The Association between Body Mass Index and Body Fat in College Students

大學生身體質量指數與體脂肪之關連性分析

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Abstract

This study explored the association between BMI and body fat assessed by bioelectrical impedance analysis (BIA) in college students. Cross-sectional studies of 2,531 college students were measured. BIA was used to quantify body fat mass (BFM), percentage of body mass (%BF) and visceral fat area (VFA). Significant correlations between BMI and BFM, %BF, VFA were found, respectively (r=0.923, 0.836, 0.912 in male, p<0.001; r=0.920, 0.741, 0.920 in female, p<0.001). Regression analysis revealed that 85.3%, 69.9%, and 83.1% of the variance for BFM, %BF, and VFA could be explained by BMI in male students (p<0.001); and 84.7%, 54.9%, and 84.6% of the variance for BFM, %BF, VFA could be explained by BMI in female students (p<0.001). BFM and VFA were highly associated with BMI in college students, suggesting that BMI serves as a good surrogate marker for obesity in college students aged 18-24 years. However, a significantly medium correlation existed in BMI and %BF, which may be a limitation for BMI, when used to study risk factors for cardiovascular or metabolic diseases.

Key words: body mass index, bioelectrical impedance analysis, body fat, college students

Introduction

Obesity is the most important nutritional disease in the developed countries of the world, where its prevalence has increased particularly rapidly over the last two decades (WHO, 2000). In Taiwan, the prevalence of overweight and obese students increased significantly between 1991 and 2003 (Liou, Huang, & Chou, 2009). Obesity is known to have serious adverse metabolic and cardiovascular consequences (Miller et al., 2004). Obesity is the condition of increased body weight caused by excessive accumulation of fat. Measuring percent body fat (% BF) is an ideal way to
Therefore, the purpose of this study was to evaluate the relationship between BMI and BFM, %BF, VFA. We wished to determine whether BMI measures could be used as surrogate markers to estimate adipose tissue in college students aged 18-24 years.

Method

Subjects

A total of 2,531 (1,648 male and 885 female) college students aged 18-24 years were recruited for this cross-sectional study in central Taiwan in 2008.

Anthropometric Measures

Height was measured to the nearest 0.5 cm using the stadiometer with subjects standing erect without shoes. BMI was calculated as weight (in kilograms) divided by height (in meters) squared.

Bioelectrical Impedance Analysis

Body composition measurements of subjects were carried out with bioelectrical impedance analysis (InBody 720 Body Composition Analyzer, Biospace, Seoul, Korea) by trained personnel. InBody 720 uses an 8-point tactile electrode system that measures the total and segmental impedance and phase angle of alternating electric current at six different frequencies. It was used according to the manufacturer's instructions. Bedogni et al. (2002) pointed out that the InBody 720 device provided precise and accurate estimates of body composition. Subjects took a rest for over 20 min before measurement. Then subjects took off excess clothing, shoes, and socks, stood on the four foot-electrodes on the instrument's platform and held the two palm-and-thumb electrodes with the arms not touching the torso. With these electrodes, microprocessor-controlled switches and impedance analyzer were operated and segmental resistance was measured at six frequencies (1 kHz, 5 kHz, 50 kHz, 250 kHz, 500 kHz, and 1 MHz) and reactance at three specific frequencies (5 kHz, 50 kHz, and 250 kHz). Thus, a set of 30 segmental resistances was measured for each individual. Each subject's height and age were entered, and the body composition data were calculated by the device's software and immediately printed on the paper obtained from the manufacturer.
Statistical Analysis

Means and standard deviations (SD) were calculated for all variables. Continuous variables were tested using the t-test. Pearson correlation coefficient was used to examine the relations between BMI and BFM, %BF, and AFM measured by InBody 720 Body Composition Analyzer. Linear regression analysis was performed with BFM, %BF, and VFA as dependent variables and BMI as independent variable. All analyses were performed using SPSS for window. Statistical significance was set at a level of p<0.05.

Results

A total of 2,531 college students (1,646 males, 855 females) aged 18-24 years were included in this study. Age, anthropometric and InBody 720 measurements data are shown in Table 1. The mean age of the students was 19.74±1.37 years (19.80±1.45 years in male; 19.63±1.21 years in female). The mean BMI of the students was 22.07±3.70kg/m\(^2\) (22.64±3.79kg/m\(^2\) in male 21.00±3.26kg/m\(^2\) in female). The mean BFM was 14.17±7.21kg (13.17±7.61kg in male; 16.01±5.98kg in female). The mean %BF was 22.23±8.53 % (18.58±7.29% in male, 29.02±6.21% in female). The mean VFA was 47.81±27.6 cm\(^2\) (51.71±29.67cm\(^2\) in male; 40.56±21.49cm\(^2\) in female). Variables including height, weight, BMI, and VFA were significantly (p<0.001) higher in male than in female. Whereas, BFM and %BF were significantly (p<0.001) higher in female than in male.

Table 2 shows the Pearson correlation coefficients between BMI measures and InBody 720 data, and with the corresponding scattergram for BFM, %BF, and VFA in Figure 1, 2, 3, respectively. Highly significant and positively correlations between BMI versus BFM, %BF, and VFA were fund in male (r=0.923, 0.836, 0.912, respectively, p<0.001) and highly significant and positively correlations between BMI versus BFM and VFA were fund in male (r=0.920, 0.920, respectively, p<0.001). Whereas, medium significant correlation between BMI and %BF was fund in female.

Regression analysis revealed that 85.3%, 69.9%, and 83.1% of the variance for BFM, %BF, and VFA could be explained by BMI in male students (p<0.001); and 84.7%, 54.9%, and 84.6% of the variance for BMI, %BF, and VFA could be explained by BMI in female students (p<0.001). Summary of regression analysis presented in Table 3.

<table>
<thead>
<tr>
<th>Variable</th>
<th>All, n=2,531</th>
<th>Male, n=1,646</th>
<th>Female, n=855</th>
<th>t-test</th>
</tr>
</thead>
<tbody>
<tr>
<td>Age (years)</td>
<td>19.74±1.37</td>
<td>19.80±1.45</td>
<td>19.63±1.21</td>
<td>3.11**</td>
</tr>
<tr>
<td>Anthropometric</td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Heigt (cm)</td>
<td>168.18±8.06</td>
<td>172.47±5.62</td>
<td>160.20±5.39</td>
<td>53.08***</td>
</tr>
<tr>
<td>Weight (kg)</td>
<td>62.70±12.84</td>
<td>67.40±12.04</td>
<td>53.96±9.21</td>
<td>31.34***</td>
</tr>
<tr>
<td>BMI (kg/m(^2))</td>
<td>22.07±3.70</td>
<td>22.64±3.79</td>
<td>21.00±3.26</td>
<td>11.40***</td>
</tr>
<tr>
<td>InBody 720</td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>BFM (kg)</td>
<td>14.17±7.21</td>
<td>13.17±7.61</td>
<td>16.01±5.98</td>
<td>-10.33***</td>
</tr>
<tr>
<td>%BF (%)</td>
<td>22.23±8.53</td>
<td>18.58±7.29</td>
<td>29.02±6.21</td>
<td>-37.91***</td>
</tr>
<tr>
<td>VFA (cm(^2))</td>
<td>47.81±27.61</td>
<td>51.71±29.67</td>
<td>40.56±21.49</td>
<td>10.85***</td>
</tr>
</tbody>
</table>

Abbreviations: BMI, body mass index; BFM, body fat mass; %BF, percent body fat; VFA, visceral fat mass; ** significant difference p<0.01, *** p<0.001.
Table 2. Pearson Correlations between BMI and InBody 720 Data.

<table>
<thead>
<tr>
<th>Variable</th>
<th>All, n=2531</th>
<th>Male, n=1646</th>
<th>Female, n=855</th>
</tr>
</thead>
<tbody>
<tr>
<td>BFM (kg)</td>
<td>0.845***</td>
<td>0.923***</td>
<td>0.920***</td>
</tr>
<tr>
<td>%BF (%)</td>
<td>0.519***</td>
<td>0.836***</td>
<td>0.741***</td>
</tr>
<tr>
<td>VFA (cm²)</td>
<td>0.915***</td>
<td>0.912***</td>
<td>0.920***</td>
</tr>
</tbody>
</table>

Abbreviations: BMI, body mass index; BFM, body fat mass; %BF, percent body fat; VFA, visceral fat mass
*** significant difference p<0.001.

Table 3. Summary of Regression Analysis of BMI with InBody 720 Data.

<table>
<thead>
<tr>
<th>Variable</th>
<th>SE of Beta</th>
<th>β</th>
<th>t</th>
<th>R²</th>
<th>F</th>
</tr>
</thead>
<tbody>
<tr>
<td>All</td>
<td>BFM(kg)</td>
<td>0.021</td>
<td>0.845</td>
<td>79.54***</td>
<td>0.714</td>
</tr>
<tr>
<td></td>
<td>%BF(%)</td>
<td>0.039</td>
<td>0.519</td>
<td>30.58***</td>
<td>0.269</td>
</tr>
<tr>
<td></td>
<td>VFA (cm²)</td>
<td>0.060</td>
<td>0.915</td>
<td>113.96***</td>
<td>0.837</td>
</tr>
<tr>
<td>Male</td>
<td>BFM(kg)</td>
<td>0.019</td>
<td>0.923</td>
<td>97.54***</td>
<td>0.853</td>
</tr>
<tr>
<td></td>
<td>%BF(%)</td>
<td>0.026</td>
<td>0.836</td>
<td>61.84***</td>
<td>0.699</td>
</tr>
<tr>
<td></td>
<td>VFA (cm²)</td>
<td>0.079</td>
<td>0.912</td>
<td>90.09***</td>
<td>0.831</td>
</tr>
<tr>
<td>Female</td>
<td>BFM(kg)</td>
<td>0.024</td>
<td>0.920</td>
<td>69.97***</td>
<td>0.847</td>
</tr>
<tr>
<td></td>
<td>%BF(%)</td>
<td>0.043</td>
<td>0.741</td>
<td>32.83***</td>
<td>0.549</td>
</tr>
<tr>
<td></td>
<td>VFA (cm²)</td>
<td>0.087</td>
<td>0.920</td>
<td>69.81***</td>
<td>0.846</td>
</tr>
</tbody>
</table>

Dependent variable: body fat mass (BFM), percent body fat (%BF), visceral fat mass (VFA),
Independent variable: body mass index (BMI)
*** statistically significant p<0.001.

Figure 1. Body mass index (BMI) vs. Body fat mass (BFM).
Figure 2. Body mass index (BMI) vs. Percent body fat (%BF).

Figure 3. Body mass index (BMI) vs. Visceral fat area (VFA).

Discussion

Objective measures of adiposity and fat distribution often are not feasible in large studies. BIA is a practical and non-invasive method to assess human body composition, and BMI is used by the World Health Organization to define severity of overweight and obesity across populations (WHO, 2004). In this study, significant relationships were detected between BMI and BFM, %BF, and VFA, quantified by the InBody 720 technique. This indicates that BMI serves as a good surrogate measurement for body fat in college students in Taiwan, both for males and females regardless of gender differences in body composition. However, a medium correlation existed for BMI and %BF especially in female students, which may be a limitation when BMI is used to study risk factors for disease in epidemiological studies of college students this age. Our finding that BMI was highly related to BFM, VFA, and medium related to %BF derived from InBody 720 body composition analyzer. However, there are large sex differences in body fat mass in prepubertal children (Arfai et al., 2002; Denker et al., 2007; Garnett et al., 2004). In the present study, we also fund sex differences in BFM, VAF, and %BF among college students. The possible explanation for differences is partly due to genetic differences in body composition, as well as to differences in food intake and the patterns of physical activity.

Height and body mass based measurements are the most common tools for assessing obesity status because of their simplicity and low cost. BMI has become the standard as a reliable indicator of overweight and obesity. Our data provide additional support for the use of BMI
in assessing overweight and obesity in Taiwan adolescents aged 18-24 years. However, this only applies to the validity of BMI as an indicator of BFM and VFA, since significantly medium correlation existed between BMI and %BF.

The purpose of the present study was to evaluate the correlation between BMI and various body fat measurements, not to establish reference values for healthy college students. The main strength of this study was the use of InBody 720 to quantify the amount of BFM, VAF, and %BF in college students. To our knowledge, this is the first study that compares the relationship between BMI and BFM, VFA, %BF among college students in Taiwan. Our study indicates that BMI serves as a good surrogate for BFM and VFA in college students aged 18-24 years in Taiwan. The practical implication of this finding is the suggestion that perhaps measurement of waist circumference or waist to hip ratio is needed in addition to BMI, if epidemiological BMI-data are to be used to study prevalence or secular trends of risk factors for cardiovascular or metabolic disease.

Conclusion

In conclusion, BFM and VFA were highly associated with BMI in the college students in Taiwan, suggesting that BMI serves as a good surrogate marker for obesity in college students aged 18-24 years. However, a significantly medium correlation existed in BMI and %BF, which may be a limitation for BMI, when used to study risk factors for cardiovascular or metabolic diseases.

Reference


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