

The impact of excessive body weight on postural balance

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Abstract

Body balance is the determinant of efficient human functioning in daily activities. The equilibrium system is a complex system that draws information about the position of the body in space and the relative position of the body parts relative to one another from the balance organ, proprioceptors and the visual system. Due to the multidimensionality of the balance system, many factors can affect its operation and disrupt the efficiency of work. Excessive weight due to the different distribution of excess body fat may disturb balance control. In addition, in the states of overweight and obesity, the muscles that are responsible for maintaining the vertical posture are very often weakened.

Balance

One of the most important factors guaranteeing the efficient functioning of people in everyday life is the efficiency and effectiveness of the postural control system. It ensures not only the proper performance of certain life activities, but also often determines the safety of a human being [1]. Maintaining the balance of the body depends on the efficient transmission of information from the three components of the equilibrium system: the balance organ, proprioceptors and the organ of sight to generate appropriate motor responses. In

biomechanics, the balance can be described as the ability to maintain the projection of the centre of gravity (COG) in the area marked by the foot envelope. Upright quiet stance is thought to be maintained primarily through the ankle torque in the anterior-posterior plane, and the hips in the lateral-lateral plane [2]. Paszko-Patej G. et al. they define the control of human balance as the ability to maintain the centre of mass projection (COM), which is located in the area of the lower abdomen, inside the support area defined by the foot contour. Keeping the balance in a standing position is a process of continuous loss and recovery [3].

Taking into account balance control, posture stability can be divided into several areas. The so-called margin of stability (SM), the centre of gravity should be in the centre of this area. The size of this area depends on the age of the man and the efficiency of the balance system. During a calm state the body performs slight oscillatory movements that are beyond conscious control. Such raising COG from the position of balance is called rocking the base. The posture stability limit is separated from the mechanical (i.e. the edge of the feet) by means of a safety margin (SM). In a situation when the centre of gravity of the body is outside the safety margin, the implemented movement program is interrupted and the body has to select and apply an appropriate correction program. However, if the body's centre of gravity moves beyond a certain arbitrary line, i.e. the stability limit (BS), there is a fall. The body is unable to restore COG to its normal position, so it is impossible to regain balance. The stability limit may extend beyond the area marked by the foot envelope [4,5].

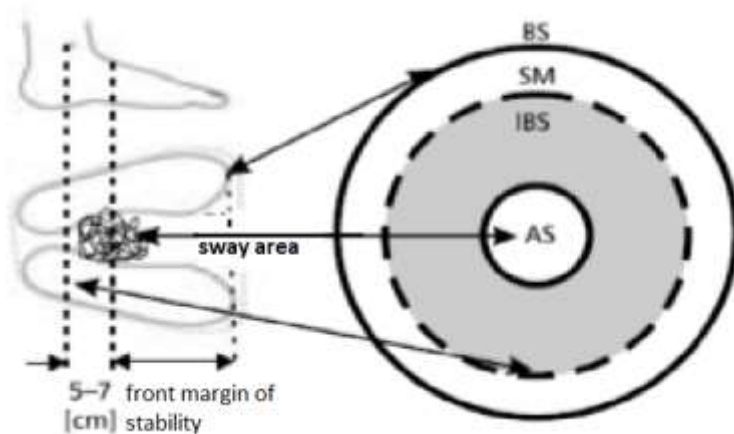


Figure 1. Heuristic model of human stability [4].

The balance of the body depends, among other things, on external forces and body composition. Morphological traits, i.e. body weight, directly affect postural control [2].

Overweight and obesity - causes and division

Obesity and overweight are treated as a global health problem. The results of epidemiological studies are alarming. In the last thirty years, the age threshold of people with excessive body mass is systematically decreasing. An extremely undesirable phenomenon is an increase in the incidence of overweight and obesity in the developmental population. The early occurrence of increased body weight has far-reaching health effects, leading to a greater likelihood of many other chronic diseases, lower quality of life and reduced efficiency of the human body in adulthood [6].

The World Health Organization (WHO) has adopted weight classifications based on the BMI- body mass index. BMI- calculated as weight in kilograms divided by square in meters [7].

BMI, kg/m ² Range	WHO Classification
< 18,5	Underweight
18,5-24,9	Normal range
25-29,9	Preobese
30-34,9	Obese class 1
35-39,9	Obese class 2
≥40	Obese class 3

Table 1. Weight Classification by Body Mass Index [7]

In practice, the WHR (waist-hip-ratio) index is also used. It is a simple measure of the so-called central obesity, i.e. excessive accumulation of fat in the abdominal area. When determining WHR, we measure the narrowest place in the waist and the widest place in the hips, and then divide the waist circumference through the hip circumference. The result obtained in women should not exceed 0.8; while in men, 0.9 [8].

Overweight should be treated as a condition before obesity, an alarming signal. This is the moment when you need to go for the right help to avoid obesity.

Obesity is a pathological increase in fat mass in the body (> 15% of the body weight of an adult male and > 25% of the body weight of an adult woman), which results in the impairment of the body's activity in many aspects of life. The consequence of such a condition is an increased risk of falling into various types of diseases and increased mortality. An important aspect of obesity is that it is not only increased fat mass, but also the accumulation of lipids in internal organs, ie liver, muscles, pancreas [7].

Two classifications of obesity are the most commonly used:

1. based on the causes of its formation,
2. based on anthropometric measurements.

The first division, based on etiopathogenesis, distinguishes:

- Simple obesity (primary, also called alimony), the cause of this type of obesity is a positive energy balance, which means inadequate, excessive supply of calories in relation to expenditure on particular types of metabolism. This type of obesity is caused primarily by environmental conditions, it means excessive consumption of highly processed food, which contains a huge amount of animal fats and simple carbohydrates, and significant reduction of physical activity is also important. This is the most common form observed among the developmental population, in particular among children.
- Secondary obesity, which may occur in the course of endocrinopathy (eg hypo-reflux, disease and Cushing's syndrome, growth hormone deficiency, hypogonadism). This type of obesity is observed among people suffering from genetically determined diseases (Prader-Willi, Lawrence-Moon-Biedl, Turner, and Klinefelter). Secondary obesity may also occur when the hypothalamus is damaged by inflammation, tumors, malformations, degenerative diseases and injuries of the central nervous system. Chronic use of certain drugs such as corticosteroids, phenothiazine derivatives, antidepressants and antiepileptics, insulin, sulphonyl urea derivatives, beta-blockers and others may increase the risk and directly affect the occurrence of obesity [10].

The second division is based on anthropometric studies and distinguishes two types of obesity. The risk of developing complications and the incidence of other lifestyle diseases varies depending on the type of obesity.

- Abdominal type (androidal, central, type "apple") its characteristic feature is excessive deposition of fat mainly in the retroperitoneal region. This type of obesity is associated with a greater risk of developing cardiovascular complications and metabolic syndrome, as well as some cancers.
- Breast-thigh type (gynoidal, peripheral, "pear" type), characterized by the deposition of fat mainly around the hips and buttocks. This type of obesity is more frequently observed in the female population as early as in puberty [6].

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Causes of excessive body weight

One of the reasons for the increase in the number of people with excessive body weight is too much energy supplied (overfeeding) in relation to its expenditure (physical activity). Among the reasons of overweight and obesity are also mentioned genetic, environmental-cultural and psychological factors [9]. It is recognized that genetic factors are responsible for the occurrence of obesity in only 25-45%. So far, no single gene has been detected that would be responsible

for the occurrence of increased body weight. The research results indicate that the inheritance of this disease is a phenomenon dependent on many genes. Nevertheless, the role of inheriting the tendency to experience excessive body mass is important. Recent scientific reports point to the role of vitamin D3 in the metabolism of the human body. It turns out that the deficiency of this vitamin affects the prevalence of overweight and obesity [6].

Epidemiology

According to the World Health Organization (WHO), around 1.6 billion overweight people live in the world, over 522 million obese people [8].

An unfavourable situation occurs in the United States. According to the Centres for Disease Control and Prevention (CDC) data, in 2009-2010 over one third of US adults (35.7%) were obese. Based on the results of the studies published in the MEDLINE database from 1990-2008, the authors showed that obesity in Europe concerns 4.0% -8.3% of men and 6.2% -35.6% of women. The highest obesity rates were found in Central, Eastern and Southern Europe, while the lowest in Southeastern Europe. The World Health Organization states that at the turn of 1980-2008 the number of obese people in the world has doubled. In 2008, 35% of adults aged 20 or over were overweight and 11% were obese.

Obesity is also a serious health problem in Poland. Research on individual food intake and nutritional status in households, conducted by the Institute of Food and Nutrition (IŻŻ) in 2000, prove that over half of adults aged 19-59 were overweight or obese. The percentage of men with obesity was 15.7%, and women 19.9%. In both groups, the prevalence of obesity increased with age [11].

The impact of overweight and obesity on the balance

Excessive body fat modifies the shape of the body, additional kilos are deposited in different areas of the body changing the load, which affects the biomechanics of the body during everyday activities. This causes functional limitations and is likely to predispose to more injuries. Increased body weight makes it difficult to change positions from sitting to standing, and also hinders walking. Scientific research proves that body weight is a strong predictor of postural stability. Obesity increases the CoP shift in a standing position [12]. Increased body weight causes instability and balance problems. People with a BMI greater than 30 kg / m² maintain their balance for a shorter time in comparison to people without excess weight [2]. In addition, overweight and obesity are usually associated with low muscle mass, which can

directly cause an inadequate muscle response in response to destabilizing forces, resulting in a poorer balance [13]. In particular, excessive weight increases the risk of falling among older people. It negatively affects the posture and balance, increasing the risk of functional problems [14].

Research

Barańska E. et al. in their study on the influence of obesity on motor organs and motor fitness, they examined 55 children, including 27 girls (49.1% persons) and 28 boys (50.9% people) aged from 12 to 18 years. Children were divided into two age groups: 12-14-year-olds and 15-18-year-olds. The average age was 14.73 years (± 1.48). The inclusion criterion was to diagnose overweight and simple obesity. On the basis of the height and weight of the subjects, the Body Mass Index (BMI) was calculated. The lowest rate was 24.6 kg / m², while the highest was 46.1 kg / m², and the average was 31.08 kg / m² (± 4.33). The share of overweight children in the study group was 41.82%, and children with grade I obesity - 40%, II degree - 16.36% and third degree - 1.82%. The children's balance was examined using the Eurofit test 1 (an equivalent posture on one leg). Analysis of the results showed that among boys, with the increase in obesity, the results of this test deteriorate [15].

Also Francesco Menegoni and others they decided to study the balance of people with excessive body fat. The study group consisted of 44 obese patients with BMI ≥ 30 kg / m². There were 22 women (mean age: 34.2 \pm 10.8 years, weight: 104.2 \pm 9.1 kg, BMI: 41.1 \pm 4.1 kg / m²) and 22 men (mean age: 34.2 \pm 11.0 years, weight: 123.8 \pm 15.7 kg, BMI) 40.2 \pm 5 kg / m²). The control group consisted of 20 healthy people; 10 women (mean age: 30.7 \pm 5.6 years, weight: 55.1 \pm 2.8 kg, BMI: 20.2 \pm 1.0 kg / m²) and 10 men (age: 30.2 \pm 5.0 years, weight: 70.6 \pm 6.6 kg, BMI: 23.0 \pm 2.2 kg / m²). The balance of the examined persons was examined using the posturo graphics platform. In males, body weight was correlated to all parameters, except angle, ($r = 0.36-0.58$, $P < 0.05$), while in females body weight was correlated with AP parameters ($r = 0.36-0.74$, $P < 0.05$) and with CoP velocity ($r = 0.35-0.74$, $P < 0.05$). The test results confirm the negative effect of overweight on the balance control [12].

Julia Greve et al. examined the correlation between body mass index (BMI) and balance in unipodal support. The study involved 40 men age 26 \pm 5 yrs, body mass 72.3 \pm 11 kg, height 176 \pm 6 cm and BMI 23.3 \pm 3.2 kg / m². Test subjects were submitted to functional balance using the Biodex® Balance System. Analysis of the results showed that the lateral-posterior and

lateral deviations increased with the increase in BMI. The authors of the study believe that greater body mass requires more displacement to maintain body balance [13].

Olivier Hue et al. also examined the effect of excessive body weight on postural balance. 59 men with BMI from 17.4 to 63.8 participated in the study. The balance of subjects was analyzed using a posturographic platform. Two research attempts were made: one with the presence of visual inspection and the other with no. With vision, the stepwise multiple regression revealed that body weight accounted for 52% of the variance of balance stability and Without vision, body weight accounted for 54% of the variance. The results indicate that increased balance disorders are correlated with increasing body weight [16]

D. Singh et al. in their work they investigated the influence of obesity on the postural sway. 10 people were tested with extreme overweight (BMI > 40 kg / m²) and 10 people with normal weight (BMI 18.5-24.9 kg / m²). Balance of the respondents was assessed by research on a graphic posture platform. The results indicate that obese people had greater balance disorders compared to people with normal body mass. In addition, body deflections increased faster with the standing time of obese people compared to the control group.

Summary

Literature analysis seems to confirm the supposition that excessive body mass affects the balance of the body negatively. The above studies indicate a strong correlation between body weight and an increased number of sways.

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