

DOI: 10.26693/jmbs03.04.124

UDC 617.559:616.18-007.271-037

Fedotov V. V.

## GAIT – PATHOLOGY OR PHYSIOLOGY

Kharkiv National Medical University, Ukraine

ibolokadze@ukr.net

The study presents the research of some mechanisms of human gait formation, and their clinical significance. The studies were performed in 4 patients with Parkinson's disease, 5 patients suffering from ischemic stroke, 4 patients with peroneal nerve neuropathy, and 2 patients with myopathy. The comparison group involved 7 healthy volunteers. 15 patients and 7 healthy volunteers, who were the control group, investigated the electromyographic and biomechanical features of the gait. In addition, interesting features of the footwear soles of these patients are also given. The article states that in all patients, with the exception of volunteers, the data of electromyography have shown the pathological process at different parts of the gait formation in a person. The nature of the changes was different and has shown the defect of some anatomical structure involved in the act of walking or biochemical defect. The inclination of the pelvis also depends on the patient's pathological condition. The study of footwear soles showed that the peculiarity also depends on a person's gait and testifies to his physical and mental health. A high-frequency, high-amplitude curves were recorded during muscle contraction in healthy volunteers. There were recorded "firing" of spindle-shaped escalation of the potentials amplitude and subsequent decrease in patients with Parkinson's disease. In patients with myopathy, the amplitude and duration of potentials were reduced. The singular potentials irregular in amplitude and frequency were recorded in patients with peroneal nerve neuropathy. Generally, all electromyograms were characterized by low amplitude activity. Only one patient had "full bioelectric activities absence", talked about the death of most nerve fibers and the depression of bioelectric activity of the muscles. In accordance with biomechanical examination in the vertical position, the vertebral-pelvic balance is regulated by the neuromuscular system, which minimizes the work of the muscles to maintain a vertical posture. The violations in the system of neuromuscular transmission also change the parameters of the vertebral-pelvic balance – the PI score may also be important in the diagnosis in patients with gait abnormalities. The conclusions present that the person's gait is being individual and absolutely unique. It testi-

fies both to health, and about a possible pathology. The type of pathological gait depends on which links of the locomotor chain has suffered: corticospinal tract, extrapyramidal system, musculoskeletal system. In setting the correct diagnosis in the presence of a pathological gait, the main place belongs to the clinical examination, as well as electromyography and biomechanical examinations.

**Keywords:** gait, electromyography, corticospinal tract, biomechanical examination.

**Research relation to the plans, programs and department themes.** The study was carried in accordance with the research plan of the State institution "Sytenko Institute of spine and joints pathology National Academy of Medical Sciences of Ukraine" ("Study of the mechanisms of degenerative lumbar spine stenosis development"; state registration number 0110U002088).

**Introduction.** A man's gait is the most natural locomotion, an automated motor act. Like handwriting or fingerprints, the gait can tell about a person's mood, about his/her state of health. In addition, the gait may be a sign of some kind of diseases. Individual features of the gait consist of the size of the steps, speed, position of the body and head, the commonwealth of the movements of the hands. To take a step, a lot of effort is needed: in the hip, knee, ankle joints, the joints of the foot and even the hands. There is a need to work the muscles of the legs and arms, the muscles of the chest and the lumbar. This complex motor process is strictly coordinated by the central nervous system. The act of the gait also involves the organs of vision and hearing [2, 3].

The tasks of the gait, as an important locomotive function of a person are the following: safe linear forward movement of the body; hold the vertical balance, preventing falling during movement; security of energy, use of the minimum amount of energy due to its redistribution during the cycle of the step. All of the above points suggest that gaits studies are important for evaluating the patient's functional capabilities. Despite clinical significance and widespread prevalence, gait disturbances have not been the subject of special study until recently [1–4]. All these factors determined the timelines of this study.

**The purpose of the study** was to research some mechanisms of human gait formation, to study some electromyographic (EMG) and biomechanical features of gait in pathological conditions and healthy volunteers.

**Material and methods.** All examinations were conducted in SE Sytenko Institute of spine and joints pathology NAMS of Ukraine. The studies were performed in 4 patients with Parkinson's disease, 5 patients suffering from ischemic stroke, 4 patients with peroneal nerve neuropathy, and 2 patients with myopathy. The comparison group involved 7 healthy volunteers.

**Results and discussion.** The gait of a person is a peculiar kind of two-legged movement, in which the support for one leg cyclically changes the bi-axial period, and then the support to the other leg. Gait is figuratively described as "controlled fall". At each new step, the person bends over and begins to fall, which is hampered by the advanced leg. After it touches the earth, the weight of the body is transferred to it, the knee bends, and erects, returning the body to its original position. That is why many authors represent gait as a model of the "inverted pendulum".

Here's how in the simplified version the first step is formed: the central nervous system sends a preformed sequence of commands to the muscles. At the spinal level, only the simplest coordinating reactions proceed, however, the spinal cord can perform quite large functions, up to the "spin pitch" in animals (so-called spinal automatism). Such qualities of motion as smoothness, accuracy are realized with the participation of the cerebellum and extrapyramidal system by regulating the temporal, velocity and spatial characteristics of motion.

It becomes clear that gait disturbances may accompany with motor disorders that arise in diseases of any system, takes part in the formation of an act of walking – muscles, peripheral nerves, spinal roots, pyramidal tracts, cerebellum, extrapyramidal formations, as well as an axial skeleton and auditory and visual analyzers.

The gait disorder is a very valuable diagnostic indicator. Shambling walk together with lowered shoulders and head, trembling hands are the symptoms of Parkinson's disease. Parkinson's disease affects the area of the extrapyramidal system, which is called a black substance, where a neurotransmitter, dopamine, is produced, whose function is to smoothly transfer impulses to ensure normal movements. The production of dopamine, and disturbs of the normal transmission of nerve impulses is reduced in patients with Parkinson's disease and thus appear the main symptoms of parkinsonism.

If a person has suffered from stroke, localized in the internal capsule, then during walking he/she falls

on one side and makes a characteristic movement: the arm is pressed against the body, the foot is set aside.

A swinging "goose gait" is observed at congenital bilateral dislocations of the hip joints and myopathy, diseases in which pathological changes occur directly in the muscles or joints [4].

"Peroneal gait" occurs when paresis of the extensor muscles of the foot appears, or there is the injury of the fibular muscles and / or the injury to the fibular nerve, which innervates this muscles group. The patient raises his leg high, throws it forward and drops sharply.

High-frequency, high-amplitude curves were recorded during muscle contraction in healthy volunteers. "Firing" of spindle-shaped escalation of the potentials amplitude and subsequent decrease were recorded in patients with Parkinson's disease. In patients with myopathy, we recorded that the amplitude and duration of potentials were reduced. In our view, this was due to decrease of the number of normal muscle fibers that can be active.

There were recorded the singular potentials irregular in amplitude and frequency singular potentials in patients with peroneal nerve neuropathy. Generally, all electromyograms were characterized by low amplitude activity. In one patient, we recorded "full bioelectric activities absence", talked about the death of most nerve fibers and the depression of bioelectric activity of the muscles.

Based on the obtained data, in all of the patients whom we were observing, we recorded EMG data which evidence pathological process. So, electromyography examination allowed objectifying the level of changes in the process of neuromuscular transmission in various diseases.

The design of the movement plan, like as its implementation, is carried out by the center controlling the posture (the motor part of the cerebral cortex), using the previous planning experience and sense of the body position. There is the possibility of "pre-programming" of motion due to direct connections between the cerebral cortex and the vestibular system. It is considered as the basis for maintaining balance and posture.

The least energy-consuming is the "convenient type" of standing and walking, in which the projection of the common center of mass locates behind the shoulder and knee joints and in front of the hip joint. The vertical posture, biomechanically and ergonomically ideal, provides physiological curves of the spine, normal values of spine-pelvic balance parameters (the relationship between the waist, lumbar vertebrae and the head of the femur), and the neutral position of the main joints of the lower extremities.

The vertebral-pelvic balance is the state of the sum of all the bends of the spine, in which, in the standing position (according to X-ray data), the line drawn through the center of the vertebral body C7 and the center of the disk L5-S1, parallel to the slope line, and which is necessary for the optimal function of the spine (Fig. 1) [5].

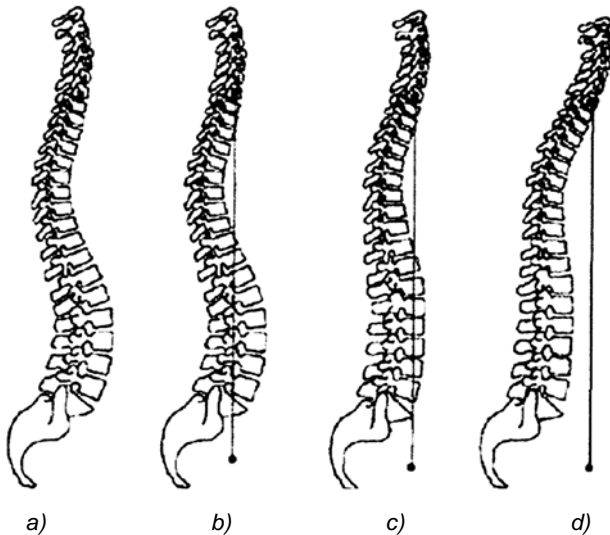


Fig. 1. Vertebral-pelvic balance: a), b) – normal; c), d) – dysbalance

The PI (pelvis incidence) value is the constant for the subject, determines other pelvic parameters and is the major parameter in the regulation of the spinal centering in the formation of the human gait. That's why we decided to determine this parameter in the patients. PI is the angle between the line connecting the middle of the upper surface of the sacrum (O) with the center of the head of the femur (F) and the perpendicular to the upper surface of the sacrum, restored at the point O (Fig. 2).

The parameter PI is anatomical and in patients it varies depending on the observation group, and depends on the pathological condition:

- PI (50.1°) – patients with peroneal nerve neuropathy and volunteers;
- PI (less than 35°) – patients with stroke;

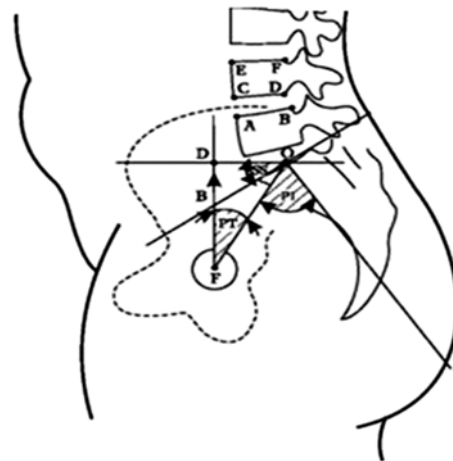


Fig. 2. Measuring the parameters of the vertebral-pelvic balance (PI value)

- PI (between 35° and 50.1°) patients with myopathy and Parkinson's disease.

What can explain such variations of PI in our patients? In the vertical position, the vertebral-pelvic balance is regulated by the neuromuscular system, which minimizes the work of the muscles to maintain a vertical posture. Therefore, it is logical to assume that the violations in the system of neuromuscular transmission also change the parameters of the vertebral-pelvic balance. So, the PI score may also be important in the diagnosis in patients with gait abnormalities.

### Conclusions

1. The person's gait, being individual and absolutely unique, testifies both to health, and a possible pathology.
2. The type of pathological gait depends on which of the links of the locomotor chain has suffered: corticospinal tract, extrapyramidal system, musculoskeletal system, etc.
3. In setting the correct diagnosis in the presence of a pathological gait, the main place belongs to the clinical examination, as well as electromyography and biomechanical examinations.

**Further studies** will be focused on the investigations of the formation of the first step.

### References

1. Haas B. *Motor control*. In: T Everett (eds): Human Moment: Human Kinetics Publishers. 2010. p. 49-58.
2. Bennett MR, Harris JWK, Richmond BG, Braun DR, Mbua E, Kiura P, Olago D, et al. Early Hominin Foot Morphology Based on 1.5-Million-Year-Old Footprints from Ileret, Kenya. *Science*. 2009; 323: 1197–2001.
3. Mayer TG, Smith SS, Keeley J, Mooney V. Quantification of lumbar function. Part 2: Sagittal trunk strength in chronic low-back pain patients. *Spine*. 1985; 10 (8): 765-72. PMID: 2934831.
4. Rose J, Gamble JG. *Human Walking*. 3rd ed. Philadelphia: Lippincott Williams & Wilkins, 2006. 234 p.
5. Marty C, Boisauvert B, Descamps H, Montigny JP, Hecquet J, Legaye J, Duval-Beaupère G. The sagittal anatomy of the sacrum among young adults, infants, and spondylolisthesis patients. *Eur Spine J*. 2002; 11 (2): 119-25. PMID: 11956917. PMCID: PMC3610511. DOI: 10.1007/s00586-001-0349-7.

УДК 617.559:616.18 – 007.271-037

### **ХОДА – ПАТОЛОГІЯ АБО ФІЗІОЛОГІЯ**

**Федотов В. В.**

**Резюме.** У статті наведені дослідження деяких механізмів формування ходи людини, їх клінічна значимість. У 15 хворих і 7 здорових волонтерах, які були контрольною групою, вивчались електроміографічні і біомеханічні особливості ходи, а також приведені цікаві особливості підметків їх взуття.

У статті відмічається, що у всіх хворих, за винятком волонтерів, дані електроміографії свідчили на користь того чи іншого патологічного процесу на різних ланках формування ходи у людини. Характер змін був різним і свідчив на користь ураження тієї чи іншої анатомічної структури, яка бере участь в акті ходи, або свідчить о біохімічному дефекті. Параметр нахилу тазу також змінювався в залежності від патологічного стану хворого. Дослідження підметків показали, що ця особливість також додає відомості про фізичний і психічний стан людини.

**Ключові слова:** хода, електроміографія, пірамідний шлях, біомеханічні дослідження.

УДК 617.559:616.18 – 007.271-037

### **ПОХОДКА – ПАТОЛОГІЯ ИЛИ ФИЗИОЛОГИЯ**

**Федотов В. В.**

**Резюме.** В статье приведены исследования некоторых механизмов формирования походки человека, их клиническая значимость. У 15 больных и 7 здоровых добровольцев, которые были контрольной группой, изучались электромиографические и биомеханические особенности походки; кроме того также приведены интересные особенности подошв обуви этих пациентов.

В статье отмечается, что у всех больных, за исключением волонтеров, данные электромиографии свидетельствовали в пользу того или иного патологического процесса на разных звеньях формирования походки у человека. Характер изменений был разным и свидетельствовал в пользу поражения той или иной анатомической структуры, участвующей в акте ходьбы или биохимическом дефекте. Параметр наклона таза также менялся в зависимости от патологического состояния больного. Исследование подошв обуви показали, что особенность так же зависит от походки человека и свидетельствует о его физическом и психическом здоровье.

**Ключевые слова:** походка, электромиография, пирамидный путь, биомеханические исследования.

Стаття надійшла 20.03.2018 р.

Рекомендована до друку на засіданні редакційної колегії після рецензування