioelectrical impedance analyser (TBF-401; TANITA, Tokyo, Japan). The measurements were performed with the subjects stepping onto the measuring platform without shoes and after wiping the soles of their feet. From weight, height, age, sex and bioelectrical impedance, BF was calculated from a built-in equation of the analyser. The amount of BF is expressed as a percentage of total weight. The analyser produces a printout with data of the BF after every measurement. The day-to-day variation in the measurement of bioelectrical impedance ranges from 0·7 to 1·7 %.

The bioelectrical impedance measurements were validated with 49 Hong Kong Chinese subjects using dual-energy X-ray absorptiometry. Their mean BMI was 23·1 (SD 3·6) kg/m², mean height 1·55 feet. From weight, height, age, sex and bioelectrical impedance, BF was calculated from a built-in equation of the analyser. The amount of BF is expressed as a percentage of total weight. The analyser produces a printout with data of the BF after every measurement. The day-to-day variation in the measurement of bioelectrical impedance ranges from 0·7 to 1·7 %.

The bioelectrical impedance measurements were validated with 49 Hong Kong Chinese subjects using dual-energy X-ray absorptiometry. Their mean BMI was 25·1 kg/m² (body weight: 60·2 (SD 26·2) kg, height: 1·55 (SD 0·16) m). The BF measured by bioelectrical impedance and dual-energy X-ray absorptiometry were 28·9 % (SD 12·8) and 27·3 % (SD 10·3) respectively. The intra-class correlation coefficient (95 % CI) was 0·765 (0·619, 0·860; \( P = 0·149 \)).

Statistical analysis

Statistical analysis was performed using the SPSS (version 9·0) software on an IBM compatible computer. All results are expressed as mean and SD or % (n) where appropriate. Student’s t test and chi-square test were used for between group comparison. A P-value <0·05 (two-tailed) was considered to be significant.

Age-adjusted partial correlation between BMI and BF was calculated in men and women. Receiver operating characteristic curve (ROC) analysis was used to assess the optimal BMI predicting BF at different levels. Youden indexes (Y) were calculated with \( Y = \) sensitivity + specificity − 1. Multiple regression analysis (forward stepwise) was performed with age, BMI and gender as independent variables to predict BF.

Results

Of the 5153 subjects, 3734 (72·5 %) were women and 1419 (27·5 %) were men. The mean age was 51·5 (SD 16·3) years (range: 18·0–89·5 years, median: 50·7 years). Table 1 summarises their BMI and BF. Age-adjusted partial correlations (r) between BMI and BF in women and men were 0·899 (\( P < 0·001 \)) and 0·818 (\( P < 0·001 \)) respectively.

According to ROC analysis, the optimal BMI to predict increased BF, high BF and very high BF were 22·5 kg/m², 24·2 kg/m² and 26·1 kg/m² in women, and 23·1 kg/m², 23·8 kg/m² and 25·4 kg/m² in men respectively. Table 2 summarises the ROC analysis of optimal BMI to predict BF in various age groups.

The 75 percentiles of BF in men and women were 25 and 35 %, respectively while the 90 percentiles of BF in men and women were 29 and 40 % respectively. Table 3 summarises the corresponding BMI to various BF cutoff values according to ROC analysis. In particular, the BMI corresponding to the conventional upper limit of normal BF was 22·5–23·1 kg/m², and the BMI corresponding to the 90 percentiles of BF was 25·4–26·1 kg/m².

### Table 1. BMI and BF of 5153 Hong Kong Chinese subjects

(Values are means and their SD for \( n \) subjects)

<table>
<thead>
<tr>
<th>Total (( n ) 5153)</th>
<th>Women (( n ) 3734)</th>
<th>Men (( n ) 1419)</th>
</tr>
</thead>
<tbody>
<tr>
<td><strong>Age (years)</strong></td>
<td><strong>Mean</strong></td>
<td><strong>SD</strong></td>
</tr>
<tr>
<td>51·5</td>
<td>16·3</td>
<td></td>
</tr>
<tr>
<td><strong>Weight (kg)</strong></td>
<td>57·4</td>
<td>10·6</td>
</tr>
<tr>
<td><strong>Height (cm)</strong></td>
<td>157·6</td>
<td>8·4</td>
</tr>
<tr>
<td><strong>BMI (kg/m²)</strong></td>
<td>23·1</td>
<td>3·6</td>
</tr>
<tr>
<td><strong>BMI ≥ 25 kg/m², % (( n ))</strong></td>
<td>28·2 (1455)</td>
<td>–</td>
</tr>
<tr>
<td><strong>BMI ≥ 30 kg/m², % (( n ))</strong></td>
<td>3·4 (177)</td>
<td>–</td>
</tr>
<tr>
<td><strong>BF (%)</strong></td>
<td>27·7</td>
<td>7·9</td>
</tr>
<tr>
<td><strong>Increased BF, % (( n ))</strong></td>
<td>54·4 (2802)</td>
<td>–</td>
</tr>
<tr>
<td><strong>High BF, % (( n ))</strong></td>
<td>26·9 (1386)</td>
<td>–</td>
</tr>
<tr>
<td><strong>Very high BF, % (( n ))</strong></td>
<td>9·7 (498)</td>
<td>–</td>
</tr>
</tbody>
</table>

BF, body fat.

\( P \)-values comparing men and women: 
- \( * < 0·05 \)
- \( ** < 0·01 \)
- \( *** < 0·001 \)

Increased BF: BF ≥30 % in women or ≥20 % in men; High BF: BF ≥35 % in women or ≥25 % in men; Very high BF: BF ≥40 % in women or ≥30 % in men.
Discussion

Our study is limited by the validity of using bioelectrical impedance in the measurement of BF. Underwater weighing is the standard method for body composition assessment, which is, however, laborious and inconvenient (Siri, 1961). Solomons & Mazariegos (1995) reviewed various techniques available for the assessment of human body compositions and commented that bioelectrical impedance analysis showed close correlation with other anthropometric measures and BF. BF measurements by the TANITA bioelectrical impedance analyser have been reported to give good estimation of BF in Caucasians (Nunez et al. 1994). The BF by the TANITA were highly correlated with BF measured by both dual-energy X-ray absorptiometry \((r = 0.88, P < 0.001)\) and hydrodensitometry \((r = 0.90, P < 0.001;\) Nunez et al. 1994). Similar positive correlation between BF obtained by TANITA and dual-energy X-ray absorptiometry was also reported in Japanese \((r = 0.893, P < 0.001;\) Sakamoto et al. 1994). We believe the present study, with a vast database on bioelectrical impedance measurements, has provided useful information regarding the validity of using BMI as a measurement of obesity in Hong Kong Chinese.

We have previously reported a much lower mean BMI in Hong Kong Chinese as compared to Americans \((23 \text{ kg/m}^2 \text{ vs. } 26.3 \text{ kg/m}^2;\) Ko et al. 1997). Yet, there is now a wealth of data showing that the prevalence of diabetes and hypertension are reaching epidemic proportions in Asians (Zimmet, 1992). The latest age-standardised prevalence of undiagnosed diabetes and impaired fasting glucose are 2.8 % and 7.3 % respectively in Hong Kong (Ko et al. 1999). These figures are comparable to the recently reported age-standardised prevalence of undiagnosed diabetes of 2.7 % and impaired fasting glucose of 6.9 % in the US according to the NHANES III data (Harris et al. 1998). So, despite having a much lower mean BMI, the prevalence of some of the obesity-related health problems in Hong Kong Chinese is similar to that in Caucasians. In agreement with this, a high likelihood ratio to have diabetes and hypertension has been found in Hong Kong Chinese with a lower BMI as compared to Caucasians (Ko et al. 1997).

<table>
<thead>
<tr>
<th>BF (%)</th>
<th>Definition</th>
<th>Corresponding BMI ((\text{kg/m}^2))</th>
</tr>
</thead>
<tbody>
<tr>
<td>30</td>
<td>Upper limit of normal (conventional)</td>
<td>22.5</td>
</tr>
<tr>
<td>35</td>
<td>75 percentiles</td>
<td>24.2</td>
</tr>
<tr>
<td>36</td>
<td>80 percentiles</td>
<td>24.5</td>
</tr>
<tr>
<td>38</td>
<td>85 percentiles</td>
<td>25.0</td>
</tr>
<tr>
<td>40</td>
<td>90 percentiles</td>
<td>26.1</td>
</tr>
<tr>
<td>20</td>
<td>Upper limit of normal (conventional)</td>
<td>23.1</td>
</tr>
<tr>
<td>25</td>
<td>75 percentiles</td>
<td>23.8</td>
</tr>
<tr>
<td>26</td>
<td>80 percentiles</td>
<td>25.1</td>
</tr>
<tr>
<td>27</td>
<td>85 percentiles</td>
<td>25.1</td>
</tr>
<tr>
<td>29</td>
<td>90 percentiles</td>
<td>25.4</td>
</tr>
</tbody>
</table>

Table 3. The BMI corresponding to various body fat (BF) cut-off values using prediction equation or ROC analysis in Hong Kong Chinese
This raised the possibility that Chinese may have a similar amount of body fat as in Caucasians despite a lower BMI. There are recent publications demonstrating high body fat with ‘relatively’ low BMI among Asians. For the same amount of body fat as Caucasians who have a BMI of 30 kg/m², it has been reported that the corresponding BMI would be 27 kg/m² for Chinese and Malays and 26 kg/m² for Indians (Yap et al. 2000). In a recent review on obesity assessment, Deurenberg & Yap (1999) concluded that the relationship between BF and BMI differs between ethnic groups and, as a consequence, cut-off points for obesity based on BMI will have to be ethnicity specific.

In this study, the mean BMI of 23–1 kg/m² in Hong Kong Chinese was similar to that reported previously (Ko et al. 1997, 1999a), which was much lower than the mean BMI of 26 kg/m² in the US or the UK (Kuczmarski et al. 1994; Lean et al. 1995). The prevalence of obesity using WHO criteria (BMI ≥ 30 kg/m²) in this study is only 3.4%. However, the prevalence of high BF (≥ 35% in females or ≥ 25% in males) was 26.9%, which is similar to the prevalence of obesity (BMI ≥ 30 kg/m²) in Caucasians (Hodge & Zimmet, 1994; Seidell & Flegal, 1997). The conventional upper limit of ‘normal’ in Caucasians with 30% BF in females and 20% in males corresponds to a BMI of 22.5–23.1 kg/m² in Hong Kong Chinese. The 90 percentiles of BF in our studied subjects were 40% in females and 29% in males with a corresponding BMI range of 25.4–26.1 kg/m².

In conclusion, with similar body fat contents, the BMI cut-off for obesity in Hong Kong Chinese should be lower as compared to Caucasians. We suggest a lower BMI cut-off of 23 kg/m² and 26 kg/m² to define overweight and obesity, respectively, in Hong Kong Chinese.

References


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