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# Body mass index, body composition and the chronic energy deficiency classification of rural adult populations in Guatemala

M. D. C. Immink[1], R. Flores A.[2] and E. O. Diaz[2]

[1]*International Food Policy Research Institute, 1776 Massachusetts Avenue, N.W., Washington, DC 20036, USA; and* [2]*Institute of Nutrition of Central America and Panama, P.O. Box 1188, Guatemala*

The present study tested the hypotheses that: (a) individual body composition estimates obtained with the Durnin–Womersley (D-W) equations have low validity in certain populations in developing countries; (b) there exists a poor relationship between the body mass index (BMI) and body composition estimates (fat mass (BFM) and fat-free mass (FFM)), and (c) BMI cut-off points provide an invalid classification of chronic energy deficiency (CED) in adults. The study involved four samples of rural men and women in Guatemala, who had mean BMI of approximately 21 kg/m$^2$. Body composition estimates were obtained by densitometry in three of the samples. Mean body fat (%) and mean FFM (kg) were: men: 11.6 (±4.7) and 47.7 (±4.9); and women: 21.6 (±5.3) and 35.8 (±3.5), respectively. The D-W equations based on various combinations of skinfold measurements consistently overestimated body fat content with low precision and validity. The BMI was more related to BFM and FFM than to fat proportion, but explained little of the variation in both body components, particularly at low BMI levels. A small number of men and women had BMI values below 18.5 kg/m$^2$, and only one woman fell below 16 kg/m$^2$. The power coefficients of height in the weight/height ratio which provided the strongest correlations with BFM and FFM were: BFM: women: 1.0; men: 1.5; FFM: 0.5 for both women and men. We conclude that the Quetelet index should not be recommended as a universally valid indicator to classify CED in adult groups similar to the study population.

Chronic energy deficiency (CED) has been defined by James, Ferro-Luzzi & Waterlow (1988) as a steady state at which an individual is in energy balance but her/his function and/or health are negatively affected. These authors proposed the body mass index (BMI), also known as the Quetelet index (weight/height$^2$), as a diagnostic tool to classify adults in developing countries as to their CED status, by identifying absolute cut-off points of the BMI distribution (18.5, 17.0 and 16.0 kg/m$^2$).

The BMI has often been advocated and used in developed countries as a diagnostic tool for obesity (Garrow & Webster, 1985). In fact, Lee, Kolonel & Ward Hinds (1981) referred to weight-corrected-for-height indices as 'obesity indices', and as such, advocated an index which is highly correlated with weight and uncorrelated with height, finding that the power type index proposed by Benn (1971) provides better results than other indices. Whether these indices are appropriate to measure human energy status in populations suffering from

Correspondence to: M. D. C. Immink.

chronic energy deficiency is not clear at present.

James *et al.* (1988) also recognized that the BMI represents both fat and lean body mass, and that both are negatively affected by CED. Norgan (1990) has recently argued that in developing countries the BMI represents a more valid indicator of fat mass than fat proportion, and that its relation to body energy stores may vary depending on body size, height, fat-free mass and initial fatness level. At present there seems to be no universally valid interpretation of the BMI as an indicator of CED, although at low values it probably represents decreased fat and fat-free mass. In reaching his conclusions, Norgan also raised an estimation problem, i.e. the use of the equations found in Durnin & Womersley (1974) may lead to overestimation of fat mass and fat proportion among adults with low energy stores.

This paper addresses three issues related to the BMI as an indicator of chronic energy deficiency in adults. First, we re-examine Norgan's argument related to the BMI and fat, and fat-free mass, relationships in Guatemalan rural populations suffering from a certain degree of CED. Second, we address the question of the estimation problems associated with the Durnin–Womersley equations and their application in Guatemalan rural adult populations. Last, we examine the application of the BMI cut-off points proposed by James *et al.* (1988) for the purpose of classifying CED in rural Guatemala. We also deal briefly with the question of alternative formulation of body mass indices.

## Methods

This study brings together data of male and female adults obtained in a number of studies undertaken among resource-poor, adult populations from rural areas in Guatemala. We shall distinguish in the presentation between: (a) two samples of male and female adults from the Western Highlands who participated in a field study conducted in 1987, (b) a sample of rural women selected at random in 1986 from four rural communities in the Western Highlands, and (c) a sample of rural men, pieced together from samples of three other studies conducted in 1967, 1983 and 1986. The study conducted in 1967 has extensively been described by Viteri (1971), and involved rural men from the Eastern region of Guatemala. The men in the 1983 study came from the Pacific coastal region, and those of the 1986 study from the same Western Highlands communities as the women in sample (b). The same measurement methodology was applied in samples (b) and (c), which included body density measurements. These were not performed in the 1987 field study.

The anthropometric measurements in the 1967, 1983 and 1986 studies were made in a laboratory setting and included: weight, height, mid-upper arm circumference, maximum calf and mid-thigh circumferences, and skinfold measurements at the biceps, triceps, subscapular, suprailiac (not available for women), abdominal, calf and thigh locations; the latter three skinfold locations were not measured in 1987. In addition, abdominal circumference, mid-axillary, chest and costal skinfolds were measured in men. All measurements were made in accordance with Weiner & Lourie (1969), Wilmore (1969) and Wilmore & Behnke (1970). Weight was measured with a beam balance with 0.01 kg sensitivity; skinfold measurements with a Lange caliper and circumferences with a metal tape, in both cases with 1 mm sensitivity. The anthropometric measurements included in the 1987 field study were: height, weight, mid-upper arm circumference, and skinfolds at biceps, triceps, and subcapular and suprailiac sites.

Body density was assessed in the 1967, 1983 and 1986 studies (women only in 1986) by underwater weighing, corrected for residual lung volume using helium dilution. Underwater weight was recorded during a forced exhalation and simultaneously with the residual lung volume determination. Water temperature was constantly kept at 36–37°C during the examinations. The technique has been described in detail elsewhere (Diaz *et al.*, 1989; Brozek & Henschel, 1961; Siri, 1956). In order to test the reproducibility of the body density measurements, 22 subjects were measured twice on two consecutive days. The intraclass correlation coefficient was $r = 0.968$, with degrees of freedom = 21 (Winer, 1971). Body mass index (BMI) was calculated in two ways. The most often used is the Quetelet index = weight (kg)/height$^2$(m). Also derived was the Benn index = weight/height$^\rho$, where $\rho = b$(mean height/mean weight), and $b$ is the linearly estimated regression coefficient of height on weight. The power coefficient $\rho$ is thus generated separately for each sample; a more detailed description can be found in Lee *et al.* (1981) and Benn (1971).

Body fat mass (BFM) was estimated in the 1967, 1983 and 1986 studies directly from the body density measurements applying Siri's equation (Siri, 1956). Fat-free mass (FFM) was calculated as the difference between body weight and BFM.

BFM and FFM in the 1987 study were estimated in two different ways. Estimates of body density were obtained with age- and gender-specific equations, based upon the sum of skinfolds, as found in Durnin & Womersley (1974). A second approach consisted of developing separate regression models for men and women, using the data from the 1967, 1983 and 1986 studies, and with the same anthropometric measurements (and indices derived from these) as predictor variables, as were available in the 1987 study: age, height, weight, mid-upper arm circumference, BMI, and skinfolds at the triceps, biceps, subscapular and suprailiac locations (the last skinfold measurement was excluded for women because measurements were not available in 1986). The 'best subset regression model' was obtained using the 'all possible subsets procedure' (SAS Institute, 1987), which assesses all possible combinations of independent variables. The best equation was selected based on the following statistics (Flores, 1989): (a) low Schwarz Bayesian Criterion (SBC) statistic to minimize the error sum of squares of each model, leading to the selection of the model which provides the maximum likelihood (Judge *et al.*, 1980), (b) lowest condition number (i.e. lowest degree of collinearity among predictor variables), and (c) highest variance explanation ($R^2$). Analysis of the normality of the distribution of residuals using the Shapiro–Wilks statistic as well as residual analyses were also performed in order to identify the best subset equation. The estimated regression parameters of the best subset equation of predictor variables were then applied to the same variables in the 1987 samples of men and women (separate equations) to estimate FFM*. FFM equations instead of BFM equations were used because they had significantly higher predictive powers. BFM estimates were obtained by subtracting the FFM estimates from total body weight.

In order to cross-validate the predictive equations in the full samples, 24 men from the 1967–1986 samples, and eight women from the 1986 sample, were selected at random, and dropped from the samples. The best subset model selection process was repeated for the subsamples with the same predictor variables. The best equations thus obtained were quite similar to those obtained in the full samples†. The root validation mean square error (RVMSE) obtained for the validation groups of men ($n = 24$) was 2.576 kg, and for the validation group of women ($n = 8$) was 2.103 kg. The subsample prediction equations produced only minor differences in the mean body composition values reported in Table 4.

Durnin–Womersley (D-W) skinfold estimates were assessed in comparison with body density estimates by linear regression analysis. The bias, as summarized by the limits of agreement, was calculated according to Bland & Altman (1986).

*The best subset equations were:
Men: FFM (kg) = −84.45 − 0.18 suprailiac − 0.44 biceps + 59.91 height + 1.86 (weight/height$^2$). $R^2 = 0.82$; RMSE = 2.07 kg.
Women: FFM (kg) = 7.04 − 0.54 biceps + 0.68 weight. $R^2 = 0.61$; RMSE = 2.25 kg.

†The best subset equations in the subsamples were:
Men: FFM (kg) = −86.42 − 0.13 suprailiac − 0.43 biceps + 61.18 height + 1.84 BMI. $R^2 = 0.84$; RMSE = 1.93 kg.
Women: FFM (kg) = 7.01 − 0.54 biceps + 0.68 weight. $R^2 = 0.61$; RMSE = 2.28 kg.

**Table 1.** Physical characteristics of different groups of rural adults, Guatemala (means ± SD)

| | Males | | Females | |
|---|---|---|---|---|
| | *1967–1986* | *1987* | *1986* | *1987* |
| *N* | 124 | 664 | 48 | 706 |
| Age (years) | 28.8 ± 7.8 | 42.7 ± 13.4 | 25.5 ± 5.4 | 34.2 ± 9.0 |
| Height (cm) | 159.8 ± 5.1 | 157.3 ± 6.2 | 147.7 ± 3.8 | 145.7 ± 5.6 |
| Weight (kg) | 54.1 ± 6.1 | 53.0 ± 6.9 | 45.8 ± 4.5 | 47.8 ± 6.7 |
| BMI (kg/m$^2$) | 21.2 ± 1.8 | 21.4 ± 2.3 | 21.0 ± 2.0 | 22.5 ± 2.7 |
| Fat[a] (%) | 11.6 ± 4.7 | | 21.6 ± 5.3 | |
| Fat[a] (kg) | 6.4 ± 3.0 | | 10.0 ± 2.9 | |
| FFM[a] (kg) | 47.7 ± 4.9 | | 35.8 ± 3.5 | |
| Skinfolds | | | | |
| Biceps (mm) | 3.6 ± 1.8 | 3.5 ± 1.7 | 4.4 ± 1.5 | 4.9 ± 2.2 |
| Triceps (mm) | 6.0 ± 2.3 | 6.2 ± 2.5 | 10.6 ± 2.9 | 9.7 ± 3.2 |
| Subscapular (mm) | 9.9 ± 4.7 | 8.6 ± 2.9 | 14.2 ± 6.2 | 10.7 ± 3.8 |
| Suprailiac (mm) | 7.8 ± 3.6 | 5.6 ± 2.4 | – | 8.0 ± 3.9 |

[a] Estimated by densitometry; not performed in 1987.

## Sample characteristics

The physical characteristics of the various samples of men and women are described in Table 1. The subjects in the 1967, 1983 and 1986 studies tended to be younger than those in the 1987 study. The 1987 male subjects tended to be on average somewhat shorter and weighed less than the males in 1967–1986 studies. The mean of the Quetelet index was the same in the two male samples, but mean subscapular and suprailiac skinfolds were lower in the 1987 study men. Mean body composition values in the 1967–1986 male subjects indicated that these men were generally lean; mean percent body fat fell at the lower end of the distributions for well-nourished men (James *et al.*, 1988; Viteri, 1971). The latter were somewhat shorter and weighed more on average.

In relation to BMI and fat mass, using the chronic undernutrition classification adopted by Barac-Nieto *et al.* (1978) for Colombian rural males, the Guatemalan men would be classified as mildly undernourished based upon mean body mass index, but severely undernourished based upon mean kg of fat mass (even if adjusted for height). This is the first evidence that the body mass index and body fat measures provide different information about the chronic energy deficiency status of men with low energy stores.

James *et al.* (1988) stated that a 6% fat proportion for men, and a 20% fat proportion for women, should be considered as the lower limit compatible with normal body function and health. Overall, the sample of Guatemalan women was close to this limit, with many women below it. The mean body fat proportion in the men was only 5% over this limit, but in most cases their energy stores were only sufficient to cover from 2 to 10 days of their usual energy needs*.

Though we are unable to characterize precisely the degree of CED generally found in the samples of Guatemalan men and women, it appears clear that a range of degrees of CED can be found in these groups. Our purpose is to examine whether in these rural adults, typical for Guatemala, the BMI is a good predictor of body composition, and whether a meaningful CED classification can be obtained with the BMI cut-off points proposed by James *et al.* (1988).

*This was calculated from the amount of fat stored (as given in Table 4) assuming an energy content of 38.9 MJ/kg (9300 kcal/kg), and an average requirement of 15.05 MJ/d (3600 kcal/d) reported for agricultural workers from the same population (Viteri & Torun, 1975). This required level of energy intake has been associated with better energy reserves (comparing supplemented vs unsupplemented agricultural workers), better physical work capacity and more leisure activity after the daily work routine.

**Table 2.** Regression models to relate body composition estimated from Durnin–Womersley equations to those obtained by densitometry, and limits of agreement, rural adults, Guatemala

| | *Males 1967–86 (n = 124)* | | | | *Females 1986 (n = 48)* | |
|---|---|---|---|---|---|---|
| | *DW1*[a] | | *DW2*[b] | | *DW2*[b] | |
| | *BF (%)* | *FFM (kg)* | *BF (%)* | *FFM (kg)* | *BF (%)* | *FFM (kg)* |
| $b_0$ | 3.64 | 2.98 | 5.00 | 6.77 | 9.39 | 1.58 |
| $b_1$ | 0.63[c] | 0.95 | 0.46 | 0.88 | 0.54 | 0.97 |
| | (0.08) | (0.05) | (0.07) | (0.05) | (0.16) | (0.49) |
| $R^2$ | 0.33 | 0.78 | 0.27 | 0.71 | 0.19 | 0.49 |
| RMSE | 3.93 | 2.26 | 4.09 | 2.64 | 4.88 | 2.54 |
| Limits of agreement | | | | | | |
| Lower | −7.46 | −5.08 | −7.37 | −6.79 | −9.28 | −5.61 |
| Upper | 9.48 | 3.95 | 12.49 | 3.96 | 11.64 | 4.44 |

[a] DW1: Durnin–Womersley equation based on triceps, subscapular and suprailiac skinfolds.
[b] DW2: Durnin–Womersley equation based on biceps, triceps and subscapular skinfolds.
[c] Regression coefficient (± standard error).

## Validation of body composition indicators

When comparing estimates obtained by two methods using linear regression, perfect agreement between estimates is present when $b_1 = 1$, and the precision of this agreement will be excellent when $R^2$ is close to 1.00. The estimation bias is best evaluated by the limits of agreement, provided that the differences between the two methods follow a Gaussian distribution. The Shapiro–Wilks test applied to our data indicated that this was the case. The poorest results were obtained for percent body fat, and the best for fat-free mass (FFM) for both men and women (Table 2). The FFM estimate obtained among males with the D-W equation based on three skinfold measurements (triceps, suprailiac and subscapular) was superior to all others. However, the limits of agreement of the estimate indicated a biologically unacceptable bias of 5.08 kg below, or of 3.95 kg above, the body density estimate. This means therefore that individual body composition estimates obtained by the D-W equations contain significant errors, and thus, have low validity for this study population.

## BMI and body composition

Simple regression models were estimated to relate the Quetelet index to the three body composition indicators obtained by densitometry (Table 3). Their results indicate that among the 1967–1986 male subjects the Quetelet index is more related to fat mass and fat-free mass than to fat proportion.

**Table 3.** Regression models to relate the body mass index to body composition indicators in rural adults, Guatemala

| | *Males 1967–1986 (n = 124)* | | | *Females 1986 (n = 48)* | | |
|---|---|---|---|---|---|---|
| | *Fat (%)* | *Fat (kg)* | *FFM (kg)* | *Fat (%)* | *Fat (kg)* | *FFM (kg)* |
| $b_0$ | −15.66[a] | −16.18 | −12.18 | 0.50 | −8.41 | 12.89 |
| | (4.44) | (2.48) | (4.04) | (7.88) | (3.80) | (4.41) |
| $b_1$ BMI | 1.29 | 1.26 | 1.68 | 1.00 | 0.88 | 1.09 |
| | (0.21) | (0.12) | (0.19) | (0.37) | (0.18) | (0.21) |
| $R^2$ | 0.23 | 0.40 | 0.38 | 0.12 | 0.32 | 0.36 |
| RMSE[b] | 4.17 | 2.33 | 3.85 | 5.03 | 2.43 | 2.82 |

[a] Regression coefficient (± standard error).
[b] Root mean square error.

The same was found to be true among the 1986 female subjects. In all equations the coefficients of determination ($R^2$) were low, ranging from 0.12 to 0.40; furthermore, root mean square errors (RMSE) in all cases were high. Thus, the Quetelet index appears to be a poor predictor of body components as determined by densitometry in these men and women. At the lower half of the distribution, the Quetelet index was poorly correlated with BFM ($r$ = 0.24) and FFM ($r$ = 0.37) estimates in the 1967–1986 male group. Correlations with BFM estimates were significantly higher at the upper half ($r$ = 0.56), but not so with FFM ($r$ = 0.47). Among the 1986 female subjects the differences in correlations between the lower and upper half of the Quetelet distribution were less pronounced: $r$ = 0.43 and $r$ = 0.48 for BFM, and $r$ = 0.28 and $r$ = 0.39 for FFM.

In order to test whether the Quetelet index, as a predictor of BFM and FFM from the densitometry measurements, changes with age, a regression analysis was undertaken among the 1967–1986 men and 1986 women, which included age and BMI as predictor variables. The results indicated that age had no statistically significant effects on FFM in the presence of BMI. The same result was obtained for BFM.

Table 4 presents two different aspects in relation to the proposed CED classification based on the Quetelet index. First, the study subjects included cannot overall be classified as chronically energy deficient based on the cut-off points proposed by James *et al.* (1988): a small number of subjects fell below 18.5 kg/m², and only one woman in the 1987 group fell below 16 kg/m². In all four groups the highest percentage consistently fell in the 20–24.9 kg/m² range.

Second, mean fat and fat-free mass values tended to show a general trend towards an increase across the higher BMI categories. In spite of this, the Quetelet index was poorly associated with fat and fat-free mass at low BMI levels, and thus was a poor predictor at the lower levels of fat and fat-free mass in these rural men and women.

## Alternative BMI estimates

The issue has been raised that the relationship between the BMI and the body composition variables is likely to be affected by the particular formulation of that index (Smalley *et al.*, 1990). In our analysis so far, we have included the Quetelet index which is the most widely used by other authors. Many other formulations have been pro-

**Table 4.** Body composition of Guatemalan rural adults classified according to the Quetelet index

| Quetelet index (kg/m²) | 1967–1986[a] | | | | 1987[b] | | | |
|---|---|---|---|---|---|---|---|---|
| | n | Fat (%) | Fat (kg) | FFM (kg) | n | Fat (%) | Fat (kg) | FFM (kg) |
| Men | | | | | | | | |
| <16.0 | 0 | | | | 0 | | | |
| 16.0–16.9 | 0 | | | | 7 | 6.43 ± 1.9 | 2.65 ± 0.79 | 38.52 ± 1.70 |
| 17.0–18.4 | 7 | 8.2 ± 4.7 | 3.87 ± 2.09 | 43.44 ± 4.08 | 46 | 7.70 ± 2.1 | 3.42 ± 0.86 | 41.34 ± 3.91 |
| 18.5–19.9 | 25 | 8.7 ± 3.2 | 4.23 ± 1.51 | 44.69 ± 3.98 | 131 | 8.94 ± 1.6 | 4.31 ± 0.76 | 44.20 ± 4.15 |
| 20.0–24.9 | 90 | 12.4 ± 4.6 | 7.00 ± 2.90 | 48.84 ± 4.67 | 437 | 11.3 ± 2.0 | 6.15 ± 1.44 | 47.94 ± 4.10 |
| >25.0 | 2 | 20.0 ± 1.3 | 12.9 ± 1.58 | 51.99 ± 1.96 | 40 | 16.2 ± 2.7 | 10.92 ± 2.59 | 55.97 ± 5.95 |
| | 1986[a] | | | | 1987[b] | | | |
| Women | | | | | | | | |
| <16.00 | 0 | | | | 1 | 19.4 | 7.6 | 31.4 |
| 16.0–16.9 | 0 | | | | 5 | 18.4 ± 3.8 | 7.0 ± 2.1 | 30.6 ± 2.8 |
| 17.0–18.4 | 3 | 17.5 ± 1.0 | 6.47 ± 0.56 | 30.56 ± 0.73 | 25 | 20.6 ± 2.4 | 8.2 ± 1.4 | 31.7 ± 2.8 |
| 18.5–19.9 | 14 | 20.2 ± 5.6 | 8.84 ± 2.89 | 34.47 ± 1.83 | 83 | 20.2 ± 2.1 | 8.4 ± 1.4 | 33.3 ± 2.2 |
| 20.0–24.9 | 30 | 22.4 ± 5.3 | 10.66 ± 2.64 | 36.83 ± 3.52 | 481 | 22.2 ± 2.6 | 10.5 ± 1.9 | 36.6 ± 2.8 |
| >25.0 | 1 | 26.9 | 15.44 | 41.97 | 111 | 25.8 ± 2.8 | 15.0 ± 3.1 | 42.8 ± 4.4 |

[a] By densitometry.
[b] By best predictive equation (see text).

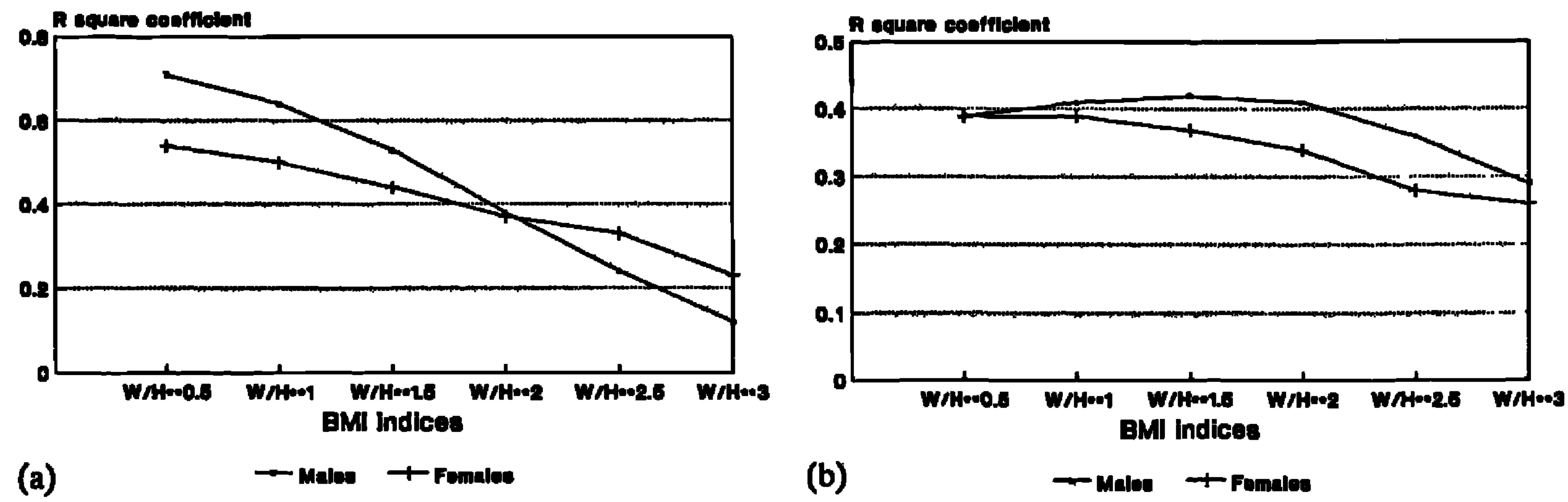


**Fig. 1.** (a) Relationship between BMI indices and fat-free mass (kg) by densitometry; (b) relationship between BMI indices and body fat (kg) by densitometry.

posed (Benn, 1971; Abdel-Malek, Mukherjee & Roche, 1985; Flegal, 1990). We considered here only variations in the value of the power coefficient of height in the weight-for-height ratio (W/H). In order to optimize the linear relationship between fat estimates and the W/H index, using the highest $R^2$ as the optimization criterion, it appears that the power coefficient should be close to 1.5 for these rural men and approximately 1.0 for these rural women (Fig. 1a and b). It is interesting to note that the power coefficient generated for the Benn index was 2.37 for men, and 1.16 for women in these samples. Thus, the Benn index, compared to the Quetelet index, provided stronger correlations with body fat mass among women than among men. It can also be seen in Fig. 1a that the Quetelet index provided poorer correlations with FFM in both men and women than, e.g. a weight-for-height index with a power coefficient of 0.5.

## Discussion

The main conclusions of the study can be summarized as follows. The Quetelet body mass index did not explain a high proportion of the variation in body fat and fat-free mass as estimated by direct body densitometry among these rural men and women in Guatemala. The CED classification proposed by James *et al.* (1988) was found not be applicable in the study population, particularly at the lower end of the BMI distribution. Thus, this index should not be recommended as a universally valid indicator of CED.

Body mass indices, with power coefficients of height less than 2, were more strongly correlated with fat and fat-free mass than the Quetelet index. A basic requirement for a valid relative weight index is that it should be independent from height (Keys *et al.*, 1972). The only index which is completely independent from height is the Benn index. Nevertheless, this index in our samples had a relatively low predictive power of body composition estimates. Alternative, population-specific, indices for the classification of CED may need to be defined in each case once their biological meaning and the appropriate cut-off points have been determined.

The findings of the relatively low body composition predictive power of the $W/H^2$ are in accordance with those reported by Norgan (1990), although he used D-W skinfold equations to estimate body composition. The D-W equations consistently overestimated the fat content with very low precision and validity in this study. We realize that researchers in many less-developed countries may not have the facilities to develop population-specific prediction equations of body composition. On the other hand, researchers in these countries should be aware that the estimates obtained with the equations from the literature may not necessarily be appropriate for their study populations.

The men in our study were generally shorter than men from Ethiopia, India and

Papua New Guinea, but weighed more than those from India and less than those from Papua New Guinea. The same differences in height and weight were found between the women in our samples and those reported by Norgan (1990). The consistency in results across samples of adults with different body dimensions adds strength to Norgan's conclusion, and allows us to question the Quetelet index as a universally valid indicator of CED.

James *et al.* (1988) defined CED as a steady state in which a person is in energy balance although at a 'cost' in terms of increased risk to his/her health and/or an impairment of body functions. They mentioned that a simple way to assess this steady state is by testing the maintenance of the same body weight from one month to the next. Unfortunately, this is not always easy in field settings, which probably explains why it was not considered in their definitions of the BMI and in the CED classification. They suggested instead several possible criteria for the definition of CED. One of these is related to energy intake as a substitute for energy expenditure, assuming that subjects are in energy balance; another is related to a kind of therapeutic test. Results obtained with these two options are not easy to interpret, because the dietary assessment methodology is not accurate enough for this purpose (Bingham, 1987). The second option has been shown very difficult to prove by several supplementation studies aimed at improving productivity among agricultural workers from Colombia (Spurr, 1987), Guatemala (Immink, Viteri & Helms, 1981), and from The Gambia (Díaz *et al.*, 1991).

We conclude that the Quetelet index should not be recommended as a universally valid indicator to classify CED in adult groups similar to the study population.

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