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Methods used to measure postural balance

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Abstract

Balance is one of the basic motor skills of a man. It is essential for the proper functioning of a human being, and every deviation from the norm strictly affects the quality of life. For the maintenance of the vertical position of the body it is a responsible interaction: the organ of balance, the sense organ of deep feeling, the organ of vision. The complex structure of the balance system requires appropriate research tools. Research techniques can be divided into: balance tests, instrumental techniques and system / physiological assessment. There is no single, universal research technique, so choosing the right tool should be dictated by individual research needs.

Postural balance

Postural balance is necessary to maintain the vertical position of the body, maintain stability during changes in the body position and perform everyday activities [1]. There are many definitions of balance in the literature.

Paszko-Patej G. et al. they determine the human balance as the ability to maintain the centre of mass projection (COM), located in the area of the lower abdomen, inside the support surface defined by the foot contour. Keeping the balance in a standing position is a process of continuous loss and recovery [2].

However, Pyskir M. et al. in their work they determine that the body is in balance if the conditions are met:

• the sum of external forces equals zero $\Sigma F = 0$

• the sum of the moments of forces equals zero $\Sigma M = 0$.

In addition, they divide the balance into three states:

• solid state - the body, after the activation of destabilizing forces, returns to balance after a specified time t1,

• neutral state - the body after the activation of destabilizing forces returns to balance after a determined change of position Δs,

• shaky state - the position of the centre of gravity of the body changes continuously, destroying the potential energy [3].

The ability to maintain balance can be disturbed by many factors, including diseases, drugs, involutionary changes.

Balance system - construction and functions

The balance system consists of several organs and senses:

• an organ of balance, ie the vestibular organ (labyrinth); there are special receptors in the inner ear, in its middle part, the so-called vestibule (otholic organ of saccule and utricle), as well as in the posterior part- in the ampulla of semicircular canals,

• the organ of the sense of deep feeling, is equipped with special receptors (proprioreseises), which are found in the muscles, tendons, fascias, joint capsules, vessels and internal organs; they record stimuli, i.e.: pressure, stretching and tension,

• eyesight [4].

Held-Ziółkowska M. distinguishes three general tasks of the balance system, i.e.:

• providing current data on the position of the body in space, the direction and speed of its movement,

• fast, anti-fall response, correcting any deviation of the centre of gravity of the body from the balance position within the base area,

• eye movement control in order to maintain a proper image of the surrounding space, during the movement of a given person, its surroundings or both simultaneously [5, 6].

Posture habits and strategies for restoring postural balance

During a calm state, the centre of gravity of the body (COG - Central of Gravity) moves involuntarily. These minimal deviations of COG from their normal equilibrium position are called displacements. The magnitude of these deflections depends on the efficiency of the equilibrium system, and their direction and speed does not have constant values [7].

Bodily uptake even during apparently maintained immobile body posture occurs due to several reasons: chest respiratory movements, heart movements and body fluids, as well as the fact that skeletal muscles are unable to maintain perfectly constant contraction force [7].

Taking into account balance control, posture stability can be divided into several areas. There are so-called the margin of stability (SM), the centre of gravity projection should be in the centre of the area. The size of this area is influenced by the age and the efficiency of the balance system. While standing calm, the body performs slight oscillatory movements that are beyond conscious control. Such deviations of COG from the equilibrium position are called the base rocking. The boundary of posture stability separates from the mechanical, i.e. the foot edge, the safety margin (SM). If the body's centre of gravity moves beyond the discontinued margin, the movement program is implemented and the body uses a specific correction program. However, if there is a situation in which the disturbances cause the centre of gravity to move beyond a certain arbitrary line, i.e. the stability limit (BS), there is a fall. The centre of gravity roll cannot be directly restored to its normal position, so it is impossible to recover the balance. The stability limit may extend beyond the area marked by the foot envelope [8, 9].

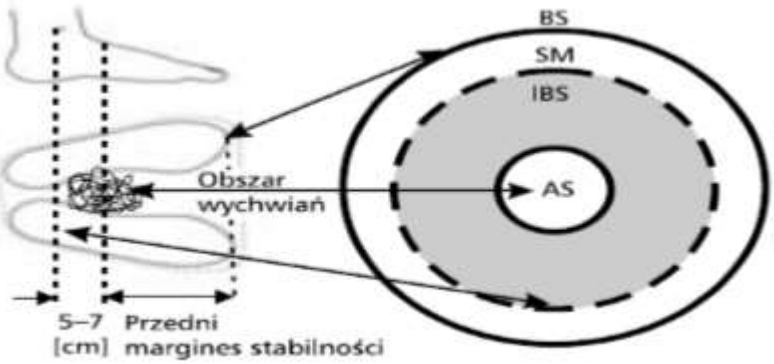

Figure 1 Heuristic model of human stability (Błaszczyk J. W., Czerwisz L., Stabilność posturalna w procesie starzenia, Gerontologia Polska 2005; 13(1); 25-36)

The human body has developed strategies for restoring postural balance. This process takes place in a sequential manner. At the beginning, disturbances in the balance are detected by the sensory system taking into account their type, size and direction.

There are three basic strategies for regaining balance:

- distal-proximal (ankle strategy),
- proximal-distal (hip strategy),
- balance management strategy (step strategy) [9, 10].

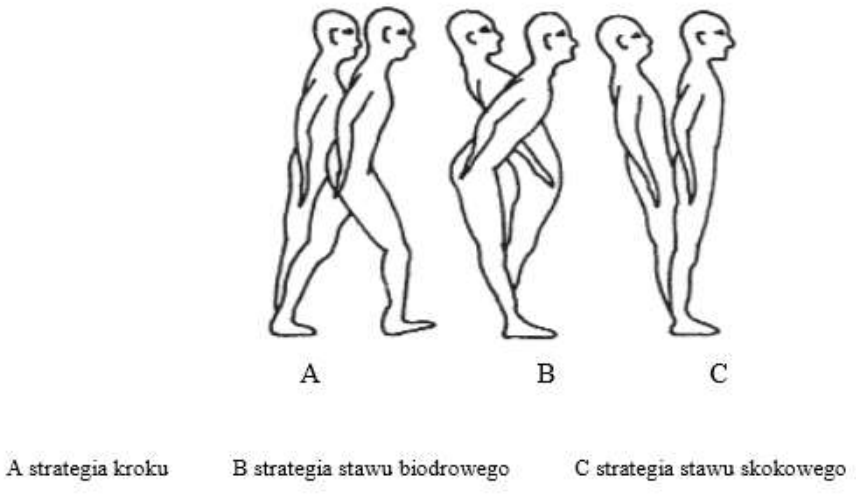

Figure 2 Motion strategies controlling the balance by maintaining the center of gravity within the support plane, in the pendulum model and in the two-valve model (Nashner 1993) (źródło: Horak F. B., Henry S. M., Shumway-Cook A., Postural Perturbations: New Insights for Treatment of Balance Disorders, Physical Therapy 1999; 77(5); 517-533)

The distal-proximal strategy starts with muscle contraction in the ankle joint, which causes slight flexion and extension movements in the ankle joints, thanks to which it is possible to maintain a vertical posture [7]. This strategy is only used if the person is standing on a rigid ground and the imbalances are small [8]. The effectiveness of this strategy consists in blocking the mobility in all major joints (hip, knee, intervertebral) and performing active movements only in the ankle joints [11].

The hip strategy involves muscle activation, starting from the thighs and torso, going down to the other muscles of the lower limbs. Activation of this sequence allows you to maintain the balance of a person standing on a narrow ground, which was affected by the same destabilizing stimulus.

The strategy used at the time of the strong destabilizing stimulus is the step strategy. It consists in making a run, which allows you to balance and protect against falling [8]. The choice and effectiveness of the strategy largely depend on the destabilizing stimulus, as well as how Nashner and others prove the size of the base surface, as well as the degree of centre of gravity deflection within the limits of stability and angular velocity of these deflections [8, 12].

Techniques of balance test

The main goals of the balance study are: determining whether or not imbalances occur and to determine the underlying cause of the balance problem. Determining whether there are problems with balance is helpful in predicting the risk of falling and assessing the effectiveness of treatment. Equilibrium assessment tools that allow you to distinguish type and balance problem can be helpful in choosing the type of intervention for more effective treatment of imbalances.

Ideally, quantitative, norm-referenced tools to assess postural control in the clinic should include measures that are: effective of both the functional capabilities and quality of postural strategies, sensitive and selective for postural control abnormalities, reliable and valid and practical (easy to use and inexpensive) [13].

Kuczyński M., Podbielska M. L. et al. in their article they divide the techniques of studying the balance into two groups:

• balance tests - a good working tool, which is characterized by simplicity but, unfortunately, also inaccuracy (eg 4-piece test for maintaining the balance, Romberg's attempt).

• instrumental techniques - very accurate tests, however, requiring specialized and expensive equipment with computer software (eg posturometers, platforms, three-dimensional balance test) [14].

The equilibrium tests allow only for a qualitative assessment of the examined feature, problems with postural balance can be described only in the form of a positive (disturbances are present) or negative (no disturbances). In addition, the study is subjective, general and inaccurate, and it does not provide an opportunity to assess the severity of the disorder, compare the examined characteristics in different groups of people and compare the results of the same person after some time [15].

In contrast, diagnostic (instrumental) methods allow for qualitative and quantitative assessment of balance and accurate analysis of equilibrium parameters using different technological solutions. In addition, the test is completely objective and the results are easy to compare.

Among the techniques of the study of equilibrium, it is also worth distinguishing the test group, which is described by Martin Mancini and Fay B Horak. The authors distinguish systems / physiological assessments. The systemic approach aims to identify the basic causes of balance problems. This group includes: the Balance Evaluation Systems Test (BESTest) -focuses on differentiating the balance systems affected and The Physiological Balance Profiles on identifying the physiological mechanisms of underlying balance [13].

Summary

There are many tools to measure balance. However, there is no one universal study that combines all the required and needed qualities. Therefore, the selection of an appropriate research technique should depend on the individual needs of the researched person or scientific research. In many cases it will be necessary to use more than one research technique to carefully assess the state of body balance.

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