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# Biochemistry of Obesity and Its World-Wide Prevalence

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## Abstract

This study focuses on obesity, which is an important health problem of our age. Accordingly, up-to-date data on the causes of obesity, its classification, the risks that it poses, its world-wide prevalence and its cost to states are presented in an integrated manner.

**Keywords:** Obesity; Obesity classification; Turkey obesity prevalence; Health expenditures

## Obesity

Obesity arises when the balance between the body weight and height is impaired in favour of weight. This impairment results from genetic factors, dietary habits, physical activity, and hormone levels influenced by the physiological and psychological condition of the individual. Paired with a decrease in the feeling of satiety, the continuous increase in positive energy balance leads to obesity. Obesity can also be defined as an abnormal increase in adipose tissue. The ratio of adipose tissue to total body weight is accepted to be 25% in healthy males and 35% in healthy females [1]. When the ratio of fat tissue exceeds these limits, obesity develops. Thus, the emergence of obesity is associated with the adipose tissue that the body contains. Several specific factors are responsible for the adipose tissue's exceeding normal limits during the metabolic activities of the body and numerous factors are at play in the development of obesity. World Health Organization reported in a 2005 study that at least 20 million children under the age of 5 and 1.6 billion adults at and above 15 years were overweight, and of the latter 400 million individuals were obese world-wide. The prevalence of obesity has doubled in the last 3 decades and is higher in females than in males. In the 2016 World Health Organization reported that 1.9 million overweight (650 million obese) and 41 million children under 5 years of age are overweight or obese. The prevalence of obesity has increased threefold from 1975 to 2016. In 1975, while the obesity rate of children and adolescents between the ages of 5 and 19 was below 1%, this rate increased to 8% in males and 6% in females in 2016 (124 million in total) [2]. Nearly one-third of adults and about 17% of adolescents in the United States are obese. According to center for disease control and prevention (CDC), 2011 to 2012 data, one out of five adolescents, one out of six elementary school age children, and one out of 12 preschool age children are obese. Obesity is more prevalent in African Americans, followed by Hispanics and whites. Southern US states have the highest prevalence, followed by the Midwest, Northeast and the west [3]. A meta-analysis indicated that obesity in children and adolescents aged 5 to 19 years has increased in Turkey since 1990, and that the rate of increase is higher in men [4]. The prevalence of obesity is currently considered to stand at 7%. The prevalence of obesity according to body mass index (BMI) in developed and developing countries is presented in Table 1 a, and Table 1 b [5]. In a 2001 study, Onat et. al. [6] reported that 25.2% of males and 44.2% of females were obese in Turkey. Despite a lack of precise data on the prevalence of obesity in our country, Obesity Research Association of Turkey reported in a study covering the period between 2000 and 2005 and 6 cities that 29.5% of the Turkish population (21.8% of males and 34.5% of females) was obese. Presently, there is widespread acceptance of the fact that obesity is a disease. Therefore, there has been a rise in the share of the cost of obesity and associated problems in health expenditures of countries [7]. Factors that affect the development of obesity which has a highly complicated etiopathology can be

classified as follows:

## Genetic Factors

The endocrine and nervous systems of the body are under genetic control. Number and size of adipose tissue cells, as well as the localization of adipose tissue in the body are determined by genetic heritage. Likewise, the amount and ratio of fat-free tissue to be formed by the body, as well as the bodily energy balance are also genetically determined. Therefore, the possibility that the children of obese parents will be obese goes up to 80%, whereas the same possibility falls below 10% in the case of healthy parents [8-10].

## Dietary Habits

Dietary culture of societies and individuals is a significant factor in the development of obesity. Increasing number of meals without regard to the needs of the body or decreasing number of meals due to additional calories taken between meals cause obesity. Besides, excess energy taken from food with a rich carbohydrate and fat content during meals leads to accumulation of fat tissue in the body. Additionally, it is known that eating quickly, smoking (after quitting smoking), excessive use of alcohol, other substance abuses and various drugs are known to directly or indirectly facilitate the development of obesity. Wrong diet programs used to lose weight cause loss of water from the body; when the program is ended, the weight lost through water loss is quickly gained back. Furthermore, rate and amount of energy consumption decreases due to the decrease in the basal metabolism rate during the implementation of diet programs, speeding up the development of obesity.

| Country | Study Year | Age interval (years) | National prevalence of excess weight % BMI ≥ 25 kg/m² | | | National prevalence of obesity % BMI ≥ 30 kg/m² | | |
|---|---|---|---|---|---|---|---|---|
| | | | Male | Female | Total | Male | Female | Total |
| Australia | 2004-2005 | 18-100 | 58.3 | 40 | 49 | 17.8 | 15.1 | 16.4 |
| Canada | 2003 | 18-100 | 56.9 | 39.6 | 48.2 | 15.9 | 13.9 | 14.9 |
| Denmark | 2000 | 16-100 | 49.6 | 34 | 41.7 | 9.8 | 9.1 | 9.4 |
| Germany | 2003 | 18-100 | 57.7 | 41.2 | 49.2 | 13.6 | 12.3 | 12.9 |
| Japan | 2004 | 15-100 | 27.3 | 19.9 | 23.2 | 2.86* | 3.30* | 3.10* |
| Norway | 2002 | 15-100 | 37.8 | 25.5 | 31.5 | 6.4 | 5.9 | 6.1 |
| Korea | 2005 | 20-100 | 35.2 | 28.3 | 31.8 | 1.70** | 3.00** | 2.40** |
| Singapore | 2004 | 18-69 | 35 | 29.9 | 32.5 | 6.4 | 7.3 | 6.9 |
| Switzerland | 2002 | 15-100 | 45.4 | 29.3 | 36.61 | 7.9 | 7.5 | 7.68 |
| UK | 2002 | 15-84 | 66.3 | 56.6 | 61 | 22.3 | 23 | 22.7 |
| USA | 2003-2004 | 20-100 | 70.8 | 61.8 | 66.3 | 31.1 | 33.2 | 32.2 |
| *2001 data; there are no 2004 data. **1998 data; there are no 2005 data. | | | | | | | | |

**Table 1a:** World-wide prevalence of adult obesity in developed countries.

| Country | Study Year | Age interval (years) | National prevalence of excess weight % BMI ≥ 25 kg/m² | | | National prevalence of obesity % BMI ≥ 30 kg/m² | | |
|---|---|---|---|---|---|---|---|---|
| | | | Male | Female | Total | Male | Female | Total |
| Bahrain | 1998-1999 | 19-100 | 60 | 62.4 | 61.23 | 23.3 | 34.1 | 28.86 |
| Brazil | 2002-2003 | 20-100 | 41.1 | 40 | 40.6 | 8.9 | 13.1 | 11.1 |
| Chile | 2003 | 17-100 | 62.2 | 57.7 | 59.7 | 19 | 25 | 21.9 |
| China | 2002 | 18-100 | 19.1 | 18.8 | 18.9 | 2.4 | 3.4 | 2.9 |
| Hungary | 2003-2004 | 18-100 | 58.92 | 49.43 | 53.24 | 17.1 | 18.2 | 17.73 |
| India | 2005-2006 | 15-49 | 9.3 | 12.6 | - | 1.3 | 2.8 | - |
| Indonesia | 2001 | 15-100 | 8.4 | 17.8 | 13.4 | 1.1 | 3.6 | 2.4 |
| Poland | 2001-2002 | 19-100 | 56.7 | 48.6 | 52.2 | 15.7 | 19.9 | 18 |
| Saudi Arabia | 1995-2000 | 30-70 | 68.8 | 75.8 | 72.5 | 26.4 | 44 | 35.6 |
| South Africa | 1998 | 15-100 | 29.09 | 56.2 | 45.06 | 11.1 | 33.2 | 24 |
| Zimbabwe | 2005 | 25-100 | 18.3 | 43.3 | 37.3 | 3.9 | 19.4 | 15.7 |

**Table 1b:** World-wide prevalence of adult obesity in developing countries.

**Age:** Adipose cells double in the first year of life in children, but this is not a determining factor in the development of obesity. It is very likely that obesity developing in the children and adolescents in the 4-11 age groups will be persistent [11]. Body fat mass increases with age and reaches a peak in 60s, after which it starts to decrease [12]. Despite the decrease in energy intake, the parallel declines in physical activity and basal metabolism may lead to obesity in the elderly. Also sleep habits, particularly high sleep duration variability in young individuals and late bedtime in the elderly, are linked with a high prevalence of obesity [13].

**Sex:** Although obesity is seen in both sexes, it is generally more prevalent in females. Women have a higher risk of developing and suffering from persistent obesity in adulthood than men.

**Socioeconomic Factors:** The data about the relation between level of socioeconomic development and obesity are inconsistent. Some studies report that obesity is more prevalent in societies with a better socioeconomic status, whereas others state that it is more prevalent in societies with a lower socioeconomic status [14-16]. However, the fact that the prevalence of obesity in developing countries constituting a large part of the world population like China and Indonesia is lower than that in developed countries like the U.S. may be associated with the influence of the level of economic and technological advancement on the life standards of individuals (Table 1a and Table 1b). A meta-analysis focusing on this topic showed that obesity in the middle socioeconomic stratum of developed countries was lower in comparison to undeveloped and underdeveloped countries [15]. In Turkey, however, obesity is more common in individuals with a high or average socioeconomic status [17]. It has been recently reported that childhood socioeconomic status modifies the genetic effect in the gene/region around SNP rs9540493 on BMI in European Americans in the HRS. The most significant SNP (rs9540488) by childhood socioeconomic status interaction within the rs9540493 gene/region was suggestively replicated in the Multi-Ethnic Study of Atherosclerosis (MESA) ($p = 0.07$) [18].

**Psychogenic, Cultural Factors and Habits:** Although there are no character differences between obese and non-obese individuals, depression and stress can cause over-eating. Eating quickly may also lead to obesity. During the intake of food, it takes approximately 10 minutes for the feeling of satiety to manifest itself. That is how eating quickly becomes an important factor in the development of obesity. Furthermore, there are some cultures which regard being overweight and obesity as symbols of affluence.

**Hormonal Factors:** The discovery of many hormones that have a part in the body weight and energy balance has guided obesity research. The centre of appetite in the hypothalamus plays a crucial role in the development of obesity. The centre receiving the satiety signals is located in the ventromedial hypothalamus and the centre receiving the hunger signals is located in the lateral hypothalamus [19]. Peptides that are involved in energy regulation in obesity are divided into two as orexigenic (appetite-stimulating) and anorexigenic (appetite-inhibiting) peptides. Orexigenic peptides are ghrelin, neuropeptide Y (NPY), agouti-related peptide (AgRP), endocannabinoids, galanin, growth hormone releasing hormone (GHRH), melanin-concentrating hormone (MCH) and opioid peptides (beta endorphins: β-endorphins). Anorexigenic peptides include obestatin, α-melanocyte-stimulating hormone (α-MSH), amylin, calcitonin (Calcitonin Gene-Related Peptide: CGRP), cholecystokinin (CCK), cocaine and amphetamine-regulated transcript (CART), corticotrophin releasing hormone (CRH), glucagon-like peptides 1 and 2 (GLP-1, GLP-2), insulin, leptin, neuromedin u (NMU), neurotensin, oxyntomodulin, Pancreatic polypeptide (PP), Polypeptide YY (PYY and $PYY_{3-36}$), urocortin and Nesfatin-1 [20]. Weight loss was shown to reduce serum leptin levels, while increasing ghrelin levels in morbid obese [21].

## Classification of Obesity

Obesity can be classified in different ways according to the criteria of examination used. Various classification criteria and their associated obesity types have been compiled and presented in Table 2 [22].

| CRITERIA | OBESITY TYPE | | |
|---|---|---|---|
| **Etiology** | Exogenous | Diet-induced | |
| | Endogenous | Associated with genetic factors | |
| | | Metabolic and hormonal origin | Associated with endocrine causes |
| | | | Associated with drug use |
| **Lipocyte Characteristics** | Hypertrophic | | |
| | Hypercellular | | |

| | | | |
|---|---|---|---|
| **BMI (kg/m²)** | < 16 | Thin | Severely |
| | 16 – 16.9 | | Moderately |
| | 17 – 18.49 | | Mildly |
| | 18.5 – 24.9 | Normal | |
| | 25 – 29.9 | Overweight | |
| | 30 – 34.9 | Obese I | |
| | 35 – 39.9 | Obese II | |
| | ≥ 40 | Obese III (Morbid: Extremely obese) | |
| **Localization of Adipose Tissue** | Ovoid | | |
| | Android | | |
| | Visceral | | |
| | Gynoid | | |
| **Age** | Childhood-onset | | |
| | Adulthood-onset | | |
| | Old age-onset | | |

**Table 2:** Obesity classification criteria and types of obesity. BMI: Body Mass Index.

## Risks Associated with Obesity

The area where the adipose tissue has accumulated in the body is critical in the obese. There is a higher risk of complications in case that the adipose tissue accumulation in the upper part of the body, around the waist in particular (android type), is higher than the adipose tissue accumulation in the lower part of the body, in the hip and legs in particular (gynoid type). Therefore, the current diagnosis of obesity includes the measurement of the waist circumference, together with BMI. The increase in waist circumference in proportion with BMI elevates the incidence of diseases such as diabetes, hypertension, dyslipidemia, coronary artery diseases, insulin resistance syndromes, degenerative arthritis, gall bladder disease, and various types of cancer (endometrium, breast, prostate and colon). In individuals with normal weight, the risk of disease development varies according to waist and hip circumference. The gender-based variation in these risk factors has been adopted from the relevant literature and presented in Table 3 [23].

| **BMI VALUE** | | **RATE OF INCREASE IN RISK FACTORS** | |
|---|---|---|---|
| Obesity Class | BMI (kg/m²) | Waist circumference: ≤ 102 cm (♂), ≤ 88 cm (♀) | Waist circumference: ≤ 102 cm (♂), ≤ 88 cm (♀) |
| Thin | < 18.5 | --- | --- |
| Normal | 18.5 – 24.9 | --- | --- |
| Overweight | 25 – 29.9 | Elevation | High |
| Obese I | 30 – 34.9 | High | Very High |
| Obese II | 35 – 39.9 | Very high | Very high |
| Obese III | ≥ 40 | Extremely high | Extremely high |
| BMI: Body Mass Index. | | | |

**Table 3:** Disease risk by body mass index and waist circumference.

## The Share of Obesity in Health Expenditures

The treatment of obesity and related diseases, which shorten the life span of individuals and decrease their life standards, places a burden on the economy of individuals and countries. Therefore, early diagnosis of obesity, which has a negative impact on the general well-being as well as the physical and psychological aspects of the life standard of individuals, is of utmost importance. Diagnosis and treatment of obesity in early ages shall contribute to bettering the well-being of individuals and reducing health expenditures. Besides, the fact that the increase in obesity prevalence has been associated with physiological conditions, rather than genetic factors, shall be guiding in the diagnosis and treatment of obesity.

In developed countries, where the working conditions, and dietary and exercising habits of individuals have changed parallel to the level of economic, scientific and technological advances, obesity leads to higher morbidity and mortality than in underdeveloped and developing countries. In the United States, the annual cost of obesity was determined to stand at 99.2 billion dollars in the year 1995 (51.6 billion dollars direct cost including the costs of preventive measures, diagnosis and treatment costs; 47.6 billion dollars indirect cost associated with morbidity, mortality, loss of productivity and income loss). In 1998, the cost of obesity to employers was estimated to be 2.4 billion in the U.S. In the U.K. 4.2 billion Euro was spent on obesity and diseases associated with weight in 2007. That this amount is estimated to rise up to 6.3 billion Euro in 2015 clearly demonstrates the gravity of the problem. In a comparative study of Finland (338 observations) and our country (611 observations), it was reported that the rate of obesity and dental problems in the 10-12 age group were 28-84% in Turkey and 20-33% in Finland, respectively. Therefore, world health associations spend huge sums on the treatment of this disease.

In conclusion, obesity which has a complicated etiopathology and is influenced by genetic factors, dietary habits, hormone levels, physical activity, as well as the physiological and psychological condition of the individual, is currently a critical health problem threatening the life of individuals in both developed and developing countries.

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