

Adult as well as childhood obesity with metabolic syndrome

Abstract

With the advancement of our technology and the ability to grow and collect food more efficiently in massive quantities and huge food industries, it's easier to eat more food than needed. As a consequence, obesity became one of today's world most alarming health problem and main culprit for development of many serious disease condition like diabetes, hypertension and cardiovascular disease. There's no doubt that obesity is now one of the modern world's concerns. Obesity is defined as abnormal or excessive fat accumulation that may impair health. The other term, overweight is defined as weighing too much. The weight may represent muscle, bone or body fat. Body mass index (BMI) is a simple index of weight-for-height that is commonly used to classify overweight and obesity in adults. It is defined as a person's weight in kilograms divided by the square of his height in meters (kg/m²). In this review study, we will try to drive deep into research to define obesity and its impacts on health. How is it measured, how is it treated, how it occurs and some of the syndromes related to obesity.

Keywords: adult obesity, childhood obesity, metabolic syndrome, BMI

Volume 8 Issue 6 - 2018

Fadel Al Abdullatif,¹ Khaled Hoobani,¹ Hasan Al Shehab,¹ Ahmad Bo Jbara,¹ Faisal Al Dera,¹ Shamim Shaikh Mohiuddin²

¹Medical Students, College of Medicine, Imam Abdulrahman Bin Faisal University, Kingdom of Saudi Arabia

²Assistant Professor, Department of Biochemistry, Imam Abdulrahman Bin Faisal University, Kingdom of Saudi Arabia

Correspondence: Dr Shamim Shaikh Mohiuddin, Assistant Professor, Department of Biochemistry, College of Medicine, Imam Abdulrahman Bin Faisal University, PO box- 1982, Dammam- 31441, Kingdom of Saudi Arabia, Email smohiwddin@iau.edu.sa, ravi941114@gmail.com

Received: November 08, 2018 | **Published:** November 21, 2018

Introduction

Obesity is become one of a major health problem with worldwide distribution particularly in developed and some developing countries. Incidence of obesity became doubled since 1980.¹ In 2014, there were more than 600million people were obese. 13% of adult were obese. Overweight and obesity kills more people than underweight.² The rate of increase of childhood overweight and obesity in developing countries has been more than 30% higher than that of developed countries.³ In Kingdom of Saudi Arabia here are almost 3.5million children who are overweight. About 28.7% of adult people in Saudi

Arabia are obese out of that female were 33.5% and male were 24.1%. There are 20,000 death from obesity and its complications every year.⁴ According to WHO criteria body mass index greater than or equal to 25 is considered as overweight and greater than or equal to 30 is considered as obesity. Body mass index (BMI) is defined as weight in kilograms divided by the square of an individual's height in meters (kg/m²). In young children, obesity and overweight are measured as weight for length percentile on the growth curve.

Comparison between obesity and overweight

(Table 1)²

Table 1 Comparison between obesity and overweight²

	Obesity	Overweight
Definition	A bodily condition marked by excessive generalized deposition and storage of fat	A condition where the person weighs more than what is considered normal for that height, age and sex
Occurrence	More around 300 million across the world	About 1 billion across the globe
Geographically	More prominent and on the increase in North America, UK, Eastern Europe, the Middle East, the Pacific Islands, Australia and China	Globally
In Children	5% of the 22 million overweight children under five are clinically obese	22 million children under five are overweight
Calculation	BMI over 30	BMI between 25 and 29.9
Risk factors	Coronary heart disease, high blood pressure, diabetes, hypertension	Depression, high blood pressure
Causes	High intake, eating fast foods, stress, depression, hormonal imbalance, sedentary lifestyle, genetics.	High intake of food than is expended by the body, genetics
Treatment	Decreasing calories, exercising and in extreme cases, surgery	Exercise, reduced intake of food

Types of obesity

According to different criteria obesity is subdivided into many categories, whether it was from unhealthy life style, or caused by some disease, or genetically.

Type 1 obesity: It is mainly caused by unhealthy life style (sedentary), for not being active and consuming too many calories without utilization, so the energy expenditure will be low, and therefore the energy will be stored in the body as fat, leads to weight gain, which further leads to obesity.

Type 2 obesity: It is caused by the disease and it's only accountable for 1% of obesity cases. Genetics also play a major role in it. The main problem behind it is that the problem is not from the food intake because in some cases even a small amount of food consumption leads to obesity. The main abnormality is the problem in our body to consume that energy from any food we take. Cushing syndrome, hypothyroidism, insulinoma, and some internal secretion diseases that cause type 2 obesity.

Child type and adult type obesity: It is according to number and size of fat obesity is classified into adult type where there is a change in size of fat cells only so it's increasing, in the other hand the child-type where a change in number of fat cells is.

The number of fat cells start to increase immediately after birth, so people who are obese since childhood they have more like 3 to 4 times fat cells than who have the obesity in adulthood. But in adult type obesity the number of fat cells is close to normal while the change is only in the size, and it happens in the middle of age.⁵ Finally abdominal obesity is usually in men while the limb obesity is more common in women.⁶

Pathophysiology and genetic predisposition

To understand the pathology of obesity we should understand how and why the human body stores fat. Our bodies stores and loses fat by obeying to the laws of thermodynamics. If our net energy intake was higher than amount of what we consume, we gain weight and vice versa. The human body stores this excess net energy mainly in the form of adipose tissue.⁷ This mechanism ensures the survival and energy balance of the organisms in case of starvation, but when it's taken to extreme, many pathological conditions start to appear. Excessive fat storage leads to the release of fatty acids that induce lipotoxicity, which in turn causes dysfunction in insulin-receptor hence, insulin resistance and consequently hyperglycemia. Lipotoxicity also contribute in the decrease of secretion of β -cell insulin, which in turn exhaust the β -cell,⁸ this may cause diabetes in the long run.⁹ Another comorbid disease that may accompany obesity is hypertension. Adipokines help regulating the endothelial vasomotor tone by secreting angiotensinogen, angiotensin II and renin, similar to those of renin-angiotensin system. In obese individuals this secretion enhances hypertension.¹⁰

One of the most interesting questions that has been asked for a long decades is "is being obese is a genetic trait and it has more significant effect on body fat than environment and caloric intake?" Even though the physiological mechanisms of gaining fat requires excess net calories, we cannot disregard genetics, as it's involved in the development of obesity by 40-70%.¹¹ By looking to a significant number of studies, we can conclude that there is a strong correlation

between obesity and some genes.¹² This article explains in details how these genes contribute to obesity such as GAD_2 which is the first gene studied to show association with obesity in morbidly obese adults.¹³ Other gene is Visfatin¹⁴ was linked to increase of visceral fat by mimicking insulin. Heredity apparently play a major role in the obesity of the offspring, there is a study showed that 80% of the children of two obese parents were obese, in comparison to 10% of the offspring of two normal weight parents are obese.¹⁵ Note that obesity is not only caused by normal physiological mechanisms in all cases, there are many genetic syndromes and monogenic disorders that cause obesity, like pleotropic syndrome, Prader-Willi syndrome (1/15,000 births)¹⁶ and Bardet-Biedl Syndrome (1/140,000 births).^{17,18}

Measurement of body composition

Anthropometry: It measures the variables which are height, weight, body proportions, and circumferences, along with skin fold thickness, and skeletal diameter. The major technique to major body fatness level is the body mass index because it's not invasive and suitable for usage in a wide range because the requirement is so simple and inexpensive.

Body mass index refer to body weight divided by the square of the body height (kg/m^2).

It's used to predict and asses increasing in weight, but it will not measure the fatness of the body "the amount of fat presented in our body". Normal BMI is ranged between 18-24.9 while if it's under 18 in will be considered as underweight. In the other hand if the BMI is (25-30) it's considered as overweight, and if it's above 30 it considered as obesity.

Waist circumference: It's valued for its relationship with central adiposity in adults. And now it's getting acceptable by younger people. Waist circumference is defined as the measurement of abdomen at its narrowest point between the lower costal 10th rib border and top of the iliac crest vertically. So it measures the distance circularly around the abdomen.¹⁹

Waist-Hip ratio: Hip measurement is used to be done by measuring the widest portion of hip. Divide circumference to this hip measurement to get Waist-Hip ratio (Figure 1).

Skin fold thickness: "It has been used traditionally to assess the subcutaneous fat layer" at many sites of the body and the main advantages for it is being inexpensive, and can be used in a wide range of sittings. But the main problem it requires high degree of technical skill, but it can be enhanced with training.

Complications

Obesity is considered as health risk for many diseases. Diabetes type 2, heart disease and cancer are common complications, which are associated with obesity. It is associated with diabetes type 2, cardiovascular disease, some types of cancer and sleep apnea.

Diabetes type 2: Obesity is the most risk factor for diabetes type 2. More than 90% of people with type 2 diabetes are obese or overweight.²⁰ Elevated lipolysis leads to increased free fatty acids (FFAs). That cause insulin uptake by the liver, which leads to gluconeogenesis and dyslipidemia. That cause increased insulin in blood and decreased skeletal insulin sensitivity. Eventually, it will lead to type 2 diabetes.²¹

Hypertension: 26% of hypertension in men and 28% of hypertension of women is associated with excess weight.²¹

Cardiovascular disease: Obesity is linked with coronary artery disease, heart failure and atrial fibrillation.²²

Obstructive sleep apnea: Excess fat make airway narrowing which causes difficulty in breathing and it may stop it for a short time.²³ Over 75% of patients with OSA are reported to be <120% of ideal body weight.

Stroke

Osteoarthritis: Most common in knee and ankle because of excess weight.

Cancer: Overweight and inactivity account for quarter to third of breast, colon, endometrium, and kidney and esophagus cancers. Increasing BMI was associated with higher death rates due to cancers of the esophagus, colon and rectum, liver, gallbladder, pancreas, kidney, non-Hodgkin’s lymphoma and multiple myeloma.

Chronic kidney disease

Postoperative complications: Obesity increases the postoperative complications of pulmonary, after operative management of tibial²⁴ and humerus²⁵ shaft fractures, total elbow arthroplasty²⁶ and surgical site infections in women undergoing caesarean sections.²⁷ Obese patients have increased morbidity in hepatectomy for colorectal cancer metastases (Figure 2).²⁸

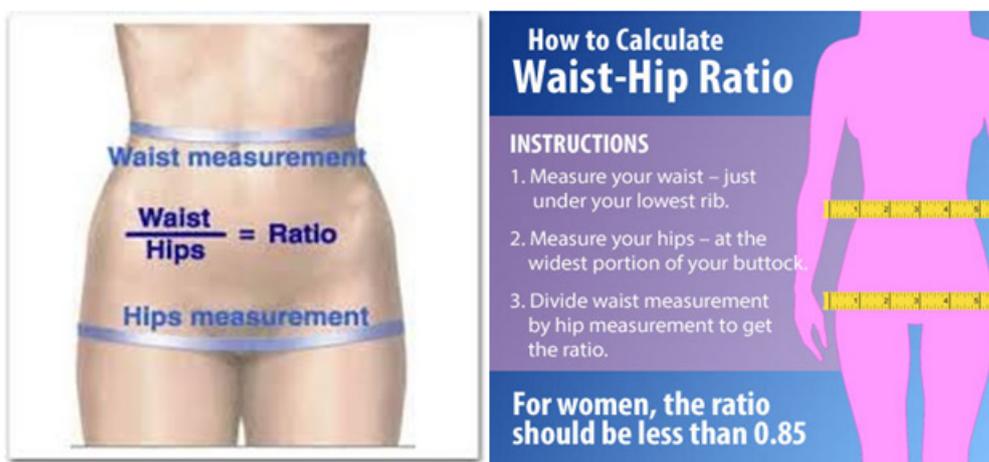


Figure 1 Waist-Hip ratio.

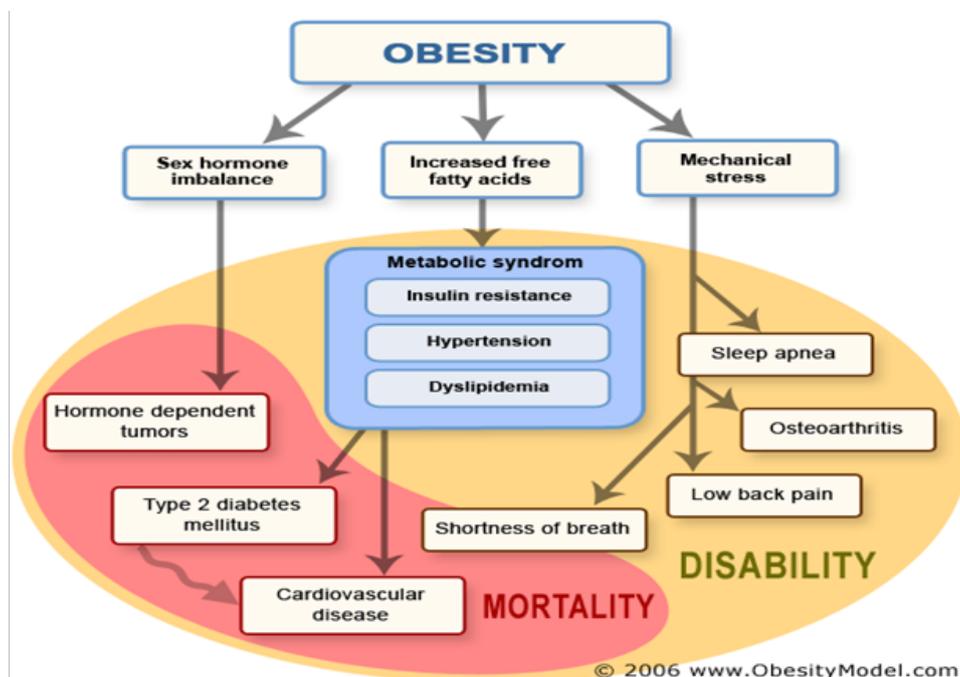


Figure 2 Metabolic syndrome of Obesity.

Prevention: To prevent obesity, we need to set programs and legislations focusing on education, nutrition and physical activities. The strategies can be applied on community, school, home and primary care clinic level.²⁹

Prevention of obesity on community level: It suggests to increase available healthy food and beverage choices, increase the available healthy food in remote areas, make it affordable, restrict the less healthy food and beverage in public places, limit the advertisements of less healthy food and beverage, discourage sweetened drinks, increase physical activities and health education in schools, support breastfeeding, support walking and bicycling.³⁰

Diagnosis and prognosis: The most common method to find out whether individuals are overweight or obese is to find out their body mass index (BMI). BMI is a good measure of your risk for diseases that occur with more body fat (Table 2).

Table 2 BMI measures for diseases that occur with more body fat

BMI	
18.5–24.9	Normal weight
25.0–29.9	Overweight
30.0–39.9	Obese
40.0 and above	Extreme obesity

Although BMI can be used for most men and women, it does have some limits. It may overestimate body fat in athletes and others who have a muscular build. BMI also may underestimate body fat in older people and others who have lost muscle (Figure 3).

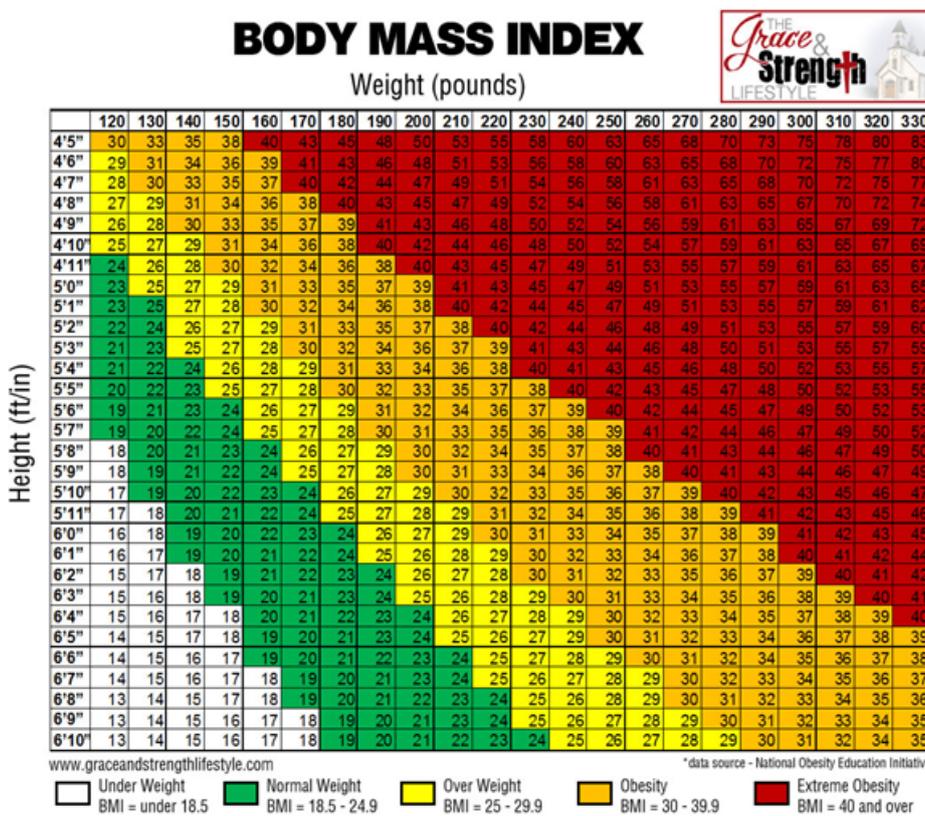


Figure 3 BMI for more body fat.

Body mass index for children and teens

Overweight and obesity are defined differently for children and teens than for adults. Children are still growing, and boys and girls mature at different rates. BMIs for children and teens compare their heights and weights against growth charts that take age and sex into account. This is called BMI-for-age percentile. A child or teen's BMI-for-age percentile shows how his or her BMI compares with other boys and girls of the same age (Table 3) (Figure 4).

Table 3 BMI-for-age percentile compares with other boys and girls of the same age

BMI-for-Age Percentile	
Less than 5%	Underweight
5% to less than the 85%	Healthy weight
85% to less than the 95%	Risk of overweight
95% or greater	Overweight

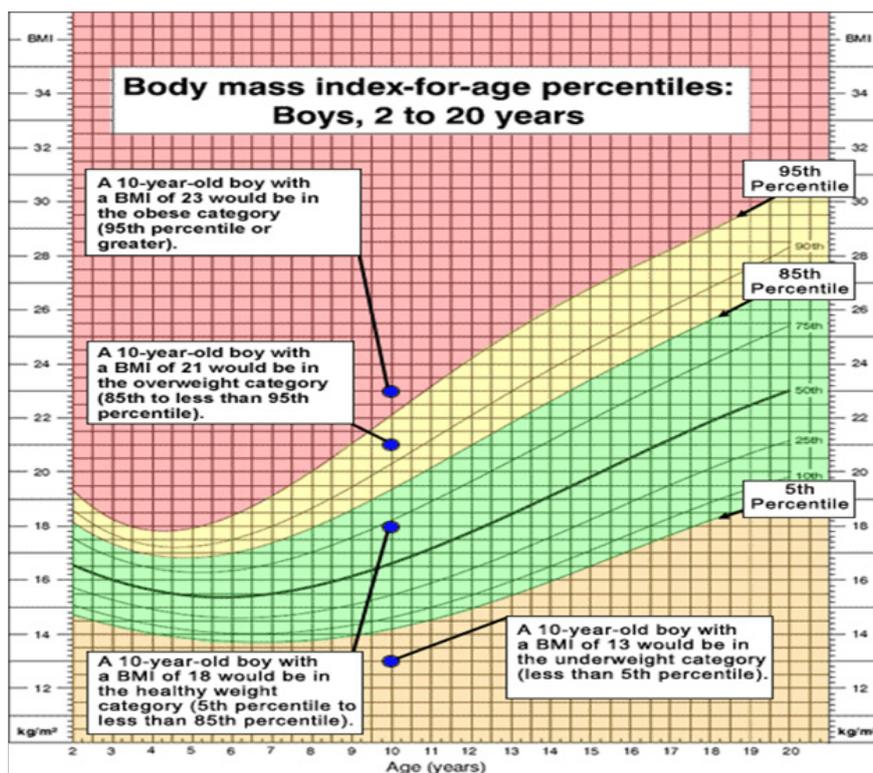


Figure 4 BMI for age percentiles.

Waist circumference

If individuals have abdominal obesity and most of their fat is around their waist rather than at their hips, then they are at increased risk for coronary heart disease and type 2 diabetes. The risk rises with a waist size that is greater than 35 inches for women or greater than 40 inches for men. You can also measure your waist size. To do so correctly, stand and place a tape measure around your middle, just above your hipbones. Measure your waist just after you breathe out.

Waist-to-hip ratio

After you determine your waist circumference, you are ready to check out your waist-to-hip ratio, which is a measurement that compares the size of your hips to the size of your waist. To do it correctly, use a tape measure, measure the circumference of your hips and use your waist circumference measurement, calculate your waist-to-hip ratio by dividing your waist circumference by your hip measurement. For women, ideal: less than 80cm, high: 80cm to 88cm, very high: more than 88cm. For men, ideal: less than 94cm, high: 94cm to 102cm, very high: more than 102cm.

Blood tests

What tests you have depended on your health, risk factors and any current symptoms you may be having. Tests may include a cholesterol test, liver function tests, a fasting glucose, a thyroid test and others. Your doctor may also recommend certain heart tests, such as an electrocardiogram.

Specialists Involved

A primary care doctor (or pediatrician for children and teens) will assess your BMI, waist measurement, and overall health risk. If you are overweight or obese, or if you have a large waist size, your doctor should explain the health risks and figure out whether you are interested and willing to lose weight. Your doctor may send you to other health care specialists if you need expert care. These specialists may include:

- An endocrinologist if you need to be treated for type 2 diabetes or a hormone problem, such as an underactive thyroid.
- A registered dietitian or nutritionist to work with you on ways to change your eating habits.
- An exercise physiologist or trainer to figure out your level of fitness and show you how to do physical activities suitable for you.
- A bariatric surgeon if weight-loss surgery is an option for you.
- A psychiatrist, psychologist, or clinical social worker to help treat depression or stress.³¹

Management

Dietary and physical Activity guideline by WHO: Recommended levels of physical activity for children aged 5–17 years: In order to improve cardio respiratory and muscular fitness, bone health, and cardiovascular and metabolic health biomarkers:

- A. Children and youth aged 5–17 should accumulate at least 60 minutes of moderate- to vigorous-intensity physical activity daily.
- B. Amounts of physical activity greater than 60 minutes provide additional health benefits.
- C. Most of the daily physical activity should be aerobic. Vigorous-intensity activities should be incorporated, including those that strengthen muscle and bone*, at least 3 times per week.

Physical activity for all: These recommendations are relevant to all healthy children aged 5–17 years unless specific medical conditions indicate to the contrary. The concept of accumulation refers to meeting the goal of 60 minutes per day by performing activities in multiple shorter bouts spread throughout the day (e.g. 2 bouts of 30 minutes), then adding together the time spent during each of these bouts. Whenever possible, children and youth with disabilities should meet these recommendations. However, they should work with their health care provider to understand the types and amounts of physical activity appropriate for them considering their disability.³²

Medical management and surgical management

Diet: While there is no single rule that applies to everybody, most obese people are advised to reduce the energy intake from their diet by 600 calories a day.

Exercise: Reducing the number of calories in your diet will help you lose weight, but if you want to keep off the weight, you must combine a calorie-controlled diet with regular exercise.

Surgery: Weight loss surgery, also called bariatric surgery, is sometimes used to treat people who are severely obese. This type of surgery is usually only available on the NHS to treat people with severe obesity that has not responded to other measures.

Severe obesity is defined as:

- I. Having a body mass index (BMI) of 40 or above
- II. Having a BMI of 35 or above and having another serious health condition that could be improved if you lose weight, such as type 2 diabetes, obstructive sleep apnea or high blood pressure. In rare cases, surgery may be recommended as the first treatment if your BMI is 50 or above.³³

Childhood obesity: Its serious condition which affects not only children but also adolescence, and it occurs when the child is above the normal weight that is linked with height, and age. The main cause of obesity is the life style behavior being inactive and eating too many calories from food and drinks. In addition genetics along with hormonal factors also contribute for obesity among children.³⁴ Immediate health problems include social isolation, that the child is no longer involved in a certain activity with other people “being neglected and ignored” besides that, potential psychological dysfunction because young obese children have been described by their peers as ugly, stupid, dishonest, and lazy. Such children are also at greater risk of co-morbidities than their counterparts, for example they are likely to develop asthma, and if they already have the disease they require more medications in order to be effective, wheeze more, experience more hospital visits, and miss more school classes as a result of their asthma than lean asthmatic children. In the short term obese children are likely to develop gastrointestinal, cardiovascular, and endocrine, orthopedic problems than their lean colleagues. In long term obesity further increase in weight is associated with

reproductive system abnormalities in girls, such as early onset of puberty and menarche, polycystic ovary syndrome. According to study from longitudinal Bogalusa heart, it suggests that in long term the cardiovascular disease risk factors increase rapidly over time.³⁵ In addition to that obesity may cause psychiatric disorder according to study on one hundred and sixty seven obese children with BMI of more than 30 along with normal weight children of BMI from 18–25 normal weight aged between 9–16 were enrolled in this study which was case control study, to assess self-concept, anxiety, and depression. The result showed that obese children may experience psychiatric disorder more than the counterpart normal children.³⁶

Metabolic syndrome

The definition of metabolic syndrome is the group of diseases that include diabetes obesity, hypertension, glucose intolerance, high triglyceride, and low high-density lipoprotein cholesterol. Metabolic syndrome is responsible for increasing the risk of coronary heart disease, myocardial infarction, stroke and cardiovascular death by 3 times.³⁷ One of the key symptoms of metabolic syndrome is central obesity (excessive abdominal fat).³⁸ The WHO has made a criteria in 1999 on how to diagnose metabolic syndrome, having more than 140/90 mmHg blood pressure, triglycerides over ≥ 1.695 mmol/L, HDL (HDL-C) ≤ 0.9 mmol/L (male), ≤ 1.0 mmol/L (female), waist to hip ratio over 0.9 (males), 0.85 (females) or body mass index over 30, urinary albumin excretion ratio ≥ 20 μ g/min or albumin: creatinine ratio ≥ 30 mg/g will indicate metabolic syndrome.

Society and cultural aspect

Economic impact of obesity: The increasing prevalence of obesity is a major public health challenge both nationally and internationally. In 2007 estimates of the direct NHS costs of treating overweight and obesity, and related morbidity in England were £4.2 billion and estimated to be £6.3 billion in 2015. Work in progress in PHE in 2014 initially suggests that an estimated extra £352 million per year is spent by local authorities on providing formal care for severely obese people compared to healthy weight people.

Education about obesity: Obesity is associated with educational attainment. Men and women who have fewer qualifications are more likely to be obese. Around a third of adults who leave school with no qualifications are obese, compared with less than a fifth of adults with degree level qualifications. Part of the reason for this is that levels of educational attainment are linked to levels of inequality and deprivation. People who are socioeconomically deprived tend to have poorer health and lower levels of education. In addition, low achievement at school among obese children may be due to a variety of factors such as poor psychological health, teasing, bullying and discrimination, low self-esteem, disturbed sleep, absenteeism and less time spent with friends or being physically active.³⁹

Conclusion

Even though obesity is a result of normal physiological mechanisms, it's dangerous for long term health condition to be in. Chronic diseases such as hypertension, bone problems and diabetes vastly affect the quality of life. Obesity can be caused by genetic problems and metabolic diseases; it's mostly the result of the person's lifestyle choices. With the promotion of health and raising awareness about obesity change can be made, pushing people not only to reach to clinical normal weight, but to go further improving every aspect of lifestyle.

Acknowledgments

None.

Funding

This project did not receive any specific grant from funding agencies in the public, commercial, or not-for-profit sectors.

Conflicts of interest

Authors declare that there is no conflict of interest.

References

- World Health Organization. *Obesity and overweight*. Switzerland: Geneva; 2015.
- Speroff L, Fritz M. *Clinical Gynecologic Endocrinology and Infertility*. 7th ed. United States: Lippincott Williams and Wilkins; 2005.
- World Health Organization. *Fact sheets: Obesity and overweight*. WHO Media centre, Switzerland: Geneva; 2015.
- Ministry of Health Portal: Kingdom of Saudi Arabia. *Minister of Health Announces the Results of the National Survey for the Health Information in the Kingdom*. 2015.
- Types of Obesity*. USA: California; 2015.
- Naish J, Court D. *Medical sciences*. 2nd ed. Saunders Ltd, Scotland: Edinburgh; 2015. 840 p.
- Scopinaro N. *The physiology of weight change*. IFSO: Italy; 2015.
- Redinger RN. The Pathophysiology of Obesity and Its Clinical Manifestations. *Gastroenterol Hepatol (N Y)*. 2007;3(11):856–863.
- Cerf ME. Beta cell dysfunction and insulin resistance. *Front Endocrinol (Lausanne)*. 2013;4:37.
- Chinetti G, Fruchart JC, Staels B. Peroxisome proliferator-activated receptors and inflammation: from basic science to clinical applications. *Int J Obes Relat Metab Disord*. 2003;27(Suppl 3):S41–S45.
- Hainer V, Toplak H, Mitrakou A. Treatment modalities of obesity: what fits whom? *Diabetes Care*. 2008;31(Suppl 2):S269–S277.
- Walley AJ, Blakemore AI, Froguel P. Genetics of obesity and the prediction of risk for health. *Hum Mol Genet*. 2006;15(Spec No 2):R124–R130.
- Boutin P, Dina C, Vasseur F, et al. GAD2 on Chromosome 10p12 Is a Candidate Gene for Human Obesity. *PLoS Biol*. 2003;1(3):E68.
- Fukuhara A, Matsuda M, Nishizawa M, et al. Visfatin: A Protein Secreted by Visceral Fat That Mimics the Effects of Insulin. *Science*. 2005;307(5708):426–430.
- Kolata G. *Rethinking thin: The new science of weight loss—and the myths and realities of dieting*. 1st ed. USA: Picador; 2007.
- What is Prader–Willi syndrome?* Foundation for Prader–Willi Research, USA; 2015.
- Bardet–Biedl syndrome*. Genetics Home Reference, USA; 2015.
- O’Rahilly S, Farooqi IS. Genetics of obesity. *Philos Trans R Soc Lond B Biol Sci*. 2006;361(1471):1095–1105.
- Waist Circumference*. McKinley Health Center, University of Illinois, USA: Pennsylvania; 2015.
- World Health Organization. *Obesity and Overweight Fact Sheet*. WHO, Switzerland: Geneva; 2015.
- Kopelman PG. Obesity as a medical problem. *Nature*. 2000;404(6778):635–643.
- Malnick SD, Knobler H. The medical complications of obesity. *QJM*. 2006;99(9):565–579.
- NIH. *Do You Know Some of the Health Risks of Being Overweight?* 2015.
- Burrus MT, Werner BC, Yarboro SR. Obesity is associated with increased postoperative complications after operative management of tibial shaft fractures. *Injury*. 2016;47(2):465–470.
- Werner BC, Rawles RB, Jobe JT, et al. Obesity is associated with increased postoperative complications after operative management of distal humerus fractures. *J Shoulder Elbow Surg*. 2015;24(10):1602–1606.
- Griffin JW, Werner BC, Gwathmey FW, et al. Obesity is associated with increased postoperative complications after total elbow arthroplasty. *J Shoulder Elbow Surg*. 2015 Oct;24(10):1594–1601.
- Anderson V, Chaboyer W, Gillespie B. The relationship between obesity and surgical site infections in women undergoing caesarean sections: An integrative review. *Midwifery*. 2013;29(12):1331–1338.
- Langella S, Russolillo N, Forchino F, et al. Impact of obesity on postoperative outcome of hepatic resection for colorectal metastases. *Surgery*. 2015;158(6):1521–1529.
- Wang Y, Wu Y, Wilson RF, et al. Childhood Obesity Prevention Programs: Comparative Effectiveness. *Comparative Effectiveness Review Summary Guides for Clinicians [Internet]*. Agency for Healthcare Research and Quality, USA: Rockville; 2013.
- Khan LK, Sobush K, Keener D, et al. Recommended community strategies and measurements to prevent obesity in the United States. *MMWR Recomm Rep*. 2009;58(RR-7):1–26.
- Chambers R, Walkley G. Obesity and Overweight matters in primary care. United Kingdom: Cartoons; 2002.
- World Health Organization. Obesity and overweight. WHO Media centre, Switzerland: Geneva; 2015.
- Obesity–Treatment. NHS choices; 2015.
- Childhood obesity*. Mayo Clinic, USA: Florida; 2015.
- Hills A, King N, Byrne N. *Children, Obesity and Exercise*. Hoboken: Taylor & Francis; 2007. 184 p.
- Topçu S, Orhon FŞ, Tayfun M, et al. Anxiety, depression and self-esteem levels in obese children: a case–control study. *J Pediatr Endocrinol Metab*. 2016;29(3):357–61.
- El Brini O, Akhouayri O, Gamal A, et al. Prevalence of metabolic syndrome and its components based on a harmonious definition among adults in Morocco. *Diabetes Metab Syndr Obes*. 2014;7:341–346.
- Rosety–Rodríguez M, Fornieles G, Rosety I, et al. Central obesity measurements predict metabolic syndrome in a retrospective cohort study of postmenopausal women. *Nutr Hosp*. 2013;28(6):1912–1917.
- Shivpuri A, Shivpuri A, Sharma S. Childhood Obesity: Review of a growing Problem. *Int J Clin Pediatr Dent*. 2012;5(3):237–241.