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The Epidemiology of Obesity

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In the United States, obesity among adults and overweight among children and adolescents have increased markedly since 1980. Among adults, obesity is defined as a body mass index of 30 or greater. Among children and adolescents, overweight is defined as a body mass index for age at or above the 95th percentile of a specified reference population. In 2003–2004, 32.9% of adults 20–74 years old were obese and more than 17% of teenagers (age, 12–19 y) were overweight. Obesity varies by age and sex, and by race-ethnic group among adult women. A higher body weight is associated with an increased incidence of a number of conditions, including diabetes mellitus, cardiovascular disease, and nonalcoholic fatty liver disease, and with an increased risk of disability. Obesity is associated with a modestly increased risk of all-cause mortality. However, the net effect of overweight and obesity on morbidity and mortality is difficult to quantify. It is likely that a gene-environment interaction, in which genetically susceptible individuals respond to an environment with increased availability of palatable energy-dense foods and reduced opportunities for energy expenditure, contributes to the current high prevalence of obesity. Evidence suggests that even without reaching an ideal weight, a moderate amount of weight loss can be beneficial in terms of reducing levels of some risk factors, such as blood pressure. Many studies of dietary and behavioral treatments, however, have shown that maintenance of weight loss is difficult. The social and economic costs of obesity and of attempts to prevent or to treat obesity are high.

In the United States and elsewhere, obesity has increased dramatically since 1980. Between 1980 and 2004 the prevalence of obesity increased from 15% to 33% among adults and the prevalence of overweight in children increased from more than 6% to 19% in the United States.[1–4] Obesity in adults is associated with an increased risk of morbidity and mortality.[5,6] Overweight children often become obese adults.[7] Obesity is a complex condition and prevention and treatment are difficult.

Definitions and Measurement of Overweight and Obesity

The human body contains essential lipids and also nonessential lipids in the form of triglycerides (triacylglycerols) stored in adipose tissue cells known as *adipocytes*. Obesity generally is defined as excess body fat. The definition of excess, however, is not clear-cut. Adiposity is a continuous trait not marked by a clear division into normal and abnormal. Moreover, it is difficult to measure body fat directly. Consequently, obesity often is defined as excess body weight rather than as excess fat. In epidemiologic studies, body mass index (BMI) calculated as weight in kilograms divided by height in meters squared is used to express weight adjusted for height.[8,9]

Measured weight and height are more accurate than self-reported data. Cost considerations, however, often lead to surveys and epidemiologic studies not being conducted in person, so that height and weight are self-reported rather than measured. Inaccurate estimates may result because respondents tend to overestimate their height and underestimate their weight. Overestimation of height increases with age and is greater among men than women. Underestimation of weight is greater among women than among men.[10–15]

Definitions for Adults

There have been many definitions of overweight and obesity for adults. In 1959 and in 1983 the Metropolitan Life Insurance Company produced tables based on the mortality experience of policy holders that indicated the range of weights by height and frame size at

Abbreviations used in this paper: **BMI, body mass index; CDC, Centers for Disease Control and Prevention; CVD, cardiovascular disease; NAFLD, nonalcoholic fatty liver disease; NHANES, National Health and Nutrition Examination Survey; PIR, poverty-income ratio; WHO, World Health Organization.**

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which the mortality rate was lowest for policy holders aged 25–59 years.[16,17] In the past, overweight often was defined as a body weight that was 20% or more above the midpoint of the weight range for a medium frame size from these Metropolitan Life tables.[18]

A variety of definitions using BMI, rather than weight-for-height tables, also have been used. Grades I, II, and III obesity, defined by BMI categories of 30–39.9 and 40 or above, for both men and women, were proposed by Garrow[19] in 1981. The value of 25 was approximately equivalent to the upper end of the weight range for large frame sizes in the 1959 Metropolitan Life tables. Bray[20] and a more recent (1995) World Health Organization (WHO)[21] expert committee also used similar BMI classifications. In 1985, an expert committee of the Food and Agriculture Organization of the United Nations/WHO/United Nations University[22] defined obesity as a BMI of 30 or more for men and of 28.6 or more for women. Also in 1985, a US National Institutes of Health Consensus Conference[18] supported a definition of overweight as a BMI of 27.8 or higher for men and of 27.3 or higher for women based on the US population distributions because these values corresponded to approximately 120% of the midpoint of the 1983 Metropolitan Life table ranges. A classification similar to the one proposed by Garrow,[19] using different terminology and with an additional cut-off point of a BMI of 35, was accepted as part of the 1997 WHO consultation on obesity.[23] The WHO classification defined overweight as a BMI of 25 or greater and obesity as a BMI of 30 or greater, along with some additional subdivisions. Similar definitions were recommended by a National Heart, Lung, and Blood Institute (NHLBI) expert committee in the NHLBI Clinical Guidelines on the Identification, Evaluation, and Treatment of Overweight and Obesity in Adults.[5] Currently, healthy weight is defined as a BMI of 18.5 up to 24.9, overweight as a BMI of 25 up to 29.9, and obesity as a BMI of 30 or greater by the US Dietary Guidelines.[24]

The interpretation of BMI in terms of body fatness and in comparison with a weight standard varies by sex, age, and other factors.[25] In part because of lower muscle and bone mass, women are characterized by a higher percentage of body fat than men. Women tend to have a higher proportion of body fat stored in subcutaneous rather than visceral adipose tissue.[26] Because of the differences in body composition between men and women, at the same BMI women will tend to have a considerably higher percentage of body fat than men. Older persons will tend to have a higher percentage of body fat than younger people at the same BMI because of the changes in body composition with age. Moreover, only if the same body weight standards (or definitions of obesity) are considered to be appropriate for both men and women does a given value of BMI have the same meaning in terms of relative weight. A given value of BMI may be numerically the same for men and women and for people of different ages, but may not represent the same percentage of body fat, the same degree of risk, or even necessarily the same degree of overweight relative to a weight standard.

Definitions of Weight Levels for Children and Adolescents

In children, the terminology for different levels of weight or BMI varies considerably.[27] *Overweight*, *obesity*, and *at risk for overweight* can be found in the literature. Even when the same term is used (eg, *overweight*) the meaning of that term may not be the same in different countries or across studies. Whatever the terminology used, definitions generally are based on weight and not on adiposity per se. For adults, the currently used definitions of overweight and obesity are related to functional outcomes of mortality and morbidity and are based on fixed values of BMI that do not vary by age or sex.[5] In children, it is unclear what risk-related criteria to use, so there are no risk-based fixed values of BMI used to determine overweight. As a result, a statistical definition of overweight based on the 85th and 95th percentiles of sex-specific BMI-for-age in a specified reference population often is used in childhood.[28,29]

Many reference data sets for childhood BMI exist and BMI reference data are used or recommended as part of monitoring children's growth in many countries.[30–35] Reference data usually are based on representative data from a given country. For example, surveys representative of England, Scotland, and Wales were used to develop the 1990 British growth references for weight, height, BMI, and head circumference.[30] In the United States, the Centers for Disease Control and Prevention (CDC) 2000 growth charts were developed from 5 nationally representative surveys (the National Health Examination Surveys II and III in the 1960s, the National Health and Nutrition Examination Survey [NHANES] I and II in the 1970s, and NHANES III, 1988–1994). The 2000 CDC charts are revised versions of the 1977 National Center for Health Statistics growth charts. They include sex-specific BMI-for-age growth curves for ages 2–19 years by single month of age.[31] Because of the observed increase in weight among children in 1988–1994,[36] all weight data from children ages 6 and older in 1988–1994 were excluded from the 2000 CDC charts. In April 2006, the WHO released BMI-for-age growth charts for preschool-age children from birth to 5 years of age.[37] The WHO charts are based on a different approach. They were created from healthy, breast-fed children from around the world and are intended to present a standard of physiologic growth and not a descriptive reference. The WHO has used cut-off values based on SD scores (z-scores), with overweight defined as a BMI-for-age value greater than or equal to a z-score of +2.[38]

References such as the 1990 UK reference, the 2000 CDC Growth Charts, and the WHO standards are intended for clinical use in monitoring children's growth.

The use of selected percentiles or z-scores on these charts to define overweight or obesity is a secondary purpose.[27]

There are also several sets of BMI reference data that are intended specifically to define childhood overweight and are not for clinical monitoring of growth patterns. One widely used reference set of BMI values consists of sex-specific smoothed 85th and 95th percentiles for single year of age from 6 to 19 years of age based on data from NHANES I, 1971–1974, in the United States.[39] In 1995, a WHO expert committee recommended the use of these reference values.[21]

In 2000, Cole et al[40] published smoothed sex-specific BMI cut-off values based on 6 nationally representative data sets from Brazil, Great Britain, Hong Kong, the Netherlands, Singapore, and the United States. The US data were the same as those from which the 2000 CDC growth charts were derived. These values, often referred to as the International Obesity Task Force cut-off values, represent cut-off points chosen as the percentiles that matched the adult cut-off values of a BMI of 25 and 30 at age 18 years. The International Obesity Task Force cut-off values were not intended as clinical definitions and were not intended to replace national reference data, but rather they were developed to provide a common set of definitions that researchers and policy makers in different countries could use for descriptive and comparative purposes internationally. Discussions on the use of national vs international reference data have been published.[41–43]

Thus, there are a plethora of different references that can be used to define childhood overweight or obesity for calculating prevalence estimates. There are also many articles that compare the use of different definitions with the same population.[44–49] As seen repeatedly, the various definitions do not give the same results. Each reference was created using slightly different data and is based on different assumptions.

The choice of cut-off points within the reference population depends on what assumptions are made. Expert committees in the United States have recommended using a BMI-for-age at or above the 95th percentile of a specified reference population to screen for overweight in adolescents and younger children.[28,29] These values were not designed to provide clinical cut-off points, but rather to serve as screening values. The same expert committees considered that children with BMI values between the 85th and 95th percentiles also possibly might be overweight, although with a lower probability and are considered *at risk for overweight*. Thus, for these children, it was recommended that they be referred to a second-level screen, including consideration of family history, blood pressure, total cholesterol, large prior increase in BMI, and concern about weight. These children would be referred for the in-depth evaluation only if they were positive for any of the items on the second-level screen. The category of *at risk for overweight* is sometimes interpreted as a designation for a child who is at risk for becoming overweight in the future. However, this is not the original intention of the term. The category as defined by the expert committees[28,29] was intended to identify children who might be obese, in the sense of excess body fat, but who should undergo a second-level screen (as described earlier) to evaluate whether they should be referred for an in-depth assessment. In the United States, *overweight* currently is defined as a BMI at or above the 95th percentile of the 2000 CDC growth charts, and *at risk for overweight* is defined as a BMI between the 85th and the 95th percentiles for children 2–19 years of age.[27]

Although no consistent recommendations for the definition of overweight among infants and children younger than 2 years of age exist, nutrition programs such as the Special Supplemental Nutrition Program for Women, Infants, and Children have used weight-for-length to determine overweight and thus program eligibility.[49] Consequently, overweight in this age group often is defined as the 95th percentile or higher of weight-for-length. All these definitions are statistical and the percentile values are age- and sex-specific, so comparisons across age or sex groups should be performed with caution.

Prevalence and Trends

Prevalence estimates of obesity usually are derived from surveys or population studies because systematic data on obesity generally cannot be gathered from medical records or vital statistics. Virtually all data on prevalence and trends are based on measurements of weight and height using the classifications described earlier rather than on body fat because of the logistical difficulties involved in measuring body fat in population studies.

The NHANES program provides national estimates of overweight for adults, adolescents, and children in the United States. A series of cross-sectional, nationally representative examination surveys conducted by the National Center for Health Statistics of the CDC, the NHANES surveys were designed using stratified multistage probability samples. Currently, NHANES includes oversampling of adolescents, Mexican Americans, and African Americans, among other groups, to improve estimates for these groups. All of the surveys included a standardized physical examination in a mobile examination center with measurement of recumbent length, stature, and weight. Stature was measured in children 2 years and older and recumbent length in children younger than 4 years.[50–53]

Estimates of the prevalence of overweight (BMI $\geq$ 25.0), obesity (BMI $\geq$ 30.0), and extreme obesity (BMI $\geq$ 40.0) among adults 20–74 years of age in the United States from the NHANES surveys from 1960 to 2004 are shown in Table 1. Because the surveys before 1988 only included individuals up through 74 years of age, trends are shown for adults 20–74 years of age. Estimates of at

Table 1. Prevalence and Trends of Overweight and Obesity Among Adults Ages 20–74 Years in the United States: 1960–2004

Sex	Survey year[a]	Overweight or obese[b]		Overweight but not obese		Obese[b]		Extremely obese[b]	
		%	SE	%	SE	%	SE	%	SE
All	1960–1962	44.9	.8	31.5	.5	13.3	.6	.9	.1
	1971–1974	47.2	.8	32.7	.6	14.5	.4	1.3	.2
	1976–1980	47.1	.8	32.1	.6	15.0	.4	1.4	.1
	1988–1994	55.9	.9	32.6	.6	23.2	.7	3.0	.3
	1999–2000	64.5	1.6	33.6	1.0	30.9	1.6	5.0	.6
	2001–2002	65.7	.7	34.4	1.1	31.3	1.2	5.4	.5
	2003–2004	66.2	1.1	33.4	1.2	32.9	1.3	5.1	.6
Men	1960–1962	49.4	1.1	38.7	.7	10.7	.7	.3[c]	.1
	1971–1974	53.8	1.1	41.7	1.1	12.1	.6	.6[c]	.2
	1976–1980	52.6	1.0	39.9	.8	12.7	.6	.4	.1
	1988–1994	60.9	1.0	40.3	.8	20.5	.7	1.8	.3
	1999–2000	67.0	1.8	39.2	1.5	27.7	1.6	3.3	.7
	2001–2002	69.9	1.0	41.5	1.5	28.4	1.1	3.9	.7
	2003–2004	71.1	1.5	39.4	1.5	31.7	1.4	3.0	.4
Women	1960–1962	40.5	1.0	24.7	.8	15.8	.6	1.4	.2
	1971–1974	40.9	.8	24.3	.7	16.6	.6	2.0	.3
	1976–1980	41.9	1.0	24.9	.8	17.0	.6	2.2	.3
	1988–1994	51.0	1.1	25.1	.8	25.9	1.0	4.1	.3
	1999–2000	62.0	2.3	28.0	1.7	34.0	1.8	6.6	.8
	2001–2002	61.4	1.0	27.3	1.6	34.1	1.6	6.8	.6
	2003–2004	61.4	1.9	27.4	1.3	34.0	1.9	7.3	1.0

NOTE. Overweight, BMI 25 to <30; obesity, BMI ≥ 30; extreme obesity, BMI ≥ 40 (in kg/m^2).
SE, standard error.
[a]National Health Examination Survey (1960–1962); National Health and Nutrition Examination Survey (I, 1971–1974; II, 1976–1980; III, 1988–1994; 1999–2000; 2001–2002; 2003–2004).
[b]Significant increasing trend for all, men, and women ($P < .05$).
[c]Does not meet standard of statistical reliability and precision. Relative SE was >30% but <40%.

risk for overweight (85th percentile ≤ BMI-for-age < 95th percentile) and overweight (BMI-for-age ≥ 95th percentile) for children and adolescents during this same time period are shown in Table 2.

In 2003–2004, 32.9% of adults 20–74 years old were obese. In the early 1960s, the prevalence of obesity was 11% among men and 16% among women. The prevalence changed relatively little over the time period from 1960 to 1980. However, between 1976 and 1980 (NHANES II) and 1988 and 1994 (NHANES III), the prevalence of obesity increased considerably, to about 21% in men and to about 26% in women. By 2003–2004 the prevalence had increased to almost 32% in men and 34% in women. Even during the short time period between 1999 and 2004 there was a significant increase in the prevalence of obesity among men, but not among women.[3]

Trends among children and adolescents were similar to those among adults (Table 2). After little change was seen in the prevalence of overweight among children and adolescents in the 1960s and 1970s there was an increase between NHANES II and NHANES III and a further increase between NHANES III and NHANES 2003–2004. By 2003–2004, more than 17% of teenagers (12–19 years of age) were overweight. The prevalence of overweight among boys and girls increased significantly during the 6-year time period from 1999 to 2004.[3]

Distribution of BMI

Changes in the prevalence of overweight and obesity do not present a complete picture of the trends in BMI. A more complete picture can be seen in the smoothed distributions of BMI in 1976–1980 and 1999–2004 for both adults (age, 20–74 y) and children and teenagers 6–19 years of age. The distribution of BMI between NHANES II (1976–1980) and NHANES 1999–2004 has shifted to the right (Figures 1 and 2), but the shift is greater at the upper percentiles of the distribution, indicating that the distribution has become more skewed. This pattern can be seen for adults as well as for children.

Differences in Obesity by Demographic Characteristics

The prevalence of overweight appears to increase with age. In 1999–2004, older adults were more likely to be obese than their younger counterparts. The only exception was adults aged 80 and older who were not significantly different from the 20- to 39-year-old adults. Among adults 20–39 years of age, 26.8% were obese. Among 40- to 59-year-old adults 34.8% were obese, and among 60- to 79-year-old adults 35.2% were obese, whereas among older adults (≥80 y) 17.3% were obese. Among children, the highest prevalence of overweight was among school-age children and adolescents; 11.5% of

Table 2. Prevalence and Trends of At Risk for Overweight and Overweight Among Children Ages 2–19 Years in the United States: 1960–2004

		2–19 y				2–5 y				6–11 y				12–19 y			
		At risk[b]		Overweight[b]		At risk		Overweight[b]		At risk[b]		Overweight[b]		At risk[b]		Overweight[b]	
Sex	Survey[a]	%	SE	%	SE	%	SE	%	SE	%	SE	%	SE	%	SE	%	SE
All																	
	1963–1965									8.8	.4	4.3	.4				
	1966–1970[c]													9.7	.4	4.6	.3
	1971–1974	10.4	.6	5.1	.3	10.9	1.1	4.8	.6	10.0	.8	4.0	.5	10.5	.8	6.1	.6
	1976–1980	9.2	.4	5.5	.4	9.2	.5	5.0	.6	9.0	.9	6.5	.7	9.2	.6	5.0	.5
	1988–1994	13.0	.7	10.0	.5	10.9	.6	7.2	.7	13.5	1.0	11.3	1.0	13.8	1.1	10.5	.9
	1999–2000	14.3	.9	13.9	.9	11.7	1.2	10.3	1.7	14.7	2.0	15.1	1.4	15.2	1.2	14.8	.9
	2001–2002	14.6	.6	15.4	.9	12.9	1.3	10.6	1.8	15.9	1.0	16.3	1.6	14.4	1.0	16.7	1.1
	2003–2004	16.5	.8	17.1	1.2	12.4	1.4	13.9	1.6	18.4	1.5	18.8	1.3	17.0	1.4	17.4	1.7
Boys																	
	1963–1965									8.3	.6	4.0	.4				
	1966–1970[c]													9.4	.6	4.5	.4
	1971–1974	10.5	.8	5.2	.5	12.3	1.3	4.9	.8	10.6	1.3	4.3	.8	9.7	1.2	6.0	.8
	1976–1980	9.4	.6	5.4	.4	8.2	.7	4.6	.6	9.7	1.1	6.7	.8	9.5	1.0	4.8	.5
	1988–1994	12.6	.9	10.2	.7	10.7	1.0	6.2	.8	13.7	1.5	11.6	1.3	12.7	1.4	11.3	1.3
	1999–2000	14.9	1.9	14.0	1.2	12.4	2.2	9.5	2.3	16.1	3.2	15.7	1.8	15.2	1.6	14.8	1.3
	2001–2002	14.2	.6	16.4	1.0	13.5	1.6	10.7	2.4	15.1	1.4	17.5	1.9	13.9	1.7	17.6	1.3
	2003–2004	16.6	1.0	18.2	1.5	12.2	2.3	15.1	1.7	16.6	1.8	19.9	2.0	18.5	1.5	18.3	1.9
Girls																	
	1963–1965									9.3	.5	4.5	.6				
	1966–1970[c]													10.1	.6	4.7	.3
	1971–1974	10.2	.8	5.0	.4	9.4	1.2	4.8	.8	9.3	1.2	3.6	.6	11.2	1.3	6.2	.8
	1976–1980	9.0	.6	5.7	.6	10.3	.9	5.4	1.0	8.2	1.3	6.4	1.0	9.0	.8	5.3	.8
	1988–1994	13.4	.9	9.8	.8	11.0	.9	8.2	1.0	13.2	1.5	11.0	1.4	15.0	1.6	9.7	1.1
	1999–2000	13.6	.8	13.8	1.1	11.0	1.8	11.2	2.5	13.1	1.6	14.3	2.1	15.2	1.9	14.8	1.0
	2001–2002	15.0	.9	14.4	1.3	12.3	1.7	10.5	1.8	16.7	1.7	14.9	2.4	14.9	1.2	15.7	1.9
	2003–2004	16.4	.9	16.0	1.4	12.5	1.8	12.6	2.4	20.4	2.5	17.6	1.3	15.3	1.9	16.4	2.3

NOTE. At risk for overweight, BMI for age 85th percentile: <95th percentile; overweight, BMI for age: ≥ 95th percentile.
SE, standard error.
[a]National Health Examination Survey (1963–1965; 1966–1970); National Health and Nutrition Examination Survey (I, 1971–1974; II, 1976–1980; III, 1988–1994; 1999–2000; 2001–2002; 2003–2004).
[b]Significant increasing trend for all, boys, and girls ($P < .05$).
[c]1966–1970: 12–17 years.

preschool-age children 2–5 years, 16.8% of school-age children 6–11 years, and 16.5% of adolescents 12–19 years were classified as overweight.

In 1999–2004, there were large disparities in obesity by race-ethnic group among women younger than 80 years of age (Table 3). For example, about 53% of non-Hispanic black women 40–59 years of age were obese compared with about 36% of non-Hispanic white women of the same age and 48% of Mexican American women. Among

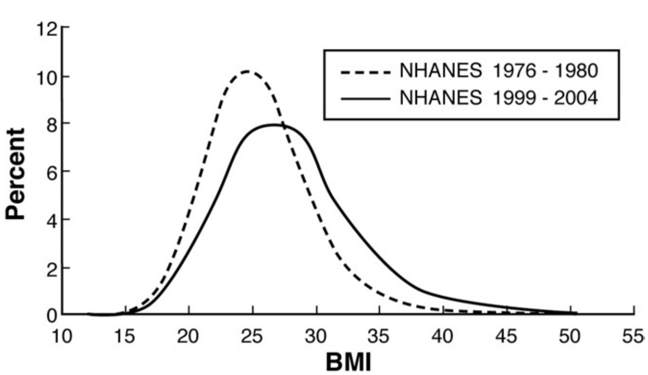

Figure 1. Change in the distribution of BMI between 1976–1980 and 1999–2004, for adults aged 20–74 years in the United States.

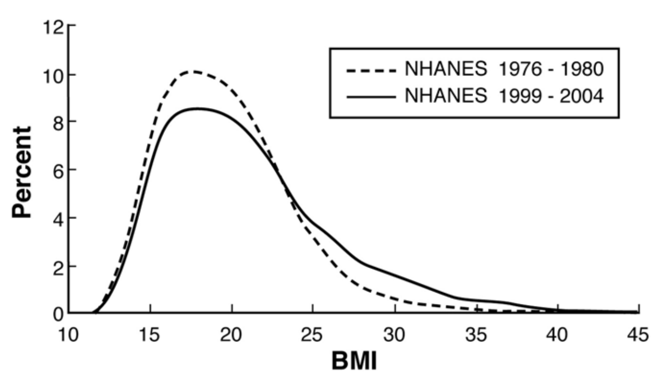

Figure 2. Change in the distribution of BMI between 1976–1980 and 1999–2004, for children and adolescents aged 6–19 years in the United States.

Table 3. Prevalence of Obesity Among Adults Age 20 Years and Older by Age and Race/Ethnicity in the United States: 1999–2004

		Race-ethnicity[a]							
		Total		Non-Hispanic white		Non-Hispanic black		Mexican American	
Sex	Age, y[b]	%	SE	%	SE	%	SE	%	SE
All	20+	31.0	.7	29.8	.8	41.4	1.1	34.2	1.4
	20–39	26.8	.8	24.4	1.0	38.1	1.9	29.4	1.9
	40–59	34.8	1.2	34.4	1.4	43.6	1.5	39.5	2.1
	60–79	35.2	1.0	35.0	1.1	45.9	2.3	36.2	1.8
	80+	17.3	1.3	17.4	1.4	25.9	4.7	11.9	4.7
Men	20+	28.8	.7	29.2	.9	30.0	1.5	28.9	1.4
	20–39	24.7	1.1	24.3	1.5	27.3	2.1	26.8	2.5
	40–59	32.2	1.3	32.8	1.6	32.5	1.8	31.5	2.5
	60–79	33.1	1.3	34.7	1.5	32.5	3.3	30.0	2.4
	80+	14.0	1.4	14.5	1.6	12.9	6.4	10.4	4.4
Women	20+	33.2	1.0	30.5	1.1	50.6	1.6	39.8	2.0
	20–39	29.0	1.2	24.5	1.6	47.7	2.4	32.9	2.9
	40–59	37.4	1.6	35.9	1.9	53.1	2.2	47.9	2.7
	60–79	36.9	1.4	35.3	1.6	55.4	3.7	41.5	2.5
	80+	19.2	1.8	19.1	2.0	31.1	5.5	13.1	6.3

NOTE. Obesity, BMI ≥ 30; National Health and Nutrition Examination Survey 1999–2004.
SE, standard error.
[a]No significant race/ethnic differences among men. Among women, non-Hispanic black > Mexican American (20–39 y and 60–79 y), non-Hispanic white < Mexican American (40–59 y), non-Hispanic black > non-Hispanic white (20–39 y, 40–59 y, and 60–79 y). Significance at $P < .05$ with Bonferroni correction.
[b]Among both men and women, significant age differences 40–59 years > 20–39 years and 60–79 years > 80+ years. Significance at $P < .05$ with Bonferroni correction, without regard to race/ethnicity.

Table 4. Prevalence of Overweight Among Children Age 2–19 Years by Age and Race/Ethnicity in the United States: 1999–2004

		Race-ethnicity[a]							
		Total		Non-Hispanic white		Non-Hispanic black		Mexican American	
Sex	Age, y[b]	%	SE	%	SE	%	SE	%	SE
All	2–19	15.6	.6	13.9	.9	18.8	.6	19.7	.9
	2–5	11.5	1.0	9.6	1.3	10.3	1.2	15.3	2.1
	6–11	16.8	.9	14.9	1.3	20.5	1.2	22.1	1.4
	12–19	16.5	.8	15.0	1.1	21.3	.9	20.2	1.0
Boys	2–19	16.4	.7	14.8	1.1	16.1	.8	22.7	.9
	2–5	11.8	1.2	9.9	1.7	8.6	1.5	17.5	2.3
	6–11	17.9	1.1	15.4	1.7	17.2	1.4	26.1	1.6
	12–19	17.2	.9	16.2	1.3	18.6	1.3	22.6	1.4
Girls	2–19	14.8	.8	13.0	1.1	21.6	.8	16.6	1.2
	2–5	11.3	1.3	9.4	1.7	12.0	1.8	13.2	2.8
	6–11	15.7	1.2	14.4	1.7	24.0	1.9	17.9	1.8
	12–19	15.7	1.1	13.6	1.6	24.2	1.3	17.7	1.4

NOTE. At risk for overweight, BMI for age 85th percentile: <95th percentile; overweight, BMI for age: ≥ 95th percentile. National Health and Nutrition Examination Survey 1999–2004.
SE, standard error.
[a]Among boys, significant race/ethnic differences: Mexican American > non-Hispanic white (6–11 y and 12–19 y), Mexican American > non-Hispanic black (6–11 y). Among girls, significant race/ethnic differences: non-Hispanic black > non-Hispanic white (6–11 y and 12–19 y). Significance at $P < .05$ with Bonferroni correction.
[b]Among boys, significant age differences: 6–11 years > 2–5 years and 12–19 years > 2–5 years. Among girls, significant age differences: 12–19 years > 2–5 years. Significance at $P < .05$ with Bonferroni correction, without regard to race/ethnicity.

Table 5. Prevalence of Obesity Among Adults Age 20 Years and Older by PIR and Race/Ethnicity in the United States: 1999–2004

		Total		Non-Hispanic white		Non-Hispanic black		Mexican American	
Sex	PIR[a]	%	SE	%	SE	%	SE	%	SE
All	Total	31.0	.7	29.8	.8	41.4	1.1	34.2	1.4
	PIR ≤ 130	33.9	1.0	33.4	1.4	40.6	1.8	34.5	2.2
	130 < PIR < 350	33.2	1.3	32.8	1.8	44.2	1.8	31.8	2.0
	PIR ≥ 350	27.6	1.0	26.8	1.0	39.1	1.8	39.8	2.3
Men	Total	28.8	.7	29.2	.9	30.0	1.5	28.9	1.4
	PIR ≤ 130	26.8	1.1	28.5	2.0	23.5	2.5	24.5	2.1
	130 < PIR < 350	30.5	1.3	31.5	2.0	32.3	2.6	29.9	2.4
	PIR ≥ 350	28.2	1.3	27.9	1.4	33.4	2.9	36.6	2.6
Women	Total	33.2	1.0	30.5	1.1	50.6	1.6	39.8	2.0
	PIR ≤ 130	39.2	1.3	37.5	1.9	51.0	2.7	44.1	2.6
	130 < PIR < 350	35.8	1.6	34.1	2.1	54.6	2.4	33.8	2.6
	PIR ≥ 350	26.9	1.1	25.5	1.3	45.5	2.7	43.1	3.8

NOTE. Obesity, BMI ≥ 30; National Health and Nutrition Examination Survey 1999–2004.
SE, standard error.
[a]Significant inverse trend ($P < .05$) by PIR among all women and non-Hispanic white women. Significant positive trend ($P < .05$) among Mexican American men.

men, however, the prevalence of obesity did not differ by race-ethnic group. Similarly, race-ethnic differences were found among school-age children and adolescents (Table 4). The prevalence of overweight in Mexican-American boys 6–11 years of age was significantly greater than in non-Hispanic white and non-Hispanic black boys. Among girls, non-Hispanic blacks were significantly more likely to be overweight compared with non-Hispanic whites.

Body size often is associated with socioeconomic status. However, the magnitude and the direction of the association tend to differ by level of economic development, sex, and race/ethnicity.[54–56] In less-developed countries, higher weight may be associated with wealth and prosperity, and there may be a positive association between socioeconomic status and body size for both men and women. Historically, in many contexts, greater body size, including tallness, increased muscularity, and increased fatness, has symbolized power, dominance, wealth, or high social standing. For men in developed countries, height is associated positively with socioeconomic status, but weight and BMI tend to be weakly, if at all, associated with socioeconomic status. For women in developed countries, however, weight and BMI have a strong inverse association with socioeconomic status. The slender body that in the past might have reflected economic deprivation, limited access to food, or the necessity for hard physical labor now may require expenditures of time, money, and effort to achieve. The finding in several studies that obesity is predictive of subsequent education and earnings for women but not for men may reflect the stronger association between obesity and low socioeconomic status at baseline for women than for men.[57,58] Weight appears to vary considerably more by

Table 6. Prevalence of Overweight Among Children Age 6–19 Years by PIR and Race/Ethnicity in the United States: 1999–2004

		Total		Non-Hispanic white		Non-Hispanic black		Mexican American	
Sex	PIR[a]	%	SE	%	SE	%	SE	%	SE
All	Total	16.6	.7	15.0	1.0	20.9	.7	21.1	.9
	PIR ≤ 130	18.3	.9	16.6	1.6	20.4	1.0	21.4	1.4
	130 < PIR < 350	17.9	1.0	16.6	1.6	21.4	1.4	22.3	1.8
	PIR ≥ 350	13.0	1.2	12.3	1.4	23.2	1.5	17.5	2.7
Boys	Total	17.5	.8	15.9	1.2	18.0	.9	24.2	.9
	PIR ≤ 130	18.8	1.3	17.1	2.4	18.0	1.4	24.4	1.8
	130 < PIR < 350	19.0	1.5	18.0	2.2	18.1	1.9	24.9	2.1
	PIR ≥ 350	14.4	1.6	13.7	1.8	19.7	2.6	20.2	3.6
Girls	Total	15.7	.9	14.0	1.2	24.1	.8	17.8	1.2
	PIR ≤ 130	17.8	1.4	16.1	2.5	22.9	1.7	18.1	1.6
	130 < PIR < 350	16.7	1.3	15.0	1.6	25.0	1.8	19.3	2.1
	PIR ≥ 350	11.5	1.4	10.9	1.7	26.8	3.4	15.5	2.9

NOTE. Overweight, BMI for age ≥ 95th percentile (kg/m^2); National Health and Nutrition Examination Survey 1999–2004.
SE, standard error.
[a]Significant inverse trend ($P < .05$) by PIR among total girls and non-Hispanic white girls.

socioeconomic status, race-ethnicity, and nationality for women than for men, suggesting that body weight may be associated more closely with social and cultural roles for women than for men.

Tables 5 and 6 contain estimates of the prevalence of obesity among adults and overweight among children 6–19 years of age in 1999–2004 by poverty-income ratio (PIR), the ratio of household income to the poverty threshold. The poverty threshold accounts for family size and inflation. In 2002, the poverty threshold for a family of 4 was between $18,000 and $19,000.[59] A PIR of 130% is the cut-off value for food stamp participation.[60] A significant inverse association between PIR and the prevalence of obesity was found for non-Hispanic white women, but for men the only significant association was a positive relationship between PIR and obesity in Mexican Americans. Among children, no significant differences were found in overweight at the 3 PIR levels.

Global Context

The United States is not alone in experiencing increases in the prevalence of obesity. Similar increases have been reported from a number of other countries and regions of the world.[23] For example, in England, the prevalence of obesity (BMI $\geq$ 30) among women 25–34 years of age increased from 12% to 24% in only 9 years between 1993 and 2002.[61] In Portugal, increases in overweight among school-age children also have been found.[62] Less-developed countries also have seen increases in obesity. Among preschool-age children in urban areas of China, the prevalence of obesity increased from 1.5% in 1989 to 12.6% in 1997.[63]

Differences in the prevalence of obesity between countries in Europe or between race-ethnic groups in the United States tend to be more pronounced for women than for men.[64] For example, in Europe, the WHO Multinational Monitoring of trends and determinants in Cardiovascular disease study, which gathered data from 39 sites in 18 countries, found the prevalence of obesity was similar for men across all sites. For women, however, there were marked differences in prevalence between sites, with higher values for women from Eastern Europe. Similarly, in the United States, there are marked differences in the prevalence of obesity by race-ethnic group for women but not for men, as shown in Table 3. Among teenagers in 1999–2004 in the United States, differences by race/ethnicity exist for both boys and girls (Table 4).

Health Implications

Morbidity in Children

Higher BMI among children is associated with higher levels of blood pressure and serum lipids,[65] factors that in adults are associated with higher cardiovascular risk. The implications of a given level of BMI for a child's future health, however, are unclear. In 2005, the Childhood Obesity Task Force of the US Preventive Services Task Force,[66] put the issue succinctly: "We do not know the best way to identify children who are at risk for future adverse health outcomes due to obesity or overweight. Although BMI is a convenient and widely agreed-on measure of obesity, it is not clear what BMI at any given age is associated with future good health." The US Preventive Services Task Force report[67] summarized the considerable gaps in knowledge of the links between childhood weight and future health outcomes. In terms of health outcomes, the task force found insufficient evidence to currently recommend screening for BMI among children and adolescents. This finding does not mean that screening is not valuable, but rather that additional evidence is needed.

Obesity and Diabetes Among Children and Adults

One concern is the emerging risk of type 2 diabetes mellitus among children and adolescents.[68] It should be noted that among youth this is a very low prevalence condition, occurring primarily in children with a strong family history of diabetes who are from certain ethnic groups, who are markedly obese by adult standards, or both.[68–75] The American Diabetes Association[69] recommends screening for diabetes in children who are overweight and have in addition 2 of the following risk factors: (1) family history of type 2 diabetes, (2) membership in specified race-ethnic groups (American Indians, African Americans, Hispanic Americans, Asians/South Pacific Islanders), and (3) signs of insulin resistance. The first cases of type 2 diabetes among children reported in the United Kingdom were 8 girls, aged 9–16 years, of Pakistani, Indian, or Arabic origin.[72] They were all overweight and had a family history of diabetes in at least 2 generations. Subsequent to this report, type 2 diabetes also was observed among 4 white children in the United Kingdom,[73] and type 2 diabetes in obese white children also has been reported from elsewhere.[74,75] Many of these cases occurred in children with very high BMIs, often in the range of 35–40, which would be considered grade 2 or grade 3 obesity in adults. More recently, population-based data on the prevalence of diagnosed diabetes in US children and adolescents has become available. The SEARCH for Diabetes in Youth Study[76] estimated crude prevalence rates of .18% for both type 1 and type 2 diabetes, but showed a great deal of variability by age and race. Among younger children (age, 0–9 y) type 1 diabetes was far more common in all races/ethnicities. Among adolescents, type 2 diabetes cases represented an increasing proportion of diabetes cases, ranging from 6% among non-Hispanic whites to 22% (Hispanic), 33% (black), 40% (Asian-Pacific Islander), and 76% (American Indian youth), clearly documenting at-risk populations. The vast majority of those with type 2 diabetes ($\geq$90%) in all racial/ethnic groups were overweight.[77]

Among adults, the relationship between BMI and type 2 diabetes is perhaps stronger than for any other comorbidity. In 2 large epidemiologic studies that used self-reported weight and height, an increase in the risk for type 2 diabetes began to be seen at relatively low BMI levels, well within the normal weight range,[78] but increased more steeply at a BMI of greater than 30. In addition, weight gain during adulthood confers additional risk, independent of initial body weight,[79–81] reinforcing the benefits of weight stability. The most recent data from NHANES[82] showed a prevalence of diabetes of 9.3% in the US adult population, of which 2.8% is undiagnosed. An additional 26% have impaired fasting glucose (defined as fasting plasma glucose level of 5.6 to <7.0 mmol/L). As with children, minority populations are at increased risk compared with non-Hispanic whites. In the case of Asian Pacific Islanders, increased diabetes risk occurs at lower BMI levels than in other racial/ethnic populations, likely because of a tendency for a more central distribution of body fat.[83]

Obesity and Nonalcoholic Fatty Liver Disease Among Children and Adults

Nonalcoholic fatty liver disease (NAFLD) and nonalcoholic steatohepatitis refer to diseases in which normal liver architecture is disrupted by the presence of fat or, in the case of steatohepatitis, fat-induced inflammation and injury to the hepatocyte that may progress to fibrosis and cirrhosis.

There are no good population-based data on the prevalence of NAFLD, although surrogates exist. One recent review placed the estimated prevalence at 3%–24%.[84] Because most patients are asymptomatic, the prevalence of NAFLD likely is underreported. In clinical practice, an increase of liver transaminase levels, especially alanine aminotransferase, without other evidence of underlying liver disease or alcohol abuse, frequently is considered suggestive for possible NAFLD, but the diagnosis remains histologic. Data from NHANES III found a prevalence of unexplained increases of serum aminotransferase levels of 7.9%.[85] Ultrasound, computed tomography, or magnetic resonance imaging also can be used to assess hepatic steatosis, but have limitations in sensitivity. A population-based study using proton magnetic resonance spectroscopy to measure hepatic triglyceride content in urban adults found that 32% had increased triglyceride content, with hepatic steatosis more common in Hispanic (45% compared with white [33%] and black [24%] subjects).[86] Men also were more likely to have increased liver triglyceride levels than women (42% vs 24% in white men and women, respectively).

Obesity is the most common risk factor associated with NAFLD, with the majority of patients with NAFLD (69%–100% in one review) being obese.[87] An autopsy study found that 18.5% of markedly obese patients but only 2.7% of lean patients had histologic evidence of steatohepatitis.[88] A very high prevalence of severely obese patients undergoing bariatric surgery have evidence of NAFLD or nonalcoholic steatohepatitis on biopsy examination.[89]

Similar to the epidemiology of diabetes, persons of Asian descent appear to be susceptible to hepatic steatosis at a relatively lower BMI than other racial and ethnic populations.[90] Unexplained increases in alanine aminotransferase levels tend to decrease with increasing age.[91] NAFLD and nonalcoholic steatohepatitis are associated with central or visceral, adiposity, and are linked strongly to insulin resistance, type 2 diabetes, and other components of the metabolic syndrome.[92] Diabetes is associated strongly with the risk of NAFLD, independent of the degree of obesity.[91]

The prevalence of NAFLD in children also appears to be increasing.[93] Although the overall prevalence of clinically diagnosed NAFLD in youth is believed to be small,[94] an autopsy study estimated fatty liver to be present in almost 10% of 2–19 year olds.[95] Estimates of the prevalence of NAFLD in obese children range from 22.5% to 52.8%.[95,96] A recent school-based study of obese (mean BMI, 35.2 kg/m^2) adolescents found that 23% had unexplained increases in alanine aminotransferase level, with similar variability by sex and ethnicity (males > females, Hispanic > white > black) to that reported in adults.[97] Also similar to adults, NAFLD is associated with increasing levels of obesity, insulin resistance, and diabetes.[93,94,97]

Obesity, Cardiovascular Disease, and the Metabolic Syndrome

Obesity is considered a major risk factor for cardiovascular disease (CVD). This is mediated in part through traditional risk factors, such as hypertension, dyslipidemia (particularly low levels of high-density lipoprotein and increased levels of triglycerides), and insulin resistance/impaired glucose tolerance.[98] More recently, there has been increasing interest in the role of inflammation as an independent factor linking obesity with CVD. In particular, the metabolically active fat associated with visceral obesity is thought to play a role in pathogenesis, and much research is currently underway to elucidate the mechanisms and metabolic pathways with a goal of developing effective treatments to disrupt the link between obesity and CVD.[99]

The association between obesity and increased CVD risk factors is strong. Both baseline BMI and change in BMI over time predict risk of developing CVD, and this association is seen in both men[100] and women.[101] Similar to both development of type 2 diabetes and NAFLD, there are racial/ethnic differences in the relationship between obesity and CVD risk, such that African Americans may have less risk at a given BMI than whites, with persons of Asian descent most at risk, likely owing to population differences in body-fat distribution.[98,102] In addition to its association with myocardial infarction, obesity also has been found to increase the risk of congestive heart failure[103] independent of traditional risk factors such as hypertension and diabetes, suggesting that other unmeasured factors play a role. Obesity is also a risk factor for atrial fibrillation[104] because of an increase in left atrial enlargement. The dilated cardiomyopathy associated with obesity may, in part, be responsible for the increased incidence of unexplained sudden death in persons with severe obesity.[98,105]

A constellation of risk factors including central adiposity, low high-density lipoprotein-cholesterol levels, high serum triglyceride levels, increased blood pressure, and impaired fasting glucose is known as the metabolic syndrome[106] and serves as a unifying principle regarding the relationship between individual risk factors and obesity. Although the utility of metabolic syndrome as a distinct diagnostic entity is controversial,[107,108] it is clear that an increasing number of metabolic and cardiovascular risk factors confer increasing risk for morbidity and mortality in adults. By using Adult Treatment Panel III definitions, NHANES 1999–2000 data showed that 27% of US adults ages 20–74 years met the criteria for metabolic syndrome.[109]

By using Adult Treatment Panel III guidelines adapted for adolescents,[110] analysis of the NHANES III cohort (1988–1994) found an overall prevalence of the metabolic syndrome among adolescents of 4.2%, which increased to 6.4% in a study using NHANES 1999–2000 data.[111] In both cohorts, approximately 30% of overweight youth (BMI ≥ 95th percentile) met the authors' criteria for metabolic syndrome (≥3 risk factors), compared with 7% of youth between the 85th and 95th percentiles and less than 1% of children with a BMI less than the 85th percentile, suggesting the utility of the 95th percentile as a threshold for increasing likelihood of risks associated with overweight. Ongoing longitudinal studies should help to determine the prognostic significance of these abnormalities during childhood for adult morbidity and mortality.

The association between obesity and increased CVD risk factors including hypertension and dyslipidemia appears to be decreasing over time. By using data from NHANES, Gregg et al[112] found a decreased prevalence of increased blood pressure and high blood cholesterol over the past 3–4 decades at all weight levels. This is, in part, owing to a secular trend toward a less-atherogenic diet and to improved medical care, including the use of effective medications for dyslipidemia and hypertension, and better primary and secondary prevention.

Mortality

Obesity has been shown repeatedly to be associated with a modestly increased risk of increased mortality. The magnitude of the association and the exact shape of the BMI-mortality relation, however, has been the subject of much discussion and controversy. A number of studies have suggested that there is a U- or J-shaped curve relating BMI to mortality, with the nadir of the curve around a BMI of 25 or even higher.[113–115]

Several studies have suggested that life expectancy is decreased among the obese. In a study from the Framingham Heart Study, 40-year-old female nonsmokers lost 7.1 years of life and similar male nonsmokers lost 5.8 years of life because of obesity.[116] In another study based on national data, obesity shortened life expectancy, especially among younger adults.[117]

The main cause of excess mortality in obesity, relative to normal weight, usually has been found to be cardiovascular disease.[118] A meta-analysis of 26 studies found that obesity (BMI ≥ 30) was associated with a relative risk for all-cause mortality of 1.22, for coronary heart disease mortality of 1.57, and for CVD mortality of 1.48, relative to the normal weight category.[119] Obesity is associated with increased levels of a number of cardiovascular risk factors, including diabetes, increased blood pressure, and dyslipidemia.[112] In the Framingham study, 0% of cardiovascular mortality among men and 10% among women was attributed to obesity,[120] even though the attributable fractions for the development of CVD in that study were higher. This finding may have been related in part to the age of the cohort. The association of BMI with mortality often has been found to be weak to nonexistent at older ages.[121,122] Obesity is associated with increased risk of developing CVD; however, a number of studies suggest that up to a certain point, higher weights may be associated with improved survival in patients with coronary artery disease,[123,124] so that the net effect of obesity on cardiovascular mortality may not be as great as the net effect of obesity on incident CVD.

The relation of obesity to all-cancer mortality is weaker than its relation to CVD. The same meta-analysis found that for cancer mortality, the relative risk was 1.07, relative to normal weight. A recent estimate was that 2%–3% of cancer mortality in developed countries is caused by obesity.[125]

The relation of overweight (BMI of 25 to <30) to all-cause or cause-specific mortality is weaker than that of obesity. A recent analysis of data from the NHANES surveys found that, relative to the normal weight category, overweight was associated with a statistically significant reduced number of deaths, after adjusting for sex, age, smoking, race-ethnic group, and alcohol consumption.[126] The meta-analysis of 26 studies also found a slightly reduced relative risk of mortality for overweight relative to normal weight.[119] Other studies similarly have found little or no increased mortality risk among the overweight.[114,115,127] The large Cancer Prevention Study II found no excess mortality for all cancers among overweight men and minimal excess mortality for overweight women. However, for certain cancers, including colorectal, esophageal, and breast, overweight was associated with significantly increased mortality risk.

Determinants of Obesity

The human body can metabolize protein, carbohydrate, and fat to meet energy needs. The principal energy storage is in the form of fat, which, unlike protein or carbohydrate, can be stored in the body in relatively large amounts. This ability to store fat allows energy stores to be mobilized in times of famine or food deprivation. From a historical and evolutionary perspective, starvation is a greater danger than overabundance. Famine and starvation still occur in the world today, especially in wartime or other adverse political and economic conditions.[128]

Throughout history, considerable effort has been devoted to finding ways to improve the adequacy and stability of the food supply and to reduce the energy expenditure required for work. As a result, an organism adapted for a situation in which food was limited and physical exertion was required now often is confronted with an environment in which palatable energy-dense foods are obtained easily with minimal physical activity.[129,130] Increased modernization and a Westernized diet and lifestyle are associated with an increased prevalence of overweight in many developing countries. This sometimes has been referred to as the *nutrition transition* or part of a transition to modernity.[131] There is little evidence, however, of a point at which this process ceases.

The factors that determine body weight and body composition in the absence of major environmental constraints are not well understood.[132] Energy intake and energy expenditure, the ability to store excess fat under conditions of overfeeding and the ability to lose fat under conditions of underfeeding, all appear to have genetic elements.[133–136] Genetic factors, however, are unlikely to explain the current increases in the prevalence of overweight and obesity occurring in the United States, the United Kingdom, and many other countries.[129,130] Surprisingly little is known about these increases in overweight and obesity. Clearly, individual behaviors along with social, cultural, and environmental factors also must play important roles. It is likely that a gene-environment interaction, in which genetically susceptible individuals respond to an environment with increased availability of palatable energy-dense foods and reduced opportunities for energy expenditure, contributes to our current high prevalence of obesity. Reductions in physical activity and changes in energy intake contribute to these but are difficult to measure.[137,138]

Poor eating habits often are established during childhood, and children often do not consume healthy diets. Many adolescents also are physically inactive. In 2005 only about 36% of adolescents met the current recommendations for physical activity (increasing heart rate for at least 60 minutes a day on 5 of the past 7 days). In addition, almost 40% watched 3 or more hours of television per day and only 33% had daily physical education in school.[139]

For adults, tobacco use could be considered among the environmental determinants of weight and overweight. Smoking cessation often is associated with an increase in weight.[140] Smoking and tobacco use are associated with lower body weights and a lower prevalence of overweight or obesity.[141] Although the precise mechanisms are not clear, this appears to be related to a direct effect of nicotine on metabolism rather than to reduced energy intake among smokers.[142]

Preventive Efforts

Public health and clinical guidelines on treatment for obesity generally consider degree of overweight, health risk factors, and comorbid conditions in identifying the most appropriate treatment for an individual.[5] Evidence suggests that even without reaching ideal weight, a moderate amount of weight loss can be beneficial in terms of reducing levels of some risk factors, such as blood pressure. Many studies of dietary and behavioral treatments, however, show that maintenance of weight loss is difficult.[143]

Weight loss has been shown to improve numerous health risk factors. However, the benefits of weight loss on long-term health outcomes, such as disease incidence and mortality, have been difficult to show. Some observational studies suggest that weight loss actually might be disadvantageous.[144,145] Because of limited and inconsistent evidence, it was suggested that there should be clinical trials of the effects of weight loss.[146,147] Several ventures are currently in progress that will help to provide answers to some of these questions. The Swedish Obese Subjects study includes surgical intervention for a cohort of severely obese individuals with follow-up data being collected on quality of life and on subsequent mortality and morbidity.[148] Results indicate that for the severely obese, bariatric surgery can result in "long term weight loss, improved lifestyle and except for hypercholesterolemia, amelioration of risk factors."[149] A clinical trial of weight loss sponsored by the National Institutes of Health and the CDC currently is underway in the United States.[147] Look AHEAD (Action For Health in Diabetes) study is a multicenter randomized clinical trial to examine the effects of a lifestyle intervention designed to achieve and maintain weight loss over the long term through decreased caloric intake and exercise in overweight and obese subjects with type 2 diabetes. The Action For Health in Diabetes study is focusing on the disease most affected by overweight and obesity, type 2 diabetes, and on the outcome that causes the greatest morbidity and mortality, CVD. The Diabetes Prevention Program was a major clinical trial, or research study, aimed at discovering whether either diet and exercise or the oral diabetes drug metformin (Glucophage; Bristol-

Myers Squibb, New York, NY) could prevent or delay the onset of type 2 diabetes in people with impaired glucose tolerance. The answer is yes. In fact, the Diabetes Prevention Program found that diet and exercise sharply reduced the chances that a person with impaired glucose tolerance would develop diabetes.[150] Metformin also reduced risk, although less dramatically, and the total cost of the intervention per participant was lower for metformin than for the lifestyle intervention.[151] It has proved difficult to prevent weight increases by interventions at the community or workforce level.[152]

Public Health Impact and Epidemiologic Issues

The net effect of overweight and obesity on morbidity and mortality is difficult to quantify. Higher body weight is associated with an increased incidence and prevalence of numerous conditions, including hypertension, diabetes mellitus, dyslipidemia, certain cancers, musculoskeletal disorders, and CVD, and with increased risk of disability.[5] Higher body weights are associated with increased risks of cardiovascular mortality and morbidity.[153] On the other hand, higher body weight also is associated with some benefits, including increased bone density and thus a lower prevalence of osteoporosis and hip fracture.[154] In the older age groups, which tend to have the highest mortality and morbidity, there appears to be less of an association of weight with mortality than in younger groups.[120,144] It has been suggested that at older ages, the negative aspects of obesity may to some extent be counterbalanced by some positive aspects,[120] although there also are some data suggesting that obesity is associated with higher levels of disability.[155]

The costs of obesity are high, although few true economic evaluations of obesity have been performed.[156] The direct medical costs of obesity in the United States have been estimated as more than $92 billion in 2002 dollars.[157] The costs of treatments for obesity also are high. For example, it has been estimated that in 1989 alone, Americans spent more than $30 billion on weight loss programs and products.[158]

Although obesity is considered a multifactorial condition, it often is viewed unidimensionally and described and studied as a simple issue of body weight. Considerable attention has been paid to body weight and BMI in epidemiologic studies. Body weight is measured easily and can be obtained through self-report, thus making it feasible for large-scale studies. However, the emphasis on body weight in epidemiologic studies may be somewhat misleading. Health risk factors may not be captured adequately by simple measurements or reports of body weight, particularly when weight is measured only at a single point in time. An individual's body weight reflects body composition and adipose tissue distribution that in turn reflect a combination of genetic factors, physiologic status, individual behaviors, and environmental and social influences. The real health risks are difficult to identify in this complex situation. For example, some research suggests that physical fitness may be a significant concern rather than weight per se.[159–161] In addition, as previously discussed, body fat distribution plays an important role in the risks of adiposity.

The social costs of obesity along with the costs of attempts to prevent or to treat obesity are high. In addition, the prevalence of obesity is increasing in most parts of the world and appears likely to continue to increase in the future. The health risks associated with these increases and the risks and benefits of treatment strategies need to be evaluated objectively.

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