The Worldwide Obesity Epidemic

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Abstract
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The recent World Health Organization (WHO) agreement on the standardized classification of overweight and obese, based on body mass index (BMI), allows a comparable analysis of prevalence rates worldwide for the first time. In Asia, however, there is a demand for a more limited range for normal BMIs (i.e., 18.5 to 22.9 kg/m^2 rather than 18.5 to 24.9 kg/m^2) because of the high prevalence of comorbidities, particularly diabetes and hypertension. In children, the International Obesity Task-Force age-, sex-, and BMI-specific cutoff points are increasingly being used. We are currently evaluating BMI data globally as part of a new millennium analysis of the Global Burden of Disease. WHO is analyzing data in terms of 20 or more principal risk factors contributing to the primary causes of disability and lost lives in the 191 countries within the WHO. The prevalence rates for overweight and obese people are different in each region, with the Middle East, Central and Eastern Europe, and North America having higher prevalence rates. In most countries, women show a greater BMI distribution with higher obesity rates than do men. Obesity is usually now associated with poverty, even in developing countries. Relatively new data suggest that abdominal obesity in adults, with its associated enhanced morbidity, occurs particularly in those who had lower birth weights and early childhood stunting. Waist measurements in nationally representative studies are scarce but will now be needed to estimate the full impact of the worldwide obesity epidemic.

Key words: prevalence, ethnic, childhood, abdominal, fetal programming

Introduction

The World Health Organization (WHO) recently published the final text of the Expert Technical Consultation on Obesity, which was held in Geneva, Switzerland in June 1997 (1). This short meeting was organized after the International Obesity Task Force (IOTF) developed a comprehensive analysis of the problem with a draft report over 2 years, which was the basis for the WHO Technical Report. This was the first attempt by WHO to consider the problem, because issues of nutrition had previously been almost exclusively concerned with such matters as breast-feeding, protein energy malnutrition, and micronutrient deficiencies. The earlier report of WHO on physical anthropometry (2) had sections related to overweight and obesity, but this earlier analysis was an attempt to cope with the requirements of measurement, to define normal weight, and to ensure that an appropriate analysis was made of a nation's prevalence of underweight or overweight in children or adults. The vast majority of the work was related to childhood underweight. In 1995, WHO accepted our views that the lower body mass index (BMI) for the normal adult range should be changed from 20.0 to 18.5 kg/m^2. The full normal range was set at a BMI of 18.5 to 24.9 kg/m^2, with this index being recognized as a crude approximation for a height-independent measure of weight. It was recognized that the power of height for women might be more appropriately set at 1.6 m rather than 2.0 m, but in the interests of simplicity the same BMI expression was used for both sexes and for all ages over 18.0 years. Below 18 years of age, there was far more concern with how best to express underweight, which was again defined on an arbitrary basis as a weight-for-height of <2 SD of the normal weight-for-height for children of the same age and sex. This categorization then tended to be applied to overweight so that overweight children would be classified as those ≥ 2 SD.

The new WHO report (1) is much more concerned with the health hazards of overweight and obesity and the issues of how best to prevent excessive weight gain and to treat different degrees of overweight and obesity. The agreement that the normal BMI should remain at 18.5 to 24.9 kg/m^2 was a compromise, because in the United States, higher levels of BMI were accepted as normal, with some experts suggesting that there should be an age-related increase in these upper limits. Table 1 shows the agreed specification of different degrees of overweight and obesity by WHO. The additional categories of extreme BMI, based on cutoff points of 35 and 40 kg/m^2, were chosen to help in the

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Table 1. WHO classification of obesity

Classification	BMI (kg/m^2)	Risk of comorbidities
Underweight	< 18.5	Low (but risk of other clinical problems increased)
Normal range	18.5 to 24.9	Average
Overweight	≥ 25	
Pre-obese	25.0 to 29.9	Increased
Obese class 1	30.0 to 34.9	Moderate
Obese class 2	35.0 to 39.9	Severe
Obese class 3	≥ 40.0	Very severe

	Waist circumference (cm)	
Comorbidity risk	**Women**	**Men**
Above action level 1	≥80	≥94
Above action level 2	≥88	≥102

development of treatment strategies. All BMI limits are arbitrary: the categorical analysis is essentially used to present comparative data from different countries, to depict secular changes in the epidemic, and, as noted, to help prepare a scheme for clinical management. In practice, Rose (3) had already highlighted, from his reanalysis of the distributions of BMI in adults studied for the Intersalt project, that the prevalence of obesity was crucially dependent on the shift in the distribution of the whole population. Thus, modest shifts in the mean of the BMI distributions caused substantial and predictable increases in the prevalence of obesity. The implications of this analysis are that total population strategies should be the primary endeavor of obesity prevention schemes and that a mean population BMI of <23 kg/m^2 was needed if the prevalence of obesity (i.e., BMI ≥ 30 kg/m^2) was to be minimized.

Not only does the categorical analysis simply reflect shifts in population distributions, but the choice of cutoff point is also arbitrary because the health hazards of different degrees of weight are not substantially changed at any particular cutoff point. Indeed, Willett et al. (4) showed that there were age-dependent changes in the relationship of BMI to total mortality and that the classic comorbidities intrinsically linked to an excess BMI, e.g., diabetes, hypertension, gall stones, and coronary heart disease, were linearly related to BMI from a BMI nadir of ~19 or 20 kg/m^2 in prospective studies of professional groups of men and women. Thus, the choice of an upper normal value of 24.9 kg/m^2 for individuals is very generous, and this value is quite different from the optimum population mean BMI, which, as in the latest WHO report, should be between 21.0 and 23.0 kg/m^2. Nonsmoking individuals are likely to have an optimum life expectancy and disability-free life if their BMIs remain at ~20 kg/m^2 throughout life.

Recently Asian investigators have returned to this issue and proposed an alternative classification system (Table 2) because they are so concerned about the high prevalence of diabetes and hypertension at very modest increases in BMI (5). Thus, they seek to identify a BMI cutoff point of 25 kg/m^2 as signifying frank obesity and an upper limit of normal as 22.9 kg/m^2. This is an important issue because although no evidence was published to support their concern, our recent analyses of the impact of comorbidities suggest that the absolute levels of diabetes and hypertension on an age- and sex-specific basis are substantially higher in individuals of Asian origin. Whereas this ethnic difference is seen by most investigators as indicative of genetic factors,

Table 2. Comorbidities risk associated with different levels of BMI and suggested waist circumference in adult Asians (5)

		Risk of comorbidities	
Classification	**BMI (kg/m^2)**	**Waist circumference (cm)**	
		<90 (men) <80 (women)	≥90 (men) ≥80 (women)
Underweight	<18.5	Low (but increased risk of other clinical problems)	Average
Normal range	18.5 to 22.9	Average	Increased
Overweight	≥23		
At risk	23 to 24.9	Increased	Moderate
Obese I	25 to 29.9	Moderate	Severe
Obese II	≥30	Severe	Very severe

the burgeoning work of Barker and his colleagues suggests that environmental factors are of exceptional importance. Thus, Law et al., (6,7) in their systematic analyses, showed a clear inverse relationship between birth weight and the prevalence of adult hypertension in the majority of >80 studies from all over the world. Analyses from Japan, China, and India suggest that the increased prevalence of hypertension and diabetes at any BMI level relates to the impact of early programming events, with hypertension being particularly related to birth weight and diabetes being predicted both from birth weight and from the mother's BMI during pregnancy. Both diabetes and hypertension are amplified in adult life by increases in BMI, but the gradient of effect may not be very different in differing societies. Therefore, the amplification in the absolute but not relative risk in adult life of particular levels of BMI may well be based on differences in fetal programming, which, in turn, may be affected by maternal nutrition before and during pregnancy.

A correlate of this amplified risk is the increased susceptibility of those born small to the selective deposition of excess fat in the truncal region, particularly within the abdomen. Numerous studies now show that the waist circumference is a useful, albeit crude, measure of increased intra-abdominal fat with an enhanced risk; recent data from Guatemala also suggest that there is a clear relationship between the prevalence of stunting—which in turn is related to low birth weight (8)—and the selective accumulation of abdominal body fat (9). Thus, the WHO Report (1) reproduced suggested waist circumference cutoff points, which not only crudely predicted whether people were overweight or obese, but also signified their propensity to hypertension and lipid disorders, particularly low high-density lipoprotein cholesterol (Table 1). The Asian report (5) also suggested lower waist values for Asians, because although Asians have an increased propensity to abdominal obesity, they still have an absolute increase in risk at any particular waist measurement (Table 2).

Therefore, it seems likely that we will continue to use the WHO classification scheme as a crude comparator for worldwide data analyses, but in preventive strategies and clinical practice, we will choose different approaches for those subsections of society and for the many countries where children are born disadvantaged.

Prevalence of Overweight and Obesity

Figure 1 provides our most recent preliminary estimates of the different prevalence rates of overweight and obesity in middle-aged men and women (45 to 59 years of age) throughout the world. We undertook this estimate for a new analysis of the Global Burden of Disease, which was first presented by Murray and Lopez (10) >10 years ago. The reanalysis of the Global Burden of Disease is now underway

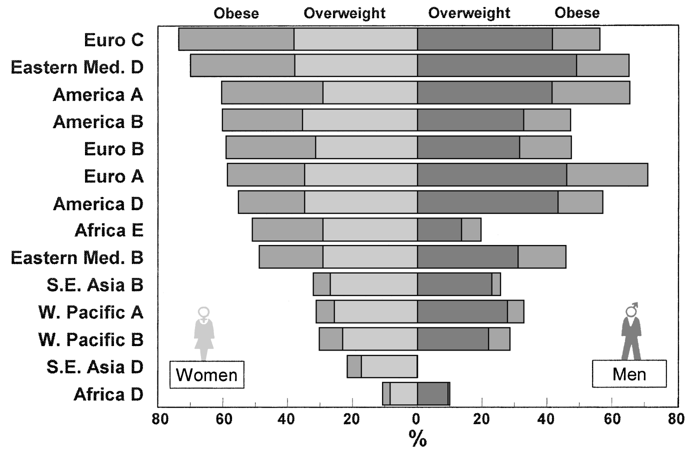

Figure 1: Preliminary estimates of the prevalence of overweight and obesity in 45- to 59-year-olds in different parts of the world. Note that 191 countries are included in the subregional groupings, which have been constructed on the basis of the observed infant mortality rates and life expectancies of the different countries. To illustrate the nature of the regions specified, the three countries with the biggest populations in each subregion is defined below. Afr D, Nigeria, Algeria, and Ghana; Afr E, Ethiopia, Congo, and South Africa; Amr A, United States, Canada, and Cuba (all the countries in region); Amr B, Brazil, Mexico, and Colombia; Amr D, Peru, Ecuador, and Guatemala; Emr B, Iran, United Arab Emirates, and Saudi Arabia; Emr D, Pakistan, Egypt, and Sudan; Eur A, Germany, France, and United Kingdom; Eur B, Turkey, Poland, and Uzbekistan; Eur C, Russian Federation, Ukraine, and Kazakhstan; Sear B, Indonesia, Thailand, and Sri Lanka (all countries in region); Sear D, India, Bangladesh, and Myanmar; Wpr A, Japan, Australia, and Singapore; and Wpr B, China, Vietnam, and Philippines.

and includes for the first time an attempt to look systematically at the principal risk factors, which contribute to the main diseases leading to early death and disability throughout the world. This reanalysis is due to be presented by WHO in May 2002, when it may prove possible to assess the relative quantitative impact of different factors, such as excess weight gain. Colleagues of Lopez in Australia have already undertaken preliminary assessments of the Burden of Disease attributable to overweight and obesity, showing that there is a maximum impact in terms of years of life lost and years of life with disability in men 55 to 64 years of age. Women have the most disabled and limited years from 55 years of age onward (11). In addition, despite halving the estimated risks of obesity to account for confounding factors, such as physical inactivity, the Australian analysis found that in both sexes over 4% of total Disability and Life Years Lost could be accounted for by overweight and obesity. In the 14 subregions of the world, chosen by Lopez for the new WHO analyses of global burdens, there is a remarkable variation in the prevalence of both overweight and obesity (Figure 1). Obesity is clearly more prevalent in women worldwide. Previously, we showed that this is evident in WHO Monica Studies in which standardized systems were used for measuring heights, weights, and the comorbidities of obesity in carefully selected adults in cities throughout the world (12). The reasons for these differences are probably biological and are related to the greater ability of men to deposit more lean than fat tissue when energy imbalance occurs with weight gain. This additional lean tissue is then metabolically active and increases the basal metabolic rate in men, thereby compensating for the discrepancy between intake and output. Women are naturally fatter, with less lean tissue than men, and have to gain far more weight to accrue the additional lean tissue needed to provide the adaptive gain in basal metabolism to match any excessive intake (12). Women are also more often in a domestic environment with constant access to food, which is more conducive to recurrent eating. Despite their biological predisposition to obesity, however, they do not always have a greater prevalence of obesity as shown by data from France, where the population is still culturally tuned to eating only at set meal times. Bray and Popkin (13) showed that the prevalence of obesity not only relates to the gross national product of a country, but also, more specifically, to the fat intake estimated, albeit crudely, from the Food and Agriculture Organization Food Balance Sheets. In addition, with economic development, there tends to be a progressive reduction in the demands for physical activity and it seems clear that it is the interaction among an energy-dense, high-fat diet, its ready availability and promotion, and increasingly sedentary lifestyles, which are particularly conducive to the development of obesity.

Detailed studies from different countries, including, for example, the United States, England, Brazil, and Japan, show that there is a progressive increase in obesity rates within each country but at very different rates. There is also a clear inverse relationship in most societies between the level of education or socioeconomic status and the prevalence of obesity. Thus, as noted recently by the Pan American Health Organization, obesity is increasingly being seen as a feature of the poor (14). Again this may relate to social circumstances and cultural differences, which alter behavior. The choice of an energy-dense diet may be determined by the relative cheapness of processed foods, with their energy derived predominantly from fats and sugars. The availability of these foods, the constant bombardment of food advertising, provision of large portion sizes as a marketing technique, and the immediate availability of fast foods everywhere mean that individuals have to constantly battle against the natural tendency to eat. The poor and less educated can also gain enjoyment from watching television and this activity requires less initiative and financial resource than engaging in a greater variety of social and leisure time activities that require more energy. It is little wonder, therefore, that as societies develop, it is the more disadvantaged who are particularly prone to obesity.

Obesity in Children

Recently, the IOTF proposed a new classification system for overweight and obesity in children (15). This proposal stemmed from a major workshop organized by the Childhood Group of IOTF (16). The BMI index was already being applied to children, e.g., Must et al. (17), and it became apparent that the method of Cole and Green (18) for developing smooth percentile BMI curves on a sex-specific basis throughout childhood was attractive. Many regions, e.g., Europe, North America, Japan, and the Middle East, were also beginning to use either a 90th, 95th, or 97th percentile as the basis for distinguishing obese children from normal; only Australia used the 85th percentile as a cutoff point (19). The IOTF group concluded that one could develop an approach that married the childhood and adult definitions by taking, at age 18 years, those percentiles that corresponded to BMIs of 25 and 30 kg/m^2 and using these same percentiles throughout the age range for specifying overweight and obesity in childhood in girls and boys separately. This assumes that individual boys and girls will tend to retain the same percentile as they grow.

The IOTF chose data from six countries, i.e., the original National Health and Nutrition Examination Survey I data from the United States, UK data, and surveys from The Netherlands, Hong Kong, Singapore, and Brazil. This choice could have been improved by the inclusion of data on well-fed children of Indian and African origin, but suitable data were not available. The composite percentile cutoff points chosen from the six datasets are now used in many parts of the world (15). The IOTF overweight cutoff points correspond approximately to the 90th and 95th percentiles for British and Dutch men, respectively, but the obesity cutoff points are above the 97th percentile for nearly all of the assessed national surveys. It is not surprising, therefore, that they show much greater variability at these extreme values.

There have been concerns about the use of BMI in a standardized form as an index of fatness in children from different societies and with different ages for the onset of puberty (16). However, Reilly et al. (20) recently assessed the sensitivity and specificity of the IOTF BMI cutoff points for overweight and obesity, using UK data and body impedance measures of total fat. They found that there was excellent specificity and sensitivity for the overweight cutoff points, but somewhat lower sensitivity for the higher obesity cutoff point (Table 3).

Tracking of Body Fat and BMI into Adult Life

The usefulness of the age- and sex specific BMI cutoff points in the IOTF reference values and the adult BMI

Table 3. Sensitivity and specificity of definitions of overweight and obesity based on the BMI cutoff points for boys and girls (20)

	Sensitivity (%, *n*)	Specificity (%, *n*)
Boys		
Overweight	90 (90/100)*	92 (1756/1910)
Obesity	46 (46/100)†	99 (1901/1910)
Girls		
Overweight	97 (94/97)	84 (1543/1841)
Obesity	72 (70/97)	99 (1813/1841)

Significant difference in sensitivity between the sexes: $*p < 0.05$; $†p < 0.01$.

Table 4. The likelihood of overweight children continuing to be obese in adulthood

*Study number	Age of monitoring (years)		Percentage still obese in adulthood	
	Childhood	Adulthood	Men	Women
1	10 to 13	29 to 34	74	72
2	9 to 13	42 to 53	63	—
3	<1	20 to 30	36	—
4	9 to 10	31 to 35	57	64
	13 to 14	31 to 35	77	70
5	1 to 5	19 to 26	27	—
6	7	35	40	20
	13	35	40	30
7	7	14	90	87
	7	16	63	62
8	2 to 14	10 to 24	43	—
9	1 to 14	10 to 23	42	66
10	13 to 17	27 to 31	58	—
11	7	33	43	63
	11	33	54	64
	16	33	64	78

* Studies cited by Power et al. (23), together with their unpublished data. The proportion of obese adults who had been the most overweight children was usually 3- to 10-fold lower than the corresponding probability of overweight children remaining of excessive weight.

cutoff points of 25 and 30 kg/m^2 would be amplified if there was good percentile tracking of both body fat and BMI through childhood into adult life. Guo and Chumlea (21) recently found from U. S. longitudinal studies that the probability of children with high BMIs still being overweight and obese at the age of 35 years rises markedly throughout childhood. The probability of being overweight at 35 years of age was 0.3 in 5-year-old children with a BMI at the 95th percentile, ~0.35 at 10 years of age, 0.5 at 15 years of age, and ~0.7 at 18 of age. IOTF, therefore, chose to concentrate on children 5 years of age and older. Rolland-Cachera et al. (22) also produced a detailed study of 164 subjects monitored from the age of 1 month to adult life. Only 41% to 42% of preschool children remained in their original category of being lean, medium, or fat into adult life if these categories were defined based on the 25th and 75th percentiles of BMI. Rolland-Cachera et al. then focused on the issue of fat-rebound in prepubertal school children, but systematic reviews of the evidence, e.g., by Power et al. (23) and Parsons et al. (24) did not find much evidence for the value of selective monitoring in the prepubertal phase to predict the emergence of obesity, if this is based on detailed analyses of weight rebound. The analyses by Power et al showed that the older the children studied, the greater the risk of their continuing to be obese in adult life. Once children were over 5 years of age, being obese incurred a great risk of this persisting, with the majority remaining obese in adult life (Table 4).

Barlow and Dietz (25) emphasized the value of concentrating on children at least over the age of 3 years, and a consensus seems to have emerged that, currently, one should focus on children of school age for predicting the risk of persisting obesity. This is quite different from assessing how many obese adults were originally overweight as children. Given the rising prevalence of obesity with age in both childhood and adult life, the prevalence of adult obesity cannot be predicted from childhood data, but increasing childhood obesity heralds a greater health burden in adult life. Thus, as the epidemic of childhood obesity emerges throughout the globe, we can confidently predict that the health impact of excess weight gain will be amplified in years to come. On this basis, we can expect the emergence of systematic epidemiological surveys throughout the world as governments confront what is already seen by WHO as the biggest unrecognized public health problem.

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