Public health

Appropriate body-mass index for Asian populations and its implications for policy and intervention strategies

WHO expert consultation*

A WHO expert consultation addressed the debate about interpretation of recommended body-mass index (BMI) cut-off points for determining overweight and obesity in Asian populations, and considered whether population-specific cut-off points for BMI are necessary. They reviewed scientific evidence that suggests that Asian populations have different associations between BMI, percentage of body fat, and health risks than do European populations. The consultation concluded that the proportion of Asian people with a high risk of type 2 diabetes and cardiovascular disease is substantial at BMIs lower than the existing WHO cut-off point for overweight ($\geqslant$25 kg/m^2). However, available data do not necessarily indicate a clear BMI cut-off point for all Asians for overweight or obesity. The cut-off point for observed risk varies from 22 kg/m^2 to 25 kg/m^2 in different Asian populations; for high risk it varies from 26 kg/m^2 to 31 kg/m^2. No attempt was made, therefore, to redefine cut-off points for each population separately. The consultation also agreed that the WHO BMI cut-off points should be retained as international classifications. The consultation identified further potential public health action points (23·0, 27·5, 32·5, and 37·5 kg/m^2) along the continuum of BMI, and proposed methods by which countries could make decisions about the definitions of increased risk for their population.

Introduction

WHO has recommended classifications of bodyweight that include degrees of underweight and gradations of excess weight or overweight that are associated with increased risk of some non-communicable diseases.[1,2] These classifications are based on body-mass index (BMI), calculated as weight in kilograms divided by height in metres squared (kg/m^2). As a measure of relative weight, BMI is easy to obtain. It is an acceptable proxy for thinness and fatness, and has been directly related to health risks and death rates in many populations.

In 1993, a WHO expert committee meeting[1] proposed BMI cut-off points of 25·0–29·9 kg/m^2 for overweight grade 1, 30·0–39·9 kg/m^2 for overweight grade 2, and $\geqslant$40·0 kg/m^2 for overweight grade 3. In 1997, a WHO expert consultation[2] proposed an additional subdivision at a BMI of 35·0–39·9 kg/m^2, recognising that management options for dealing with obesity differ above a BMI of 35 kg/m^2.

The 1993 expert committee emphasised that weight gain in adult life is associated with increased morbidity and mortality at increasing BMIs, and that cut-off points for the amount of overweight should not be interpreted in isolation but in combination with other risk factors of morbidity and mortality. Type 2 diabetes, cardiovascular disease and increased mortality are the most important sequelae of obesity and abdominal fatness, but other associations are seen in musculoskeletal disorders, limitations of respiratory function, and reduced physical functioning and quality of life.[3]

The WHO BMI classifications of overweight and obesity are intended for international use. They reflect risk for type 2 diabetes and cardiovascular diseases, which are

rapidly becoming major causes of death in adults in all populations—even in those who still have substantial malnutrition. However, the absolute prevalence and incidence of type 2 diabetes varies greatly among ethnic groups, such as the very high prevalence in Pima Indians, and including some who have simliar BMIs, such as higher rates in Taiwanese and Japanese Americans than in European populations.[3]

Three specific factors led WHO to convene another expert consultation on BMI classifications. First, there was increasing evidence of the emerging high prevalence of type 2 diabetes and increased cardiovascular risk factors in parts of Asia where the average BMI is below the cut-off point of 25 kg/m^2 that defines overweight in the current WHO classification. Second, there was increasing evidence that the associations between BMI, percentage of body fat, and body fat distribution differ across populations. In particular, in some Asian populations a specific BMI reflects a higher percentage of body fat than in white or European populations. Some Pacific populations also have a lower percentage of body fat at a given BMI than do white or European populations. Third, there had been two previous attempts to interpret the WHO BMI cut-offs in Asian and Pacific populations,[4,5] which contributed to the growing debates on whether there are possible needs for developing different BMI cut-off points for different ethnic groups.

The WHO expert consultation on BMI in Asian populations, which met in Singapore from July 8–11, 2002, focused exclusively on issues related to overweight and obesity. The consultation therefore did not discuss the health consequences at the low range of BMI (ie, <18·5 kg/m^2), which indicates underweight, though this has been addressed before.[1] Here, we discuss the highlights of the expert consultation's deliberations, describe the evidence base available for review, and present the main conclusions and recommendations of the consultation.

Background
Asian populations

The umbrella term Asian characterises a vast and diverse portion of the world's population. Diversity in Asian

countries is based on ethnic and cultural subgroups, degrees of urbanisation, social and economic conditions, and nutrition transitions. There are also many Asian immigrants throughout the world to whom the considerations addressed in the consultation might apply. When taken together, these populations cover a wide range of morbidity and mortality profiles, social and economic determinants of health, with high absolute risks in some cases. What these populations have in common is that, in general, the mean or median BMI is lower than that observed for non-Asian populations (and hence the BMI distribution is shifted to the left), although the tendency towards abdominal obesity might be greater than in non-Asian populations. Such a trend leads to the concern that application of the current WHO BMI cut-off points will underestimate obesity-related risks in these populations.

Uses of BMI cut-off points

BMI cut-off points for overweight and obesity have many uses, all of which are applicable to Asian countries. For policy purposes, such cut-off points are applied to population data to inform and trigger policy action, to facilitate prevention programmes, and to measure the effect of interventions. For epidemiological purposes, associations between BMI and health outcomes within and across populations are used to help ascertain the cause of diseases. When assessing the effect of BMI on health outcomes, the rate difference was regarded as the best measure, since relative risk depends on baseline data and could be misleading when baseline rates are vastly different.[6] However, relative risk should be considered when investigating causes. Population attributable risk is particularly useful for policy since it identifies the largest burden of risk.

BMI cut-off points are also used clinically to identify high-risk individuals for screening; identify individuals for absolute risk assessment; determine the type and intensity of treatment; monitor individuals for effects of treatment over time; determine institutional policies on individuals, for example, insurance reimbursement; and increase awareness of risk for individuals. Factors to be considered, and a relevant clinical decision-making algorithm, were described by the 1997 WHO Expert Consultation.[2] For clinical applications, the cut-off points should be used with an individual's clinical history and with other clinical measurements, such as waist circumference and presence of other related risk factors.

The associations of BMI and comorbidities are probably not stable within populations over time. In the same way that there are environmentally determined differences in these associations across different population groups, these associations also vary within populations according to environmental changes and nutritional transitions.[7] Variation in socioeconomic status (as assessed by education) is associated with obesity and differences in obesity are seen in the same population group by place of origin and migration status.[7] For example, at present in the USA there are low proportions of Asian Americans who are overweight according to the current classifications; this proportion will increase with more USA-born Asian Americans and with longer stays in the USA.[8]

A European perspective on the relations between BMI, body composition, and risk factors noted that whenever populations are divided into subgroups, heterogeneity of risk will be found.[9] Consideration of absolute risk for a given BMI in the context of other risk factors is preferable for treatment.[10] Ethnic-specific BMI cut-off points are not

	Overweight		Obesity	
	Point analyses*	ANCOVA†	Point analyses*	ANCOVA†
China	24	25	29	30
China (Hong Kong)	23	22	27	27
Indonesia	24	22	26	27
Japan	25	24	30	29
Singapore	22	23	27	27
Thailand (urban)	25	23	30	28
Thailand (rural)	27	25	31	30

Values are calculated cut-off points (kg/m²) rounded to two significant figures. *Values based on the assumption that the percentage of body fat in Asians at the cut-off point for overweight and obesity is the same as the percentage of body fat in white people with a BMI of 25 and 30 kg/m², respectively. †Values based on the analysis of co-variance with BMI as the dependent variable, "country" as grouping variable (white people as reference), and age, sex, and percentage of body fat as covariates.

Calculated body-mass index (BMI) cut-off points for overweight and obesity in Asian populations by different methods

used in Europe despite heterogeneity and widely varying disease risk and obesity prevalence. Ethnic-specific cut-off points for BMI were thought to increase confusion in health promotion, and disease prevention and management in the increasingly multicultural societies in Europe.[10]

Methodological considerations in use of BMI to indicate fatness

Results of several studies[11,12] have shown that BMI correlates highly with percentage of body fat and is largely independent of height, enabling an unbiased comparison between short and tall population groups. It should, however, be kept in mind that BMI is no more than weight adjusted for height, and that BMI is also related to fat free mass and to a lesser extent, also to body build. Body composition (ie, specific determination of body fat as distinct from lean tissues such as bone and muscle) can be measured in vivo by various techniques.[13] Some of these techniques are not feasible or are inaccurate in epidemiological field settings. The validity of assessment of body composition, and the implications for population measures chosen to be collected in field settings are summarised below.

Validity of body composition methods

Methods to measure body composition in vivo can be direct, indirect, and doubly indirect.[14] Direct methods measure directly the component of interest—eg, in-vivo neutron activation analysis (IVNAA). IVNAA can measure amounts of chemical elements in the body, from which information about body components of interest can be obtained (eg, total body protein=$6.25\times$total body nitrogen).[15] IVNAA is expensive. Worldwide, only a few laboratories use the this method, and it is used mainly for clinical purposes.

Indirect methods, such as densitometry, deuterium oxide dilution, and dual energy X-ray absorptiometry (DXA), rely on assumptions that might not always be true. A chemical four-compartment model is generally regarded as the best choice to measure body composition.[16] For example, in a four-compartment model the amount of minerals, protein, and water in the body is measured, and body fat (fourth compartment) is calculated by difference. The number of assumptions in such a four-compartment model is small, and consequently the possible bias is small. For cross-population comparisons, be it young versus old, lean versus obese, or between different ethnic groups, the four-compartment model should be the method of choice. Unfortunately, it is expensive and time-consuming and few laboratories have the capacity for using it, since

densitometry or IVNAA, deuterium oxide dilution, and DXA must be available. The maximum bias in measured body fat is 3% for densitometry, 2% for deuterium oxide dilution, 3–4% for DXA, and about 1% for a four-compartment model.

Doubly indirect methods rely on a statistical association between easily measurable body variables and a measure of body composition, usually obtained by an indirect method. Thus, they are no more than a prediction, and the bias at an individual level, and at a population level, can be substantial. Examples of doubly indirect methods are skinfold thicknesses, bioelectrical impedance, waist circumference, and BMI-based prediction equations for the percentage of body fat.

Associations of BMI with body fat

Many studies have been published in which the association between BMI and the percentage of body fat was investigated. Most show that the relation between BMI and the percentage of body fat depends on age and sex, and differs across ethnic groups.[11,12,17–22] For example, Wang and colleagues[17] showed that Chinese people originating from the Shanghai region and living in New York City have a lower BMI but a higher percentage of body fat than white people of the same age and sex. Guricci and co-workers[18] showed that Indonesians have, for the same age, sex, and percentage of body fat, a BMI that is about 3 kg/m^2 lower than that of white people in the Netherlands. Swinburn and colleagues[20] showed that, conversely, Polynesians have a lower percentage of body fat than do white people, for the same age, sex, and BMI. Nevertheless, not all studies found differences between ethnic groups in the relation between BMI and percentage of body fat. Gallagher and colleagues[12] could not find differences between American blacks and whites, although other studies[23] strongly suggest such differences. Deurenberg and co-workers[24] found no differences between white people in the Netherlands and Chinese people in Beijing.

Evidence considered by the expert consultation
BMI and body fat

A series of analyses of BMI, body composition, and risk factors in Asian populations was compiled for the
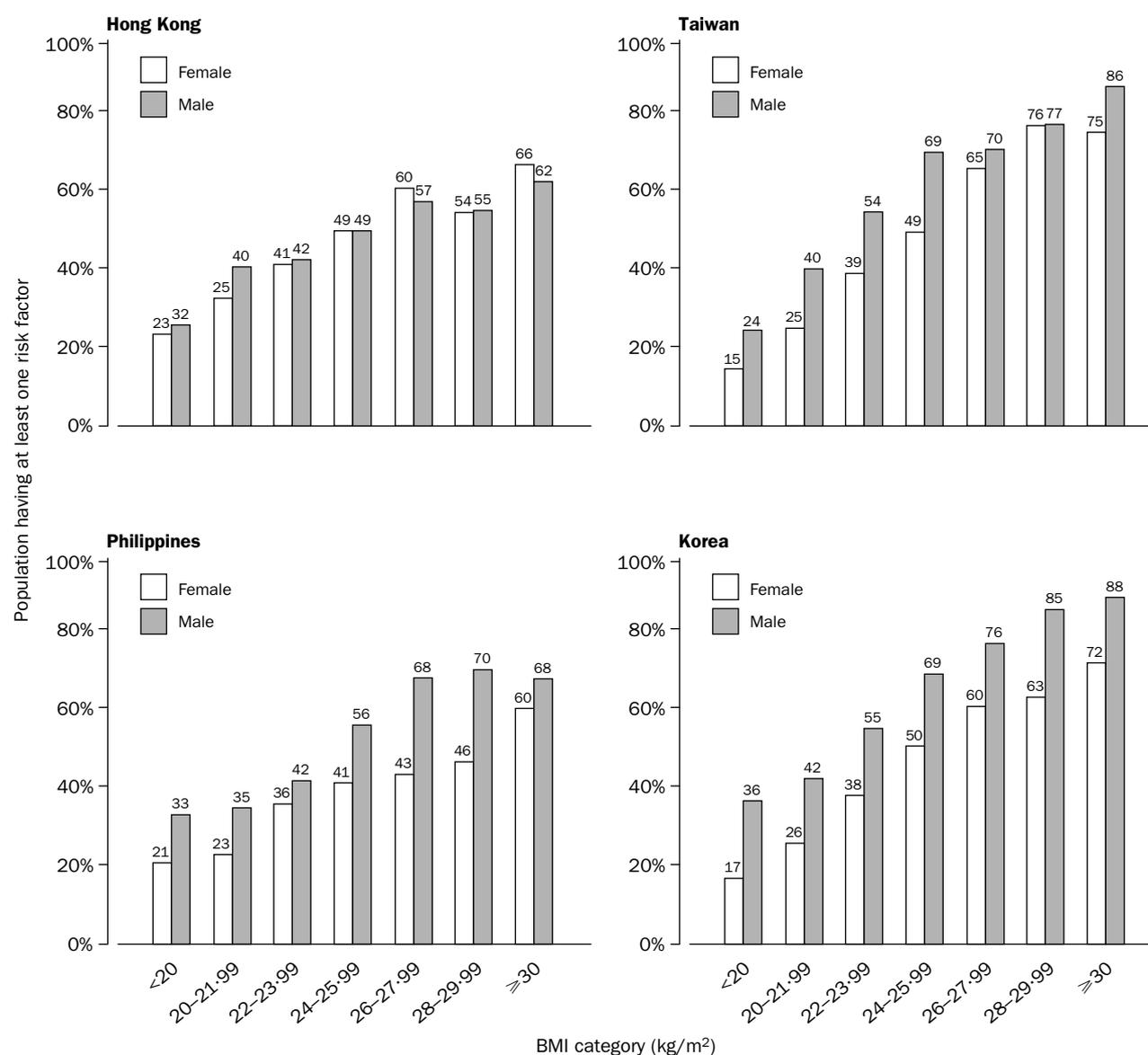

Figure 1: **Proportion of population in various body-mass index (BMI) categories with at least one risk factor for cardiovascular disease**
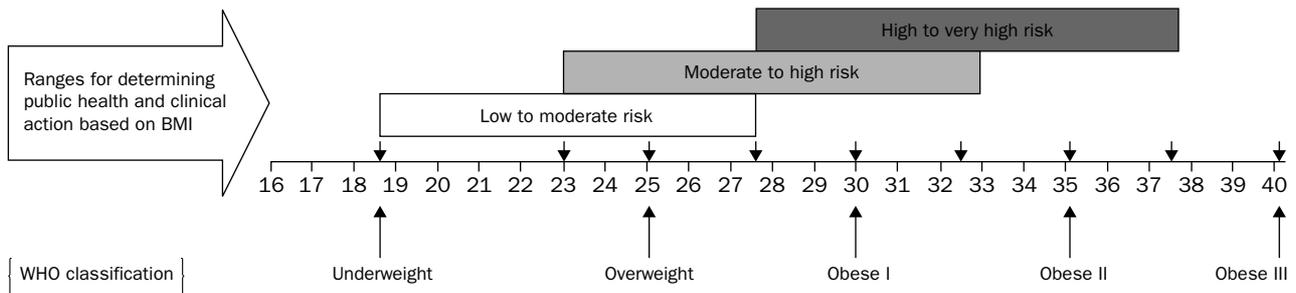
Figure 2: **Body-mass index (BMI) cut-off points for public health action**

consultation from studies in China, Hong Kong, India, Indonesia, Japan, Republic of Korea, Malaysia, Philippines, Singapore, Taiwan, and Thailand.[25] Of the 15 data sets initially analysed to assess the relation between BMI and the percentage of body fat in Asians, six sets were later excluded because the method used for assessment of body composition (bioelectrical impedance or anthropometry) was not deemed sufficiently valid for inclusion in a cross-population comparison of the association between BMI and body fat. As mentioned above, prediction equations for body composition based on anthropometry or bioelectrical impedance are generally not accurate and are population specific.

The series of body composition analyses using a standard format confirmed that there are obvious differences in the relation between BMI and the percentage of body fat across ethnic groups. It also highlighted the large variation among Asian populations. From the analyses undertaken, Hong Kong Chinese, Indonesians, Singaporeans, urban Thai, and young Japanese had lower BMIs at a given body fat compared with Europeans, whereas Beijing (northern) Chinese and rural Thai had similar values to those of Europeans. These differences across Asian groups might be because of the methods used, but might also reveal real differences among the ethnic groups. There are also reported differences in the relation between BMI and the percentage of body fat among white people. White people in the USA generally have a lower percentage of body fat for the same BMI than do those in Europe.[19] Therefore, if the US prediction formula[12] is applied to the European population, the percentage of body fat in Europeans is underestimated by 2·8 (SD 4·6%).

In general, Asian females (but not the Chinese) have a lower BMI for the same age and percentage of body fat than do white women. The differences range from –0·3 kg/m² (rural Thai females) to –3·6 kg/m² (Hong Kong Chinese females). Asian males (except rural Thai) have a lower BMI for the same age and the percentage of body fat than white males; values range from –0·9 kg/m² (Japanese males) to –2·7 kg/m² (Indonesian males). If all Asian groups are combined, their BMI is 1·3 kg/m² (±0·1) lower in females and 1·4 kg/m² (±0·1) lower in males compared with their European counterparts. If rural Thai are not included, these values are slightly higher at 1·4 kg/m² (±0·1) and 1·6 kg/m² (±0·1) for females and males, respectively. The differences across the countries seemed too big to justify the merging of data, not least because there might be good explanations for these differences (ie, differences in body build, amount of physical activity).

If obesity in white people is defined as a BMI of 30 kg/m² or higher, the corresponding percentage of body fat in white people can be calculated with the equation for white people (Europeans). The percentage of body fat, which depends on age and sex, was in the range 37–45%

(mean 41%) for females and 25–36% (mean 28%) for males. Similarly, overweight (≥25 kg/m²) corresponded to 31–39% (mean 35%) body fat in females and 18–27% (mean 22%) body fat in males. If these criteria for the percentage of body fat for overweight and obesity are applied to the Asian populations, the corresponding BMIs can be calculated with country-specific equations (table).

When the BMI cut-off points for overweight and obesity were calculated, based on the assumption of a percentage of body fat at BMI values of 25 kg/m² and 30 kg/m², respectively, these values were slightly different and generally higher than the values obtained using analysis of co-variance with the percentage of body fat, age and sex as covariates (table).

BMI and health risks

The relative percentage of body fat at different BMIs clearly varies within populations. It depends on environmental factors, such as the amount of physical activity, as observed in the differences between rural and urban populations in India and Thailand, as well as physiological factors. Of greater concern to the expert consultation than these relations between BMI and body fat, was whether the higher percentage of body fat at lower BMIs also reflects increased risk of disease (ie, diabetes and heart disease), risk factors for chronic disease, and death at lower BMIs in Asian populations.

Consistent with the previously discussed data for BMI and body fat, published studies on Hong Kong Chinese,[22,26] Singaporean Chinese, Malays and Indians,[21] Indonesians,[18] and Japanese[27] suggest that these Asian populations have a high percentage of body fat at a low BMI. Studies in Hong Kong and Singapore[26,28] showed that the risk of having cardiovascular disease or diabetes is high at lower BMIs. Data from China indicate that the prevalence of hypertension, diabetes, dyslipidaemia, and clustering of risk factors all increased with increasing BMIs even at indices below the current cut-off point for overweight (ie, 25 kg/m²).[29] Data from Hong Kong, Korea, Philippines, and Taiwan, analysed in preparation for the expert consultation, show that the relative risk of having at least one risk factor for cardiovascular disease is high at a low BMI in Chinese from Hong Kong and from Taiwan, in Filipinos, and in Koreans (figure 1), as has also been found for mainland Chinese[30] and in Indians.[31] Nevertheless, progression in the prevalence of diabetes with increasing BMI and waist circumference is seen in all populations.

The consultation also acknowledged that Pacific populations, although small, have the highest rates of obesity in the world. Compared with Europeans, Polynesians have a low proportion of fat mass to lean mass, but also have a higher prevalence of diabetes. By contrast, Asians have both a higher body fat percentage and diabetes rate than Europeans.

Conclusions

On the basis of the available data in Asia, the WHO expert consultation concluded that Asians generally have a higher percentage of body fat than white people of the same age, sex, and BMI. Also, the proportion of Asian people with risk factors for type 2 diabetes and cardiovascular disease is substantial even below the existing WHO BMI cut-off point of 25 kg/m². Thus, current WHO cut-off points do not provide an adequate basis for taking action on risks related to overweight and obesity in many populations in Asia.

However, the available data do not necessarily indicate one clear BMI cut-off point for all Asians for overweight or obesity. The BMI cut-off point for observed risk in different Asian populations varies from 22 kg/m² to 25 kg/m²; for high risk it varies from 26 kg/m² to 31 kg/m². Lowering cut-off values by three units (as seems appropriate for Hong Kong Chinese, Indonesians, and Singaporeans) would have been too much for other populations (eg, northern Chinese and Japanese). Where the indicated change in BMI cut-off values would be small (eg, from 30 kg/m² to 29 kg/m²), the wisdom of making a change for such a minor difference in weight could be questioned.

The purpose of a BMI cut-off point is to identify, within each population, the proportion of people with a high risk of an undesirable health state that warrants a public health or clinical intervention. When applied to a population, the purpose of anthropometric cut-off points is to identify independent and interactive risks of adverse health outcomes associated with different body compositions, so as to inform policy, trigger action, facilitate prevention programmes, and assess the effect of interventions. Reducing BMI cut-off values for action on overweight and obesity would increase their prevalence rates overnight and, therefore, increase governmental and public awareness. However, such a change would require public health policies and clinical management guidelines to be changed, and could lead to increased costs for governments (ie, more treatment at lower thresholds).

The expert consultation, therefore, agreed that BMI cut-off points should be: based on easy-to-obtain valid and reliable measurement in surveys and clinical settings; sensitive to important health-related change over time for monitoring purposes; science-based, with a sound general foundation, and with validity in the population in question; able to predict risks in populations and detect difference in risks between population groups; useful for comparisons across populations; and based on ideas that are easy for policy-makers, clinicians, and the public to understand.

The consultation made no attempt to redefine BMI cut-off points for each population separately. Rather, they identified potential public health action points along the continuum of BMI and proposed the methods by which countries could make decisions about the definitions of increased risk for their population. Such an approach has several advantages: the BMI cut-off points will cover differential risk and BMI versus body fat relations; lack of availability of data for a specific population does not invalidate the cut-off points; identification of a specific set of divisions should promote a standardised approach among countries; the cut-off points should persist long term because the availability of new data will not trigger a revision; the values are relevant both for public health purposes and to development of clinical guidelines; and finally, it does not require additional measurement of waist for public health purposes but still allows for additional use of waist for screening and clinical purposes. The panel shows the recommendations made by the consultation.

Recommendations

1 The current WHO BMI cut-off points of <16 kg/m² (severe underweight), 16·0–16·9 kg/m² (moderate underweight), 17·0–18·49 kg/m² (mild underweight), 18·5–24·9 kg/m² (normal range), ≥25 (overweight), 25–29·9 kg/m² (preoboese), ≥30 kg/m² (obesity). 30–39·9 kg/m² (obese class I), 35–39·9 kg/m² (obese class II), ≥40 kg/m² (obese class III) should be retained as international classification. But the cut-off points of 23, 27·5, 32·5, and 37·5 kg/m² (figure 2) are to be added as points for public health action.

2 For continuity, particularly in countries with concurrent problems of undernutrition and overnutrition, the distribution should continue to be presented as a continuum beginning with BMI <16 kg/m², through the BMI category of ≥40 kg/m². Below 18·5 kg/m² the categories are based on existing WHO standards for grades of undernutrition (ie, <16, 16–16·9, 17–18·5 kg/m²). Above 18·5 kg/m² the categories are midway between the current cut-off points, except for the 18–24·9 kg/m² category. In this latter case, the intermediate cut-off point (23 kg/m²) was chosen as the public health action point on the basis of the results of the meta-analysis involving results from nine countries in Asia and other published work. Also, the earlier optimum population range (21–23 kg/m²)2 gives some intuitive consistency for policy makers.

3 For many Asian populations, additional trigger points for public health action were identified as 23 kg/m² or higher, representing increased risk, and 27·5 kg/m² or higher as representing high risk. The suggested categories are as follows: less than 18·5 kg/m² underweight; 18·5–23 kg/m² increasing but acceptable risk; 23–27·5 kg/m² increased risk; and 27·5 kg/m² or higher high risk.

4 Guidance should be provided to countries to identify public health action points that are most useful for the situation in each country. Countries should be aware that the increased risk is a continuum with increasing BMI, and that cut-off points are merely a convenience for public health and clinical use.

5 In considering BMIs of less than 21, it should be borne in mind that the lower range of BMI might reflect undernutrition in populations with current or recent widespread undernutrition.

6 Wherever possible, countries should use all categories for reporting purposes, with a view to facilitating international comparisons (ie, 18·5, 20, 23, 25, 27·5, 30, 32·5 kg/m², and in many populations, 35, 37·5, and 40 kg/m²).

7 Where possible, in populations with a predisposition to central obesity and related increased risk of developing the metabolic syndrome, waist circumference should also be used to refine action levels on the basis of BMI. For example, action levels based on BMI might be increased by one level if the waist circumference is above a specified action level. The choice of that level should be based on population-specific data and considerations. Therefore, a WHO working group was formed to examine available data on the relation between waist circumference and morbidity and the interaction between BMI, waist circumference, and health risk to further investigate next action and develop recommendations for the use of additional waist measurements to further define risks.

Research needs

The consultation did not have enough data to adequately describe either the association of BMI with body fat, or the association of BMI or fatness with morbidity and mortality in populations in Asian countries, or in subgroups within countries. Furthermore, some of the available data were not suitable for cross-population comparisons because of the techniques used to assess body fat. Some data from earlier attempts to address Asian BMI issues were just being published.[5]

Meaningful body composition studies do not require large samples, but do require an adequate and valid methodology. Similarly, to allow cross-country comparisons, the techniques should be standardised. A multicentre study across Asian countries with some 200 men and women aged 20–65 years with a BMI of 17–35 kg/m^2 per centre, using an adequate reference technique in addition to predictive methods for body composition, would provide the necessary data for reliable comparisons between BMI and the percentage of body fat. It would also allow participating countries to validate prediction methods such as impedance and anthropometry for use in larger population studies.

Further body composition studies are needed not only for Asian, but also for the Pacific Island populations to determine equivalent amounts of fatness and the relation to body size and BMI. Such studies would assist in determining whether some populations preferentially deposit abdominal fat, and would also help to develop waist circumference cut-off points.

Longitudinal studies are also needed in both Asian and Pacific Island countries (ie, Melanesians, Micronesians, and Pacific-based Polynesians) to determine the relation between BMI, waist circumference, and risk of developing co-morbidities, such as type 2 diabetes, hyperlipidaemias, and hypertension. Such studies would help further validate selected BMI cut-off points defined on health outcome data.

The role of abdominal obesity in Asians (as identified by waist circumference, waist to hip or waist to height ratio), in predicting the metabolic syndrome needs further investigation. Also the impact of fetal nutrition on adult diseases needs further research, especially in Asian societies, who have many children born with low birthweights. Indian and some other data presented showed the association between early nutritional disadvantage and later weight gain and how this is a particularly strong indicator of enhanced morbidity.[31]

Other research needs include: (i) prospective studies on body composition and risk factors; (ii) studies on younger populations and adolescents; (iii) model studies; (iv) health impact studies of overweight and obesity in Asian countries; (v) studies on policy application of BMI cut-off points; (vi) further research on the prevention of obesity; (vii) further studies to investigate the attitudes to obesity in different populations (including attitudes about fatter children) in the Asian and Pacific Island countries to help guide interventions; and (viii) studies on how to effectively communicate findings and general health promotion information.

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Clinical picture

The Y-Y paradox

Chittaranjan S Yajnik, John S Yudkin

BMI
22·3   22·3
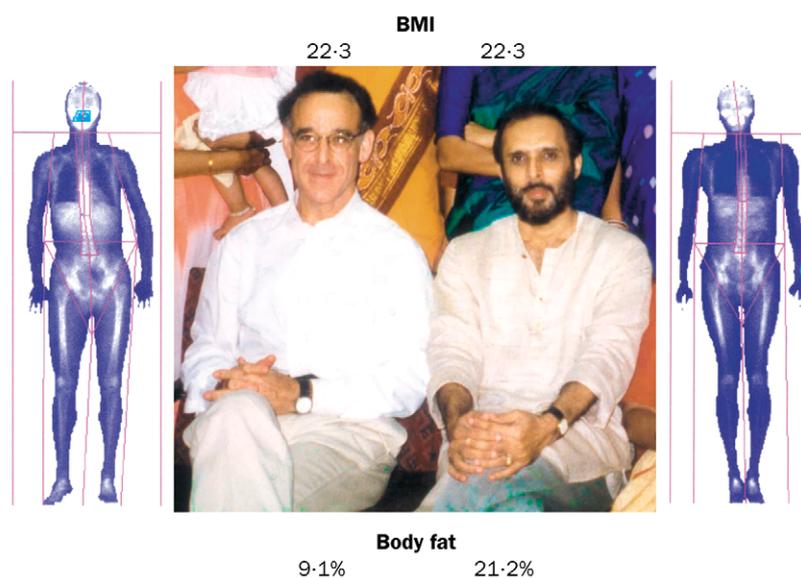
Body fat
9·1%   21·2%

The two authors share a near identical body-mass index (BMI), but as dual X-ray absorptiometry imagery shows that is where the similarity ends. The first author (figure, right) has substantially more body fat than the second author (figure, left). Lifestyle may be relevant: the second author runs marathons whereas the first author's main exercise is running to beat the closing doors of the elevator in the hospital every morning. The contribution of genes to such adiposity is yet to be determined, although the possible relevance of intrauterine under-nutrition is supported by the first author's low birthweight. The image is a useful reminder of the limitations of BMI as a measure of adiposity across populations.

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