Epidemiology and Economic Impact of Obesity and Type 2 Diabetes

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The epidemic of obesity has been increasing globally in the last 30 years. Developed countries were more affected, but developing countries have increasingly contributed to this epidemic as they continue to modernize. The national and global burden of obesity, with its public health and financial implications, is projected to markedly increase in the next 2 decades.1,2

DEFINITION OF OBESITY

Body Mass Index Criteria

The basic definition of obesity is the accumulation of abnormal or excess body fat. It is a complex, multifactorial disease that results from the interaction of genetic and environmental factors. Excess body weight is associated with increased morbidity and mortality, including increased risk of type 2 diabetes mellitus, heart disease, dyslipidemia, osteoarthritis, sleep apnea syndrome, and some cancers.3

The most commonly used measurement that closely correlates with body adiposity is the body mass index (BMI), defined as the weight in kilograms divided by the square of the height in meters (kg/m²). According to the World Health Organization (WHO), overweight and obesity are defined as a BMI equal to or greater than 25 kg/m² and 30 kg/m², respectively.4 Obesity is further classified as class I for BMI values between 30 kg/m² and 34.9 kg/m², class II between 35 kg/m² and 39.9 kg/m², and class III for a BMI 40 kg/m² or greater.4 Normal BMI values are between 18.5 kg/m² and 24.9 kg/m², and a BMI less than 18.5 kg/m² is considered underweight.4

Keywords
• Diabetes • Obesity • Bariatric surgery • Epidemic • Morbid obesity

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Among obese individuals, health risks increase proportionately with increasing BMI. The BMI criteria used to establish the classifications of obesity are based on statistical data from reference populations that reflect excess morbidity and mortality associated with increasing body fat content. BMI definitions of obesity classifications are the same for both genders and for all ages of adults.

However, BMI may not be an accurate measurement of body fat when considering specific populations, because of differences in body proportions. In Asian populations, for example, it has been identified that type 2 diabetes and cardiovascular disease are prevalent among patients who do not meet the traditional definitions of overweight or obesity. BMI can also overestimate the degree of adiposity in muscular patients. Consequently, adiposity and associated health risks must be interpreted within the context of assessments of body composition and medical comorbidities. Therefore, anthropometric measurements, such as waist circumference (WC), neck circumference (NC), and waist/hip ratio (WHR), better reflect central adiposity and are being used, with increasing frequency, to associate obesity with health risk factors.

Types of Obesity (Central vs Peripheral)

Body composition differs between men and women. For a given BMI, men tend to have more lean mass and central distribution of adipose tissue, whereas women exhibit a higher overall proportion of adiposity with primarily peripheral distribution. The central fat distribution involves primarily the trunk and reflects a preponderance of visceral adiposity, whereas peripheral fat distribution is deposited in the limbs and hips, particularly in the lower body. The type of fat distribution has been associated with the development of obesity-related complications. Compared with subcutaneous fat, visceral fat is more sensitive to lipolysis induced by catecholamines and less sensitive to the antilipolytic effects of insulin, which increases the levels of free fatty acids in the portal and systemic circulation. The resulting metabolic abnormalities, including decreased glucose tolerance, reduced insulin sensitivity, and adverse lipid profiles, become risk factors for type 2 diabetes and cardiovascular disease. The peripheral fat distribution, more common in women, is associated with improved insulin sensitivity.

WC and WHR are often used as indicators of central obesity. Abdominal obesity is defined as WC greater than 88 cm or WHR greater than 0.85 in women and WC greater than 102 cm or WHR greater than 0.90 in men. Central obesity has been shown to be a risk factor for acute myocardial infarction (AMI) in men and women. Moreover, in a large study of 27,098 participants from 52 countries, the likelihood of AMI increased proportionately with WHR in both genders and in most ethnic groups. Seidell concluded that WC and WHR are related to increased risk of all-cause mortality, particularly in younger adults and in those with low BMI (BMI $\geq$ 24.9 kg/m²). These concepts are particularly important when considering health risks caused by adiposity in patients who do not meet the BMI definitions for overweight and obesity. For example, WC and WHR have been strongly associated with risk of ischemic heart disease in the Asia Pacific region, regardless of the BMI. Thus, body composition and fat distribution should factor prominently in the management of obese patients and, specifically, when considering patients for bariatric or metabolic operations.

Obesity-Associated Morbidity and Mortality

Obesity adversely affects health by causing several medical conditions. The comorbid manifestations of obesity are hypothesized to result from either hyperplasia of adipose tissue or increased metabolic activity from hypertrophic adipocytes. Sleep apnea in obese patients has been attributed to an increased NC from parapharyngeal...
Osteoarthritis results from the trauma to joints associated with excess body weight. Other significant comorbidities associated with obesity are nonalcoholic fatty liver disease, gallbladder disease, stroke, idiopathic intracranial hypertension, several types of cancer (eg, colon, rectum, prostate, endometrium, breast), and endocrine changes in overweight women, including irregular menses, amenorrhea, and infertility. Metabolic syndrome (association of type 2 diabetes mellitus, hypertension, and dyslipidemia with obesity) predisposes obese patients to cardiovascular complications. The association of obesity with type 2 diabetes is strong in that overweight persons have a threefold risk of developing this comorbidity compared with individuals of normal weight, and class I obese persons are 20 times more likely to develop diabetes. As expected from this significant obesity-related morbidity, several long-term epidemiologic studies have indicated that overweight and obesity are associated with increased mortality.

**OBESITY EPIDEMIC**

**Statistics in the United States**

Obesity is increasing at an alarming rate in the United States. Data from the National Health and Nutrition Examination Survey (NHANES) indicate that, in 2003 to 2004, 32.2% of US adults were obese. Compared with data from 1999 to 2000, the prevalence of obesity among adult men significantly increased, from 27.5% to 31.1%, by 2003 to 2004, whereas the prevalence among adult women remained stable (33.4% vs 33.2%). By 2003 to 2004, approximately 30% of non-Hispanic white adults were obese, whereas 45% of non-Hispanic black adults were obese and 36.8% of Mexican-American adults were obese. In the same year, the prevalence of obesity among US adults between 20 and 39 years of age was 28.5%. This rate was 36.8% for adults 40 to 59 years of age and 31.0% for individuals more than 60 years of age.

Concurrently, 17.1% of children and adolescents (aged 2–19 years) had become overweight (defined as at or above the 95th percentile of the gender-specific BMI). Within this group, prevalence of overweight increased significantly for women (13.8%–16%) and men (14.0%–18.2%) between 1999 to 2000 and 2003 to 2004.

However, such large increases have been projected to continue in the next 2 decades. Analysis of NHANES data, collected between 1970 and 2004, predicts that 90% of US adults will become overweight or obese by 2030 and that more than 50% will become obese. Among adults, black women and Mexican-American men are expected to be most affected. At the same time, the prevalence of overweight and obesity in children and adolescents is expected to increase 1.6-fold to approximately 30%.

**Statistics Worldwide**

Numerous factors contribute to the obesity pandemic. In many places worldwide, environmental factors such as food, socioeconomic status, and eating behaviors interact with genetic and physiologic characteristics and lead to metabolic changes and obesity.

In a study of 106 countries, representing 88% of the world’s population, 23.2% of adults were found to be overweight (24% in men and 22.4% in women) and 9.8% were found to be obese (7.7% in men and 11.9% in women) in 2005. The number of overweight people worldwide is projected to increase from 937 million in 2005 to 1.35 billion in 2030, whereas the number of obese individuals is expected to increase from 396 million to 573 million.
In developed countries, the prevalence of obesity is similar for men and women. However, a greater proportion of women than men is obese in the developing world. In developing countries, obesity is more prevalent in urban areas because of several factors, including the shift from rural to urban lifestyles and decreased physical activity. The higher prevalence of obesity in women is mainly attributed to cultural factors.

Health Impact and Cost

Obesity is a major public health concern. It is associated with numerous comorbidities that range from metabolic and physiologic conditions, such as diabetes and cardiovascular disease, to psychological impairment and low quality of life. Some conditions, such as type 2 diabetes mellitus, dyslipidemia, obstructive sleep apnea, obesity hypoventilation syndrome, idiopathic intracranial hypertension, and nonalcoholic steatohepatitis, are highly associated with obesity (relative risk >5). Other factors, including all-cause mortality, hypertension, myocardial infarction, stroke, cholelithiasis, polycystic ovarian syndrome, osteoarthritis, and gout, are not as strongly associated with obesity but still occur with relative risks between twofold and fivefold higher than normal. Other medical issues, including cancer mortality, breast cancer, prostate cancer, colon cancer, impaired fertility, asthma, and gastroesophageal reflux, are associated with obesity at a relative risk of 1 to 2. Thus, compared with the general population, obese individuals are at significantly higher risk of a multitude of medical problems, some of which can lead to significant morbidity and mortality.

Several studies have linked obesity with increased mortality. Obese individuals are at increased risk of mortality from cardiovascular disease, diabetes, kidney disease, and obesity-related cancers. In addition, obese nonsmoking women and men have been reported to lose 7.1 and 5.8 years of their life expectancy, respectively. In a 16-year study of 90,000 US adults, death attributable to overweight and obesity was estimated at 4.2% to 14.2% in men and 14.3% to 19.8% in women. Obesity has become a major public health concern in the United States, and its financial impact on health care costs seems to grow every year. In an analysis of data from the Medical Expenditure Panel Surveys, the per capita medical expenditure for obese individuals was 42% higher than that for normal-weight individuals. In 2008, annual medical spending related to obesity was $147 billion dollars, which accounted for 9.1% of all medical expenditure. Overweight and obesity are projected to cost $860 billion to $956 billion (15.8%–17.6% of total health care costs) by 2030. In addition to direct health-related costs, obesity is associated with indirect costs associated with disability, absenteeism, and loss of productivity. The annual indirect cost of obesity related to absenteeism alone has been estimated at $4.3 billion. Worldwide, the economic burden of obesity has been estimated at between 0.7% and 2.8% of total health expenditure. This economic impact reached 9.1% for overweight and obese.

Type 2 Diabetes Mellitus Epidemic

Statistics in the United States

Type 2 diabetes mellitus is a prevalent disease, affecting approximately 8.3% of people in the United States. Of these individuals, 18.8 million have been diagnosed, whereas an additional 7 million remain undiagnosed. The Centers for Disease Control (CDC) 2011 National Diabetes Fact Sheet reported that 1.9 million cases were diagnosed in 2010 and that 11.3% of adults more than the age of 25 years, and 26.9% of those more than the age of 65 years, have diabetes. Although gender
does not significantly affect the prevalence of diabetes (11.8% of women and 10.7% of men), ethnicity does seem to play a role. This disease affects 7.1% of non-Hispanic white, 10.8% of Hispanic, and 12.8% of non-Hispanic black individuals.

**Statistics Worldwide**

Type 2 diabetes mellitus is a worldwide epidemic, with its incidence increasing in the past few years. It is estimated that 285 million people currently have diabetes and that this figure will increase to 438 million (7.8% of the world adult population) by 2030. Increases in the incidence of diabetes correlate with improvement in national socioeconomic status, as shown by sharp increases in obesity and diabetes in India and China. Currently, India ranks highest in the prevalence of diabetes, with 51 million cases, followed by China, with 43 million cases, and then the United States, with 25.8 million cases. It has been projected that, by the year 2030, the prevalence of diabetes will almost double.

**Health Impact and Cost**

In the year 2004, an estimated 3.4 million people died of hyperglycemic complications. The WHO projects that this mortality will double between 2005 and 2030. Most direct fatalities from diabetes occur in low-income and middle-income countries. Diabetes was previously ranked as the eighth leading cause of death worldwide, but now ranks fifth, following infections, cardiovascular disease, cancer, and trauma.

Although mortality caused by diabetes is lower in the United States than in developing countries, it still directly accounted for 71,382 deaths and was a factor in 160,022 deaths, in 2007. Thus, according to the CDC, diabetes contributed to 231,404 deaths out of almost 2.5 million total deaths. These figures will likely increase, because the lifetime risk of diabetes in the United States has been predicted to reach 1 in 3 for children born in the year 2000.

Along with significant health consequences, diabetes imposes a significant economic load. Several studies have examined the cost of diabetes around the world and have indicated that developed countries tend to have bigger financial burdens through direct treatment costs and indirect costs from losses in productivity. In 2010, the United States was estimated to have spent $198 billion, or 52.7% of the global expenditure, on diabetes treatment. This corresponds with an average annual cost of $9677 per diagnosed patient and $2864 per undiagnosed individual to treat diabetes and its associated comorbidities. Indirect costs, from lost earnings and decreased productivity, reached $58 billion in the United States in 2007. In India and China, these indirect costs were even higher because of early mortality related to diabetes.

About 12% of the worldwide health care expenditure was spent on diabetes in 2010, corresponding with approximately 14% of total health care spending in the United States. In contrast, hypertension, stroke, and myocardial infarction represented only 10% of global health care expenditure. The WHO predicts that India and China will be spending 40% of their gross health care expenditure on management of diabetes by 2025, when they will be expected to have 130 million cases. The global expenditure for prevention and treatment of diabetes is projected to exceed $490 billion by 2030.

**Pathophysiologic Connection Between Diabetes and Obesity**

According to the CDC, 90% to 95% of adult US diabetics are type 2 diabetics. Most of these cases are hypothesized to be secondary to insulin resistance and
a hyperinsulinemic state, which increases insulin production and eventually leads to an irreversible state in which pancreatic β-cells burn out and cease to produce insulin.37 Clinically, most of these patients can initially be managed with lifestyle modifications, but disease progression leads to a need for oral medications and, ultimately, insulin replacement. The deleterious effects of diabetes on other organs, such as the renal, cardiovascular, and ophthalmic systems, depend on the duration and management of the disease.

The development of diabetes is multifactorial. Although genetic predisposition has been shown to play a role, poor nutrition, physical inactivity, and obesity remain the most common risk factors.30,38 There are many hormonal mediators that regulate food intake and metabolism, including several gastrointestinal, pancreatic, and adipocyte-derived peptides. Adipose tissue is not only a calorie storage organ but is an active endocrine organ, secreting factors like leptin, lipocalin 2, TNF-α, interleukin 6, and adiponectin.39 Adiponectin is an antiinflammatory factor and an insulin sensitizer.39 It is secreted in abundance by adipocytes in insulin-sensitive persons but is deficient in obese persons, making it a contributor to insulin resistance.39 Leptin regulates food intake, and its absence has been shown to lead to uncontrolled food intake and obesity.39 There is mounting evidence that these mediators link obesity to the development of diabetes and the other components of metabolic syndrome.

The association between obesity and type 2 diabetes is so strong that the new term diabesity is being used in the literature. The prevalence of obesity among patients at the initial diagnosis of diabetes has markedly increased since the 1970s.40 It is estimated that individuals with BMI greater than 40 kg/m2 are 7 times more likely to develop diabetes than those with BMI in the normal range.41

Physical activity, diet modification, and weight loss are recommended for the management of prediabetes and early diabetes, because such simple lifestyle changes can significantly delay the progression of the disease and its end-organ damage.30 Individuals with difficulty losing weight can benefit from weight loss programs, either surgical or nonsurgical. Bariatric surgery results in clinical remission of diabetes in 64% to 83% of patients.37 The benefit of early intervention to prevent β-cell dysfunction should be emphasized. Gastric bypass induces remission of diabetes in 95% of patients with diabetes duration less than 5 years, but in only 54% of patients with diabetes duration greater than 10 years.42

OPTIONS FOR MEDICAL AND SURGICAL MANAGEMENT

The health risks of obesity diminish with weight loss. Even a modest weight loss can result in a 20% reduction in all-cause mortality.43 A weight gain of 5 to 7 kg can increase the risk of diabetes by 50%, whereas a reduction of as little as 5 kg decreases the risk by the same amount.44 When considering obesity in the context of type 2 diabetes, management has to integrate good glycemic control with weight loss. As soon as diabetes is diagnosed, effective therapies for weight management should be implemented. By the same principle, in diabetic patients or patients with impaired glucose tolerance, the prevention of weight gain should be one of the main goals when deciding on therapy.45

Conventional medical therapy for diabetes includes the use of insulin, insulin sensitizers (eg, thiazolidinediones), insulin secretagogues (eg, sulfonylureas), and modulators of hepatic glucose production (metformin). Most of these medications are associated with weight gain, except for metformin, which has been associated with weight neutrality or a modest weight reduction.45 Among newer treatment modalities are the incretin therapeutic agents, which include glucagonlike peptide-1 (GLP-1)
receptor agonists (exenatide, liraglutide) and dipeptidyl peptidase-4 (DPP-4) inhibitors (sitagliptin, vildagliptin, saxagliptin). Both groups improve GLP-1 activity and, thereby, stimulate the synthesis and glucose-dependent secretion of insulin and suppress glucagon secretion. GLP-1 receptor agonists also slow gastric emptying and increase satiety, with a net effect of weight loss. They have also been associated with beneficial effects on cardiovascular risk factors. Thus, lifestyle modifications and metformin can be effective initial therapeutic choices to treat the overweight or obese patient with type 2 diabetes, and GLP-1 receptor agonists can be added to facilitate weight loss, normalize satiety, and improve postprandial glucose excursions.46

Weight loss therapy is recommended for patients with BMI of 30 kg/m² or greater and for patients with BMI between 25 kg/m² and 29.9 kg/m² or high-risk WC and 2 or more risk factors.7 Diet should consist of low-calorie, low-fat foods with a caloric goal of 1000 to 1200 kcal/d for most women, and 1200 to 1600 kcal/d for men.7 Physical activity increases energy expenditure, helps with weight maintenance, and reduces the risk of heart disease.7

Pharmacotherapy can be added if lifestyle modifications are not successful in achieving weight loss. Currently, the only medication approved for the long-term treatment of obesity is orlistat, which inhibits pancreatic lipases and, thereby, decreases fat absorption from the gastrointestinal tract.47 A systematic review of orlistat showed that the mean weight loss at 1 year was 2.9 kg.48 Although this minor weight loss is insufficient to make any clinical difference, it may be useful as an adjunct in patients waiting for bariatric surgery.49

Nonoperative management of obesity with diet, exercise, behavioral modification, and medications rarely achieves adequate durable weight loss.50 However, bariatric surgery is effective at achieving weight loss and improving or resolving comorbidities. In a prospective, randomized trial, bariatric surgery achieved considerably better weight loss and improvement in comorbidities than medical therapy at 10 year follow-up.51 A meta-analysis by Buchwald and colleagues52 in 2004 reported a mean excess weight loss of 61% with bariatric surgery and substantial improvement or complete resolution of diabetes mellitus, hypertension, dyslipidemia, and obstructive sleep apnea. This study also found a low operative 30-day mortality of 0.5% for patients who underwent gastric bypass.52 In addition, bariatric surgery has been shown to decrease overall mortality in obese individuals in the long-term, on the order of 40%.53,54 This effect was most pronounced in mortality related to diabetes mellitus, heart disease, and cancer.54

SUMMARY

Obesity is a burgeoning health care crisis in the United States and around the world. This disease is closely associated with numerous medical problems, including diabetes mellitus. Weight reduction is the cornerstone of therapy for obesity and diabetes. Current nonsurgical weight loss therapies consist of lifestyle modifications and medications and have been shown to be largely ineffective. Bariatric surgery has repeatedly been shown to be safe and highly efficacious in achieving and maintaining meaningful weight loss, as well as treating the medical comorbidities of obesity. As such, early intervention must be considered in obese, diabetic patients, and bariatric surgery should play a prominent role in the treatment algorithm.

REFERENCES


