

The Epidemiology of Obesity: A Review

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Abstract

Obesity is a major public health problem worldwide contributing to increased morbidity and mortality. There are several indices of obesity which include body mass index, waist-hip circumference ratio and skinfold thickness. The prevalence of obesity varies from 7% in France to 32.8% in Brazil. However, the comparison of obesity across different countries is difficult as there are different age structures of the population, measurement techniques are not the same and surveys may not be population-based. Trends in developed and developing countries suggest that the rates of obesity are increasing. This rising trend may be contributed by factors such as low levels of physical activity, high calorie intake and long hours of watching television. Cohort and cross-sectional studies have shown that obesity may be linked to an increased risk of coronary heart disease, hypertension, diabetes mellitus and gallstones. There is also a positive association between obesity and cancer. The mortality of obese adults, adolescents and children is higher than that of the general population. Multi-pronged intervention strategies are needed to prevent obesity and its associated complications.

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Key words: Body mass index, Mortality, Overweight, Prevalence, Risk factors

Introduction

Obesity is a major health problem contributing to increasing cardiovascular morbidity and mortality rates. There has been extensive research on the risk factors, consequences, prevention and treatment of obesity. Yet, there is still controversy over the relationship between obesity and the various diseases such as cardiovascular disease, hypertension, gallbladder disease, diabetes mellitus, gout, arthritis and certain cancers. The accuracy of the different measurements for obesity also varies. Several epidemiologic studies have examined the impact of childhood and adult obesity on premature death and the incidence of chronic diseases such as cancer and coronary heart disease. Childhood obesity leads to approximately 30% of adult obesity and studies have suggested that obese children that become obese adults have more severe obesity than adults whose obesity started in adulthood.¹ This review will cover the prevalence and demography as well as the risk factors and complications of obesity.

Measurements of Obesity

Obese individuals have a high proportion of body fat with an increased fat cell size. There are many techniques to quantify body fat and determine whether an individual is obese. It is often not possible to directly measure body fat and indirect anthropometric measure-

ments are often made. The definitions of obesity also vary and arbitrary levels were established to define obesity. However, there is much scope for improving the validity and reliability of body fat measurements.² We will describe the usefulness and limitations of the different methods of assessing obesity.

One measurement is relative weight, which is the body weight divided by the midpoint of desirable weight of a person of medium frame, as recommended from a standard weight by height and age table.³ These charts measure ranges of body weight in relation to height. This is the preferred measurement technique in children and both weight and height are easily measured.

A widely used measurement in adults is the body mass index (BMI) which is body weight (in kg) divided by the square of height (in meters) (body mass index = kg/m²). This measurement has a correlation between 0.7 and 0.8 with body fat measured by body density.⁴ In the NHANES II study, obesity was defined as a BMI of greater than 85th percentile of 20- to 29-year-old adults which corresponds to a BMI that exceeds 27.8 in men and 27.3 in women.⁵ Other advantages are: it allows comparisons between different populations and is independent of height. However, the BMI which incorporates stature in the index is often confounded by frame size which accounts for a variation of weight in children of up to 20% of the same height. The BMI cannot distin-

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guish between the contribution of body weight of fat and of muscle, bone and water. In children, the BMI is not an appropriate measurement, as growth and development are not considered.

Another important measurement is the waist-hip circumference ratio which measures the distribution of fat in the body. Android obesity with fat distribution primarily in the abdominal region results in an increased waist-hip circumference ratio.⁶ This increase in waist-hip circumference ratio, especially if above 1.0 in men and above 0.8 in women, is associated with increased morbidity from hypertension, diabetes mellitus and stroke. Gynoid obesity with deposition of fat mainly in the buttocks and thighs does not have strong associations.

The measurement of skinfold thickness is a common measure but varies with gender, race and age of the individual. A skinfold caliper is used to measure skinfold thickness in at least 10 body sites. The two most common sites are the subscapular skinfold measurement which measures truncal body fat and the triceps skinfold which measures fat in the extremities. Since body fat distribution varies with age and sex, there are separate standards for each age-sex specific group. Childhood obesity is currently defined as a triceps skinfold in excess of the 85th percentile for children or adolescents of the same age and sex. Super-obese children are defined as those with triceps skinfold measurements greater than or equal to the 95th percentile. Other obesity indices include densitometry, whole body potassium counting and body water determination. However, these methods are complex, expensive and not practical.

Prevalence and Demography

Estimates of the prevalence of obesity and overweight vary in different countries (Table I). However, it is difficult to compare obesity rates in different countries

as not all surveys are population-based, the criteria and measurements tools for obesity vary, and age range of subjects in different surveys is often not similar and the time period of the surveys vary by a decade or more.

In Singapore, the prevalence of obesity in school children aged 6 to 18 years was 16.1% in 1993 based on weight for height charts.⁷ Obesity is the second most important health problem in Singapore school children. The National Health Survey in 1992 revealed that 5% of the Singapore population were obese based on a definition of BMI >31. In Bahrain, cross-sectional study of 825 children aged 15 to 21 showed that 15.6% of the boys and 17.4% of girls were obese as classified by a BMI of more or equal than 25.⁸ In urban Delhi, 27.8% of 13 414 adults aged 25 to 64 years were obese as defined by a BMI of more than 25.⁹

In Brazil, the overall prevalence of obesity was 32.8% in a nationwide survey conducted in 1989.¹⁰ Thirty per cent of women and 10% of men aged 40 to 79 years in Barbados were obese as defined by a BMI of more than 30.¹¹ In the United States, the NHANES II study indicated that 34 million (25.7%) adults were overweight with 19 million women and 15 million men affected.¹² In this review, overweight was defined as a BMI greater than or equal to the 85th percentile values of the body mass index distributions for men and women aged 20 to 29 years. In Canada, the 1990 Ontario Health Survey of 61239 persons aged 20 to 64 years revealed a prevalence of obesity (BMI of 27 greater) of 33.6% in women and 22.8% in men.¹³

To accurately compare the prevalence of obesity in three different countries, a population-based cross-sectional study of obesity prevalence in 5580 individuals aged 16 to 50 years from France, United Kingdom and United States was conducted. There were significant differences in obesity with the prevalence of obesity of

TABLE I: SUMMARY OF THE PREVALENCE OF OBESITY OF SELECTED STUDIES IN VARIOUS COUNTRIES

Country	Author (year)	Population-based	Criteria for obesity	Age range (years)	Prevalence (percentage)
United States	Kuczmarski (1976 to 1980)	Yes	BMI >85th percentile	20 to 74	25.7
Brazil	Sichieri (1989)	Yes	BMI >25	>18	32.8
Canada	Ostbye (1990)	Yes	BMI >27	20 to 64	33.6 in women 22.8 in men
Bahrain	Musaiger (1993)	Yes	BMI >25	15 to 21	15.6 in boys 17.4 in girls
Singapore	Raj an (1993)	Yes	Weight for height charts	6to 18	16.1
Delhi, India	Gopinath (1994)	Yes	BMI >25	25 to 64	27.8

BMI: Body mass index

7% in France, 9% in the United Kingdom and 15% in the United States.¹⁴ Another study integrated data from three large surveys carried out in the United Kingdom, Canada and the United States from 1976 to 1981. Obesity was defined as a BMI of more or equal to 30. For the 20 to 64 years age group, the prevalence of obesity was lowest in the United Kingdom with 8%, followed by 9% in Canada and highest in the United States with 12%.¹⁵

There is evidence that obesity is a growing problem in both developed and developing countries. Often, the prevalence of obesity is concomitant with increasing affluence of the society which is associated with a diet higher in calories, protein and fat. The rapid rise in obesity rates suggests a changing environment rather than genetic factor. In Singapore, obesity rates have increased from 2.3% in 1976 to 16.1% in 1993 in children aged 6 to 18 years.⁷ In pre-school children attending Maternal and Child Health clinics, the prevalence of obesity increased from 2.6% in 1988 to 6.8% in 1991.⁷ The changing dietary patterns in developing countries such as China has led to an increasing prevalence of obesity of 1.3% from 1989 to 1991 as reported in the China Health and Nutrition survey of eight provinces in China.¹⁶ In Thailand, the prevalence of obesity of 1156 schoolchildren aged 6 to 12 years increased from 12.2% in 1991 to 15.6% in 1993.¹⁷ Similar increases in obesity rates were noted in Brazil and Sweden.^{10,18} The prevalence of obesity has increased over time in the United States between 1960 and 1980.¹⁹ In children aged 6 to 11 years, there was a 54% increase in obesity prevalence from 1976 to 1980 according to the National Health and Nutrition Examination Survey.²⁰ Weight for height increased for all ages between 1980 and 1989 according to the National Heart Foundation's Risk Factor Prevalence Study in Australia.²¹ Thus, obesity is a growing worldwide problem that is close to epidemic proportions.

Obesity is more prevalent with advancing age, except after the age of 55 years, and is more common among women than men. Among Singapore adults, the prevalence of obesity is 16.7% in Chinese, 22.4% in Malays and 14% in Indians.²² In 1993 among Primary One Singapore students, the prevalence rate was 14% in Chinese and 15% in Malays and Indians. In the United States, the prevalence of obesity is higher in black women compared to white women and those women from the lower socioeconomic group.²³ Similarly, obesity is more prevalent in other minority groups in the United States such as Hispanic Americans, American Indians, Alaskan Natives and Native Hawaiians.²⁴

Risk Factors for Obesity

Both environmental and genetic risk factors contribute to the development of childhood and adult obesity. Obese individuals have lower levels of physical activity. Reduced energy expenditure is an important predictor

of obesity. Since energy intake in excess of expenditure is a requirement for the development of obesity, dietary intake must still play an important role. It has been observed that high fat and calorie diets (often deep-fried or sweet food) may contribute to obesity. Television viewing has been associated with increased snacking, decreased exercise and thus an increase in obesity. The exact genetic contribution to obesity is unknown and as much as 40% may be heritable.² Positive parent-child correlations have been described and this association could be related to genetic factors as well as similar environments.²⁵

Consequences of Obesity

Several studies have shown an association between adult obesity and an increased morbidity and mortality in men and women (Table II). Adult obesity has been associated with several chronic diseases such as hypertension, hypercholesterolaemia, non-insulin dependent diabetes mellitus, and decreased pulmonary function.^{26,27} Most of the epidemiologic studies are cross-sectional and cohort studies. However, different epidemiologic studies have led to contradictory findings. Cohort studies often require large number of subjects and long follow-up periods as the incidence of certain chronic diseases is low. Not all the studies have an adequate length of follow up or large enough sample size, some studies failed to control for confounding variables such as cigarette smoking and did not exclude individuals with chronic diseases in the initial population. The definitions and methods of measurement of obesity vary and there are inconsistencies in the diagnosis of disease endpoints. Obesity may also be a marker of decreased physical activity or increased food intake rather than a risk factor.

A positive association between initial body mass index and coronary heart disease incidence was found in the Manitoba Heart Study, the Framingham Study and the Nurses' Health Study in the United States.²⁸⁻³⁰ Similarly, the population-based NHANES II study conducted in the United States from 1976 to 1980 showed that overweight individuals have a higher prevalence of cardiovascular risk factors including hypertension, hypercholesterolaemia and diabetes.³ An association between hypertension and obesity was demonstrated in the Framingham study.³¹

Overweight individuals have a two-fold risk of developing gallbladder disease.²⁴ There is a possibility that increased cholesterol production and secretion provides an increased risk of gallbladder disease in the obese. Results from three industrial and two community-based studies were pooled together in the Pooling Project to increase power and sample size. Eight thousand, four hundred and twenty-two men aged 40 to 64 years in the five studies with a mean length of follow up of 8.6 years

TABLE II: SUMMARY OF MAJOR EPIDEMIOLOGIC STUDIES OF THE ASSOCIATED MORBIDITY AND MORTALITY OF OBESITY

Author (year)	Name and type of study	Study population	Results
The Pooling Project Research Group (1978)	Pooling Project (five concurrent cohort studies)	8422 men aged 40 to 64 years	relative risk of coronary heart disease of two in overweight men
Lew et al (1979)	American Cancer Society (concurrent cohort study)	750 000 men and women	coronary heart disease mortality risk ratio of two for persons more than 40% above average weight
Larsson et al (1981)	Gothenburg Study (concurrent cohort study)	855 men aged 50 years	increased risk of kidney stones, gallstones and diabetes mellitus in obese men
Hubert et al (1983)	Framingham Heart Study (concurrent cohort study)	28 18 women aged 28 to 62 years	positive association between relative weight and coronary heart disease incidence
Rhoads et al (1983)	Honolulu Heart Study (concurrent cohort study)	8006 Honolulu Japanese men aged 45 to 68 years	quadratic (U-shaped curve) relationship between total mortality and BMI
Garrison et al (1985)	Framingham Study (concurrent cohort study)	2251 men	30-year mortality risk ratios of 3.9 in overweight non-smoking men
Hoffmans et al (1989)	Dutch Study (nested case-control study)	78 612 men	adjusted coronary heart disease mortality risk ratio of 2.5 for men with a BMI >25 at 18 years of age
Must et al (1992)	Third Harvard Growth Study (concurrent cohort study)	508 adolescents	all-cause mortality risk ratio of 1.8 for men who were overweight adolescents
Nieto et al (1992)	Washington County study (nested case-control study)	13 146 children aged 5 to 18 years	linear increase in odds ratio of mortality with prepubertal relative weight and postpubertal relative weight in females

BMI: Body mass index

were included. The relative risk of coronary heart disease incidence was greater than two.³² A cohort study of 855 fifty-year-old men in Gothenburg, Sweden who were followed for 10 to 12 years, showed that obese men had a higher likelihood of developing kidney stones, gallstones and diabetes mellitus.³³ Obesity also causes a reduction in lung volume leading to hypoventilation in the Pickwickian syndrome which is characterised by somnolence, obesity, and hypoventilation.³⁴

Obesity is not without social and psychological consequences. A cohort study of 10 039 individuals aged 16 to 24 years revealed that overweight individuals were less likely to be married and completed fewer years of school.³⁵ Occasionally, an obese individual may suffer from psychological imbalances such as a disparagement of body image.

Obesity has also been linked to increased mortality. The Framingham study showed that the relative risk of premature death before 70 years for overweight individuals is greater than two and the relationship between mortality and obesity was denoted by a U-shaped curve.³⁶ The American Cancer Society from its data on more than 750 000 individuals in 25 different states followed from 1959 to 1972 found increased mortality due to coronary heart disease, diabetes, digestive diseases and cancer in individuals with excess weight.³⁷ Obese males had a higher mortality from colon, prostate and rectal cancer whereas obese females had a higher mortality from cancer of the gallbladder, biliary passages, breast, uterus, and ovaries. A nested case-control study of 78 612 Dutch men born in 1932 demonstrated an adjusted mortality risk ratio of 1.5 for overweight men.³⁸ A U-shaped curve

linking the relationship between mortality and obesity was reported in a 10-year follow up study of 8006 Honolulu Japanese men aged 45 to 68 years old. The top quintile of the BMI was associated with an increase in cardiovascular mortality.³⁹

The effect of obesity in childhood as well as adolescents has been evaluated. A population-based nested case-control study in Maryland of 13 146 persons aged 5 to 18 years from 1933 to 1945 linked childhood obesity to overall mortality.⁴⁰ A limitation of the study was that data on adult weight were not available and the extent to which adult obesity contributed to the overall mortality is unknown. Adolescent obesity was associated with an increase in total mortality and morbidity from coronary heart disease, stroke, and colorectal cancer in men in the 55-year follow up of the Harvard Growth Study of 508 adolescents aged 13 to 18 years.⁴¹

Conclusion

As seen in this review, there is evidence for increased mortality and morbidity in obese children and adults. Social, emotional and psychological complications may also arise as a result of obesity. Thus, the growing number of obese individuals in both developed and developing countries is a major public health problem. The economic burden of obesity in the United States is estimated to be more than \$39.3 billion.⁴² The treatment of obesity is complex and resistant to most conventional modalities of treatment. Our best hope lies in strategies for the prevention of obesity which should be an important and essential component of public health programmes. Individuals, families and communities are

potential targets of public health programmes. Caloric restriction, increased physical activity and spending less time watching television are modifiable behaviour patterns. The involvement of parents and schools in education and behaviour modification is also important.

In Singapore, programmes by the School Health Service to curb obesity include school screening programmes, school health fairs, and counselling of overweight children. In addition, the Trim and Fit (TAF) programme is introduced in schools to enhance physical fitness among schoolchildren.⁴³ The Singapore Sports Council has special fitness programmes that encourage participation in physical activity in Singapore. Thus, in Singapore and in other countries, a multidisciplinary team with a long-term plan for health education and intervention would facilitate efforts to prevent the onset of obesity and its associated diseases.

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