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DIAGNOSIS AND TREATMENT USING "ZEBRIS" DEVICE IN PHYSIOTHERAPY

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Abstract: *Modern diagnostic and treatment methods are insufficiently represented in our region. The very analysis of the gait, observation and study of the way of walking can lead to the medical history and assumption of the course of the patient's illness, before the examination has even begun. However, by using the "Zebris" device, the diagnosis of the disease itself can be determined in more detail and, based on the determination of its nature, the disease itself can be treated in modern, more effective ways, using software that enables the implementation of gait training in virtual reality while performing tasks that require constant variations in gait and balancing, and which at the same time motivate both the patient and the therapist towards better, faster and more efficient treatment. The paper discusses the evolution of man and bipedalism, biomechanics and muscle activity in the walking phase, the joint-movement-muscle relationship, the roles of body segments in walking, the walking cycle, and how all this can be monitored with the help of the "Zebris" device. The description of how the device works, the diagnostics and the parameters obtained with this device are the core of the work, because on the basis of it, a comparison of the gait of a healthy and sick person can be made. Also, "Zebris" offers the possibility of conducting therapy with the aim of training for activities of daily life with the monitoring of gait parameters on the sensor strip and the use of a screen, as one of the forms of feedback that gives the patient and the physiotherapist a new dimension of therapy, but also the possibility to improve cognitive skills they try and improve the patient in the very phase of recovery. The goal of this work refers to the expansion of the horizons and possibilities that this device provides, but also to the development of new technologies, virtual reality and artificial intelligence (eng. artificial intelligence - AI), which can raise diagnostics and rehabilitation in physiotherapy to a completely new level and which will bring Bosnia and Herzegovina closer to Europe in its daily work. This research proves that diagnosis and treatment with the "Zebris" device leads physiotherapy towards new technologies in Bosnia and Herzegovina.*

Keywords: *"Zebris", diagnosis, treatment, gait, new technologies*

Introduction

An overall aging population and longer life expectancy will drive more patients to seek medical care to reduce age-related musculoskeletal deterioration and injury. This burden is not isolated only to the elderly population, but also to the lifetime of individuals who suffer from high and low energy orthopedic trauma from sports, work and everyday life. Through advances in technology, post-injury rehabilitation takes advantage of these opportunities and raises the bar for accelerated recovery, standardization of treatment, closer discharge, and reduced disability [1].

The diagnostic process is very important for the course of treatment itself. It is our basic guide that is used at the beginning, during and at the end of the treatment process itself. For medical professionals, this process is a map that leads to healing. However, misdiagnosis leads to the wrong choice of treatment methods, which can, in some cases, be fatal for the patient. For this reason, better, faster and more efficient treatment results can be achieved by following world standards, constant training of staff, as well as by applying special methods of patient observation.

Subjective examination of gait, scales and tests such as: manual muscle test, 6-minute gait test, mini mental test, Bartel or Film test, Brooke and Vignos scale [2][3], tests such as measuring movement in space, activity muscles, and energy consumption, give us an insight into the assessment of motor skills. Even though we can use them to get tested and reliable results, there is always a search for faster, better and more precise methods and machines. One of such machines is "Zebris", which with its characteristics and performance has proven a new level of use in physiotherapy and other branches of medicine.

Evolution and development of bipedalism through life cycles

Assessment of gait, its analysis and understanding is one of the basic assessments in physiotherapy. In order to understand gait itself, it is necessary to observe the origin of gait, the appearance and evolution of bipedalism, as well as the development of gait in children; during life, until late life, as well as its relationship with body posture.

Evolution of bipedalism

During the development of bipedalism through human evolution, there were anatomical changes, as well as changes in the structure and arrangement of bones and muscles, especially in the foot. The man of that time began to flex his knees, to stabilize himself and stand on one leg. The gluteal muscles are responsible for this stabilization, which enables standing on one leg and connecting the pelvis and femur. Also, there is a shift in the valgus angle allowing the feet to be placed directly below the center of gravity during walking [2].

The lifting of the front limbs at that time resulted in the fact that the surface of the support decreased, and the center of gravity of the body rose upwards. Then, the powerful stance was reflected in the body's center of gravity, which was shifted forward, which required greater expenditure of energy and increased activity of the extensor muscles of the gluteus maximus, m. quadriceps femoris and m. triceps surae in the hip, knee and ankle joints. Also, for the balance of the upright posture, the muscles of the abdominal and back musculature such as m. rectus, transversus abdominis and m. the erector spinae had to be additionally activated. All those muscles became static, opposing the forces of gravity [2].

Although upright walking required a lot of effort, time and risk, with disadvantages such as overloading the spinal column and lower limbs, difficulty in breathing and transporting blood to the brain [4], bipedalism carried an advantage over other groups, species and populations. The upright position provided a better overview of the surroundings, which resulted in better orientation in nature. They got the ability to reach up and reach things, and better use of hands and a more flexible thumb gave potential for new possibilities, which was reflected in the realization of more complex kinetic structures with brain development [2].

Development of gait through life cycles

Growth and development, as two processes that cannot be separated from each other, are the basic characteristics of children's age. Growth represents a quantitative change, and development a qualitative change. Their connection through the increase in dimensions, mass of the body, organs, tissues and cells, as well as their changes in structure and maturation, give the whole of the child's physical, psychological and social maturation. The most significant development for humans is the one that takes place in the infant period of life. Then comes the basic development of motor skills, oculomotor vision, hearing, speech and sociability. The infant occupies various positions of the body which are the basis for their further development. In practice, the following positions can be recognized:

Table 1. Stages of child development per months [5]

0 month	position of total flexion
1st month	process of craniocaudal extension (lifting the chin, face and neck)
3rd month	resists on the forearms and elbows
3rd-6th month	rests his/her palms on the base with outstretched elbows, the head and neck are vertical on the base and starts turning
3-5th month	on the back, posture is initially asymmetrical, then symmetrical
5th month	lifting the head from the base
3rd month	head briefly follows the axis of the body
6th month	the head actively follows the axis of the body
5-6th month	sitting position in total kyphosis
6-8th month	sits firmly with the support of his/her hand and for a long time
1st-3rd month	automatic walking during compliance
3rd-5th month	does not actively resist (astasia and abasia)
5th month	later he/she resists again
8-9th month	crawls
9-10th month	will certainly stand with adherence
10-12th month	sits without support
11-12th month	balances for a few seconds without holding on
12-15th month	walking and walking independently

During walking, the child touches the ground with flat feet, because the arches are not yet formed, and maintains a wide base of support with arms raised high for easier balance. In children, we can also notice internal rotation of the hips, because in children, the angle of torsion of the femur (anteversion) is higher than the adult average. The period of preschool age (2-5 years) or 6th year is characterized by rapid physical growth, and during school age the child goes through puberty and acquires greater similarities with an adult. Then enters the period of adolescence from the period of onset of sexual maturity until the end of physical growth and puberty (women 14/16-16/18; men 15/17-18/20) [2]. Then, in addition to quantitative development, there is also qualitative development, i.e. to maturing both physically and psychologically.

Although in older age changes do not occur with such great intensity as in children, the changes still need to be monitored closely and reacted to in a timely manner. In the period of older age above 60 years, there is an increase in the period of double support by 3-11%, the length of steps decreases, which increases the number of steps at the expense of the length and range of motion in the joints [2].

Anatomy and biomechanics of gait

Gait can be defined as a cyclical, alternating movement of the lower limbs, which is accompanied by reciprocity of the upper part of the body, thanks to which the body moves on the surface through space with an exchange of single and double support [6].

One step, or one cycle, can be divided into two phases:

(1) Support phase on both legs 60%

At this stage, the support is on both feet, so that the heels of one and the toes of the other foot touch the surface, thus making the size of the support approximately equal to one foot. Then the stability in the direction of movement is the highest, and the lateral stability is the lowest due to the position the body occupies [6].

(2) Phase of support on one leg 40%

In this phase, due to the action of the forces of inertia and the strong reflection of the leg behind the vertical line of the center of the body, the center of gravity shifts to the leg in front, lifting the rear leg and giving the difference between the "carrying" and "swinging" legs. The swinging leg goes through the flexion of the upper leg and lower leg, which lifts the entire foot off the ground, shifting the entire center of gravity to the supporting leg, which reduces the stability of the body [6].

When the swinging leg crosses the midline of the body, then there is extension of the lower leg and continuation of flexion of the upper leg until the heel of the swinging leg touches the ground, thus starting a new cycle and support on both legs [4].

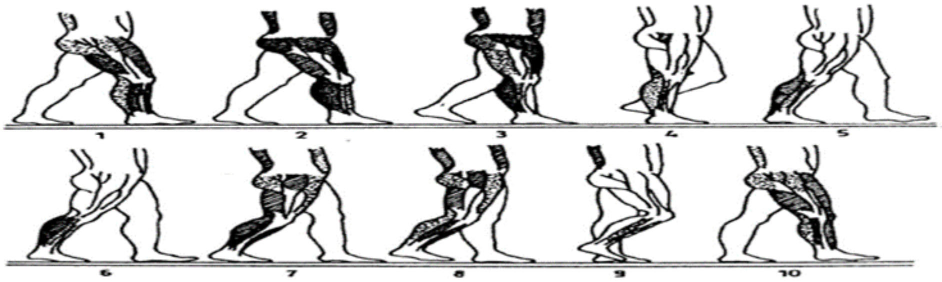

Figure 1. Phases of walking: Presentation of the role of muscles in the kinetic structure (V.S. Gurfinkel). The darker areas of the muscles correspond to the intensity of their contractions (Biomechanics of the human body, M.Dodig, 1994)

Pelvic movements are very important to us when we walk. During one cycle, the pelvis goes through phases of vertical oscillation, lateral tilt, pelvic rotation, lateral displacement, and anterior-posterior displacement. During walking, movements of the upper part of the body and movements of the hands are performed synchronously, namely: vertical oscillations of the upper part of the body, lateral tilting of the trunk in the frontal plane around the sagittal axis, rotation of the trunk and synchronous movements of the hands in reciprocity with the movements of the legs [4].

The bones of the lower limbs (ossa membri inferioris), which are essential for taking steps and for standing, are the bones of the pelvic girdle (cingulum membri inferioris), which include: the pelvic bone (os coxae) which originally consisted of three bones, the femur (os ilii), inguinal (os pubis) and sciatic (os ischi); the bones of the free part of the leg (pars libera membri inferioris), which include the femur, patella, tibia and fibula; and 26 bones of the foot (ossa pedis) which are divided into three groups, bones of the knife (ossa tarsi), foot (ossa metatarsi) and bones of the toes (ossa digitorum pedis) [7].

The joints that make up these bones are the joints of the pelvic girdle (articulations cingula pelvicis) and these include: the joint of the pubic bones (symphysis pubica) and the sacroiliac joint (art. sacroiliaca), which connects the bones of the lower extremities with the spinal column. This is very important for us because of the understanding of the relationship between the lower limbs, trunk and upper limbs when moving and standing. Also, the hip joints (art. coxae), knee joint (art. genus), tibiofibular joint (art. tibiofibularis), upper ankle joint (art. talocruralis) and foot joints (articulations pedis) are important to us, as well as the directions and the range of motion performed in those joints [7].

The following picture shows the muscles involved in walking:

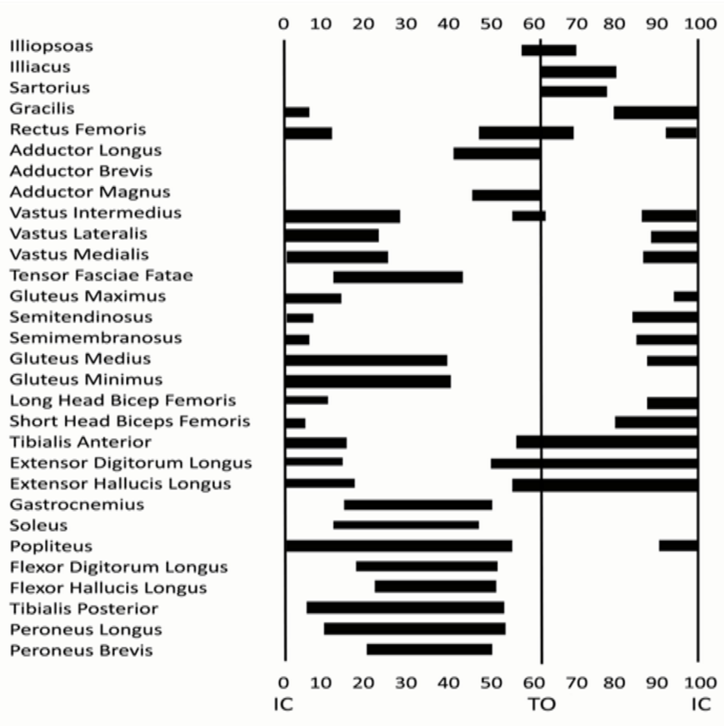

Figure 2. The timing of muscle activity across the running gait cycle for various lower limb muscles (Kamen and Gabriel, 2010)

The motor system has 4 hierarchical levels: spinal cord, brainstem, motor cortex and associative zone. Along with those levels, there are two lateral loops of the basal ganglia and the cerebellum that cooperate with all four levels via the thalamus [8].
The motor region, responsible for movement, is located in the back half of the frontal lobe of the cerebral cortex. The primary motor area is in the precentral gyrus. It is characterized by large pyramidal motoneurons which, in the system of the pyramidal path (corticospinal), descend through the brainstem to the motoneurons of the spinal cord. Most of the fibers of this pathway cross in the area of the brain stem (decussatio pyramidalis), so that the right cerebral hemisphere controls the skeletal muscles of the left half of the body and vice versa [9].

Information for the purpose of controlling motor activities or for use in thinking processes in the future is mostly stored in the cerebral cortex, which contains 50% of the neurons of the entire nervous system [8] [10]. Only a small part of important sensory information leads to immediate motor function and is stored in the cortex itself, because 99% of all sensory information is rejected as unimportant in the brain [10].

The cerebellum is particularly important for controlling very fast muscle movements such as running, typing, playing the piano, and speaking. It is responsible for planning motor activity and correcting motor activities initiated in other parts of the brain. It compares the current state of each part of the body, shown by sensory information [10].

The spinal cord is the phylogenetically oldest part of the central nervous system and has a conducting and reflex function. Motor fibers emerge from the anterior horns of the spinal cord and innervate the skeletal muscles, as well as the posterior sensory fibers [7].

The motor cortex, cerebellum, basal ganglia, thalamus and brainstem simultaneously participate in the overall control of motor activities and are very important. The failure of the function of any link gives a specific clinical picture of the motor neuron [9].

Also, each person has unconditional reflexes that are stable and are the same for everyone, and conditional reflexes that require the activity of the cerebral cortex and are characteristic of the individual. The organism must be awake, the conditioned attraction must be associated with the unconditioned attraction, and it is necessary that other stimuli are absent [7].

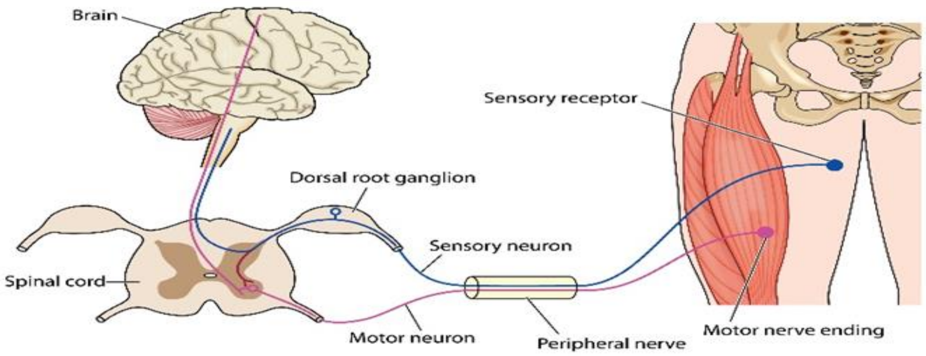

Figure 3. Brain and muscle connestion,(Available from: https://www.acquiredbraininjury-education.scot.nhs.uk/wp-content/uploads/104298341-Central-Nervous-System.jpg)

“Zebris” device

"Zebris" is a medical device used for biomechanical analysis, diagnosis and treatment of musculoskeletal disorders. It is a system that uses pressure sensors to measure the forces acting on the feet during walking. This data can then be used in fields such as sports medicine, orthopedics and pediatrics, to analyze the pattern and identify any abnormalities or deviations from normal gait, posture, and other biomechanical parameters. Zebris can provide detailed information about a patient's gait pattern, including: stride length, stride width, stance, swing, and foot pressure distribution. This information can be used to identify any areas of weakness or imbalance in the patient's gait that may be contributing to symptoms. After diagnosis, "Zebris" can also be used to develop a treatment plan for patients. This may involve exercises or physical therapy to strengthen weak muscles, or it may involve the use of orthotics or other devices to correct any structural abnormalities in the feet or legs. [11]

Health workers, researchers and athletes use "Zebris" because it has the following advantages:

(1) Precise analysis: "Zebris" devices use advanced sensor technology that captures real-time data and algorithms to calculate and record detailed information about human movement. This data can be used to accurately diagnose injuries, determine the most effective treatment options, monitor rehabilitation progress, and optimize performance.

(2) Non-invasive: Unlike traditional diagnostic methods, "Zebris" devices are non-invasive and do not expose patients to harmful radiation, incisions and other invasive methods. This makes them safer and more comfortable for patients.

(3) Adaptable: "Zebris" devices can be adapted to the specific needs of different patients and applications. They can be used to analyze everything from basic gait patterns to complex athletic movements.

(4) Versatility: They can be used to analyze a wide range of movements, from simple tasks like walking and standing to complex athletic maneuvers like jumping and running. This makes them particularly useful in orthopedics, rehabilitation, neurology and sports medicine, where athletes must perform at their best and the risk of injury is minimized.

(5) Portable: Many “Zebris” devices can be easily transported between different locations. This makes them ideal for use in sports clinics, rehabilitation centers and other healthcare facilities.

(6) Cost-effective: This technology can help reduce the need for expensive diagnostic tests and invasive procedures, which can save healthcare money over time. This makes "Zebris" available to a wider range of patients and healthcare professionals. [11]

One of the primary applications of "Zebris" technology is in the treatment of sports injuries. By analyzing the biomechanics of an athlete's movement, health professionals can identify areas of weakness or instability that may be contributing to their injury. This information can then be used to develop a targeted rehabilitation program that focuses on strengthening these areas and improving overall movement patterns.

"Zebris" technology can also be used in the treatment of chronic pain conditions such as back pain or osteoarthritis. By analyzing a patient's gait and posture, healthcare professionals can identify areas of excessive pressure or strain that may be contributing to their pain. This information can then be used to develop a treatment plan that includes exercises and therapies designed to reduce this pressure and improve overall movement patterns.

Finally, "Zebris" can be used in the treatment of neurological disorders such as Parkinson's disease or cerebral palsy. By analyzing a patient's movements, healthcare professionals can identify areas of weakness or instability that may be contributing to their symptoms. This information can then be used to develop targeted rehabilitation programs that focus on improving these specific areas.

The "Zebris" device has proven to be very useful in the world when it comes to the treatment of: stroke, Parkinson's disease, spinal cord syndrome, arthrosis, hip and knee endoprosthesis, exoprosthesis, as well as torn ligaments, bone fractures and muscle injuries.

The advantages of the "Zebris" device are [11]:

- Assisting medical and sports workers,
- Help in developing cognitive functions, coordination, postural control of sensorimotor function,
- Preventing falls and improving activities of daily living,
- Through a large number of repetitions, movement becomes automatic,
- With detailed information, it is possible to support and correct gait,
- Using videos and measuring pressure distribution,
- Using visual and acoustic signals for gait training,
- The use of virtual reality in the therapy itself,
- Training with dual tasks and simultaneous testing of the coordination of cognitive functions,
- An arm rest that relieves the patient and protects him from falls - safety,
- Reduction of the patient's own weight in order to start the therapy even in the early stages of the disease.

Diagnostics

The basic analyzes provided by the "Zebris" device are the analysis of the patient's gait, posture and pressure mapping. Gait analysis is an assessment of how the body moves, usually by walking or running, from one place to another. The Zebris machine can analyze a patient's gait to identify any abnormalities or asymmetries in their gait pattern. Gait abnormalities include unusual gait patterns that may be caused by disease or injury. Such irregularities can lead to pain in the hips, back, neck, feet, knees or ankles. This analysis can help identify the source of muscle, nerve or skeletal problems, detect the source of a patient's pain while standing or walking, diagnose bone deformities or skeletal misalignment, detect muscle or nerve dysfunction, and check the progression of diseases such as arthritis or muscular dystrophy [12] .

According to Greenman (1996), for a good analysis of gait, it is necessary to observe the patient in several directions: while walking towards the examiner, away from him, next to the examiner, while observing the length of the step, arm swing, heel strike, toe deviation, pelvic tilt and shoulder adjustment, where the functional capacity of walking is sought, not the usual pathological conditions. Of particular importance is the cross pattern of the walk and the symmetry of the step [13]. If possible, the patient's gait is observed when he is not aware that he is being assessed, for example when the patient is escorted to the examination room, etc. [14]. Gait analysis using three-dimensional (3D) systems is currently the gold standard for measuring parameters, including spatio-temporal variables and joint kinematics [15].

During daily activities, changes in joint mechanics modify the loads on musculoskeletal tissues, increasing the risk of orthopedic dysfunctions. Approximately 80% of the population has changes in the feet, which can often be corrected with adequate assessment. For this purpose, it is necessary to know whether the feet pass or create changes. Today, it is considered that the problem, as a whole, from the feet to the head, is related to postural adaptations in the entire body, which is determined by bad posture or some painful manifestation that is the result of a certain condition. People with flat feet, as a result of congenital trauma, muscle weakness and ligament laxity, are known to exhibit excessive pronation, as the subtalar joint is unable to achieve a neutral position before heel lift, making the base of support unstable. Also, people with a high arch, which was caused by congenital problems, neurological problems or caused by muscle imbalance, show deviations from the physiological gait, which entails painful conditions. Modifications of the plantar arches and overloading of certain regions can be analyzed using the "Zebris" device [4].

The primary sign of an antalgic or painful gait is a decreased amount of time spent in the stance phase. This is because people do not want to spend more time than necessary on a foot that is causing them pain. Another sign of painful walking is a reduced stride length. This occurs as a result of patients not wanting to push off the painful foot as hard. Therefore, one step tends to be much longer than the other [16].

The parameters that can be seen on the graph read by the device help in diagnosis and during treatment. On them you can see: 3D graph of average pressure, maximum forefoot/rearfoot load, gait parameters, geometry (foot rotation, degree), stride length, stride width, phases, timing, stride time and speed, gait line, lateral symmetry , maximum speed of the gait line, force and pressure (maximum force, maximum pressure, maximum time force), load change and heel-toe transition time [11].

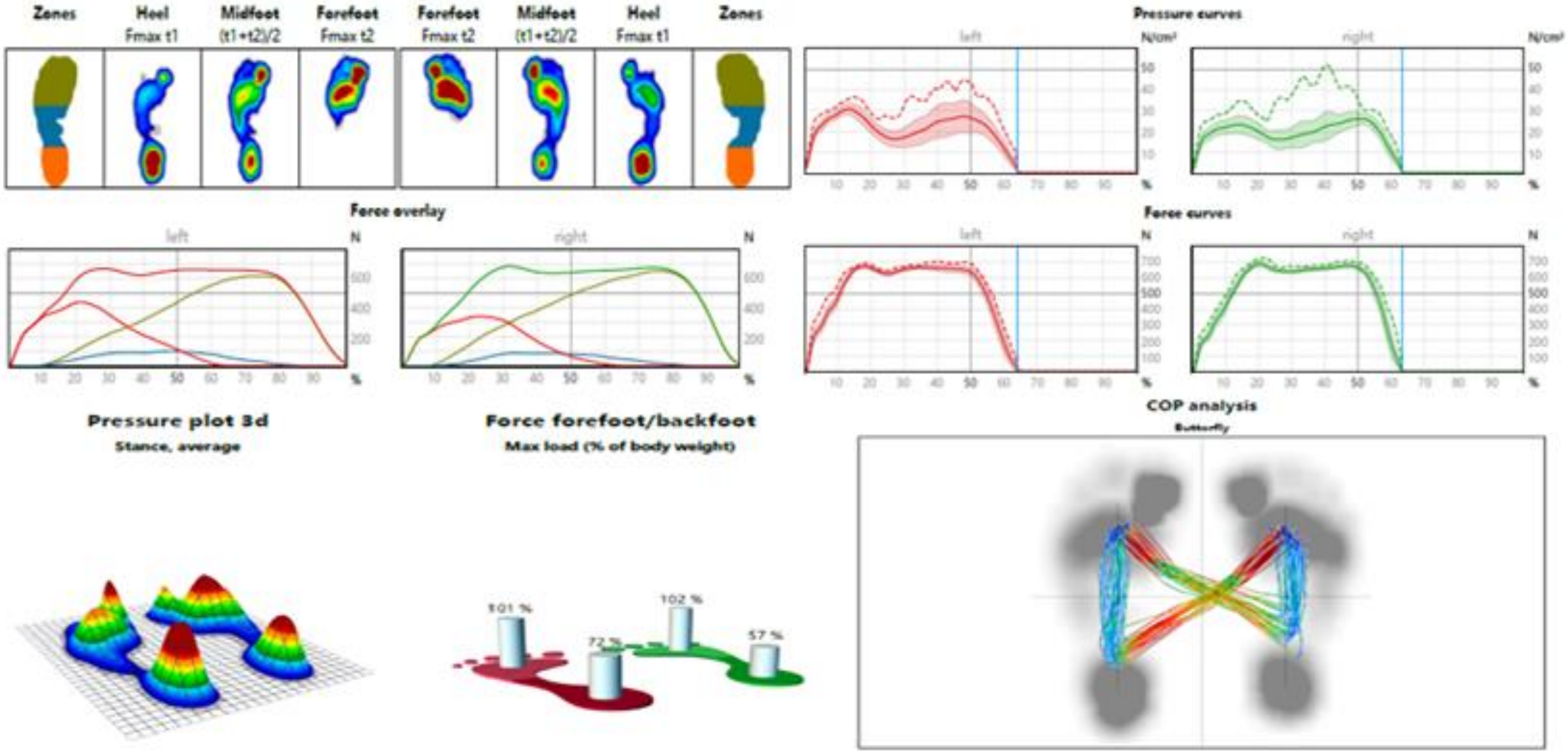

Figure 4. The results of research with the Zebris device [11]

Treatment

In addition to diagnostics, the basic application of the "Zebris" device is dynamic and visual gait training. Using dynamic and visual cues, the medical professional guides the patient to relearn how to walk properly. During the treatment itself, the ideal walking pattern is projected on a treadmill where the patient should place his feet as precisely as possible, and the results of the performance are projected on the screen. All parameters can be adjusted to the patient himself and his level of disturbance at any time.

Gait training through visual marking of steps can be carried out in the early phase of treatment in order to symmetrize and rhythmize the gait pattern, correct its length and thereby improve gait efficiency. Through games that are projected on the patient's screen, which are coordinated with what the patient is doing on the tape, the patient's balance and agility can be improved by walking through the virtual forest, balancing on stones and avoiding obstacles, while watching his own steps on the screen. Walking through the virtual forest requires a constant variation of walking, through simulation in everyday life. Intersections and byways create a new training scenario, making it suitable for individualization for each patient. [11].

Figure 5. Treatment methods with the Zebris device [11]

Real-time video or motion recording biofeedback increases the patient's awareness of their movement. Patients can interact with live motion capture displays to modify or correct their motion based on clinical cues. Displaying graphical summaries of movement, such as range-of-motion bar charts, provide patients with simple goals to achieve during rehabilitation exercises [17].

An engram is formed only by repeating the precise pattern of that engram. In repeating a precise pattern, the inhibition of muscles that should not be in the pattern is as important as the excitation of the muscles that participate in the pattern. Thousands of repetitions are needed for an engram to begin to form, and millions of repetitions to perfect it [18]. For severely affected patients, these repetition rates can actually only be achieved with the aid of a gait trainer [19]. Intensive walking exercises should be started already in the acute phase [20].

Guidelines from the American College of Sports Medicine and the American Heart Association recommend:

- Training 3 to 5 times a week for 20 to 40 minutes,
- Training at 50 to 80% maximum heart rate,
- Documentation of results (10-meter walk test, 6-minute walk test, force test),
- Strength training always with one leg, 10 to 12 repetitions, 3 series each with a break.

When we repeat a certain action several times, the connection between the centers becomes more stable and the activity is performed better and more skillfully with less and less energy consumption. Then the resulting pathways provide fine coordination with precisely adjusted muscle tone [7]. Therapists should praise patients undergoing training and inform them of clear improvements based on numbers [21].

The effect of treatment is also influenced by the social aspect. Research shows that patients who shared their diagnosis with several friends received important informational and emotional support resources that mitigated the impact of functional impairment and thereby improved quality of life and satisfaction [22].

Also, results showed that participants who competed showed significantly greater improvements in all cognitive abilities and reported greater satisfaction than their non-competitive peers [23].

Conclusion

The use of "Zebris" in treatments offers numerous advantages for both patients and healthcare professionals. From accurate measurements to non-invasive procedures and objective data, this technology has revolutionized the way health conditions are diagnosed and treated.

New technologies have a wide range of applications in the diagnosis and treatment of musculoskeletal disorders. By providing detailed information about a patient's movement patterns, they allow healthcare professionals to develop more effective treatment plans that are tailored to the needs of each individual patient.

Technological functionalities that could contribute to the further improvement of the "Zebris" device concern the possibility of changing the relief of the surface, which would achieve a more realistic simulation of walking on sand, stones, grass or other surfaces, which would additionally affect proprioception. Also, during the cognitive tests performed during the treatment, the combination of the "Zebris" device and the EEG of the brain could provide a more detailed insight into the functioning of the brain and the effectiveness of the tests themselves. By using smart technologies, virtual masks and headphones, we enhance the virtual aspect that the device itself offers.

"Zebris" also shows potential in connecting patients with the same or similar problems around the world. Their connection and communication about the same problems and overcoming them could speed up the recovery process in all aspects.

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DIJAGNOSTIKA I LIJEČENJE „ZEBRIS“ APARATOM U FIZIOTERAPIJI

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Sažetak: *Savremene metode dijagnostike i liječenja su nedovoljno zastupljene u našem regionu. Samo analiza hoda, posmatranje i proučavanje načina hoda (GAIT) može uvesti u istoriju, ali pretpostavku toka bolesti samog pacijenta, a da pregled nije ni počeo. Korištenjem „Zebris“ aparata može se detaljnije odrediti dijagnoza same bolesti i na osnovu određivanja njene prirode, liječiti samu bolest na savremene, učinkovitije načine, pomoću softvera koji omogućava sprovođenje treninga hoda u virtuelnoj realnosti, uz izvođenje zadataka koji zahtjevaju stalne varijacije u hodu i balansiranju, koje ujedno motivišu i pacijenta i terapeuta ka boljem, bržem i efikasnijem liječenju. U radu se govori o evoluciji čovjeka i bipedalizma, biomehanici i aktivnosti mišića u fazi hoda, odnsu zglob-pokret-mišić, ulogama segmenata tijela u hodu, ciklusu hoda, i kako se sve to može pratiti uz pomoć „Zebris“ aparata. Opis kako sam aparat radi, dijagnostika i parametri koji se dobijaju ovim aparatom, su srž rada, jer na osnovu njega se može izvšiti komparacija hoda zdrave i bolesne osobe. Takođe, „Zebris“ pruža mogućnost sprovođenja terapije u cilju osposobljavanja za aktivnosti dnevnog života (ADŽ) uz praćenje parametara hoda na senzornoj traci, upotrebu ekrana, kao jedan od oblika povratne informacje, koji daje pacijentu i fizioterapeutu novu dimenziju terapije, ali i mogućnost da se i kognitivne vještine pacijenta iskušaju i unaprijede u samoj fazi oporavka. Cilj ovog rada odnosi se na proširenje vidika i mogućnosti koje ovaj aparat pruža, ali i na razvoj novih tehnologija, virtuelne realnosti i vještačke inteligencije (eng. artificial intelligence - AI) koje dijagnostiku i rehabilitaciju u fizioterapiji mogu podići na jedan sasvim novi nivo i koji će Bosnu i Hercegovinu približiti Evropi u njenom svakodnevnom radu. Ovo istraživanje dokazuje da dijagnostika i liječenje „Zebris“ aparatom vodi fizioterapiju ka novim tehnologijama u Bosni i Hercegovini.*

Ključne riječi: *„Zebris“, dijagnosta, liječenje, hod, nove tehnologije*