49. Health Implications of Obesity

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Introduction

Current knowledge of human obesity has progressed beyond the simple generalizations of the past. Formerly, obesity was considered fully explained by the single adverse behavior of inappropriate eating in the setting of attractive foods. The study of animal models of obesity, biochemical alterations in man and experimental animals, and the complex interactions of psychosocial and cultural factors that create susceptibility to human obesity indicate that this disease in man is complex and deeply rooted in biologic systems. Thus, it is almost certain that obesity has multiple causes and that there are different types of obesity.

To assess the health implications of obesity, new knowledge and new epidemiologic observations have introduced a variety of complications that must be addressed. Thus, a reassessment of definitions and measurements of obesity is required. There is controversy surrounding the interpretation of data showing an association of body weight with morbidity and mortality. The interpretations of data from different studies have been complicated by the confounding effects of smoking behavior, the coexistence of diseases other than obesity, and variations in methods of data collection and followup. Because population samples in some studies have not been representative of the U.S. population, there have been uncertainties as to how far their conclusions can be generalized for recommendations for dietary advice and treatment.

There is evidence that an increasing number of children and adolescents are overweight. Even though all overweight children will not necessarily become overweight adults, the increasing prevalence of obesity in childhood is likely to be reflected in increasing obesity in adult years. The high prevalence of obesity in our adult population and the likelihood that the nation of the future will be even more obese demand a reassessment of the health implications of this condition.

For the special purpose of resolving the pressing questions relating to the health implications of obesity, the NIH Office of Medical Applications of Research, the National Institute of Arthritis, Diabetes, and Digestive

and Kidney Diseases, and the National Heart, Lung, and Blood Institute convened a consensus development conference on the health implications of obesity on February 11-13, 1985. After listening to 1 days of presentations by experts in the field, hearing audience comments, and reviewing the medical literature, a consensus panel representing the professional fields of nutrition, nutritional biochemistry and metabolism, endocrinology, internal medicine, gastroenterology, epidemiology, biostatistics, psychiatry, pediatrics, and family medicine considered the evidence and agreed on answers to the following questions:

- What is obesity?
- What is the evidence that obesity has adverse effects on health?
- What is the evidence that obesity affects longevity?
- What are the appropriate uses and limitations of existing height-weight tables?
- For what medical conditions can weight reduction be recommended?
- What should be the directions of future research in this area?

Only the above questions were addressed. Extremely important issues relating to obesity such as prevention, treatment (including exercise), and the impact on society were not addressed by this panel. The special relationship of obesity to lower socioeconomic status was not addressed.

What Is Obesity?

Adipose tissue is a normal constituent of the human body that serves the important function of storing energy as fat for mobilization in response to metabolic demands. Obesity is an excess of body fat frequently resulting in a significant impairment of health. The excess fat accumulation is associated with increased fat cell size; in individuals with extreme obesity, fat cell numbers are also increased. Although the etiologic mechanisms underlying obesity require further clarification, the net effect of such mechanisms leads to an imbalance between energy intake and expenditure. Both genetic and environmental factors are likely to be involved in the pathogenesis of obesity. These include excess caloric intake, decreased physical activity, and metabolic and endocrine abnormalities. Hence, a number of subtypes of obesity exist.

The precise determination of the amount of body fat requires technically sophisticated methods that are available only in research laboratories. For public health studies and clinical practice, simple and convenient anthropometric measurements based on height, weight, and skinfold thickness are recommended. For adults of 20 years and older, two methods are now in wide use: (1) estimation of relative weight (RW = measured body weight divided by midpoint of medium frame desirable weight recommended in the 1959 or 1983 Metropolitan Life Insurance Company tables) and (2) calculation of body mass index (BMI = [body weight in kg] divided by [height in m]^2). Because body composition varies among individuals of the same height and weight, these measurements only approximate the precise magnitude of fatness. Nevertheless, they correlate with the risk of adverse effects on health and longevity. Separate criteria must be used for evaluating fatness in children and adolescents.

Adipose tissue depots do not constitute a uniform organ; fat cells around the waist and flank and in the abdomen are more active metabolically than those in the thigh and buttocks. The location of body fat has emerged as an important predictor of the health hazards of obesity. Sites of body fat predominance are easily measured by the ratio of waist to hip circumferences. High ratios are associated with higher risks for death and illness.

Based on indices of body fat, studies of large populations have shown that there is a continuous relationship between RW or BMI and morbidity and mortality. Thus, it becomes important to establish ranges of these indices as guidelines for developing appropriate and effective approaches for the treatment and prevention of obesity.

Since the amount of body fat, as estimated by the above indices, is a continuous variable within the population, all quantitative definitions of obesity must be arbitrary. The panelists agree that an increase in body weight of 20 percent or more above desirable body weight constitutes an established health hazard. Significant health risks at lower levels of obesity can present hazards, especially in the presence of diabetes, hypertension, heart disease, or their associated risk factors.

What Is the Evidence That Obesity Has Adverse Effects on Health?

Clinical observations have long suggested a connection of obesity (particularly in its extreme forms) with a variety of illnesses. Obesity creates an enormous psychological burden. In fact, in terms of suffering, this burden may be the greatest adverse effect of obesity. At the present time, the strongest evidence that obesity has an adverse effect on physical health comes from population-based prevalence (cross-sectional) and cohort (followup) studies. These data are complemented by weight-reduction trials.

The most comprehensive data on prevalence of cardiovascular disease (CVD) risk factors and obesity are the National Health and Nutrition Examination Surveys (NHANES). NHANES I was conducted from 1971 through 1974 and NHANES II from 1976 through 1980. Both were based on a representative sample of residents of the United States.

Data from NHANES II were analyzed by comparing several parameters for the subjects at or above, or below, the 85th percentile of the reference population.* At or above this cutoff point, males have a BMI greater than or equal to 27.8 and females have a BMI greater than or equal to 27.3. This analysis showed a strong association between the prevalence of obesity and CVD risk factors. Based on these criteria, the prevalence of *hypertension* (blood pressure greater than 160/95) is 2.9 times higher for the overweight than for the nonoverweight. The prevalence is 5.6 times higher for the young (20 through 44 years old) overweight than for the nonoverweight subjects in this age group. The prevalence is twice as high for the obese older (45 through 74 years old) group as it is for the nonoverweight subjects of the same age. The prevalence of *hypercholesterolemia*(blood cholesterol over 250 mg/dl) in the young overweight age group is 2.1 times that of the nonoverweight group; overweight and nonoverweight subjects show similar prevalences for hypercholesterolemia after age 45.

* Noninstitutionalized, nonpregnant U.S. residents, ages 20 to 29, 1976-1980.

Levels of blood pressure and serum cholesterol vary with levels of obesity in a continuous manner. This relationship holds for the so-called normal as well as the elevated range in observational studies. Intervention studies confirm that levels of blood pressure and serum cholesterol can be reduced by weight reduction.

The prevalence of reported *diabetes* is 2.9 times higher in overweight than nonoverweight persons in the NHANES data. Type II diabetes (maturity onset or noninsulin-dependent mellitus--NIDDM) appears to be an inherited disease; however, studies clearly show that weight

reduction can reverse the abnormal biochemical characteristics of NIDDM.

Coronary Artery Heart Disease (CAHD)

The relationship of obesity to the incidence of CAHD has been studied in a large number of cohort studies. In contrast to the consistent relationship of obesity to CAHD risk factors found in the overwhelming majority of prevalence studies, widely divergent results have been reported for the relationship of obesity to the incidence of CAHD. Thus, the eight cohort studies of the U.S. Pooling Project found discrepant results, including no association, a U-shaped relationship, and a positive relationship of obesity to CAHD. However, when data from these same studies were combined, there was a positive relationship of obesity to the risk of CAHD. Possible explanations for the discrepant findings include differences in health status of industrial workers in contrast with health status of the total population, varying duration of followup among the studies, and inadequate sample sizes.

Studies in which obesity predicted CAHD usually found that obesity was not a risk factor independent of the standard risk factors. However, the Framingham Study, a large general population-based study that is strengthened by having long duration followup data, recently disclosed an increasing risk of CAHD with increasing levels of obesity, independent of the other standard risk factors.

Other recent studies indicate that the distribution of fat deposits may be a better predictor of CAHD than is the degree of obesity. Excess abdominal fat is more often related to disease than are fat deposits in the thigh or gluteal areas.

Cancer

There are numerous epidemiological studies of obesity and site-specific malignancies, one of the largest of which is the American Cancer Society (ACS) Study involving more than 1 million men and women. Through the last followup year (1972), 93 percent of the subjects were traced (alive or dead). Obese males, regardless of smoking habits, had a higher mortality from cancer of the colon, rectum, and prostate. Obese females had a higher mortality from cancer of the gallbladder, biliary passages, breast (postmenopausal), uterus (including both cervix and endometrium), and ovaries. In the case of endometrial cancer, women with marked obesity showed the highest relative risk (5.4) for the obese versus the nonobese.

What Is the Evidence That Obesity Affects Longevity?

Obesity, when measured by relative weight (actual weight as a percentage of average or desirable weight for a given height/age/sex group) has an adverse effect on longevity. Convincing evidence of this has been evaluated in four very large insurance studies (1903 to 1979), the Framingham 30-Year Followup Study, the American Cancer Society Study, and other smaller cohort studies. Some additional cohort studies do not show this adverse effect, but these studies present problems in interpretation due to small size, followup 10 years or less, occupational bias, or a population otherwise not representative of the U.S. population. The greater the degree of overweight, the higher the mortality ratio or excess death rate. Both mortality ratio and excess deaths per 1,000 per year increase with length of followup. Two small groups of insurance policyholders who reduced weight to acceptable levels for standard insurance had a decline in mortality to normal. In the insurance studies, the increased mortality with overweight was observed in normotensive men and women, without other major impairment, who would have been eligible for standard insurance rates except for being overweight. Smokers were not differentiated from nonsmokers. In the Framingham and ACS studies, the increase in excess mortality with increasing degrees of overweight was present in both smokers and nonsmokers.

The pattern of excess mortality variation with relative weight is illustrated in men ages 15 to 39 years at entry from data in the 1979 Build Study:

Weight Relative to Average Weight	Mortality Ratio
65-75%	105%
75-95	93
95-105 (average)	95
105-115	110
115-125	127
125-135	134
135-145	141
145-155	211
155-165	227

For those with relative weight of 125 to 135 percent at entry, the aggregate mortality ratio was 134 percent, as shown above. When mortality was analyzed by duration, the mortality ratio increased from 110 percent at the 0 to 5-year interval to 169 percent at the 15 to 22-year interval. The weight class for lowest mortality shown above is below the average weight category. There is higher mortality in the lowest relative weight class, 65 to 75 percent of average. In extreme obesity ("morbid" obesity), the mortality ratio has been reported in a small series as being of the order of 1,200 percent. A recent analysis has shown that the body mass index of minimum mortality, derived from the data in the 1979 Build Study, increases with age in a straight line relationship, the lines for male and female being virtually identical. The 1959 and 1983 Metropolitan Life Insurance Company tables of ranges of weight with minimal mortality do not provide for any age variation.

The increase in mortality versus relative weight is steeper in men and women under age 50 than in older persons, and the increase with duration is also steeper. These findings suggest that particular attention should be paid to efforts to reduce weight in younger patients.

Recent studies suggest that the distribution of fat deposits may be a better predictor of mortality than BMI or RW. If confirmed, it may be important in the future to measure fat distribution in addition to using height-weight tables.

What Are the Appropriate Uses and Limitations of Existing Height-Weight Tables?

There is consensus that a measure of obesity is needed to overcome the subjectivity introduced by simply relying on visual inspection as an estimate of obesity. Equipment for measuring height and weight, height-weight tables, and weight-related indices are widely available.

Various indices for adults are available. These can be categorized into three groups:

- Tables of average weights by height and age.
- Tables of desirable weights for height associated with lowest mortalities in insured populations.
- Indices that are derived from height and weight such as body

mass index.

Extensive height-weight data (e.g., National Center for Health Statistics) are available for estimating obesity in infants and children.

Tables of Average Weights by Height and Age

These tables report cross-sectional data on a representative sample of the noninstitutionalized population living in the United States. They represent averages rather than optimal data and may be useful for descriptive purposes.

Tables of Desirable Weights by Height

These tables are based on weights associated with the lowest mortality rate among insured populations of adults. At least two versions are in current use: the 1959 Metropolitan Life Insurance Company table and the 1983 revision.

Confusion exists as a result of the slight increases in desirable weights seen in the 1983 as opposed to the 1959 tables. In the 1983 tables, desirable weights for men and women in the shortest stature groups are 12 and 14 pounds higher respectively than they were in 1959. It is recognized that such increased body weight may contribute to high blood pressure, hypercholesterolemia, and glucose intolerance or similar risk factors, apart from the impact of weight on mortality. Neither the 1959 nor the 1983 height-weight tables reflect current weight and mortality relationship for the American population, since, of necessity, the deaths reflect the mortality experiences of policyholders with a cutoff date of 11 years prior to the publication of the tables.

Uses

- Clinical: To establish the presence of obesity and the approximate degree of risk and to guide treatment.
- Educational and informational.
- Research.

Limitations

- Tables are formulated on specific populations; they may not be applicable to the entire population, particularly those of lower socioeconomic and some ethnic groups.
- The mortality and morbidity related risks of obesity are influenced by concurrent risk factors such as smoking.
- Tables do not provide information on body fat distribution or degree of obesity.

- Frame size as used for estimation of lean (fat-free) body mass is subjectively determined in the 1959 tables. The use of elbow width to judge frame size, as suggested in the 1983 tables, may or may not eliminate the problem.
- Age is not taken into account.

Body Mass Index

The body mass index

$$BMI = \text{Body wt in Kg}/(\text{Ht in m})^2$$

is a simple measurement highly correlated with other estimates of fatness. It minimizes the effect of height and is useful for descriptive or evaluative purposes. It has the advantage of permitting comparison of populations. The major limitation of the BMI is that it is difficult to interpret this mathematical index to patients and to relate it to weight that must be lost.

The consensus panel recommends that physicians adopt this measure as an additional factor in evaluating patients and that nomograms be used to facilitate calculations of BMI.

For What Medical Conditions Can Weight Reduction Be Recommended?

Weight reduction may be lifesaving for patients with extreme obesity, arbitrarily defined as weight twice the desirable weight or 45 kg (100 pounds) over desirable weight. When obesity is accompanied by severe cardiopulmonary manifestations, as in the Pickwickian syndrome, weight reduction should be part of the treatment for this medical emergency.

In view of the excess mortality and morbidity associated with obesity (as discussed above), weight reduction should be recommended to persons with excess body weight of 20 percent or more above desirable weights in the Metropolitan Life Insurance Company tables (using the midpoint of the range for a medium-build person). In the 1983 tables, 20 percent over desirable weight is a higher weight than would be obtained by the use of the 1959 tables. The maximum increase is found in those of short stature and does not exceed 17 percent for men or 13 percent for women. Although not a specific recommendation of the panel, use of the lower weights as goals would be advisable in the

presence of any of the complications or risk factors summarized below. The body mass index values, which correspond to 20 percent above desirable weight, are 27.2 and 26.9 for men and women, respectively, using the 1983 tables and 26.4 and 25.8 for men and women, respectively, using the 1959 tables. These values are not substantially different from the BMI values for men and women identified with the lower cutoff point for overweight as determined by the National Center for Health Statistics--27.8 and 27.3 for men and women, respectively (NHANES II population, bare feet, no clothes).

Weight reduction is also highly desirable, even in patients with lesser degrees of obesity, in many other circumstances, including the following:

- Noninsulin-dependent diabetes mellitus, a family history of diabetes mellitus, women with a history of gestational diabetes or history of birth of an infant large for gestational age.
- Hypertension (hypertension due to specific, identifiable causes such as renal artery stenosis or pheochromocytoma should be treated for those specific causes).
- Hypertriglyceridemia or hypercholesterolemia.

Weight reduction is likely to be helpful, although the benefits may not be as clear as in the circumstances listed above, in other circumstances, including:

- Coronary artery heart disease.
- Gout.

In any circumstance in which excessive weight imposes functional burdens, weight reduction may improve functioning of the affected system, organ, or region. Such conditions include many common disorders, for example:

- Heart disease of other types.
- Chronic obstructive pulmonary disease.
- Osteoarthritis of the spine, hips, or knees.

Weight reduction in the treatment of these conditions should be under the direction of a physician because accurate diagnosis is needed before treatment is started, and weight reduction may have to be accompanied by other treatments. In addition to physicians, the assistance of other health professionals is critical for treatment in any weight-reduction program. When exercise is prescribed as an adjunct to other methods of weight-reduction, assessment by a physician of the cardiopulmonary risk of exercise is especially important.

The panel views with concern the increasing frequency of obesity in children and adolescents. Obese children should be encouraged to bring their weight to within normal limits. Although childhood obesity does not necessarily lead to obesity in adulthood, there is evidence that it is a significant risk factor for adult obesity. Because dietary restriction can adversely affect parent-child relationships, eating behavior, and growth and maturation, physicians must carefully monitor any dietary restrictions.

What Should Be the Directions of Future Research in This Area?

It is vitally important to increase the understanding of obesity to enable prevention. Because obesity is so prevalent, any effective strategy for prevention will have public health importance. The following areas of investigation, dealing mainly with the questions addressed to this panel, are stressed:

- In infancy and childhood, we must search for biological (genetic, metabolic, or anthropometric) markers as predictors of adult obesity. Having such predictors would permit the study of the development of the disease, would provide a powerful epidemiological tool, and would allow treatment to begin very early in life.
- The factors that regulate the regional distribution of fat and methods to assess the distribution must be developed. We need to define the mechanism by which body fat distribution is associated with adverse effects of obesity.
- Regulation of energy balance is complex, but many aspects have begun to yield to investigation. Promising leads are:
    - effects of the central and autonomic nervous systems and the endocrine system.
    - adipose tissue cellularity (in tissue culture) and metabolism.
    - the role of various components of thermogenesis in the overall control of energy balance.
    - control of food intake (e.g., endogenous opioids).
    - satiety factors (e.g., gut hormones).
- Studies utilizing cultural and physical measurements in several cultures, including minority, low socioeconomic, and rapidly changing cultures, should be conducted.
- The data from large CAHD cohort studies initiated 20 to 30 years

ago should be identified and archived. Archiving should be encouraged for data obtained from ongoing and future studies.
- Relative risk tables that incorporate both fat distribution and height-weight data should be developed.

Great advances of modern biological science as applied to obesity can generate new information that can now be tested at the bedside. Clinical investigation utilizing the biological advances is timely. The best of public health sciences, including the anthropological and sociological, should be brought into the study of the prevention of obesity.

Conclusions

The evidence is now overwhelming that obesity, defined as excessive storage of energy in the form of fat, has adverse effects on health and longevity. Obesity is clearly associated with hypertension, hypercholesterolemia, NIDDM, and excess of certain cancers and other medical problems. Height and weight tables based on mortality data or the body mass index are helpful measures to determine the presence of obesity and the need for treatment. Thirty-four million adult Americans have a body mass index greater than 27.8 (men) or 27.3 (women). At this level of obesity, which is very close to a weight increase of 20 percent above desirable, treatment is strongly advised. When diabetes, hypertension, or a family history for these diseases is present, treatment will lead to benefits even when lesser degrees of obesity are present.

Obesity research efforts should be directed toward elucidation of biologic markers, factors regulating the regional distribution of fat, studies of energy regulation, and studies utilizing the techniques of anthropology, psychiatry, and the social sciences.

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