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Static posturography as an instrument to assess the balance among athletes

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Summary

Equilibrium is defined as the ability to maintain the roll centre of gravity (centre of mass - COM), which is located in the abdomen, inner support surface defined by the contour of the foot. The process to maintain standing balance involves continuous loss of balance and recovery [1]. The balance is considered to be the basic motor skills and is especially important for athletes. Examination of postural balance is a troublesome scientific issue, but static posturography allows for a reliable assessment of this aspect.

Balance

Balance is defined as the state of the body, in which the sum of forces acting on them is zero. It follows the stabilizing internal forces, i.e. the motor effect of the nervous system, should balance the destabilizing external forces. This means that the body can be at rest or in motion at a constant speed. If the body wobbles around a certain resting position, and should be at rest, the greater amplitude of these tilts means worse balance [2].

The condition of the body to remain in balance is a constant tense muscles and anti-gravity changes the voltage must be corrected by the pulses coming from the organ of balance. With this operation there is only a small deflection centre of gravity. Also they play a significant role postural reflexes that occur as a result of stimulation of the vestibular apparatus in the head deviation from the vertical position. In the process of maintaining the balance of body they are also important in deep feeling and about eyesight [3, 4].

Equilibrium system

At the equilibrium system consists of the interaction of several organs and senses:

- **organ of balance**, the vestibular (labyrinth), which is equipped with special receptors located in the inner ear (labyrinth) in its central portion (ear vestibule) and in the rear portion, that is, ampulla of the semicircular canals;
- **feeling a deep sense organ,** which receptors (proprioceptors) are located in the muscles, tendons, fascias, joint capsules, vessels and internal organs; these receptors register stimuli such: compression, tension and strain
- **eye** [5].

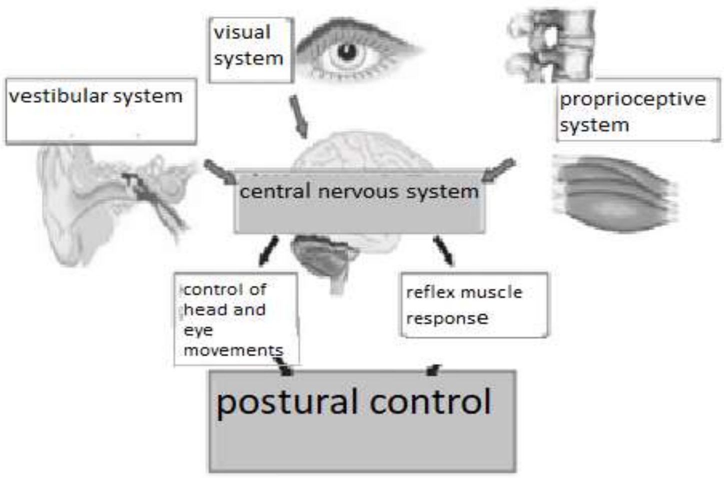

Figure 1 **Postural control** (źrodlo: Kuczyński M., Podbielska M. L. I in., Podstawy oceny równowagi ciała: czyli co, w jaki sposób i dlaczego powinniśmy mierzyć?, Acta Bio- Optica et Informatica Medica. Inżynieria Biomedyczna 2012; 18(1); 243-249)

The vestibular organ appears to be the main element of the equilibrium system, which is supported by the study of the etiology of the disturbances of equilibrium. The vestibular apparatus is located in the membranous labirynth. It is made of a saccule, utricle and three semi-circular ducts. The vestibular apparatus is filled with a liquid called lymphaden (endolymph).

The receptor cells (sensory) of the sense of balance are found in the saccule, the gullet and in the extensions of semicircular ducts, so-called membranaceous ampulla. These cells owe their name to the hairs they are equipped with. Hairs are in the cell's pole, which is directed to the inside of the membranous labyrinth. The second pole of the cell connects to the vestibular nerve (part of the VIII cranial nerve). The gelatinous substance that clusters the hair of the receptor cells forms the tubule in membranous membranes and the otolithic membrane in the saccule and utriculus. In the otolithic membrane there are otoliths - small pebbles made of calcium carbonate [3, 4].

Vestibular can be divided into the peripheral and central part.

- Peripheral part:

1. saccule,
2. utriculus,
3. three semicircular canals,
4. vestibular nerve trunk to the level of the brainstem,
5. area-pontine cerebellar angle.

- Central part:

1. vestibular nuclei of the brainstem,
2. the combination of these nuclei with other CNS structures: the cerebellum, spinal cord, other stem nuclei, reticular creation,
3. atrial field in the cerebral cortex [5, 6].

Otoliths in the otolithic membrane have a greater specific gravity than the endolymph, thereby moving the head otholits follow the movement with a slight delay. Hairs in receptor cell and otolithic membrane at the beginning deflected in the opposite direction of head movement, inertia is due to the otoliths, but then return to its original position. Receptors saccule and utriculus does not react when the head is tilted, record in static mode only minor deviations from the vertical position of the head. Utriculus receptors react to sudden dynamic motions forward and record the linear acceleration from approximately 0.05m / s2. Saccule receptors are stimulated in the same way during the vertical movements of the head, for example jumps. The reaction of the utriculus receptors is the result of sudden acceleration initial inflection hair back. Therefore, in the initial phase of the run person opposes, leaning forward strongly and straightens out when the otoliths in macula of the utricle will return to normal position [3, 4].

Semicircular canals are arranged relative to each other at right angles. The widening of each canal (membranaceous ampulla) is a crista ampullaris and on top of it are hair cells. Hairs through the conglomeration being gelatinous form a dome. The top of the dome is partially attached to the ceiling ampulla. Rotational movement of the head causes movement of endolymph that exerts pressure on the dome, which causes a change in its shape and bending the hairs.

Receptors of the crista ampullaris are stimulated by the bank returns the body causing sudden head movement, since they react to changes in the rotation head, that is, angular acceleration, a value of 1 ° / s^2. This information already warns movement centres ,that will change the position of the body. If the expected position is adjusted in the appropriate connection of different muscle groups [3, 4].

Each receptor cell is equipped with one long hair - kinocilum (or kinetililium) and 60 to 120 shorter hairs - stereocilia. The hair tips connect the thin fibers of the so-called apical connectors. Balance organ cells are stimulated in a similar way as in the case of capillary cells in the hearing organ.

Movement of the otolithic membrane causes the kinocilium to bend, in the same direction, stereocilia bends, which are pulled by the conjunctivus. In this way, a force is created that stretches the stereocilium membrane, resulting in the opening of the ion channels contained therein. The K + ions pass through the open channels into the cytoplasm of the receptor cell, resulting in the depolarization of the cell membrane. Depolarization of the cell membrane causes the opening of voltage-dependent calcium channels, so a certain amount of Ca2 + ions gets from the outside into the cell. Cell depolarization increases. Then the potassium channels are opened, which are sensitive to the concentration of Ca2 + ions. Then a certain amount of K + ions escapes from the inside of the cell to the external environment, resulting in a reduction in depolarization. Interactions that occur between calcium and potassium currents lead to an oscillation of the intracellular potential that regulates the release of the neurotransmitter in the synapse between the capillary cell and the end of the vestibular nerve fiber.

Atrial nerve fibers conduct at rest of about 100 impulses within 1s. The conductivity increases several times when the cells are stimulated when bending the hair towards kinetocilium. However, excitability decreases significantly when the hair bends away from the kinetocilium [3, 4].

Atrial nuclei belong to the central part of the equilibrium system. They are part of the vestibulo-oculist reflex arc and vestibulo-spinal reflexes. Information from the vestibular apparatus is transmitted by the vestibular nerve to the vestibular nuclei. From the upper and medial vestibular cortex, the medial longitudinal tuft of the testicles, which are responsible for the movements of the eyeballs. This connection is an element of the arch of the vestibulo-right reflex, which is designed to adjust the position of the eyeballs to changes in the position of the head, so that the observed object does not disappear from the field of view. Information from the lower vestibular nucleus is directed to the cerebellum and reaches the flocculonodular lobe which is responsible for maintaining the balance of the body.

The vestibular nuclei are two ways vestibulospinals: the medial and lateral, they are important in the regulation of muscle tone. Route medial nucleus begins in the upper and medial and extends to the centres of the spinal cord supplying the muscles of the neck. Voltage change these muscles cause a change in head position. While the side road begins in the nucleus and vestibular side it is important in correcting muscle torso and lower limbs. These muscles play a significant role in maintaining the vertical position of the body [3, 4].

Visual inspection it is an important component in maintaining the balance of the body. Sight allows the orientation of the body position in space, and the focus of vision at one point facilitates the maintenance of a balance [7]. Many studies have been conducted that compare the stability of body conditions: full control of the sight and without visual control. It can be seen, the correlation between the amount of deflection of the human body with eyes open and closed. Numerous studies indicate that when the eyes are closed markedly higher ranges imbalances of the body. Hunter and Hoffman in his study on the balance prove that the exclusion of control leads to a deterioration of sight postural stability [8].

Proprioception, or deep feeling is the sense of orientation, which allows you to feel the schema of the body, the arrangement of its individual parts relative to one another and the position of the body in space. Proprioceptors are located in muscles, tendons, ligaments, fascias and joints. Their task is to transfer information from the mentioned structures about the position of body parts and their movements to the nerve centers at the level of the spinal cord and midbrain, which gives rise to reflex reactions [9, 10].

The sense of proprioception can be divided into:

• a conscious component,

• unconscious component [9, 11].

Archeoproprioception is component of the unconscious. It refers to the flow of signals from proprioceptors peripheral that reach the oldest subcortical structures CNS (spinal cord, midbrain, cerebellum). It is essential to stabilize the joint, both functional, static and dynamic.

While the component of the conscious is a special kind of sense of touch, indicating the position and feeling the movement in the joint (kinaesthesia). Conscious proprioception component reaches the cerebral cortex [9].

Techniques balance test

Balance test based on measuring the movements of the human body, which is either free or is subjected to a disturbance. While standing motionless, you will notice minor raising of body from the vertical, which reflects the activity of the equilibrium constant and indicates the continued operation of the system dynamics. The amplitude of sway will increase from the feet to the head, as in the case of static body behaves like a one-segment inverted pendulum. Value sway in the vicinity of the center of mass of the body is about 10-20 mm and that the value (displacement of the center of mass of the body relative to the bearing plane) is a balance tests important source of information. Balance test was conducted decades ago, before they were introduced more modern and accurate measuring devices [2].

The balance can be tested using techniques are divided into two groups:

- balance tests - simple and good working tool, but at the expense of accuracy (eg. 4-part test to maintain a balance, trying Romberg) [2].
- instrumental techniques - very accurate, but require specialized expensive equipment and computer software (eg. posturometry, platforms, three-dimensional examination of balance)

Balance tests give only a qualitative picture of the examined characteristics, balance problems can be assessed only in the form of positive (from occurring disorders) or negative (without deviations from conventionally accepted norm). In addition, the survey is subjective, general and imprecise and does not allow for an assessment of the severity of disorders, the study comparing the features of different groups of people and to compare the results of the same person after some time (eg. the equivalent of training athletes) [12].

In contrast, diagnostic methods (instrumental) allows for a quantitative assessment of the balance and accurate analysis of balance parameters using different technologies.

Posturography

Stabilometric platforms, allow for simple, fast and reliable evaluation of the stability of the patient in the standing position. Static posturography provides information on the balance on the basis of small, involuntary movements of the body's center of gravity during quiet standing with both feet or one leg on the platform. The test may be performed with eyes open and closed, allowing the analysis of the process of maintaining static equilibrium during full control of sight and turned off after [13]. Posturographic platform is a plate of small size (50 × 50 cm) having strain gauges recording force and moments exerted on the ground by the feet of the subject. In four supports placed in the corners of the platform are sensors, which detect displacement of the centre of gravity of the subject's body in the plane of the platform. Displacement values are digitized, and then recorded in the computer system on an ongoing basis and presented on the monitor. On the basis of these parameters is calculated position of the centre foot pressure, which on standing is the projection centre of gravity (COG) on a plane support. After the test, using a computer calculated the standard parameters of each measurement, and the computer automatically performs the basic analysis of the recorded signals and gives the test result. The study did not require any preparation of the patient. Posturography can be carried out under various conditions, normally in a standing position, with eyes open, and then closed with. The person examined during the test must stand still. The test can also be carried out using the visual feedback by showing the point of instantaneous position of the centre of gravity of the monitor screen as mobile spots, this allows the execution of the test hand-eye coordination. At the height of the axis of sight of the subject is the monitor. The person examined by observing the position of its centre of gravity corrects its position by means of voluntary mobility. Thanks to posturographic research you can analyse many important parameters:

- The length of the curve - the length of the road, covering the COG. In people with impaired balance this road is usually extended. Analysis of the individual components of that route, i.e. sway in the sagittal plane (X) and in the frontal plane (Y) can provide additional information.
- Sway range - in the X and Y plane. Individual ranges is defined as the difference between the maximum deviations of the centre of gravity along the respective axis.
- Developed area of graph of pressure centre deviations - envelope analysis based on a combination of extreme points of graphs lines. Arises irregularly shaped polygon and the computer calculates the surface area.
- Radius - in order to simplify the analysis fits sway points in a circle, or ellipse. The geometrical dimensions of the resulting figures, for example, the radius of the circle described or length of rays and tilt axis of the ellipse, are other important indicators of the quality of control of balance.
- The average speed - is calculated during the displacement of the COG complex task separately and components X, Y [14].

Posturography has many advantages in favour of that, this is one of the better methods for testing balance. First of all, this study is objective, reproducible, and the results are easy to compare. The survey can be carried out under different conditions, and the subjects do not have to be specially prepared, which is particularly important when testing athletes who train in different places and conditions.

Balance in sport

Postural balance is essential for the proper functioning of people, and its quality is especially important for athletes. The level of training of the equilibrium system in many sports can be a determinant of the results achieved. Stability of posture is essential for competitive sporting. Maintaining balance in various environmental conditions (eg moving ground, wind) is a complicated task depending on many components that make up the balance system. Due to the large amount of information and the complex structure, the process of posture control is still not fully understood, however, it is certain that sports activity affects its performance [15]. Depending on the sports discipline, these changes may have different character [16]. For example, people training shooting show very good balance while standing on both feet, while gymnasts are characterized by high balance while standing on one leg [17].

Summary

There are many methods to test the balance among athletes, however, posturography seems to be the best method, not only because of its objectivity and ease of implementation, but mainly because of its repetition and the ability to compare results. Regular checking of the balance of an athlete can help in the selection of the most effective type of equivalent training, determine what progress the athlete makes in the field of posture control, and also help in assessing the current form of the player.

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