體重指數與營養狀況: 調整體重指數對用相對坐高去預測慢性能量缺乏、超重和肥胖症發病率的效用

Body mass index and nutritional status: the effect of adjusting body mass index for the relative sitting height on estimates of the prevalence of chronic energy deficiency, overweight and obesity

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Low body mass index (BMI) has been proposed as a practical measure of adult chronic energy deficiency (CED), although it was well-known limitations. One of these is that its interpretation is complicated by the influence of body proportions, in particular the relative leg length. This has been quantified by examining data collected before 1970 of 349 adult Australian Aborigines following a largely traditional way of life. These Australian Aborigines exhibited low sitting height: stature ratios (SH/S), 0.48±0.02, (mean±sd), range 0.41–0.54, ie they are relatively long legged, and low BMI, 19.9±3.2, range 12–30 kg/m^2. Thirty percent of individuals had BMI less than 18.5 kg/m^2, a suggested cut-off for CED. The regression of BMI on SH/S was determined in men and women separately but found by covariance analysis not to be different and a common equation for both sexes was calculated. When BMIs were standardized to a SH/S of 0.52, a value found in Europeans and other Indo-Mediterraneans, the percentage classed as chronically energy-deficient fell to 7%. In Asians and indigenous Americans with their high SH/S, the percentage of the population with overweight and obesity could be overestimated and the extent of CED underestimated. In populations with a mean SH/S of 0.52, such as Europeans and Pacific peoples, standardizing SH/S to 0.52 would not effect the prevalence of CED or overweight and obesity but could move individuals across diagnostic boundaries as there is variability in SH/S in all population groups. In conclusion, when using BMI to assess energy nutritional status single cut-offs are not applicable to all individuals and population groups without allowance for the body form and type.

Introduction

The body mass index (BMI, weight/height^2, kg/m^2) is used widely as a measure of overweight and obesity. On the basis of the mortality experience of insured North Americans, the desirable range of BMI in men is regarded as 20–25 kg/m^2 and in women 18.7–23.8 kg/m^2 [1]. By common use, BMI of 25–30 is described as overweight, and of over 30, as obesity. More recently, it has been proposed that low BMI can be used as a practical measure of energy undernutrition[2,3]. Three grades of chronic energy deficiency (CED) have been defined, as BMI less than 18.5, 17 and 16 kg/m^2.

BMI has several well-known limitations such as being a poor measure of energy stores in some age groups compared with other anthropometric techniques, being a measure of size as much as composition[4,5] and of being related differently to body composition in different population groups[5]. Some of this variation is related to differences in body proportions, particularly the ratio of sitting height: stature (SH/S), also known as the relative sitting height. In the Asia-Pacific region, the widest range of SH/S in any geographical area is found, being lowest in Australian Aborigines (0.475) and highest in Japanese (0.55). This paper illustrates the effect of the SH/S ratio causing an overestimation of the prevalence in CED in Australian Aborigines. For Asians, the prevalence of CED will be underestimated and those of overweight and obesity will be overestimated using the proposed criteria.

Methods

Individual anthropometric data for 349 adult Australian Aborigines were obtained from the Australian Institute for Aboriginal and Torres Straits Islander Studies, Canberra, ACT, Australia. The data was collected by the Australian physical anthropologist Andrew A. Abbie, using Martin field anthropometry equipment, over a number of years in groups living a largely traditional way of life or after recent settlement. The data comes mainly from groups in central and northern areas of Australia and were collected before 1970. The data set used here has been described previously[6]. The original data were cleaned and restructured by Freedman and Macho[7] and further explored and restructed by the author.

Adults aged 20–65 years were selected for this analysis although estimates of ages of all groups may have been only approximate. Separate regression equations for the sexes were calculated for BMI on SH/S. Testing by covariance analysis[8] showed the slopes and intercepts were not significantly different and the sexes were combined. The combined equation was: BMI = 57.2* SH/S – 7.4, r^2 = 0.15, standard error of the estimate = 2.9 kg/m^2. This equation was used to estimate the BMI at a SH/S ratio of 0.52, the mean value in European populations including those used to determine

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mortality rates of different weight-height and hence BMI groups. Individual BMI were then standardized to SH/S of 0.52 by adding the residuals to the estimated BMI at an SH/S of 0.52, using the following equation:

$$BMI_{std} = BMI_{0.52} + (BMI_0 - BMI_1),$$

where BMI_{std} = standardized BMI
$BMI_{0.52}$ = estimated BMI at SH/S of 0.52
BMI_0 = actual BMI
BMI_1 = estimated BMI at actual SH/S.

The proportions of men and women in the three groups of CED or who were overweight or obese were calculated.

Results

The ages and physical characteristics of the Australian Aborigine men and women are shown in Table 1. The mean BMI and SH/S are low compared with other population groups. The proportions in different categories of BMI before and after standardization are shown in Table 2. Standardization reduced the prevalence of CED (BMI<18.5 kg/m^2) from 35 to 7%. The number of individuals classified as Grade 3 (severe) CED, according to the classification of James, Ferro-Luzzi and Waterlow[2], fell from 30 (9%) to 1 (<1%).

Table 1. The age and physical characteristics (mean ± SD) of the sample of Australian Aborigine men and women.

	Men		Women	
	Mean	SD	Mean	SD
Number	189		162	
Age, years	39	14	35	14
Height, m	1.68	0.07	1.57	0.07
Sitting height, m	0.80	0.04	0.75	0.03
Weight, kg	57.2	8.9	48.4	9.9
Body mass index, kg/m^2	20.2	2.6	19.6	3.7
Sitting height: statue	0.477	0.021	0.477	0.022

Discussion

The question of appropriate anthropometric reference data and cut-off points for groups other than young adult Europeans has always been controversial, particularly in the area of child growth and nutritional status. Similar considerations apply in the case of adults, where the use of BMI as a practical measure of CED and undernutrition is being proposed. Here, the importance of standardization and cut-offs arises from the narrow distribution of BMI around the cut-off points which is illustrated by the steepness of the cumulative frequency plot of BMI in most Third World groups. Small changes in cut-offs have marked effects on the numbers falling into different classes. Conversely, small adjustments in BMI to standardize for variations in, for example SH/S, also affect prevalences.

Australian Aborigines have a relative leg length greater than that of most other groups and hence the effect demonstrated may not be exceeded in other groups unless BMI are distributed more critically around the cut-offs. In contrast, mean SH/S in Far East Asian groups are higher than in other population groups, being 0.55 in Japanese, 0.54 in Chinese and Koreans and slightly less in Thai and Vietnamese[9]. In these groups, standardization to the European mean of 0.52 would reduce the BMI with the effects of reducing the estimated prevalence of overweight and obesity and increasing that of CED. Of the other groups, Africans have the lowest SH/S, the longest legs relatively and, like the Australian Aborigines, the prevalence of CED may be overestimated unless an allowance is made for SH/S. Even in groups with SH/S of 0.52, where standardization will not affect the estimated overall prevalence of overweight and obesity or CED, because of the considerable intra-group variation in SH/S, individuals will move across cut-offs and boundaries. As an example, in a sample of 420 Papua New Guinean adults of mean SH/S 0.52, standardization of individual scores to 0.52 did not affect the estimated prevalence of CED but more than 12% of individuals changed BMI by 1 unit or more (Norgan, unpublished). In conclusion, low BMI has been a feature of many Australian Aborigine groups due, in part, to a low SH/S, arising from their relatively long legs. This is supported by paradoxically high adipose and muscle mass status[6]. Therefore, single cut-offs of BMI are not applicable to all population groups and allowance has to be made for the body proportion in using BMI to assess energy nutritional status.

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Table 2. The effect of adjusting the body mass index (BMI) to at relative sitting height of 0.52 in Australian Aborigines on the distribution of BMI values.

		Men				Women			
		Actual		Adjusted		Actual		Adjusted	
BMI, kg/m^2	Category	n	%	n	%	n	%	n	%
<16	CED 3	7	4	0	0	23	14	1	1
16–16.99	CED 2	9	5	3	2	18	11	2	1
17–18.49	CED 1	37	20	4	2	32	20	16	10
18.5–24.99	–	123	66	154	82	74	45	116	71
25–29.99	Overweight	11	6	26	14	17	10	20	12
30+	Obesity	0	0	0	0	0	0	7	4

CED = chronic energy deficiency.

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