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Simple estimation of ideal body weight from body mass index with the lowest morbidity

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Abstract

Body mass index (BMI) is expressed by the body weight (kg) divided by height (m) squared. Therefore, if we know ideal BMI, ideal body weight (kg) of each individual can be calculated by a formula: Ideal BMI × height (m)^2. In order to estimate ideal BMI, we investigated average BMI with the lowest morbidity using 4565 Japanese men and women aged 30 to 59 years. Their BMI distributed widely with the highest frequency at 23 in men and 21 in women. The morbidity was evaluated by the number of medical problems that the subjects with each BMI have.

The BMI associated with the lowest morbidity was calculated to be 22.2 kg/m^2 in men and 21.9 kg/m^2 in women according to the quadratic regression curves derived from the relation between BMI and morbidity.

From these data, we propose that an ideal body weight in Japanese is 22 × height (m)^2.

Introduction

Estimation of the extent of obesity has been performed several ways without any consensus. Body mass index (BMI) is derived by dividing body weight (kg) by height (m) squared and is internationally accepted as an index to express the extent of overweight or underweight [1,2]. The examination performed by the Japanese Ministry of Health and Welfare in 1986 showed that the mean BMI is constant over a wide range of height. However, these kinds of indexes do not easily enable individuals to understand their body weight excess. It is more desirable to know how much the actual body weight exceeds ideal body weight (IBW). Most ideal body weights are estimated from the height and weight table based on life expectancy [3–9]. For clinical use, ideal body weight with respect to morbidity might be more practical than with respect to life expectancy, and its estimation from a formula is more convenient than from height and weight tables. Therefore, we propose a formula for the estimation of IBW; ideal BMI × height (m)^2. In this study, we investigated an ideal BMI with the lowest morbidity using 3582 Japanese men and 983 Japanese women.

Subjects and Methods

3582 Japanese men (749 aged 30–39 years, 1905 aged 40–49 years, 928 aged 50–59 years) and 983 Japanese women (395 aged 30–39 years, 340 aged 40–49 years, 248 aged 50–59 years). The occupations of the men varied widely from physical laborers such as firemen to sedentary occupations such as office-workers and teachers. Most of the women were housewives. BMI was calculated for each subject.

Cholesterol and triglyceride, plasma glucose, glutamicoxaloacetic transaminase and glutamic pyruvic transaminase, uric acid, red blood cell count and hemoglobin were measured. Plasma glucose was measured again 1 h after a 75 g oral glucose load. Urine protein was measured and occult blood was tested in the urine. Systolic and diastolic blood pressures were determined, and X-ray examination of the chest and Barium examination of upper gastrointestinal tract were performed.

The morbidity in each subject was estimated using the criteria of the ten medical problems shown in Table 1. We assigned to each person one point for each of their problems. After adding these points together, we calculated the average number of points per person (morbidity index) for each BMI. The morbidity index versus the BMI was plotted and the following equation was solved by computer for both men and women; $Y = ax^2 + bx + c$. (Y = morbidity index; x = BMI; a, b and c are constants.)

Results

The BMI in both men and women showed a normal distribution and a mean value was 23.3 and 21.8 kg/m^2 in men and women, respectively (Figs. 1 and 2).

Table 1. Abnormality criteria for medical problems evaluated

Diagnosis	Abnormality criteria
1. Lung disease	Abnormal shadow on chest X-ray
2. Heart disease	Abnormal electrocardiogram
3. Upper gastrointestinal tract disease	Abnormal shadow on upper gastrointestinal X-ray
4. Hypertension	Systolic blood pressure > 140 mmHg and/or Diastolic blood pressure > 90 mmHg
5. Renal disease	Proteinuria and/or hematuria
6. Liver disease	GOT > 40 U/l and/or GPT > 35 U/l
7. Hyperlipidemia	Total cholesterol > 250 mg/dl and/or Triglyceride > 170 mg/dl
8. Hyperuricemia	Uric acid > 7.0 mg/dl (man) Uric acid > 6.0 mg/dl (woman)
9. Glucose intolerance	Fasting plasma glucose > 110 mg/dl and/or glucose 1 h after 75 g OGTT > 160 mg/dl
10. Anemia	RBC < 420 x 10^4/mm^3 and/or Hb < 14.0 g/dl (man) RBC < 380 x 10^4/mm^3 and/or Hb < 12.0 g/dl (woman)

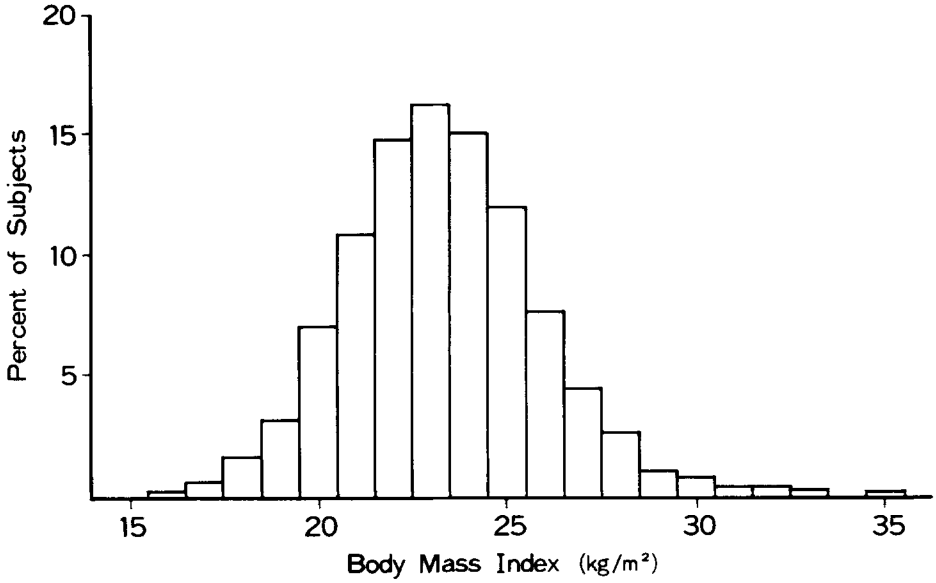

Fig. 1. Distribution of body mass index in 3582 Japanese men.

The BMI positively correlated to the prevalence of hypertension, hyperlipidemia, glucose intolerance and hyperuricemia. There was no relationship between the BMI and the prevalence of heart, renal and liver diseases. An inverse relationship was demonstrated between the BMI and the prevalence of lung diseases, upper gastrointestinal tract diseases and anemia.

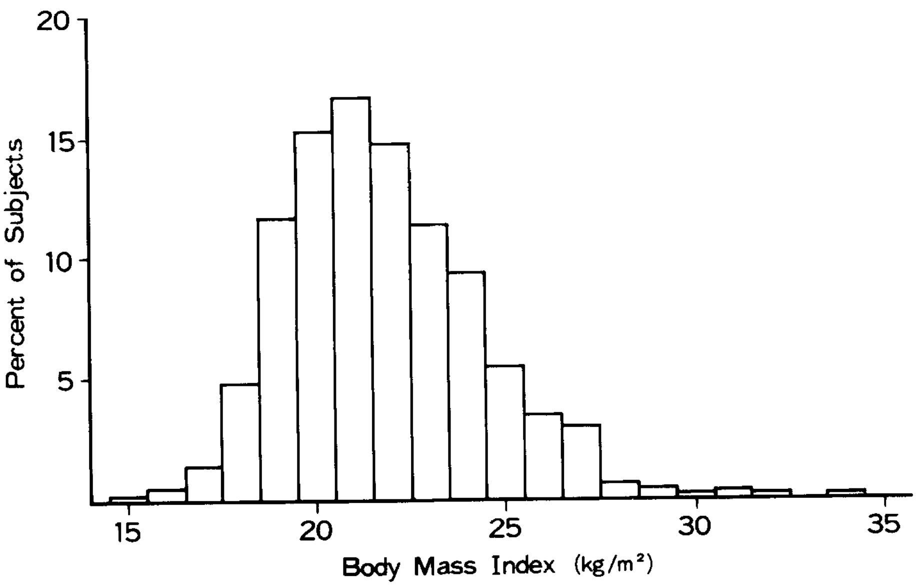

Fig. 2. Distribution of body mass index in 983 Japanese women.

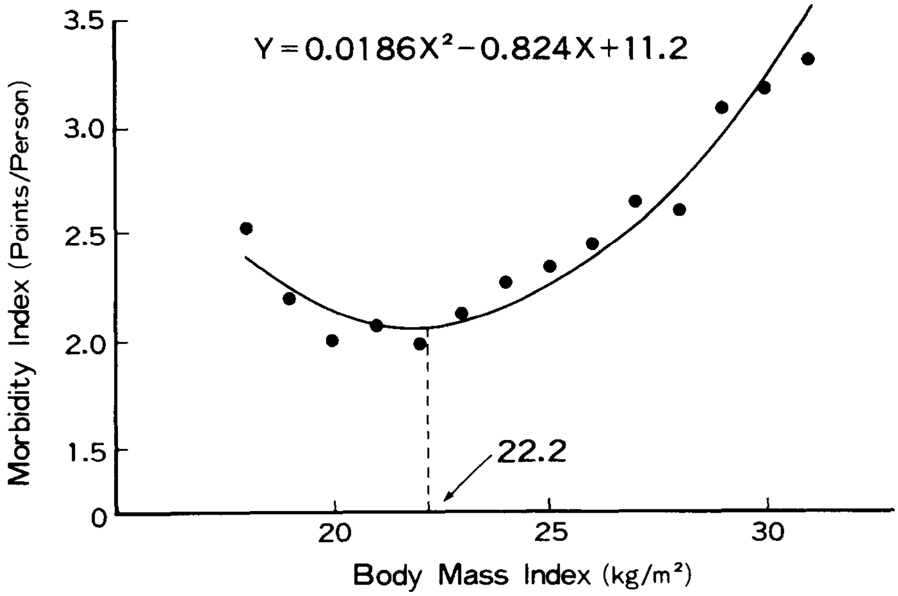

Fig. 3. Relationship between body mass index and morbidity in Japanese men.

The morbidity index versus each BMI was plotted as shown in Figs. 3 and 4. These data fit a quadratic curve (J shape). The quadratic regression curve relating the BMI and the morbidity fit the formula: $Y = 0.086x^2 - 0.824x + 11.2$ in men

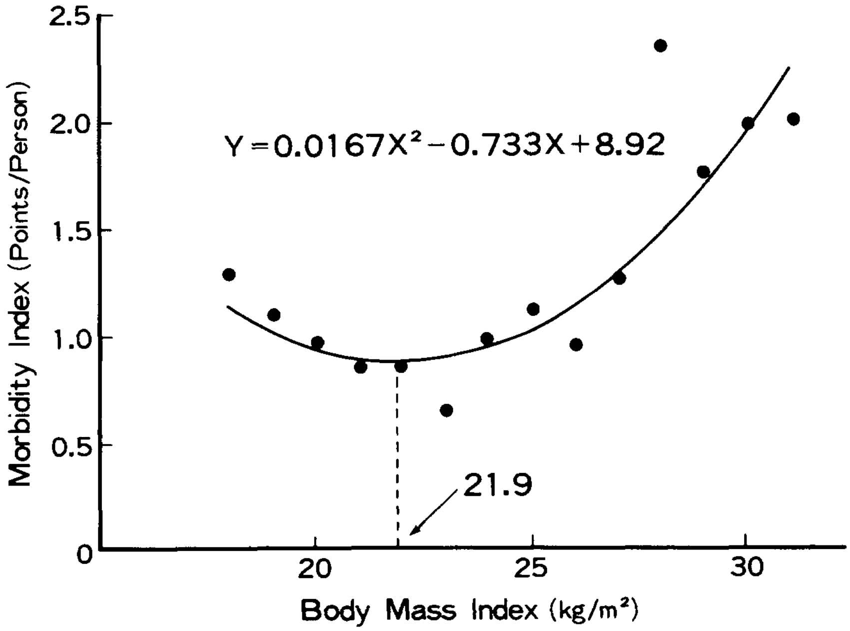

Fig. 4. Relationship between body mass index and morbidity in Japanese women.

(Fig. 2) and $Y = 0.0169x^2 - 0.733x - 8.92$ in women (Fig. 3). The body mass index at the lowest point of the parabolic curve was 22.2 kg/m^2 in men and 21.9 kg/m^2 in women. Twenty two is the closest integral number to ideal BMI in both men and women. From these results, the ideal body weight can be calculated for both men and women as follows:

$$\text{IBW (kg)} = 22 \times \text{height (m)}^2$$

Discussion

A J-shaped curve was observed when an average number of medical problem (morbidity index) versus each BMI was plotted in both men and women. This result may be derived from the following relationship between the BMI and the prevalence of each medical problem. The prevalence of hypertension, hyperlipidemia, glucose intolerance, hyperuricemia and liver disease increased with BMI. The prevalence of lung disease, gastrointestinal tract disease and anemia decreased with BMI.

From the J-shaped curve, we demonstrated that the BMI value associated with the lowest morbidity is 22.2 for men and 21.9 for women. This value was very close to the BMI with the lowest mortality rate which was derived from the weight and height tables analyzed by Tsukamoto [8] and the 1983 Metropolitan Life Association Table [9]. Therefore, 22 can be applied as an ideal BMI from the standpoint of both morbidity and mortality.

Thus, we propose the formula: IBW (kg) = $22 \times$ height (m)^2. The estimation of IBW by this formula seems to be reasonable in the following regards. This is based on the present health hazards and is the most suitable for clinical use. BMI, used in this formula, is an internationally accepted criteria and is constant over a wide range of height in average of general population in Japan. Besides, this formula is convenient as one does not require height and weight tables. In other words, one need only remember the simple formula and the number 22.

The Broca index is also easy to calculate, but it is not suitable for shorter subjects and is based on neither morbidity nor mortality.

Recently, many studies including ours have revealed that fat distribution in obesity is also important with respect to morbidity and that visceral fat accumulation closely correlates to metabolic disorders or cardiac dysfunctions [10–14]. So the combination of the estimation of overweight by our formula with that of fat distribution by waist/hip ratio or visceral fat/subcutaneous fat ratio would be a better indicator of morbid obesity.

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