

Causes and Consequences of Obesity

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INTRODUCTION

The prevalence of obesity is increasing globally, with nearly half a billion of the World's population now considered to be overweight or obese (Rossner, 2002). The pandemic of obesity is so great that it has even spawned a new word 'globesity' (Speakman, 2003). The obesity epidemic is related both to dietary factors and to an increasingly sedentary lifestyle. Obesity has significant co-morbidities and these are associated with substantial health care and social costs. It is a complex disorder of appetite regulation and energy metabolism controlled by specific biological factors.

Obesity can be defined as a disease in which excess body fat has accumulated such that health may be adversely affected (Kopelman, 2000). Obesity can only occur when the energy value of food eaten exceeds energy expended. This situation is known as "a positive energy balance". In this situation the excess intake of energy inevitably appears as deposits of fat. Obesity is a worldwide communal health problem. The problem does not only affect developed countries, as there is now a significant increase in overweight and obesity throughout the developing world (CPHA, 2006).

A more common and scientifically acceptable definition is the "Quetelet Index", also known as the "Body Mass Index" (BMI). This is calculated by dividing the weight of a person in kilograms by the square of the height in metres (Sanchez-Garcia, 2007). For example, a person who weighs 63.5 kg and is 1.68 m tall has a BMI of: $63.5/1.68^2 = 22.5 \text{ kg/m}^2$. A BMI of 25 is regarded as the upper limit of normality, a BMI of 18-20 as the lower limit. A BMI between 25 and 30 is considered overweight. Unless an overweight person is also at extra risk for other life-threatening diseases, due to smoking habits, high serum cholesterol levels etc., this condition does not require urgent treatment. A BMI above 30 is considered obese. This condition requires treatment quite urgently. Assessing obesity in children is more difficult than in adults. Application of the BMI to children is generally considered to be inappropriate (Mukhopadhyay et al., 2005).

Obesity is caused by a combination of both genetic and environmental influences. It may develop at any age in either sex and is an increasing health problem. The excess of fat in men tends to accumulate in the upper abdomen. In women the favored sites for the accumulation of fat are the buttocks, hips and thighs (Bose, 1995). The site of fat accumulation is considered a predominant factor for metabolic disorders of obesity (Van Gaal et al., 1988). However, the incidence of obesity was found to be higher among women than men (Pi-Sunyer, 1994).

Current prevalence data from individual national studies collated by the International Obesity Task force (IOTF, 2007) suggest that obesity ranges from 10 to 20% for men, and 10 to 25% for women. Kopelman (2000) suggests that obesity is now so common within the world's population that it is beginning to replace under-nutrition and infectious diseases as the most significant contributor to ill health. It is estimated that, at the beginning of this century, more people will die from complications of overnutrition than of starvation.

In most industrial societies, obesity and overweight are increasing in prevalence. The prevalence of obesity has recently increased in Asian as well as Western countries (Ohzeki et al., 1990). Obesity is relatively common in Europe. In the UK it was estimated in 1987 that 8% of men and 12% of women were obese, while 37% of men and 24% of women were overweight. In Germany (West) in 1992 42% of men and 28% of women were overweight, while 11% of men and 12% of women were obese. In the Netherlands in 1992 self-reported prevalence of obesity (depending on age) was estimated at 2% to 6% for men and 4% to 15% for women (WHO, 2000).

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 (NIH, 1985).

Childhood obesity and its consequences are emerging as a global problem. Data from 79 developing countries and a number of industrialized countries suggest that, by WHO standards, about 22 million children aged under 5 are overweight globally. Obesity affects almost 10% of schoolchildren in industrialized countries and high rates are also emerging in some of the developing ones. Some 30% of obese children become obese adults (IOTF, 2007).

The increasing prevalence of childhood obesity throughout the past two decades has been emphasized in many Western countries. The World Health Organization (2000) recognized obesity as a major public health epidemic worldwide, in developed as well as in some developing countries. In the UK, the prevalence of overweight in children was 14.7% in 1989 and 23.6% in 1998, while that of obesity increased from 5.4 to 9.2% during this period (Bundred et al., 2001). Between 1975 and 1995 the prevalence of overweight rose from 10.0 to 16.3% in German boys, and from 11.7 to 20.7% in German girls (Kromeyer-Hauschild et al., 1999). Between 1963 and 1991, the prevalence of overweight increased from 15 to 22.5% in 6-11 years old North American children, while that of obesity increased from 5 to 11% (Troiano et al., 1995).

CAUSES OF OVERWEIGHT AND OBESITY

Genetic influence

Obesity is a complex multifactorial chronic disease developing from interactive influences of numerous factors-social, behavioral, physiological, metabolic, cellular and molecular. Genetic influences are difficult to elucidate and identification of the genes is not easily achieved in familial or pedigree studies. Furthermore, whatever the influence the genotype has on the etiology of obesity, it is generally attenuated or exacerbated by nongenetic factors.

A large number of twin, adoption, and family studies have explored the level of heritability of obesity; that is, the fraction of the population variation in a trait (e.g., BMI) that can be explained by genetic transmission. Recent studies of individuals with a wide range of BMIs, together with information obtained on their parents, siblings, and spouses, suggest that about 25 to 40 percent of the individual differences in body mass or body fat may depend on genetic factors

(Bouchard et al., 1988; Vogler et al., 1995). However, studies with identical twins reared apart suggest that the genetic contribution to BMI may be higher, i.e., about 70 percent (Stunkard, 1990). There are several other studies of monozygotic twins reared apart that yielded remarkably consistent results (Allison et al., 1996a). Some of the reasons behind the different results obtained from twin versus family studies have been reported (Allison, 1995; Allison and Pi-Sunyer, 1995; Maes et al., 1997). The relative risk of obesity for first-degree relatives of overweight, moderately obese, or severely obese persons in comparison to the population prevalence of the condition reaches about 2 for overweight, 3 to 4 for moderate obesity, and 5 and more for more severe obesity (Allison et al., 1996b; Lee et al., 1997).

Support for a role of specific genes in human obesity or body fat content has been obtained from studies of Mendelian disorders with obesity as one of the clinical features, single-gene rodent models, quantitative trait loci from crossbreeding experiments, association studies and linkage studies. From the research currently available, several genes seem to have the capacity to cause obesity or to increase the likelihood of becoming obese (Chagnon et al., 2003). The rodent obesity gene for leptin, a natural appetite-suppressant hormone, has been cloned (Zhang et al., 1994), as has been its receptor (Tartaglia et al., 1995). In addition, other single gene mutants have been cloned (Tartaglia et al., 1995; Montague, 1997). However, their relationship to human disease has not been established, except for one study describing two subjects with a leptin mutation (Montague, 1997). This suggests that for most cases of human obesity, susceptibility genotypes may result from variations of several genes.

Severely or morbidly obese persons are, on the average, about 10 to 12 BMI units heavier than their parents and siblings. Several studies have reported that a single major gene for high body mass was transmitted from the parents to their children. The trend implies that a major recessive gene, accounting for about 20 to 25 percent of the variance, is influenced by age and has a frequency of about 0.2 to 0.3 (Bouchard et al., 1998). However, no gene(s) has (have) yet been identified. Evidence from several studies has shown that some persons are more susceptible to either weight gain or weight loss than others (Bouchard and Tremblay, 1990). It is important for the practitioner to recognize that the pheno-

menon of weight gain cannot always be attributed to lack of adherence to prescribed treatment regimens.

Research continues into the genetics of obesity and an update of the human obesity gene map has been published. More than 300 genes, markers, and chromosomal regions have been associated or linked with human obesity phenotypes. The number of genes and other markers associated or linked with human obesity phenotypes continues to expand (Chagnon et al., 2003). Of course, some of these loci will turn out to be more important than others, and many will eventually be proven to be false positives. The main goals remain to identify the combination of genes and mutations that are contributing to the predisposition to human obesity and to determine the environmental circumstances under which these gene combinations and mutations occur. As we near the completion of the final draft of the human genome sequence and, with it, a more exhaustive annotation of the genome, we expect continuous advances in the understanding of the genetic basis of the predisposition to human obesity (Rossner, 2002).

Environmental Origin

The environment is a major determinant of overweight and obesity. Environmental influences on overweight and obesity are primarily related to food intake and physical activity behaviors (James, 1995). In developed countries like the United States, there is an overall abundance of palatable, calorie-dense food. In addition, aggressive and sophisticated food marketing in the mass media, supermarkets, and restaurants, and the large portions of food served outside the home, promote high calorie consumption. Many of our sociocultural traditions promote overeating and the preferential consumption of high calorie foods. For many people, even when calorie intake is not above the recommended level, the number of calories expended in physical activity is insufficient to offset consumption. Mechanization limits the necessity of physical activity required to function in society. Many people are entrenched in sedentary daily routines consisting of sitting at work, sitting in traffic, and sitting in front of a television or a computer monitor for most of their waking hours. In this obesity-promoting environment, individual attitudes and behaviors are critical in weight management.

Many individuals may need extended treatment in clinical or community settings to enable them to cope with the complexities of long-term weight management, especially if there is a history of unsuccessful attempts at self-treatment (Thomas, 1995). When the typical daily routine is so strongly biased towards promoting and perpetuating overweight and obesity, very high levels of knowledge, motivation, personal behavioral management skill, and lifestyle flexibility are required for an overweight or obesity-prone individual to avoid becoming overweight, or progressing to moderate or severe obesity.

Although there are unquestionably some inter- and intra-population variations in the genetic predisposition to become overweight or obese, several lines of evidence suggest that genetic factors alone cannot explain the demographic and ethnic variations in overweight and obesity prevalence. For example, there is a difference in obesity prevalence among low- and high-income white women in industrialized societies (Sobal and Stunkard, 1989; Kumanyika, 1994). Other studies of populations, including migration studies, have shown an increase in average body weight in those who move from a traditional to a Westernized environment (Kawate et al., 1979; Kawate et al., 1980; Taylor et al., 1985; Ravussin et al., 1994). Culturally determined attitudes about food, physical activity, and factors that vary with income, education, and occupation may increase the level of difficulty in weight management. Body image concerns and other motivations for avoiding obesity or controlling weight within given limits also vary with ethnic background, age, socioeconomic status, and gender. Thus, the competence of practitioners in working with diverse socio-cultural perspectives can be a critical factor in the success of obesity treatment (Kumanyika and Morssink, 1997).

HEALTH IMPLICATIONS OF OVERWEIGHT AND OBESITY

Morbidity Pattern

Above a BMI of 20 kg/m², morbidity for a number of health conditions increases as BMI increases. Higher morbidity in association with overweight and obesity has been observed for hypertension (Stamler et al., 1978; Criqui et al., 1982; Dyer and Elliott, 1989), type 2 diabetes (Lew and Garfinkel, 1979; Colditz, 1990; Chan et al.,

1994), coronary heart disease (CHD) (Lundgren et al., 1989; Haffner et al., 1991), stroke (Hubert et al., 1983; Walker et al., 1996; Rexrode, 1997), gallbladder disease (Stampfer et al., 1992; Khare et al., 1995), osteoarthritis (Hart and Spector, 1993; Hochberg et al., 1995; Cicuttini et al., 1996), sleep apnea and respiratory problems (Shepard, 1992; Chua and Chediak, 1994; Loubé et al., 1994) and some types of cancer (endometrial, breast, prostate and colon) (Rosenberg et al., 1990; Chu et al., 1991; Hunter and Willett, 1993; Giovannucci, 1995; Schottenfeld and Fraumeni, 1996). Obesity is also associated with complications of pregnancy, menstrual irregularities, hirsutism, stress incontinence and psychological disorders (depression) (Keppel and Taffel, 1983; Garbaciak et al., 1985; Dunaif, 1992; Rich-Edwards, 1994). The nature of obesity-related health risks is similar in all populations, although the specific level of risk associated with a given level of overweight or obesity may vary with ethnicity, and also with age, gender, and societal conditions. For example, the absolute risk of morbidity in chronic conditions such as CHD is highest in the aged population, while the relative risk of having CHD in obese versus nonobese individuals is highest in the middle adult years (Rabkin et al., 1977; Feinleib, 1985; Garrison and Castelli, 1985). A high prevalence of diabetes mellitus in association with obesity is observed consistently across ethnicities, while the relative prevalence of hypertension and CHD in obese versus nonobese populations varies between groups.

The additional health consequences of overweight and obesity are associated with increased risks of gall bladder disease, incontinence, increased surgical risk, and depression. Obesity can affect the quality of life through limited mobility and decreased physical endurance as well as through social, academic, and job discrimination. The principal health implications of overweight and obesity are depicted below :

(a) Diabetes Mellitus

The increased risk of diabetes as weight increases has been shown by prospective studies in Norway (Westlund and Nicolaysen, 1972), the United States (Lew and Garfinkel, 1979), Sweden (Larsson et al., 1981) and Israel (Medalie et al., 1974). More recently, the Nurses' Health Study, using data based on self-reported weights, found that the risk of developing type 2 diabetes

increases as BMI increases from a BMI as low as 22 (Colditz et al., 1990). Since women in particular tend to underreport weight, the actual BMI values associated with these risks are likely to be higher than the Nurses' Health Study data would suggest. An association between type 2 diabetes and increasing relative weight is also observed in populations at high risk for obesity and diabetes, such as in American Indians (Knowler et al., 1981). In recent studies, the development of type 2 diabetes has been found to be associated with weight gain after age 18 in both men (Chan et al., 1994) and women (Colditz et al., 1990). The relative risk of diabetes increases by approximately 25 percent for each additional unit of BMI over 22 kg/m² (Colditz et al., 1995). In addition, in a prospective study representative of the U.S. population, it was recently estimated that 27 percent of new cases of diabetes was attributable to weight gain in adulthood of 5 kg (11 lb) or more (Ford et al., 1997). Both cross-sectional (Sparrow et al., 1986; Haffner et al., 1991), and longitudinal studies (Lundgren et al., 1989; Chan et al., 1994) show that abdominal obesity is a major risk factor for type 2 diabetes (Sparrow et al., 1986; Chan et al., 1994).

(b) Hypertension

Data from NHANES III show that the age adjusted prevalence of high blood pressure increases progressively with higher levels of BMI in men and women (Brown et al., 2000). High blood pressure is defined as mean systolic blood pressure ≥ 140 mmHg, and or mean diastolic blood pressure ≥ 90 mmHg, or currently taking anti-hypertensive medication. The prevalence of high blood pressure in adults with BMI ≥ 30 is 38.4 percent for men and 32.2 percent for women, respectively, compared with 18.2 percent for men and 16.5 percent for women with BMI < 25 , a relative risk of 2.1 and 1.9 for men and women, respectively. The direct and independent association between blood pressure and BMI or weight has been shown in numerous cross-sectional studies (Stamler et al., 1978; Criqui et al., 1982), including the large international study of salt (INTERSALT) carried out in more than 10,000 men and women (Dyer and Elliott, 1989). INTERSALT reported that a 10 kg (22 lb) higher body weight is associated with 3.0 mmHg higher systolic and 2.3 mmHg higher diastolic blood pressure (Dyer and Elliott, 1989). These differences in blood pressure translate into an estimated 12 percent

increased risk for CHD and 24 percent increased risk for stroke (Cutler et al., 1985). Positive associations have also been shown in prospective studies (Ballantyne et al., 1978; Brennan et al., 1980). Obesity and hypertension are co-morbid risk factors for the development of cardiovascular disease. The pathophysiology underlying the development of hypertension associated with obesity includes sodium retention and associated increases in vascular resistance, blood volume, and cardiac output. These cardio-vascular abnormalities associated with obesity are believed to be related to a combination of increased sodium retention, increased sympathetic nervous system activity, alterations of the renin-angiotensin system and insulin resistance. The precise mechanism whereby weight loss results in a decrease in blood pressure is unknown. However, it is known that weight loss is associated with a reduction in vascular resistance, total blood volume and cardiac output, an improvement in insulin resistance, a reduction in sympathetic nervous system activity, and suppression of the activity of the renin angiotensin aldosterone system (Tuck et al., 1981; Reisin et al., 1983; Rocchini et al., 1989).

(c) Coronary Heart Disease (CHD)

Observational studies have shown that overweight, obesity, and excess abdominal fat are directly related to cardiovascular risk factors, including high levels of total cholesterol, LDL cholesterol, triglycerides, blood pressure, fibrinogen and insulin (Haffner et al., 1991) and low levels of HDL-cholesterol (NIH, 1985). Plasminogen activator inhibitor-1 causing impaired fibrinolytic activity is elevated in persons with abdominal obesity (Landin et al., 1990). Overweight, obesity, and abdominal fat are also associated with increased morbidity and mortality from CHD (Hubert et al., 1983; NIH, 1985). Recent studies have shown that the risks of nonfatal myocardial infarction and CHD death increase with increasing levels of BMI. Risks are lowest in men and women with BMIs of 22 or less and increase with even modest elevations of BMI. In the Nurses' Health Study, which controlled for age, smoking, parental history of CHD, menopausal status, and hormone use, relative risks for CHD were twice as high at BMIs of 25 to 28.9, and more than three times as high at BMIs of 29 or greater, compared with BMIs of less than 21 (Willett et al., 1995). Weight gains of 5 to 8 kg (11

to 17.6 lb) increased CHD risk (nonfatal myocardial infarction and CHD death) by 25 percent, and weight gains of 20 kg (44 lb) or more increased risk more than 2.5 times in comparison with women whose weight was stable within a range of 5 kg (11 lb) (Willett et al., 1995). In British men, CHD incidence increased at BMIs above 22 and an increase of 1 BMI unit was associated with a 10 percent increase in the rate of coronary events (Shaper et al., 1997). Similar relationships between increasing BMI and CHD risk have been shown in Finnish, Swedish, Japanese, and U.S. populations (Tokunaga et al., 1991; Willett et al., 1995; Jousilahti et al., 1996).

A relationship between obesity and CHD has not always been found. Two reasons may account for this: the first is an inappropriate controlling for cholesterol, blood pressure, diabetes, and other risk factors in statistical analysis; and the second is that there was not an adequate control for the confounding effect of cigarette smoking on weight. People who smoke often have a lower body weight but more CHD (Lundgren et al., 1989).

(d) Congestive Heart Failure (CHF)

Overweight and obesity have been identified as important and independent risk factors for congestive heart failure (CHF) in a number of studies, including the Framingham Heart Study (Hubert et al., 1983; Kannel and Cupples, 1988; Eriksson et al., 1991; DiBianco, 1994). CHF is a frequent complication of severe obesity and a major cause of death; duration of the obesity is a strong predictor of CHF (Shimizu and Isogai, 1993). Since hypertension and type 2 diabetes are positively associated with increasing weight, the coexistence of these conditions facilitates the development of CHF (Urbina et al., 1995). Data from the Bogalusa Heart Study demonstrate that excess weight may lead to acquisition of left ventricular mass beyond that expected from normal growth (Urbina et al., 1995). Obesity can result in alterations in cardiac structure and function even in the absence of systemic hypertension or underlying heart disease. Ventricular dilatation and eccentric hypertrophy may result from elevated total blood volume and high cardiac output. Diastolic dysfunction from eccentric hypertrophy and systolic dysfunction from excessive wall stress result in so-called "obesity cardiomyopathy" (Garavaglia et al., 1988; Alpert and Hashimi, 1993). The sleep/apnea obesity

hyperventilation syndrome occurs in 5 percent of severely obese individuals, and is potentially life-threatening. Extreme hypoxemia induced by obstructive sleep apnea syndrome may result in heart failure in the absence of cardiac dysfunction (Ritter et al., 1990).

(e) Dyslipidemia

High Total Cholesterol: The relationship of the age-adjusted prevalence of high total cholesterol, defined as ≥ 240 mg/dL (6.21 mmol/L), to BMI from NHANES III data (Brown et al., 2000) shows that at each BMI level, the prevalence of high blood cholesterol is greater in women than in men. In a smaller sample, higher body weight is associated with higher levels of total serum cholesterol in both men (Denke et al., 1993) and women (Denke et al., 1994) at levels of BMI > 25 . Several large longitudinal studies also provide evidence that overweight, obesity and weight gain are associated with increased cholesterol levels (Shekelle et al., 1981; Hershcopf et al., 1982). In women, the incidence of hypercholesterolemia also increases with increasing BMI (Manson et al., 1990). In addition, the pattern of fat distribution appears to affect cholesterol levels independently of total weight. Total cholesterol levels are usually higher in persons with predominant abdominal obesity, defined as a waist-to-hip circumference ratio of ≥ 0.8 for women and ≥ 1.0 for men (Reeder et al., 1992).

High Triglycerides: The strong association of triglyceride levels with BMI has been shown in both cross-sectional and longitudinal studies, for both sexes and all age groups (Carlson and Lindstedt, 1968; Mann et al., 1988; Denke et al., 1993, 1994). In three adult age groups, namely 20 to 44 years, 45 to 59 years, and 60 to 74 years, higher levels of BMI, ranging from 21 or less to more than 30, have been associated with increasing triglyceride levels; the difference in triglycerides ranged from 61 to 65 mg/dL (0.68 to 0.74 mmol/L) in women ((Denke et al., 1994) and 62 to 118 mg/dL (0.70 to 1.33 mmol/L) in men ((Denke et al., 1993).

Low High-Density Lipoprotein Cholesterol: The age-adjusted prevalence of low high-density lipoprotein (HDL)-cholesterol in relation to BMI levels, based on NHANES III data (Brown et al., 2000) reveals that HDL-cholesterol levels at all ages and weights are lower in men than in women. Although low HDL-cholesterol in this study was

defined as < 35 mg/dL (0.91 mmol/L) in men and < 45 mg/dL (1.16 mmol/L) in women (Brown et al., 2000). Cross-sectional studies have reported that HDL-cholesterol levels are lower in men and women with higher BMI (Glueck et al., 1980; Garrison et al., 1980). Longitudinal studies have found that changes in BMI are associated with changes in HDL-cholesterol. A BMI change of 1 unit is associated with an HDL-cholesterol change of 1.1 mg/dL for young adult men and an HDL-cholesterol change of 0.69 mg/dL for young adult women (Anderson et al., 1987).

Normal to Elevated Low-Density Lipoprotein Cholesterol: The link between total serum cholesterol and CHD is largely due to low-density lipoprotein (LDL). A high-risk LDL-cholesterol is defined as a serum concentration of ≥ 160 mg/dL. This lipoprotein is the predominant atherogenic lipoprotein and is therefore the primary target of cholesterol-lowering therapy. Cross-sectional data suggest that LDL-cholesterol levels are higher by 10 to 20 mg/dL in relation to a 10 unit difference in BMI, from levels of 20 to 30 kg/m² (Denke et al., 1993, 1994). According to extensive epidemiological data, a 10 mg/dL rise in LDL-cholesterol corresponds to approximately a 10 percent increase in CHD risk over a period of 5 to 10 years (Law et al., 1994).

Small, Dense Low-Density Lipoprotein Particles: Only some large-scale epidemiological data are available on small, dense LDL particles (Miller et al., 1996; Lamarche et al., 1997). Clinical studies have shown that small, dense LDL particles are particularly atherogenic and tend to be present in greater proportion in hypertriglyceridemic patients with insulin resistance syndrome associated with abdominal obesity (Reaven et al., 1993; Tchernof et al. 1996; Miller et al., 1996; Lamarche et al., 1997).

(f) Stroke

The relationship of cerebrovascular disease to obesity and overweight has not been as well studied as the relationship to CHD. A report from the Framingham Heart Study suggested that overweight might contribute to the risk of stroke, independent of the known association of hypertension and diabetes with stroke (Hubert et al., 1983). More recently published reports (Walker, 1996; Rexrode, 1997) are based on larger samples and delineate the importance of stroke subtypes in assessing these relationships. They

also attempt to capture all stroke events, whether fatal or nonfatal. These studies suggest distinct risk factors for ischemic stroke as compared to hemorrhagic stroke, and found overweight to be associated with the former, but not the latter. This may explain why studies that use only fatal stroke outcomes (and thus over represent hemorrhagic strokes) show only weak relationships between overweight and stroke. These recent prospective studies demonstrate that the risk of stroke shows a graded increase as BMI rises. For example, ischemic stroke risk is 75 percent higher in women with BMI > 27, and 137 percent higher in women with a BMI > 32, compared with women having a BMI < 21 (Rexrode, 1997).

(g) Cancer

Colon Cancer: Many studies have found a positive relation between obesity and colon cancer in men but a weaker association in women (Lew and Garfinkel, 1979; Giovannucci et al., 1995; Martinez et al., 1996). More recent data from the Nurses' Health Study suggest that the relationship between obesity and colon cancer in women may be similar to that seen in men. Twice as many women with a BMI of > 29 kg/m² had distal colon cancer as women with a BMI < 21 kg/m² (Giovannucci et al., 1996). In men, the relationship between obesity and total colon cancer was weaker than that for distal colon cancer. Other data from the Nurses' Health Study show a substantially stronger relationship between waist-hip ratio and the prevalence of colon polyps on sigmoidoscopy, than with BMI alone (Giovannucci et al., 1995). Even among leaner women, a high waist-to-hip ratio is also associated with significantly increased risk of colon polyps (Giovannucci et al., 1996).

Breast Cancer: Epidemiologic studies consistently show that obesity is directly related to mortality from breast cancer, predominantly in postmenopausal women (Lew and Garfinkel, 1979) but inversely related to the incidence of premenopausal breast cancer (Rosenberg et al., 1990; Chu et al., 1991). Ten or more years after menopause, the premenopausal "benefit" of obesity has dissipated (Hunter and Willett, 1993). Among postmenopausal women, peripheral fat is the primary source of estrogens, the major modifiable risk factor for postmenopausal breast cancer. This crossover in the relationship of obesity with breast cancer, pre- and post-menopausally,

complicates prevention messages for this common female cancer. Data from the Nurses' Health Study, however, show that adult weight gain is positively related to risk of postmenopausal breast cancer. This relation is seen most clearly among women who do not use postmenopausal hormones. A gain of more than 20 lb from age 18 to midlife doubles a woman's risk of breast cancer. Even modest weight gains are positively related to risk of postmenopausal cancer (Huang et al., 1997).

Endometrial Cancer: Obesity increases the risk of endometrial cancer. The risk is three times higher among obese women (BMI ≥ 30 kg/m²) compared to normal weight women (Schottenfeld and Fraumeni, 1996). However, the absolute risk of this condition is low when compared to breast cancer, heart disease, and diabetes. Adult weight gain is also related to increased risk (Schottenfeld and Fraumeni, 1996).

Gallbladder Cancer: Obesity is related to the risk of gallbladder cancer, particularly among women (Garfinkel, 1986). Using a weight index of 100 as the average weight with a corresponding mortality ratio of 1.0 for the cohort, mortality ratios were 1.16 at a weight index of 120 to 129, 1.22 at 130 to 139, and 1.53 at ≥ 140.

(h) Osteoarthritis

Individuals who are overweight or obese increase their risk for the development of osteoarthritis (Hart and Spector, 1993; Hochberg et al., 1995; Cicuttini et al., 1996). The association between increased weight and the risk for development of knee osteoarthritis is stronger in women than in men (Felson et al., 1988). In a study of twin middle-aged women, it was estimated that for every kilogram increase of weight, the risk of developing osteoarthritis increases by 9 to 13 percent. The twins with knee osteoarthritis were generally 3 to 5 kg (6.6 to 11 lb) heavier than the co-twin with no disease (Cicuttini et al., 1996). An increase in weight is significantly associated with increased pain in weight-bearing joints (Huang et al., 1997). There is no evidence that the development of osteoarthritis leads to the subsequent onset of obesity (Carman et al., 1994). A decrease in BMI of 2 units or more during a 10-year period decreased the odds for developing knee osteoarthritis by more than 50 percent; weight gain was associated with a slight increase in risk (Felson et al., 1992). A randomized controlled trial of 6 months' duration examined the effect of weight

loss on clinical improvement in patients with osteoarthritis (Williams and Foulsham, 1981). Patients taking phentermine had an average weight loss of 12.6 percent after 6 months while the control group had an average weight loss of 9.2 percent. There was improvement in pain-free range of motion and a decrease in analgesic use in association with weight loss; patients with knee disease showed a stronger association than those with hip disease. Similarly, improvement of joint pain was observed in individuals who had undergone gastric stapling, resulting in an average weight loss of 45 kg (99 lb) (McGoey et al., 1990; Felson, 1995).

(i) Gallstones

The risk of gallstones increases with adult weight. Risk of either gallstones or cholecystectomy is as high as 20 per 1,000 women per year when BMI is above 40, compared with 3 per 1,000 among women with BMI < 24 (Stampfer et al., 1992). According to NHANES III data, the prevalence of gallstone disease among women increased from 9.4 percent in the first quartile of BMI to 25.5 percent in the fourth quartile of BMI. Among men, the prevalence of gallstone disease increased from 4.6 percent in the first quartile of BMI to 10.8 percent in the fourth quartile of BMI (Khare et al., 1995).

(j) Sleep Apnea

Obesity, particularly upper body obesity, is a risk factor for sleep apnea and has been shown to be related to its severity (Young et al., 1993). The major pathophysiologic consequences of severe sleep apnea include arterial hypoxemia, recurrent arousals from sleep, increased sympathetic tone, pulmonary and systemic hypertension, and cardiac arrhythmias (Shepard, 1992). Most people with sleep apnea have a BMI > 30 (Chua and Chediak, 1994; Loube et al., 1994). Large neck girth in both men and women who snore is highly predictive of sleep apnea. In general, men whose neck circumference is 17 inches or greater and women whose neck circumference is 16 inches or greater are at higher risk for sleep apnea (Davies and Stradling, 1990).

(k) Women's Reproductive Health

Menstrual Function and Fertility: Obesity

in premenopausal women is associated with menstrual irregularity and amenorrhea (Hartz et al., 1979). As part of the Nurses' Health Study, a case control study suggested that the greater the BMI at age 18 years, even at levels lower than those considered obese, the greater the risk of subsequent ovulatory infertility (Rich-Edwards, 1994). The most prominent condition associated with abdominal obesity is polycystic ovarian syndrome (Dunaif, 1992), a combination of infertility, menstrual disturbances, hirsutism, abdominal hyperandrogenism, and anovulation. This syndrome is strongly associated with hyperinsulinemia and insulin resistance (Garbaciak et al., 1985).

Pregnancy: Pregnancy can result in excessive weight gain and retention. The 1988 National Maternal and Infant Survey observed that 41.6 percent of women reported retaining ≥ 9 lb of their gained weight during pregnancy, with 33.8 percent reporting ≥ 14 lb of retained weight gain (Keppel and Taffel, 1983). Another study on a national cohort of women followed for 10 years reported that weight gain associated with childbearing ranged from 1.7 kg (3.7 lb) for those having one live birth during the study to 2.2 kg (4.9 lb) for those having three (Williamson et al., 1994). In addition, higher prepregnancy weights have been shown to increase the risk of late fetal deaths (Cnattingius et al., 1998).

Obesity during pregnancy is associated with increased morbidity for both the mother and the child. A tenfold increase in the prevalence of hypertension and a 10 percent incidence of gestational diabetes has been reported in obese pregnant women (Johnson et al., 1987). Obesity also is associated with difficulties in managing labor and delivery, leading to a higher rate of induction and primary Caesarean section. Risks associated with anesthesia are higher in obese women, as there is greater tendency toward hypoxemia and greater technical difficulty in administering local or general anesthesia (Prentice and Goldberg, 1996). Finally, obesity during pregnancy is associated with an increased risk of congenital malformations, particularly of neural tube defects (Prentice and Goldberg, 1996). A certain amount of weight gain during pregnancy is desirable. The fetus itself, expanded blood volume, uterine enlargement, breast tissue growth, and other products of conception generate an estimated 13 to 17 lb of extra weight. Weight gain beyond this, however, is predominantly maternal

adipose tissue. It is this fat tissue that, in large measure, accounts for the postpartum retention of weight gained during pregnancy.

In turn, this retention reflects a postpartum energy balance that does not lead to catabolism of the gained adipose tissue. In part, this may reflect reduced energy expenditure through decreased physical activity, even while caring for young children, but it may also reflect retention of the pattern of increased calorie intake acquired during pregnancy (Shils et al., 1994). One difficulty in developing recommendations of optimal weight gain during pregnancy relates to the health of the infants. A balance must be achieved between high-birth-weight infants who may pose problems during delivery and who may face a higher rate of caesarean sections and low-birth-weight infants who face a higher infant mortality rate (Cogswell et al., 1995). However, data from the Pregnancy Nutrition Surveillance System from the CDC showed that very overweight women would benefit from a reduced weight gain during pregnancy to help reduce the risk for high birth-weight infants (Cogswell et al., 1995).

The Institute of Medicine report made recommendations concerning maternal weight gain. It recommended that each woman have her BMI measured and recorded at the time of entry into prenatal care. For women with a BMI of less than 20, the target weight gain should be 0.5 kg (1.1 lb) of weight gain per week during the second and third trimester. For a woman whose BMI is greater than 26, the weight gain target is 0.3 kg (0.7 lb) per week during the last two trimesters. Women who are overweight or obese at the onset of pregnancy are advised to gain less total weight during the pregnancy (Institute of Medicine, 1990).

Mortality Pattern

In the majority of epidemiologic studies, mortality begins to increase with BMIs above 25 kg/m² (VanItallie, 1985; Manson et al., 1987; WHO, 1995; Troiano et al., 1996). The increase in mortality generally tends to be modest until a BMI of 30 kg/m² is reached (WHO, 1995; Troiano et al., 1996). For persons with a BMI of 30 kg/m² or above, mortality rates from all causes, and especially from cardiovascular disease, are generally increased by 50 to 100 percent above that of persons with BMIs in the range of 20 to 25

kg/m² (WHO, 1995; Troiano et al., 1996). Two aspects of the association between obesity and mortality remain unresolved:

(a) Association of Body Mass Index with Mortality

Many of the observational epidemiologic studies of BMI and mortality have reported a 'U-' or 'J-shaped' relationship between BMI and mortality (WHO, 1995). Mortality rates are elevated in persons with low BMI (usually below 20) as well as in persons with high BMI (WHO, 1995; Troiano et al., 1996). In some studies, adjustment for factors that potentially confound the relationship between BMI and mortality, such as smoking status and pre-existing illness, tends to reduce the upturn in mortality rate at low BMI (Manson et al., 1987), but in a meta-analysis the higher mortality at low BMIs was not eliminated after adjustment for confounding factors (Troiano et al., 1996). It is unclear whether the elevated mortality observed at low BMI is due to an artifact of incomplete control for confounding factors (Lee et al., 1993), inadequate body fat and/or inadequate body protein stores that result from unintentional weight loss (Allison et al., 1997), or individual genetic factors. Currently, there is no evidence that intentional weight gain in persons with low BMIs will lead to a reduction in mortality.

(b) Association of Body Mass Index with Mortality in Older Adults

Many of the observational epidemiologic studies suggest that the relationship between BMI and mortality weakens with increasing age, especially among persons aged 75 and above (Diehr et al., 1998). Several factors have been proposed to explain this observation. Older adults are more likely than younger adults to have diseases that both increase mortality and cause weight loss leading to lower body weight (Baumgartner et al., 1995; Fried et al., 1998). In addition, as people age, they tend to have larger waist circumferences that increase their risk of mortality even at lower BMIs. Also, weight in middle age is positively related to risk of mortality in old age. The impact of smoking on body weight and mortality is likely to be much stronger in older adults because of the cumulative health effects of smoking (Willett et al., 1998).

BMI, which is an indirect estimate of adiposity,

may underestimate adiposity in older adults whose BMI is similar to younger adults (Roche, 1994). It is also possible that persons most sensitive to the adverse health effects of obesity are more likely to have died before reaching older ages, resulting in older cohorts that are more "resistant" to the health effects of obesity. Recently, a 20-year prospective study of a nationally representative sample of U.S. adults aged 55 to 74 years suggested that lowest mortality occurs in the BMI range of 25 to 30 (Durazo-Arvizu et al., 1998). After adjusting for smoking status and pre-existing illness, lowest mortality occurred at a BMI of 24.5 in white men, 26.5 in white women, 27.0 in black men, and 29.8 in black women (Sorkin et al., 1996).

PREVENTION OF OVERWEIGHT AND OBESITY

Prevention of obesity is much more desirable than treatment of the condition once it is established. Prevention of overweight and obesity is supposed to begin early in life. Prevention includes primary prevention of overweight or obesity itself, secondary prevention or avoidance of weight regain following weight loss, and prevention of further weight increases in obese individuals unable to lose weight (National Task Force on Prevention and Treatment of Obesity, 1994; Thomas, 1995). National and international observational data suggest that environmental and behavioral factors are likely to be important in the tendency of individuals within and between populations to be obese during childhood or to gain weight progressively with age during adulthood (WHO, 2000). These factors are also influenced by the genetic makeup of individuals. There has been a paucity of intervention research to demonstrate how these factors can be manipulated to prevent obesity (National Task Force on Prevention and Treatment of Obesity, 1994). In two community studies, namely the Minnesota Heart Health Program and the Stanford Five City Study, multifaceted weight loss and weight control programs within the community were not associated with prevention of weight gain in longitudinally followed cohorts (Winkleby et al., 1997). In another community study, the Pawtucket Heart Health Program, BMI levels did not change in the intervention cities while they increased in the comparison cities (Carleton et al., 1995). One

obesity prevention study of American Indian children who are at high risk of becoming obese is under way (Davis, 1996). Otherwise, the only long-term report suggesting an effective approach to obesity prevention is from follow-up of obese children in an experimental study in which they had been treated with or without a family-oriented treatment program. Long-term follow-up (10 years) of these children supported the importance of family involvement in reducing the progression of obesity (Epstein et al., 1990). One population-based randomized controlled pilot study of obesity prevention suggests that programs for weight gain prevention are feasible and effective in adults (Forster et al., 1988). Another study in China has shown that the prevention of weight gain through diet, physical activity, and their combination can help prevent diabetes (Pan et al., 1997).

It has been suggested that primary prevention of obesity should include environmentally based strategies that address major societal contributors to over-consumption of calories and inadequate physical activity such as food marketing practices, transportation patterns, and lack of opportunities for physical activity during the workday (Jeffery, 1991). People at lower socioeconomic levels living in urban areas also lack access to physical activity sites. Such strategies will be essential for effective initial and long-term prevention of obesity for large numbers of individuals and for the community at large. Research is needed to clarify the role of societal policies, procedures, laws, and other factors that serve as disincentives to lifelong caloric balance. The importance of obesity prevention needs to be brought to the attention of health care payors and practitioners, employers, educators, and public officials as an important priority to be addressed in policies, programmes, and direct services to individuals and families. The development and implementation of appropriate policies and programmes will require outcomes research that identifies effective weight gain prevention approaches. These programmes must be useful for multiple settings, including health care facilities, schools, worksites, community and religious institutions, and be applicable to a broad population (NIH, 1998).

In the end, efforts should be made to make the general public more aware of the need to prevent overweight and obesity. Efforts to understand the genetic, developmental, environ-

mental, and behavioral underpinnings of obesity and to mount successful prevention strategies are particularly critical for populations in which overweight and obesity and related health problems such as diabetes are disproportionately prevalent; for example, women in lower socioeconomic groups and women and sometimes men in many ethnic minority populations. Public health approaches for preventing obesity, that is, approaches designed to reduce the difficulty for any given individual of adopting healthful eating and activity patterns, will particularly benefit the socially disadvantaged, who—compared to the more advantaged—may have less access to preventive health services and fewer feasible options for making changes in their daily routines and lifestyles (Link and Phelan, 1996). Primary care practitioners are an important element in preventing and managing obesity in the developed countries. Prevention of overweight and obesity in primary care settings is compatible with efforts to prevent their health consequences, through control of dyslipidemia, high blood pressure, and type 2 diabetes. Thus, both the quality and quantity of life may be enhanced through preventive strategies. As high blood pressure, high blood cholesterol, and type 2 diabetes should be aggressively treated in overweight patients and may be treated prior to and in conjunction with weight loss.

ECONOMIC BURDEN OF OVERWEIGHT AND OBESITY

The costs of obesity to a community and individuals may be divided into the direct costs to the health system and the indirect or social costs to the individual and community (e.g. sick days, individual expenditure on weight loss). The direct costs depend in the main part on the diseases caused by obesity and the cost of these diseases. One of the problems in this assessment is the relative risk of the disease in different communities and ethnic groups. Several methods have been used to calculate these costs and there have been a wide range of results on the cost of obesity in different countries. Some diseases which have been included in the calculations are Type 2 diabetes, heart disease, hypertension, endometrial cancer, arthritis and colorectal cancer. Indirect costs also vary widely. One of the latest estimates in the United States for indirect costs was US \$47.6 billion per year. Little data is yet

available for the Asia-Pacific region. It is necessary to develop a standard way of calculating the costs of obesity so that various countries' health expenditure can be compared and for the benefits of treatment to be calculated. For these reasons, suggested standard formulae are being prepared (WHO, 2000).

FUTURE RESEARCH

Obesity is a heterogeneous chronic disorder that has many causes, although the fundamental basis is an imbalance between energy intake and energy expenditure. Future research needs to examine the most effective ways to treat and prevent obesity, the causes of obesity and their mechanisms, the influence of fat distribution on health risk, and the development of better methods for assessing energy intake and energy expenditure (NIH, 1998; WHO, 2000).

INTERVENTION APPROACHES

Considerable research is needed on intervention approaches to treat and prevent obesity. Increased research on behavioral theory specifically addressing obesity treatment and prevention for all individuals, including children and adolescents, needs to be conducted. Intervention methods to prevent weight gain with smoking cessation are of particularly high priority in helping achieve smoking cessation. More research is needed on behavioral intervention methods conducted in various settings, particularly the primary care setting. Effective programmes to treat or prevent obesity in culturally, ethnically, and socio economically diverse populations need to be developed and tested. Simple screening tools should be tested for their predictive value in achieving lifestyle modifications that lead to weight loss or weight control practices. Research is needed on identifying appropriate and successful intervention content. Of particular importance is research on the optimal amount of physical activity to promote weight loss, the maintenance of weight loss, and the prevention of obesity. Research on surgical interventions for weight loss should include evaluating surgical risk, including not only complications, morbidity, and mortality, but also long-term postoperative surveillance to monitor vitamin and mineral nutritional adequacy. Evaluation of the health benefits of weight loss

from surgery should include changes in fat distribution; cardio respiratory fitness; obesity-related co-morbidities, including blood pressure, blood lipids, and glucose tolerance; and degree of success in long term weight loss maintenance. Finally, research is needed on techniques for integrating behavioral methods to promote long-term maintenance of weight loss after surgical treatment. Likewise, research on pharmacologic interventions for weight loss should include evaluating changes in fat distribution, cardio respiratory fitness, obesity-related co-morbidities, and the degree of success of long-term weight loss maintenance. Better methods for integrating behavioral methods, along with pharmacologic treatment, should also be investigated. Finally, research is needed on environmental and population-based intervention methods, including community- and school-based interventions, to augment public health approaches toward promoting weight maintenance and preventing obesity in the general population.

CAUSES AND MECHANISMS OF OBESITY

The regulation of energy balance needs to be explored, including the neuroendocrine factors that control energy intake, energy expenditure, and the differentiation of adipose tissue resulting from excess calories. The genes that are important in human obesity need to be identified. These include those that alter eating and physical activity behaviors, those that affect thermogenesis, and those associated with the co-morbidities of obesity. The roles of environmental and behavioral influences on metabolic factors important in obesity, as well as gene-environment interactions, need to be studied. Predictive factors should be examined to identify who is most at risk of developing obesity, and whether there are critical periods of life when these factors are most operative. In addition, the influence of the intrauterine environment on the development of obesity needs to be investigated, particularly to determine whether early deprivation leads to a later propensity for overweight and associated co-morbidities, such as insulin resistance, or if high maternal weight gain and high birth weight are related to the risk of obesity and its co-morbidities.

CENTRAL BODY FAT, BODY WEIGHT AND DISEASES

The influence of abdominal fat independent of total body fat on health risk needs to be further defined. More information is needed on the relationship between differential body fat compartments and increased risk, the distribution of body fat compartments among various racial group populations, and the relationship between abdominal fat and disease risk in racial groups. Weight loss studies should include measurements of abdominal fat, as well as cardio respiratory fitness, to better assess health improvement. Intentional weight loss treatments need to be examined in terms of their acute and chronic effect on the development and progression of diabetes, heart disease, and overall mortality. Large prospective studies are needed to examine the relationship of body mass index and body fat distribution to overall mortality.

EVALUATION SYSTEM

Much of the current research is hampered by the lack of good methods to accurately, objectively, and economically assess energy intake and expenditure, including physical activity, body composition and fat distribution, and behavioral and psychological variables. More research is therefore needed to focus on measures to assess intake of fat and other dietary components, levels of physical activity, energy metabolism, and body fat and visceral obesity. In addition, better methods for assessment of psychological, behavioral, and psychosocial variables that may be related to behavioral risk factors for obesity (such as poor diet and inactive lifestyle) are needed, and particularly so for special population segments based on race, ethnicity, and socio-economic status. Methods for assessing culture, social integration, and psychological stress should also be developed.

REFERENCES

- Allison, D.B.: Methodological issues in obesity research: examples from new directions in assessment and management. pp. 129-132, In: *Obesity*. T. B. VanItallie and A. P. Simopoulos (Eds.). Charles Press, Philadelphia (1995).
- Allison, D.B. and Pi-Sunyer, F.X.: *Obesity Treatment: Establishing Goals, Improving Outcomes, and Reviewing the Research Agenda*. Plenum Press, New York (1995).

- Allison, D.B., Kaprio, J., Korkeila, M., Koskenvuo, M., Neale, M.C. and Hayakawa, K.: The heritability of body mass index among an international sample of monozygotic twins reared apart. *Int. J. Obes.*, **20**: 501-506 (1996a).
- Allison, D.B., Faith, M.S. and Nathan, J.S.: Risch's lambda values for human obesity. *Int. J. Obes.*, **20**: 990-999 (1996b).
- Allison, D.B., Faith, M.S., Heo, M. and Kotler, D.P.: Hypothesis concerning the U-shaped relation between body mass index and mortality. *Am. J. Epidemiol.*, **146**: 339-349 (1997).
- Alpert, M.A. and Hashimi, M.W.: Obesity and the heart. *Am. J. Med. Sci.*, **306**: 117-123 (1993).
- Anderson, K.M., Wilson, P.W.F., Garrison, R.J. and Castelli, W.P.: Longitudinal and secular trends in lipoprotein cholesterol measurements in a general population sample: The Framingham offspring study. *Atherosclerosis*, **68**: 59-66 (1987).
- Ballantyne, D., Devine, B.L. and Fife, R.: Interrelation of age, obesity, cigarette smoking, and blood pressure in hypertensive patients. *BMJ*, **1**: 880-881 (1978).
- Baumgartner, R.N., Heymsfield, S.B. and Roche, A.F.: Human body composition and the epidemiology of chronic disease. *Obes. Res.*, **3**: 73-95 (1995).
- Bose, K.: A comparative study of generalised obesity and anatomical distribution of subcutaneous fat in adult White and Pakistani migrant males in Peterborough. *J. Roy. Soc. Hlth.*, **115**: 90-95 (1995).
- Bouchard, C., Perusse, L., Leblanc, C., Tremblay, A. and Theriault, G.: Inheritance of the amount and distribution of human body fat. *Int. J. Obes.*, **12**: 205-215 (1988).
- Bouchard, C. and Tremblay, A.: Genetic effects in human energy expenditure components. *Int. J. Obes.*, **14**(Suppl 1): 49-55 (1990).
- Bouchard, C., Perusse, L., Rice, T. and Rao, D.C.: The genetics of human obesity. Chapter 10, In: *Handbook of Obesity*. G. A. Bray, C. Bouchard and W. P. T. James (Eds.). M. Dekker, New York (1998).
- Brennan, P.J., Simpson, J.M., Blackett, R.B. and McGilchrist, C.A.: The effects of body weight on serum cholesterol, serum triglycerides, serum urate, and systolic blood pressure. *Aust. N. Z. J. Med.*, **10**: 15-20 (1980).
- Brown, C.D., Higgins, M., Donato, K.A., et al.: Body mass index and the prevalence of hypertension and dyslipidemia. *Obes. Res.*, **8**: 605-619 (2000).
- Bundred, P., Kitchiner, D. and Buchan, I.: Prevalence of overweight and obese children between 1989 and 1998: population based series of cross sectional studies. *Brit. Med. J.*, **10**: 326-328 (2001).
- Carleton, R.A., Lasater, T.M., Assaf, A.R., Feldman, H.A. and McKinlay, S.: The Pawtucket Heart Health Program: community changes in cardiovascular risk factors and projected disease risk. *Am. J. Public Health*, **85**: 777-785 (1995).
- Carlson, L.A. and Lindstedt, S.: The Stockholm prospective study. 1. The initial values for plasma lipids. *Acta Med. Scand.*, **493** (Suppl.): 1-135 (1968).
- Carman, W.J., Sowers, M., Hawthorne, V.M. and Weissfeld, L.A.: Obesity as a risk factor for osteoarthritis of the hand and wrist: a prospective study. *Am. J. Epidemiol.*, **139**: 119-129 (1994).
- Chagnon, Yvon C., Rankinen, T., Snyder, E.E., Weisnagel, S.J., Pe'russe, L. and Bouchard, C.: The Human Obesity Gene Map: The 2002 Update. *Obes. Res.*, **11**: 313-367 (2003).
- Chan, J.M., Rimm, E.B., Colditz, G.A., Stampfer, M.J. and Willett, W.C.: Obesity, fat distribution, and weight gain as risk factors for clinical diabetes in men. *Diabetes Care*, **17**: 961-969 (1994).
- Chu, S.Y., Lee, N.C., Wingo, P.A., Senie, R.T., Greenberg, R.S. and Peterson, H.B.: The relationship between body mass and breast cancer among women enrolled in the Cancer and Steroid Hormone Study. *J. Clin. Epidemiol.*, **44**: 1197-1206 (1991).
- Chua, W. and Chediak, A.D.: Obstructive sleep apnea. Treatment improves quality of life—and may prevent death. *Postgrad. Med.*, **95**: 123-138 (1994).
- Cicuttini, F.M., Baker, J.R. and Spector, T.D.: The association of obesity with osteoarthritis of the hand and knee in women: a twin study. *J. Rheumatol.*, **23**: 1221-1226 (1996).
- Cnattingius, S., Bergstrom, R., Lipworth, L. and Kramer, M.S.: Prepregnancy weight and the risk of adverse pregnancy outcomes. *N. Eng. J. Med.*, **338**: 147-152 (1998).
- Cogswell, M.E., Serdula, M.K., Hungerford, D.W. and Yip, R.: Gestational weight gain among average-weight and overweight women—what is excessive? *Am. J. Obstet. Gynecol.*, **172**: 705-712 (1995).
- Colditz, G.A., Willett, W.C., Stampfer, M.J., et al.: Weight as a risk factor for clinical diabetes in women. *Am. J. Epidemiol.*, **132**: 501-513 (1990).
- Colditz, G.A., Willett, W.C., Rotnitzky, A. and Manson, J.E.: Weight gain as a risk factor for clinical diabetes mellitus in women. *Ann. Intern. Med.*, **122**: 481-486 (1995).
- CPHA (Canadian Public Health Association): The continuing challenge of obesity. *Can. J. Public Health*, **97**: 428 (2006).
- Criqui, M.H., Mebane, I., Wallace, R.B., Heiss, G. and Holdbrook, M.J.: Multivariate correlates of adult blood pressures in nine North American populations: The Lipid Research Clinics Prevalence Study. *Prev. Med.*, **11**: 391-402 (1982).
- Cutler, J.A., Psaty, B.M., MacMahon, S. and Furberg, C.D.: Public health issues in hypertension control: what has been learned from clinical trials, pp. 253-270, In: *Hypertension: Pathophysiology, Diagnosis, and Management*. J. H. Laragh and B. M. Brenner (Eds.). Raven Press, New York (1995).
- Davies, R.J. and Stradling, J.R.: The relationship between neck circumference, radiographic pharyngeal anatomy, and the obstructive sleep apnoea syndrome. *Eur. Respir. J.*, **3**: 509-514 (1990).
- Davis, S.M.: Cardiovascular Health Promotion Project. American Indian Program Recaptures Past to Improve Children's Future (Pathways). *Heartmemo.*, (Special Edition): 25-27 (1996).
- Denke, M.A., Sempos, C.T. and Grundy, S.M.: Excess body weight. An underrecognized contributor to high blood cholesterol levels in white American men. *Arch. Intern. Med.*, **153**: 1093-1103 (1993).
- Denke, M.A., Sempos, C.T. and Grundy, S.M.: Excess body weight. An underrecognized contributor to dyslipidemia in white American women. *Arch. Intern. Med.*, **154**: 401-410 (1994).
- DiBianco, R.: The changing syndrome of heart failure: an annotated review as we approach the 21st century. *J. Hypertens.*, **Suppl.**, **12**: S73-S87 (1994).

- Diehr, P., Bild, D.E., Harris, T.B., Duxbury, A., Siscovick, D. and Rossi, M.: Body mass index and mortality in nonsmoking older adults: The cardiovascular health study. *Am. J. Public Health*, **88**: 623-629 (1998).
- Dunaif, A.: *Polycystic Ovary Syndrome*. Blackwell Scientific Publications, Boston (1992).
- Durazo-Arvizu, R.A., McGee, D.L., Cooper, R.S., Liao, Y. and Luke, A.: Mortality and optimal body mass index in a sample of the U.S. population. *Am. J. Epidemiol.*, **147**: 739-749 (1998).
- Dyer, A.R. and Elliott, P.: The INTERSALT study: relations of body mass index to blood pressure. INTERSALT Co-operative Research Group. *J. Hum. Hypertens.*, **3**: 299-308 (1989).
- Epstein, L.H., Valoski, A., Wing, R.R., McCurley, J.: Ten-year followup of behavioral, family-based treatment for obese children. *JAMA*, **264**: 2519-2523 (1990).
- Eriksson, H., Wilhelmsen, L., Caidahl, K. and Svardsudd, K.: Epidemiology and prognosis of heart failure. *Z. Kardiol.*, **80** (Suppl 8): 1-6 (1991).
- Feinleib, M.: Epidemiology of obesity in relation to health hazards. *Ann. Intern. Med.*, **103**: 1019-1024 (1985).
- Felson, D.T., Anderson, J.J., Naimark, A., Walker, A.M. and Meenan, R.F.: Obesity and knee osteoarthritis. The Framingham Study. *Ann. Intern. Med.*, **109**: 18-24 (1988).
- Felson, D.T., Zhang, Y., Anthony, J.M., Naimark, A. and Anderson, J.J.: Weight loss reduces the risk for symptomatic knee osteoarthritis in women. The Framingham Study. *Ann. Intern. Med.*, **116**: 535-539 (1992).
- Felson, D.T.: Weight and osteoarthritis. *J. Rheumatol.*, **Suppl.**, **43**: 7-9 (1995).
- Ford, E.S., Williamson, D.F. and Liu, S.: Weight change and diabetes incidence: findings from a national cohort of US adults. *Am. J. Epidemiol.*, **146**: 214-222 (1997).
- Forster, J.L., Jeffery, R.W., Schmid, T.L. and Kramer, F.M.: Preventing weight gain in adults: a pound of prevention. *Health Psychol.*, **7**: 515-525 (1988).
- Fried, L.P., Kronmal, R.A., Newman, A.B., et al.: Risk factors for 5-year mortality in older adults (for the Cardiovascular Health Study Collaborative Research Group). *JAMA*, **279**: 585-592 (1998).
- Garavaglia, G.E., Messerli, F.H., Nunez, B.D., Schmieder, R.E. and Grossman, E.: Myocardial contractility and left ventricular function in obese patients with essential hypertension. *Am. J. Cardiol.*, **62**: 594-597 (1988).
- Garbaciak, J.A. Jr., Richter, M., Miller, S. and Barton, J.J.: Maternal weight and pregnancy complications. *Am. J. Obstet. Gynecol.*, **152**: 238-245 (1985).
- Garfinkel, L.: Overweight and mortality. *Cancer*, **58**: 1826-1829 (1986).
- Garrison, R.J., Wilson, P.W., Castelli, W.P., Feinleib, M., Kannel, W.B. and McNamara, P.M.: Obesity and lipoprotein cholesterol in the Framingham offspring study. *Metabolism*, **29**: 1053-1060 (1980).
- Garrison, R.J. and Castelli, W.P.: Weight and 30-year mortality of men in the Framingham Study. *Ann. Intern. Med.*, **103**: 1006-1009 (1985).
- Giovannucci, E.: Insulin and colon cancer. *Cancer Causes Control*, **6**: 164-179 (1995).
- Giovannucci, E., Ascherio, A., Rimm, E.B., Colditz, G.A., Stampfer, M.J. and Willett, W.C.: Physical activity, obesity, and risk for colon cancer and adenoma in men. *Ann. Intern. Med.*, **122**: 327-334 (1995).
- Giovannucci, E., Colditz, G.A., Stampfer, M.J. and Willett, W.C.: Physical activity, obesity, and risk of colorectal adenoma in women (United States). *Cancer Causes Control*, **7**: 253-263 (1996).
- Glueck, C.J., Taylor, H.L., Jacobs, D., Morrison, J.A., Beaglehole, R. and Williams, O.D.: Plasma high-density lipoprotein cholesterol: association with measurements of body mass. The Lipid Research Clinics Program Prevalence Study. *Circulation*, **62**: IV-62-69 (1980).
- Haffner, S.M., Mitchell, B.D., Hazuda, H.P. and Stern, M.P.: Greater influence of central distribution of adipose tissue on incidence of non-insulin-dependent diabetes in women than men. *Am. J. Clin. Nutr.*, **53**: 1312-1317 (1991).
- Hart, D.J. and Spector, T.D.: The relationship of obesity, fat distribution, and osteoarthritis in women in the general population: the Chingford Study. *J. Rheumatol.*, **20**: 331-335 (1993).
- Hartz, A.J., Barboriak, P.N., Wong, A., Katayama, K.P. and Rimm, A.A.: The association of obesity with infertility and related menstrual abnormalities in women. *Int. J. Obes.*, **3**: 57-73 (1979).
- Hershcopf, R.J., Elahi, D., Andres, R., et al.: Longitudinal changes in serum cholesterol in man: an epidemiologic search for an etiology. *J. Chronic Dis.*, **35**: 101-114 (1982).
- Hochberg, M.C., Lethbridge-Cejku, M., Scott, W.W. Jr., Reichle, R., Plato, C.C. and Tobin, J.D.: The association of body weight, body fatness and body fat distribution with osteoarthritis of the knee: data from the Baltimore Longitudinal Study of Aging. *J. Rheumatol.*, **22**: 488-493 (1995).
- Huang, C., Ross, P.D., Lydick, E. and Wasnich, R.D.: Factors associated with joint pain among postmenopausal women. *Int. J. Obes.*, **21**: 349-354 (1997).
- Huang, Z., Hankinson, S.E., Colditz, G.A., et al.: Dual effects of weight and weight gain on breast cancer risk. *JAMA*, **278**: 1407-1411 (1997).
- Hubert, H.B., Feinleib, M., McNamara, P.M. and Castelli, W.P.: Obesity as an independent risk factor for cardiovascular disease: a 26-year follow-up of participants in the Framingham Heart Study. *Circulation*, **67**: 968-977 (1983).
- Hunter, D.J. and Willett, W.C.: Diet, body size, and breast cancer. *Epidemiol. Rev.*, **15**: 110-132 (1993).
- IOTF (International Obesity Task Force): Official Home Page of IOTF (2007). From <<http://www.ietf.org/>> (Retrieved January 10, 2007)
- James, W.P.: A public health approach to the problem of obesity. *Int. J. Obes.*, **19** (Suppl 3): S37-S45 (1995).
- Jeffery, R.W.: Population perspectives on the prevention and treatment of obesity in minority populations. *Am. J. Clin. Nutr.*, **53** (6 Suppl): 1621S-1624S (1991).
- Johnson, S.R., Kolberg, B.H., Varner, M.W. and Railsback, L.D.: Maternal obesity and pregnancy. *Surg. Gynecol. Obstet.*, **164**: 431-437 (1987).
- Jousilahti, P., Tuomilehto, J., Vartiainen, E., Pekkanen, J. and Puska, P.: Body weight, cardiovascular risk factors, and coronary mortality. 15-year follow-up of middle-aged men and women in eastern Finland. *Circulation*, **93**: 1372-1379 (1996).

- Kannel, W.B. and Cupples, A.: Epidemiology and risk profile of cardiac failure. *Cardiovasc. Drugs. Ther.*, **2** (Suppl 1): 387-395 (1988).
- Kawate, R., Yamakido, M. and Nishimoto, Y.: Diabetes mellitus and its vascular complications in Japanese migrants on the Island of Hawaii. *Diabetes Care*, **29**: 161-170 (1979).
- Kawate, R., Yamakido, M. and Nishimoto, Y.: Migrant studies among the Japanese in Hiroshima and Hawaii. *Proc 10th Congr Int Diabetes Federation*, 526-531 (1980).
- Keppel, K.G. and Taffel, S.M.: Pregnancy-related weight gain and retention: implications of the 1990 Institute of Medicine guidelines. *Am. J. Public Health*, **83**: 1100-1103 (1993).
- Khare, M., Everhart, J.E., Maurer, K.R. and Hill, M.C.: Association of ethnicity and body mass index (BMI) with gallstone disease in the United States. *Am. J. Epidemiol.*, **141**: S69 (1995).
- Knowler, W.C., Pettitt, D.J., Savage, P.J. and Bennett, P.H.: Diabetes incidence in Pima Indians: contributions of obesity and parental diabetes. *Am. J. Epidemiol.*, **113**: 144-156 (1981).
- Kopelman, P.G.: Obesity as a medical problem. *Nature*, **404**: 635-643 (2000).
- Kromeyer-Hauschild, K., Zellner, K., Jaeger, U. and Hoyer, H.: Prevalence of overweight and obesity among school children in Jena (Germany). *Int. J. Obes.*, **23**: 1143-1150 (1999).
- Kumanyika, S.K. and Morssink, C.B.: Cultural appropriateness of weight management programs. pp. 69-103. In: *Overweight and Weight Management: The Health Professional's Guide to Understanding and Practice*. S. Dalton (Ed.). Aspen Publishers, Gaithersburg, MD (1997).
- Kumanyika, S.K.: Obesity in minority populations: An epidemiologic assessment. *Obes. Res.*, **2**: 166-182 (1994).
- Lamarche, B., Tchernof, A., Moorjani, S., et al.: Small, dense low-density lipoprotein particles as a predictor of the risk of ischemic heart disease in men. Prospective results from the Quebec Cardiovascular Study. *Circulation*, **95**: 69-75 (1997).
- Landin, K., Stigendal, L., Eriksson, E., et al.: Abdominal obesity is associated with an impaired fibrinolytic activity and elevated plasminogen activator inhibitor-I. *Metabolism*, **39**: 1044-1048 (1990).
- Larsson, B., Bjorntorp, P. and Tibblin, G.: The health consequences of moderate obesity. *Int. J. Obes.*, **5**: 97-116 (1981).
- Law, M.R., Wald, N.J. and Thompson, S.G.: By how much and how quickly does reduction in serum cholesterol concentration lower risk of ischaemic heart disease? *BMJ*, **308**: 367-773 (1994).
- Lee, I.M., Manson, J.E., Hennekens, C.H. and Paffenbarger, R.S. Jr.: Body weight and mortality. A 27-year follow-up of middle-aged men. *JAMA*, **270**: 2823-2828 (1993).
- Lee, J.H., Reed, D.R. and Price, R.A.: Familial risk ratios for extreme obesity: implications for mapping human obesity genes. *Int. J. Obes.*, **21**: 935-940 (1997).
- Lew, E.A. and Garfinkel, L.: Variations in mortality by weight among 750,000 men and women. *J. Chronic Dis.*, **32**: 563-576 (1979).
- Link, B.G. and Phelan, J.C.: Understanding sociodemographic differences in health—the role of fundamental social causes. *Am. J. Public Health*, **86**: 471-473 (1996).
- Loube, D.I., Loube, A.A. and Mitler, M.M.: Weight loss for obstructive sleep apnea: the optimal therapy for obese patients. *J. Am. Diet. Assoc.*, **94**: 1291-1295 (1994).
- Lundgren, H., Bengtsson, C., Blohme, G., Lapidus, L. and Sjostrom, L.: Adiposity and adipose tissue distribution in relation to incidence of diabetes in women: results from a prospective population study in Gothenburg, Sweden. *Int. J. Obes.*, **13**: 413-423 (1989).
- Maes, H.H.M., Neale, M.C. and Eaves, L.J.: Genetic and environmental factors in relative body weight and human adiposity. *Behav. Gene.*, **27**: 325-351 (1997).
- Mann, J.I., Lewis, B., Shepherd, J., et al.: Blood lipid concentrations and other cardiovascular risk factors: distribution, prevalence, and detection in Britain. *BMJ*, **296**: 1702-1706 (1988).
- Manson, J.E., Stampfer, M.J., Hennekens, C.H. and Willett, W.C.: Body weight and longevity. A reassessment. *JAMA*, **257**: 353-358 (1987).
- Manson, J.E., Colditz, G.A., Stampfer, M.J., et al.: A prospective study of obesity and risk of coronary heart disease in women. *N. Engl. J. Med.*, **322**: 882-889 (1990).
- McGoe, B.V., Deitel, M., Saplys, R.J. and Kliman, M.E.: Effect of weight loss on musculoskeletal pain in the morbidly obese. *J. Bone Joint Surg. [Br.]*, **72-B**: 322-323 (1990).
- Medalie, J.H., Papier, C., Herman, J.B., et al.: Diabetes mellitus among 10,000 adult men. I. 5-year incidence and associated variables. *Isr. J. Med. Sci.*, **10**: 681-697 (1974).
- Miller, B.D., Alderman, E.L., Haskell, W.L., Fair, J.M. and Krauss, R.M.: Predominance of dense low-density lipoprotein particles predicts angiographic benefit of therapy in the Stanford coronary risk intervention study. *Circulation*, **94**: 2146-2153 (1996).
- Montague, C.T., Farooqi, I.S., Whitehead, J.P., et al.: Congenital leptin deficiency is associated with severe early-onset obesity in humans. *Nature*, **387**: 903-908 (1997).
- Mukhopadhyay, A., Bhadra, M., and Bose, K.: Human obesity: A background. pp. 1-9. In: *Human obesity: A Major Health Burden*. K. Bose (Ed.). Human Ecology Special Issue No. 13. Kamla-Raj Enterprises, Delhi (2005).
- National Institutes of Health (NIH): *Health implications of obesity*. NIH Consensus Development Conference Statement. *Ann. Intern. Med.*, **103**: 1073-1077 (1985).
- National Institutes of Health (NIH): *Clinical Guidelines on the Identification, Evaluation, and Treatment of Overweight and Obesity in Adults*. NIH Publication No. **98-4083**. National Institutes of Health. Bethesda, MD (1998).
- National Task Force on Prevention and Treatment of Obesity: Towards Prevention of Obesity: Research Directions. *Obes. Res.*, **2**: 571-584 (1994).
- Ohzeki, T., Hanaki, K., Motozumi, H., Ishitani, N., Matsuda, O. H., Sunaguchi, M. and Shiraki, K.: Prevalence of obesity, leanness and anorexia nervosa in Japanese boys and girls aged 12-14 Years. *Ann. Nutr. Metab.*, **34**: 208-212 (1990).

- Pan, X.R., Li, G.W., Hu, Y.H., et al.: Effects of diet and exercise in preventing NIDDM in people with impaired glucose tolerance. The Da Qing IGT and Diabetes Study. *Diabetes Care*, **20**: 537-544 (1997).
- Pi-Sunyer, F.X.: Obesity. pp. 984-1006. In: *Modern Nutrition in Health and Disease*. M. E. Shils, J. A. Olson and M. Shike (Eds.). Lea & Febiger, London (1994).
- Prentice, A. and Goldberg, G.: Maternal obesity increases congenital malformations. *Nutr. Rev.*, **54**: 146-152 (1996).
- Rabkin, S.W., Mathewson, F.A. and Hsu, P.H.: Relation of body weight to development of ischemic heart disease in a cohort of young North American men after a 26 year observation period: the Manitoba Study. *Am. J. Cardiol.*, **39**: 452-458 (1977).
- Ravussin, E., Valencia, M.E., Esparza, J., Bennett, P.H. and Schultz, L.O.: Effects of a traditional lifestyle on obesity in Pima Indians. *Diabetes Care*, **17**: 1067-1074 (1994).
- Reaven, G.M., Chen, Y.D., Jeppesen, J., Maheux, P. and Krauss, R.M.: Insulin resistance and hyperinsulinemia in individuals with small, dense low density lipoprotein particles. *J. Clin. Invest.*, **92**: 141-146 (1993).
- Reeder, B.A., Angel, A., Ledoux, M., Rabkin, S.W., Young, T.K. and Sweet, L.E.: Obesity and its relation to cardiovascular disease risk factors in Canadian adults. Canadian Heart Health Surveys Research Group. *Can. Med. Assoc. J.*, **146**: 2009-2019 (1992).
- Reisin, E., Frohlich, E.D., Messerli, F.H., Dreslinski, G.R., et al.: Cardiovascular changes after weight reduction in obesity hypertension. *Ann. Intern. Med.*, **98**: 315-319 (1983).
- Rexrode, K.M., Hennekens, C.H., Willett, W.C., et al.: A prospective study of body mass index, weight change, and risk of stroke in women. *JAMA*, **277**: 1539-1545 (1997).
- Rich-Edwards, J.W., Goldman, M.B. and Willett, W.C.: Adolescent body mass index and infertility caused by ovulatory disorder. *Am. J. Obstet. Gynecol.*, **171**: 171-177 (1994).
- Ritter, M.M., Schraudolph, M., Richter, W.O., Herbert, M., Wiebecke, B. and Schwandt, P.: Obesity, heart failure and pulmonary insufficiency in a 26-year-old female. *Med. Klin.*, **85**: 371- 375 (1990).
- Rocchini, A.P., Key, J., Bondie, D., et al.: The effect of weight loss on the sensitivity of blood pressure to sodium in obese adolescents. *N. Engl. J. Med.*, **321**: 580-585 (1989).
- Roche, A.F.: Sarcopenia: a critical review of its measurements and health related significance in the middle-aged and elderly. *Am. J. Hum. Biol.*, **6**: 33-42 (1994).
- Rosenberg, L., Palmer, J.R., Miller, D.R., Clarke, E.A. and Shapiro, S.: A case-control study of alcoholic beverage consumption and breast cancer. *Am. J. Epidemiol.*, **131**: 6-14 (1990).
- Rossner, S.: Obesity: the disease of the twenty-first century. *Int. J. Obes.*, **26**: S2-S4 (2002).
- Sanchez-Garcia, S., Garcia-Pena, C., Duque-Lopez, M.X., et al.: Anthropometric measures and nutritional status in a healthy elderly population. *BMC. Public Health*, **7**: 2 (2007) [Epub ahead of print].
- Schottenfeld, D., Fraumeni, J.F.: *Cancer Epidemiology and Prevention*. Oxford University Press, New York (1996).
- Shaper, A.G., Wannamethee, S.G. and Walker, M.: Body weight: implications for the prevention of coronary heart disease, stroke, and diabetes mellitus in a cohort study of middle aged men. *BMJ*, **314**: 1311-1317 (1997).
- Shekelle, R.B., Shryock, A.M., Paul, O., et al.: Diet, serum cholesterol, and death from coronary heart disease. The Western Electric study. *N. Engl. J. Med.*, **304**: 65-70 (1981).
- Shepard, J.W. Jr.: Hypertension, cardiac arrhythmias, myocardial infarction, and stroke in relation to obstructive sleep apnea. *Clin. Chest. Med.*, **13**: 437-458 (1992).
- Shils, M.E., Olson, J.A. and Shike, M. (Eds.): *Modern Nutrition in Health and Disease*. Lea & Febiger, Philadelphia (1994).
- Shimizu, M. and Isogai, Y.: Heart failure due to metabolic heart disorders. *Nippon Rinsho.*, **51**: 1362-1366 (1993).
- Sobal, J. and Stunkard, A.J.: Socioeconomic status and obesity: A review of the literature. *Psychol. Bull.*, **105**: 260-275 (1989).
- Sorkin, J.D., Zonderman, A.B., Costa, P.T. Jr. and Andres, R.: Twenty year follow-up of the NHANES I cohort: tests of methodologic hypotheses. *Obes. Res.*, **4** (Suppl 1): M46 (1996).
- Sparrow, D., Borkan, G.A., Gerzof, S.G., Wisniewski, C. and Silbert, C.K.: Relationship of fat distribution to glucose tolerance. Results of computed tomography in male participants of the Normative Aging Study. *Diabetes*, **35**: 411-415 (1986).
- Speakman, S.R.: Obesity. Part one-The greatest health threat facing mankind. *Biologist*, **50**: 11-14 (2003).
- Stamler, R., Stamler, J., Riedlinger, W.F., Algera, G. and Roberts, R.H.: Weight and blood pressure. Findings in hypertension screening of 1 million Americans. *JAMA*, **240**: 1607-1610 (1978).
- Stampfer, M.J., Maclure, K.M., Colditz, G.A., Manson, J.E. and Willett, W.C.: Risk of symptomatic gallstones in women with severe obesity. *Am. J. Clin. Nutr.*, **55**: 652-658 (1992).
- Stunkard, A.J., Harris, J.R., Pedersen, N.L. and McClearn G.E.: The body-mass index of twins who have been reared apart. *N. Engl. J. Med.*, **322**: 1483-1487 (1990).
- Tartaglia, L.A., Dembski, M., Weng, X., et al.: Identification and expression cloning of leptin receptor, OB-R. *Cell*, **83**: 1263-1271 (1995).
- Taylor, R., Bennett, P., Uili, R., Joffres, N., Levey, S. and Zimmet, P.: Diabetes in Wallis Polynesians: a comparison of residents of Wallis Island and first generation migrants of Noumea. *Diabetes Res. Clin. Pract.*, **1**: 169-178 (1985).
- Tchernof, A., Lamarche, B., Prud'Homme, D., et al.: The dense LDL phenotype: association with plasma lipoprotein levels, visceral obesity, and hyperinsulinemia in men. *Diabetes Care*, **19**: 629-637 (1996).
- Thomas, P.R. (Ed.): *Weighing the Options. Criteria for Evaluating Weight- Management Programs*. National Academy Press, Washington DC (1995).
- Tokunaga, K., Matsuzawa, Y., Kotani, K., et al.: Ideal body weight estimated from the body mass index with the lowest morbidity. *Int. J. Obes.*, **15**: 1-5 (1991).

- Troiano, R.P., Flegal, K.M., Kuczmarski, R.J., Campbell, S.M. and Johnson, C.L.: Overweight prevalence and trends for children and adolescents. The National Health and Nutrition Examination Surveys, 1963 to 1991. *Arch. Pediatr. Adolesc. Med.*, **149**: 1085-1091 (1995).
- Troiano, R.P., Frongillo, E.A. Jr., Sobal, J. and Levitsky, D.A.: The relationship between body weight and mortality: a quantitative analysis of combined information from existing studies. *Int. J. Obes.*, **20**: 63-75 (1996).
- Tuck, M.I., Sowers, J., Dornfield, L., et al.: The effect of weight reduction on blood pressure plasma renin activity and plasma aldosterone level in obese patients. *N. Engl. J. Med.*, **304**: 930-933 (1981).
- Urbina, E.M., Gidding, S.S., Bao, W., Pickoff, A.S., Berdusis, K. and Berenson, G.S.: Effect of body size, ponderosity, and blood pressure on left ventricular growth in children and young adults in the Bogalusa Heart Study. *Circulation*, **91**: 2400-2406 (1995).
- Van Gaal, L., Rillaerts, E., Creten, W. and Leeuw, I.D.E.: Relationship of body fat distribution pattern to atherogenic risk factors in NIDDM: Preliminary results. *Diabetes Care*, **11**: 103-106 (1988).
- VanItallie, T.B.: Health implications of overweight and obesity in the United States. *Ann. Intern. Med.*, **103**: 983-988 (1985).
- Vogler, G.P., Sorensen, T.I., Stunkard, A.J., Srinivasan, M.R. and Rao, D.C.: Influences of genes and shared family environment on adult body mass index assessed in an adoption study by a comprehensive path model. *Int. J. Obes.*, **19**: 40-45 (1995).
- Walker, S.P., Rimm, E.B., Ascherio, A., Kawachi, I., Stampfer, M.J. and Willett, W.C.: Body size and fat distribution as predictors of stroke among US men. *Am. J. Epidemiol.*, **144**: 1143-1150 (1996).
- Westlund, K. and Nicolaysen, R.: Ten-year mortality and morbidity related to serum cholesterol. A follow-up of 3,751 men aged 40-49. *Scand. J. Clin. Lab. Invest.*, (Suppl.), **127**: 1-24 (1972).
- Willett, W.C., Stampfer, M., Manson, J. and VanItallie, T.: New weight guidelines for Americans: justified or injudicious? *Am. J. Clin. Nutr.*, **53**: 1102-1103 (1991).
- Williams, R.A. and Foulsham, B.M.: Weight reduction in osteoarthritis using phentermine. *Practitioner*, **225**: 231-232 (1981).
- Willett, W.C., Manson, J.E., Stampfer, M.J., et al.: Weight, weight change, and coronary heart disease in women. Risk within the 'normal' weight range. *JAMA*, **273**: 461-465 (1995).
- Williamson, D.F., Madans, J., Pamuk, E., Flegal, K.M., Kendrick, J.S. and Serdula, M.K.: A prospective study of childbearing and 10-year weight gain in US white women 25 to 45 years of age. *Int. J. Obes.*, **18**: 561-569 (1994).
- Winkleby, M.A., Feldman, H.A. and Murray, D.M.: Joint analysis of three U.S. community intervention trials for reduction of cardiovascular disease risk. *J. Clin. Epidemiol.*, **50**: 645-658 (1997).
- World Health Organization. *Physical status: the use and interpretation of anthropometry*. Report of a WHO Expert Committee. World Health Organization Technical Report Series. **854**. WHO, Geneva (1995).
- World Health Organization: *Obesity: Preventing and Managing the Global Epidemic*. Report of a WHO Consultation of Obesity. World Health Organization Technical Report Series. **894**. WHO, Geneva (2000).
- Young, T., Palta, M., Dempsey, J., Skatrud, J., Weber, S. and Badr, S.: The occurrence of sleepdisordered breathing among middle-aged adults. *N. Engl. J. Med.*, **328**: 1230-1235 (1993).
- Zhang, Y., Proenca, R., Maffei, M., Barone, M., Leopold, L. and Friedman, J.M.: Positional cloning of the mouse obese gene and its human homologue. *Nature*, **372**: 425-432 (1994).

KEYWORDS Overweight. Biological Factors. Public Health Problem. Energy Regulation

ABSTRACT Obesity, simply defined, is the state of being excessively overweight. It afflicts a significant and possibly growing proportion of people in developed as well as developing societies. It has emerged as the most prevalent serious public health problem of the new millennium. Obesity may not be regarded simply as a cosmetic problem affecting certain individuals, but a crisis that threatens global well being. An estimated 300 million people around the world are obese. The International Obesity Task Force (IOTF) conservative estimates, based on current trends, show that obesity levels will continue to rise in the early 21st century - with severe health consequences - unless urgent action is taken now. It is half a century since obesity was introduced into the international classification of diseases. In the 21st century it has become an epidemic. Obesity levels in some countries have doubled in recent years and are rising in developing countries too. Several factors may contribute to the development of obesity. Obesity develops over time and, once it develops, is difficult to treat. Certain detrimental effects to health are attributed to obesity. Obesity is clearly associated with hypertension, hypercholesterolemia, NIDDM, and excess of certain cancers and other medical problems. The risk to health increases with the degree of obesity. The consequences of ignoring obesity are increasing levels of serious illness and rising health costs. 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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