Body mass index of the elderly derived from height and from armspan

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The body mass index (BMI) has been promoted as a useful indicator for chronic energy deficiency, and to a lesser extent to indicate obesity. For the growing sector of elderly in developing countries, such as Indonesia, both issues are taking on public health relevance. The aging process leads to a progressive loss of height, and questions have been raised as to the appropriate value to include in the denominator of the BMI formula, Wt/(H²/2), when applied in this age-group. The armspan has been advanced as a surrogate for height, correcting for the lifelong loss of stature. In a data-set from 69 elderly in Indonesia, 36 women and 33 men, aged 60 to 69 y, we have examined the interrelationships of height and armspan. The correlation coefficient for the regression of the two measures were r = 0.83 and r = 0.81 (p < 0.001), for men and women, respectively. Substituting the armspan in the denominator to compose a Body Mass using Armspan (BSMA) index, we observe for this population a 32% increase in estimates for Chronic Energy Deficiency (CED) for women and 24% increase in estimates of CED for men. Corresponding estimates for obesity rates declined by 45% and 81% respectively. The senescent changes in stature raise important questions for our capacity to estimate prevalences of body composition disorders in the older population.

Introduction

Poor nutritional status is common among the elderly, and is associated with increased mortality and morbidity.1,2 Yet, until recently, we have not had information on the nutritional status of the elderly.3 Aging is accompanied by changes in body composition and stature.4 Furthermore, racial differences have been reported in anthropometric indices5,6, making the analysis of nutritional status in elderly more complex and discouraging.

Numerous methods are available to assess nutritional status by way of body composition, also applicable for the elderly.7 Body mass index (BMI) has usually been the index of choice in studies, because its components - height and weight - are rapid and simple to measure. The robustness of the BMI as an indicator of chronic energy deficiency (CED) has been challenged8, and it is still defended as an index of overweight as well.9,10 Furthermore, both extremes of BMI have proven to be strong predictors of increased mortality and morbidity.11,12

Functional decline is a reality for the elderly and the superimposition of age and CED would be expected to compound an adverse situation. How well, we might ask, does the BMI serve as a predictor of CED; those of advanced age, and are the cut-off points proposed in the classification applicable for the elderly? Using height in calculating BMI could be inappropriate because of height-loss due to aging, due to compression of vertebrae, kyphosis and osteoporosis.7 Solomons et al12 have raised the question of an appropriate weight to cover a frame in which the vertical dimension (height) is shrinking. Correlation of the measured weight by an estimate of the stature that existed in young adulthood was suggested.12. It might be that by using height in calculating BMI the prevalence of CED in elderly is underestimated. Armspan is relatively independent of aging and is highly related to the height of an individual.13 Therefore, to predict the prevalence of CED in elderly it may be more reliable to use armspan in the determination of weight related to body stature.

Asian populations are notable for their low BMIs, putatively reflecting lack of CED. Thus, the aim of the present study was to examine the nutritional status of the elderly by measuring BMI, and then substituting the armspan for the BMI. We also examine the level of correspondence between the two measures (armspan and BMI) in Indonesian elderly, providing novel information on the body composition of the older population in urban Jakarta.

Materials and methods

The study was carried out in the community of Kelurahan Kemayoran JR, a suburb of Jakarta, Indonesia, during April/May 1993. The elderly were selected by simple random sampling out of community lists. If somebody had moved away or died, or could not be located after trying twice, another elderly was selected from the same sex and from the same suburb of Kelurahan Kemayoran was chosen.

In the collection of the anthropometric data, weight, height and armspan measurements were taken after standardising of the examiner. The subjects were measured barefoot with light-weight clothing. Body weights were recorded with an exactness of 0.1 kg using SECA digital weighing scale (Hamburg, Germany). To measure height, the barefoot subjects were requested to stand straight on a horizontal surface, heels together, the eyes straight forward. The height measuring equipment consisted of a micro-trammel. Armspan was measured in the same position as the height, but with the extended arms in a 90° angle to the body, using a flexible tape. It was measured across the

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Table 1. Age and selected anthropometric data of a group of elderly females and males from Jakarta Indonesia (mean, standard deviation and range).

<table>
<thead>
<tr>
<th></th>
<th>Females (n=36)</th>
<th>Mean</th>
<th>SD</th>
<th>Range</th>
<th>Males (n=33)</th>
<th>Mean</th>
<th>SD</th>
<th>Range</th>
</tr>
</thead>
<tbody>
<tr>
<td>Age</td>
<td></td>
<td>64.4</td>
<td>± 2.9</td>
<td>60-69</td>
<td>63.6</td>
<td>± 2.9</td>
<td>60-69</td>
<td></td>
</tr>
<tr>
<td>Weight</td>
<td></td>
<td>46.7</td>
<td>± 10.2</td>
<td>30.2-70.4</td>
<td>52.9</td>
<td>± 10.5</td>
<td>32.1-75.9</td>
<td></td>
</tr>
<tr>
<td>Height (cm)</td>
<td></td>
<td>146.8</td>
<td>± 4.7</td>
<td>136.1-154.3</td>
<td>157.9</td>
<td>± 5.7</td>
<td>143.0-166.3</td>
<td></td>
</tr>
<tr>
<td>AS (cm)</td>
<td></td>
<td>154.0</td>
<td>± 6.0</td>
<td>141.2-164.0</td>
<td>165.7</td>
<td>± 6.8</td>
<td>152.1-176.8</td>
<td></td>
</tr>
<tr>
<td>HT/AS</td>
<td></td>
<td>0.96</td>
<td>± 0.05</td>
<td>0.9-1.01</td>
<td>0.95</td>
<td>± 0.06</td>
<td>0.84-1.02</td>
<td></td>
</tr>
<tr>
<td>BMI (kg/m²)</td>
<td></td>
<td>21.7</td>
<td>± 4.7</td>
<td>14.3-30.2</td>
<td>21.3</td>
<td>± 4.2</td>
<td>13.8-30.0</td>
<td></td>
</tr>
<tr>
<td>BMIA (kg/m²)</td>
<td></td>
<td>19.7</td>
<td>± 4.7</td>
<td>13.5-26.8</td>
<td>19.7</td>
<td>± 4.3</td>
<td>13.5-26.8</td>
<td></td>
</tr>
</tbody>
</table>

AS - Armspan; HT - Height; BMI - Body mass index; BMIA - Body mass index calculated by height.

* Significant difference mean values between females and males: p < 0.05; ** Significant difference mean values for females and males: p < 0.01

Results

Sixty-nine subjects, 36 women and 33 men aged 60 to 69 years, were examined. Table 1 lists sex-specific means, standard deviations and ranges of the age and anthropometric measurements for the subjects. Women had significantly lower weight, height and armspan than men (p < 0.05). No significant differences between sexes were found for the height/armspan/relationship (HT/AS), the BMI and the BMIA.

On average the armspan of the females was 7.3 cm longer than height, that of the males was 7.6 cm longer (Table 2). The range of difference between armspan and height was wide, from 2.4 cm up to 17.0 cm in both genders. The BMIA was, on average, 2.0 kg/m² lower than the BMI for both sexes on average.

Table 2. Difference between armspan and height and between BMI and BMIA in a selected group of elderly males and females from Jakarta.

<table>
<thead>
<tr>
<th>Group</th>
<th>N</th>
<th>Mean</th>
<th>SD</th>
<th>Range</th>
</tr>
</thead>
<tbody>
<tr>
<td>AS - HT (cm)</td>
<td>All</td>
<td>69</td>
<td>7.9</td>
<td>± 4.0</td>
</tr>
<tr>
<td></td>
<td>Women</td>
<td>36</td>
<td>7.3</td>
<td>± 3.3</td>
</tr>
<tr>
<td></td>
<td>Men</td>
<td>33</td>
<td>7.6</td>
<td>± 3.6</td>
</tr>
<tr>
<td>BMI - BMIA (kg/m²)</td>
<td>All</td>
<td>69</td>
<td>2.0</td>
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<td></td>
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<td>33</td>
<td>2.0</td>
<td>± 1.2</td>
</tr>
</tbody>
</table>

AS - Armspan; HT - Height; BMI - Body mass index; BMIA - Body mass index calculated by height.

Figures 1 and 2 show the correlation coefficients of the linear regression between armspan and height, for females (0.83) and males (0.81), respectively. Their significance was p < 0.001. A similar statistical significance was observed for the relation between the BMI and the BMIA; the correlation coefficients of the latter were 0.98 for women and 0.96 for men (Figures 3 and 4).

Discussion

Indonesian elderly in this sample are dramatically smaller and lighter than their American counterparts. The difference in mean height between Indonesian and American subjects was 20 kg for both sexes. Furthermore the mean values of BMI in this study were found to be lower than those of developed countries. The ECOEURONUT SENECTA Study, which assessed representative samples aged 75 to 81 in 12 European countries, found a range in mean values of BMI from 23.9 to 30.5 kg/m² for women, and from 24.4 to 30.3 kg/m² for men. Our mean BMIs of 21.7 kg/m² for females and 21.3 kg/m² for males, were below the lowest mean BMIs of any European subsample. These findings support those of other studies, which found that small stature as well as low body weight, seems to be more common in developing countries than in developed countries. Reasons for differences have been suggested to have genetic or environmental bases. furthermore, racial differences in the relationship between body composition and BMI have been reported. Because BMI reflects body fat mass as well as lean body mass, the same BMI can represent a completely different body composition in different races. Therefore, comparison between different populations have to be viewed cautiously.

James et al. proposed a classification with three cut-off points for Chronic Energy Deficiency (CED). Low values of BMI reflect low fat and lean body mass, a state of greater concern than low fat mass alone, and are perhaps more typical of Chronic Energy Deficiency than low fat mass alone. Values below 18.5 kg/m² were in general considered as incompatible with normal good health; values below 17.0 kg/m² were found to be related to evidence of poor production and increased morbidity and mortality. With values below 16.0 kg/m², the mortality risk increased progressively. This is of great concern because values outside the range considered as normal have been shown to be...
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<td><strong>Mean</strong></td>
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</tr>
<tr>
<td>Age (yr)</td>
<td>± 2.9</td>
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</tr>
<tr>
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</tr>
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**AS** = Arm span, **HT = Height, BMI = Body mass index, BMA = Body mass index calculated by height.

*Significant difference mean values between males and females: p < 0.05. **Significant difference mean values for females and males: p < 0.01

Figure 1. Correlation between height and armpasp in a selected group of elderly females from Jakarta.

Figure 2. Correlation between height and armpasp in a selected group of elderly males from Jakarta.

Table 2. Difference between armpasp and height and between BMA and BMI in a selected group of elderly males and females from Jakarta.

<table>
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</tr>
<tr>
<td>BMA - BMI (kg/m²)</td>
<td>All</td>
<td>69</td>
<td>2.0</td>
<td>± 1.0</td>
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Figure 3. Correlation between BMI and BMA in a selected group of elderly females from Jakarta.

Figure 4. Correlation between BMI and BMA in a selected group of elderly males from Jakarta.

Figure 5. Distribution of body mass index of a selected group of elderly females and males from Jakarta according to the classification of James et al. and Garrow and Webster.

Figure 6. Distribution of body mass index calculated by armpasp (BMA) of a selected group of elderly females and males from Jakarta according to the classification of James et al. and Garrow and Webster.

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incompatible with health. Grade III of CED (10% of the subjects) showed a tripling of mortality rates compared to the normal range - a situation demanding special attention. Grade II of CED has been related to the recognition of the presence of obesity and to increased morbidity and mortality. The finding that 31% of female subjects and 21% of the males were classified as obese is also of concern because obesity classified by BMI has been established as a risk factor for morbidity and mortality. These results have to be judged carefully. Although the classification of James et al was based on findings of developing countries, the anthropometric values of those aged 20 to 45 y. However, mean values of BMI have been reported to decrease with aging and it is clear that values in the older Indians are low (although we do not have a young adult population from Jakarta which with to assess age-related trends).

On the other side of the BMI equation, cut-off points for obesity correspond in their classification to the grades of obesity of Girgour and Wechsler: Grade 1 = 19.9 kg/m² (overweight), 30.0 to 39.9 kg/m² (Grade 2 - obese), and 40.0 kg/m² (Grade 3 - morbid obesity). As shown in Figures 5 and 6, in the upper panels, a parallel percentage of women, 32 and 31%, respectively, had some degree of CED or obesity, with none of the latter in the Grade III extremity. For men, the rates of all classes of obesity, 21% was only two-thirds of their respective rate of overweight.

The high correlation between height and armpans of 0.83 for females and 0.81 for males, found in this sample of Indonesian elderly, confirmed that armpans approximate the same rank-ordering of the subjects were included. Although age could have induced Kuala Lumpur 1989; 43:146-179.


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B. Rabe, M. Thamin, R. Gross, N. Solomons, W. Schultink

Abstract

Indeks Massa Tubuh (BMI) telah dikenal sebagai indikator yang berguna pada masaan defisiensi energi yang kronis dan juga dapat mengindikasikan masalah kegemukan/obesi. Di negara berkembang seperti Indonesia dimana sektor luar usia (lais) makul berkelompok, keadaan ini menjadi sangat relevan dalam kesehatan masyarakat. Dengan terjadinya penyumbatan, tingkat badan yang dibahayakan oleh proses penyumbatan, akan lebih meningkat. Sehingga jika BMI bawah 18,5 akan terus meningkat, semakin tinggi tingkat badan yang dibahayakan oleh proses penyumbatan, semakin tinggi tingkat badan yang dibahayakan oleh proses penyumbatan. Oleh karena itu, BMI yang dibawah 18,5 perlu diperhatikan. Mengingat pengaruh BMI pada tingkat badan yang dibahayakan oleh proses penyumbatan, sangatlah penting bagian pengaruh BMI pada tingkat badan yang dibahayakan oleh proses penyumbatan.

References