Clinical posturology and digitalised biometrics

Posturology is a field of medicine which, based on anatomical, biomechanical and neurophysiological acquisitions, studies the balance, the strategies and the rewards that are used to maintain it in all circumstances.
Posture is the position of the human body in space and the relative relationship between its body segments.
Clinical posturology (Kliniké's clinic: art related to those lying in bed), is the practical application of the physical and instrumental semeiotics of medicine that are taught in all faculties of medicine and surgery.
It is clear that in its everyday meaning, physical semeiotics presupposes particular and specific knowledge typical of the discipline, which can only be learned in part in university courses, but which, if there is interest on the part of the doctor, can be deepened through courses update, master or other.
The same thing goes for instrumental semeiotics, which must be deepened and specialized beyond university studies. A particular aspect of clinical posturology is digitized biometrics.

The application of mathematics to the study of biological phenomena is called biometrics (1782-1863 Louis-René Villermé, 1800-1890 Edwin Chadwick, 1822-1911 Francis Galton, 1857-1936 Karl Pearson).

In physical and rehabilitative medicine biometrics is a spatio-temporal definition of the static and dynamic morphological data of each individual. It is the anthropometric identity card of each subject fixed in time and space, for the attitude one wants to study , comparable both chronologically and with statistical models (Konings L., Van Celst M. 2000). It uses mathematics and statistics to perform measurements in the biological field.

Digitized biometrics is a branch of medicine that applies the laws of physics and mathematics to the study of movement and posture with the aim of describing and predicting their behavior. It is the technical evolution of the classical general biometry (Schiffer R. 4/6/2006 XXXIV SIMFER National Congress)

In the clinic, we doctors perform biometrics simply when we measure height, limb we weigh them or ask them what foot number they have. And again, if we simply observe a patient stripped upright in frontal, posterior, sideways (hyperciphosis, lordosis), while walking, observing him from above to see if the hemithoraxes are symmetrical or not, if we make him tilt his torso forward and we detect the haunches (scoliosis).

Posturography was born in 1864. Vierdot records the movements of the human body in a standing static station, fixing a pen on the tip of the soldiers' helmet, rubbing against a disk covered in black smoke, recording the oscillations on the sagittal and frontal planes and their amplitude. The culmination was the establishment of a posturography school in Berlin, where the foundations are laid for the first studies on global human kinematics.
In the same years the French Marey and the Englishman Muybridge take the first photos of moving animals. Marey was a university professor of physiology. He tried to synthesize it on a plate

photographic successive movements of animate beings: the journey of a man or the flight of a bird observed from a single point of view. He invented the photographic rifle (1888, chronophotographer), precursor of the camera, with it the chronophotography that represented the different phases of the movement, demonstrating its continuity.
Using the techniques suggested by Eugène Chevreul (gluing white stripes to the upper and lower limbs of a man and intermittently opening the shutter of the camera) he obtained the diagram of the oscillations of the moving figure in the sagittal plane.
All this can be seen in the chronophotographic study of human locomotion "of 1886 which is located in Beaune at the Musée E.J.Marey et des Beaux Arts, explained in the three representations of: a man in black costume covered with white lines and dots; successive images of a man running; man walking in white costume with a leg painted black.
He was certainly the forerunner of today's systems of computerized optor detection with markers (Elite systems, Vicon). With his trajectories, he influenced painters such as Seurat, Degas and later futurists such as Boccioni or Duchamp.

Eadward Muybridge (English photographer) in his book "Animal locomotion" used photographs taken from different cameras combining the results of individual shots as to form a history of movement. He combined twenty-four devices with wires that the running horses, when passing, broke by triggering the shutters. He observed that in certain phases of the gallop, all the four legs of the horse did not touch the ground, and were never extended all together (unlike what was pictorially expressed by certain artists). In 1878 he published a book entitled "The horse in motion". Then he directed his interest to the man: acrobats, patients in hospital, studying their abnormal, pathological movements compared to normal.

In posturographic chronology, reaching 1927, Sutherland and Hagy described a cinematographic method to obtain kinematic parameters. In 1938 Elftman set up a set of cinematic force platforms. By processing the values of the forces obtained by mathematical algorithms, he obtained data on the displacement on the vertical and horizontal plane. The same author in 1939 will develop a system that will allow the measurement of the amplitude and the detection of the position of the force component of the ground reaction.
In Italy Lenadro Canestrelli in 1944, at La Sapienza, devised a "Graphic and cyclographic method in examining static equilibrium" (Il Valsalva, XX, 1944).
In 1950, Bresler and Frankel, using simultaneous cinematic and dynamometric measurements, will be able to determine forces and moments of force on the joints in all three dimensions. Their work will then be expanded in 1965 by Paul. Saunders in 1953 emphasizes the translation and rotation of the trunk and limbs. It arrives to give a definition of the primary determinants of the step: pelvic rotation, pelvic oscillation, lateral displacement of the pelvis, knee flexion, foot-ankle movement. It defines that the human body tries in normal conditions to reduce the variations in potential and kinetic energy to a minimum, maintaining its center of gravity constant and keeping a linear trajectory as much as possible. The same concepts will be taken up and confirmed by Contini in 1965. Gollnick and Karpowich will also give their contribution in 1964, studying the temporal and kinematic variations during the passage on a horizontal plane and at various inclinations. with the use of footwear. In the same year, Finley and Karpovich will study the parameters of the normal and pathological step. In 1966 Elftman will resume Saunders' studies on the position of the center of gravity in relation to muscular energy expenditure. Morrison in 1970 will return to using force platforms associated with the motion picture shootings. In 1972 Kettlekamp will make a significant contribution by studying the characteristics of the gait in patients with rheumatoid arthritis. Winter in 1976 will do a great job trying to calculate the energy of each body segment on the sagittal plane. In 1983 the same author will support the usefulness of moments of strength as diagnostic information, detecting the differences existing between normal and pathological.

With the works of Luhtanen and Komi in 1978, it will come to determine that the muscles in each instant of the gait cycle perform a positive or negative job depending on the moment.
The studies of Lowery in 1982 owe the calculation of the energy expenditure of the step in hemiplegic patients towards normal subjects.

The force platforms in synergy with other equipment will be used by various authors for the study of the race. The same Elftman already in 1940 measures the articular forces in response to gravity, inertia and contact force in the race. James and Brubaker in 1973 evaluated the temporal phases of the race, followed by Mann and Winter respectively in 1981 and 1983. Burrett in 1982 notes that during the run the compressive forces are worth 10-13 times the weight of the body compared to those only 5 times greater during the normal step. In 1985, Tesio will study the movement of the center of gravity. Different authors used the same equipment to evaluate patients during the ascent and descent from the stairs.
Andriacchi and colleagues in 1980 and then in 1982 will use an optoelectronic system with EMG associated with dynamometry. The same thing McFadyen and Winter will do in 1988.
Sport has also made its contribution. Sports gestures such as kicking and jumping have always been studied with the same instruments by authors such as Zernicke and Roberts (1976, football in football), in 1978 by Gainor and others (top football and flat), Hubley and Wells (1983, vertical jumps with and without screwing), Van Soest and others (1985 jumping at the same level and on one foot).
During the lifting of the graves, the movements of the vertebral column in whole during the load were evaluated. And it will be thanks to Davis and others that in 1965 attention will be given to the moment of inertia.
While in 1974 Ayob and others evaluated the limits in the various lifting activities.

Currently given the cultural evolution, since all those born after 1985 by definition digital born, while those born before are definable natives paper, the use of the digitalization of the instrumental semeiotics for the analysis of instrument of the posture (Mark Prensky “has been adopted) Digital Natives, Digital Immigrants 2001). In practice it is a person who grew up with digital technologies such as computers, Internet, mobile phones and MP3s referring to people born (in the USA) after 1985 as a new group of students that accesses the education system. against those who are not digital natives but use technologies would be a digital immigrant. As a result of what has been said, digitalized biometrics was born, which means in simple terms to represent physical quantities in numerical form through an operation that translates an analogue data into digital form. The eyes have become cameras, and the other senses ... ... of the sensors. All the data are processed using algorithms with which the various applications are equipped, and the images with the tables can be printed.
Fundamental: the data must always be analyzed by the doctor and the report drawn up by the same.
Instrumental analysis, like all exams, is an added value and should only be requested after a thorough medical history has been detected, an accurate physical examination performed. It is used to confirm, refute, direct or modify a therapy (surgical, medical, physical / rehabilitative).

As with all instrumental analyzes, the parameters or indicators must refer to normality values, something that biometrics are not subtracted from. We recall that normality can be defined in various ways, for example according to Kuhn "The normal is what is common, in a given period, or to a collectivity of specialists"; differently for F.Basaglia “The threshold that separates health from illness is not fixed, but varies according to historical, social, political, economic and cultural conditions“.
In this context we will dissert on the following, bearing in mind that for the English, ilness is the subjective experience of malaise, the experience of unease, the state of suffering perceived by the sufferer himself. Disease the biomedical definition of disease, the alteration of the organism with

signs symptoms. Sickness is the social meaning of the evil being formalized at the time of diagnosis. It follows by definition that it is pathological all that is not normal.

Paraphrasing and modifying Susanne K.Langer (philosopher) we have that "posturography is the objectification of sensation and the subjectification of posture". It therefore follows that in the context of motion analysis kinetics (the mechanical energy of a moving body; F = mxa) should not be confused with kinematics (relative to the geometric aspects of movement).

In posturography, indicators are used clinically, that is to say the variables used to formulate a judgment, are selected on the basis of hypotheses, values and objectives. They serve to predict, plan, diagnose, decide. Their value is different, it can be quantitative or qualitative. Quantitative when expressed by an integer or not, qualitative when they detect aspects of reality with intrinsic or extrinsic characteristics (constitutive characters of a style, function, meaning).
The characteristics of an indicator depend on the fact that it must be relevant, that is able to refer to the phenomenon that one wants to analyze. Clinically relevant, ie it must represent aspects such as effectiveness, efficiency and safety. It must be valid, that is, it must objectively measure what it is intended to measure. Be reproducible, without significant variations in different environments. In other words, it must be able to differentiate conditions that are important to consider different. Finally practicable, easily available.

Applications (tools) for motion analysis have indicators that are generally found in all devices on the market. In the discussion we will refer to those that are mostly used in world literature.

For example: subtended area, trace length, radius permanence, frequency domain in antero-posterior (AP), middle-lateral (ML); statokinesigram, stabilogramma; resulting mean or graph of the center of mass (CoM), resulting partial to the right or left foot or graphing of the center of force (CoF), and many more. After all, "man wants everything to use only half" (unknown advertising).

In practice, the indicators depend on the type of application in use, on the imagination of the manufacturer or of the bioengineer who designed it. In summary, they can be: kinetic, cinematic, mixed.

The systems in this period on the market, can be classified as follows in accordance with which posture you want to study and are tools for the evaluation of:

• Station erected on a plumb line test
• Station Erected Perturbated
• Sitting Position
• Gait
• Foot plant
• March on the spot

Then there are systems for:

• three-dimensional reconstruction and measurement of the spine.

• morphometry of the whole body, segmental

• kinetic and kinematic reconstruction of the movement for segmental movements, segmentary movements during walking, segmental movements during the march on the spot
Let's analyze them individually.

Stabilometry

The posturographic study of the standing erect station in the position of the plumb line or with perturbation (thrusts) therefore dynamic, is carried out through the use of stabilometry.
By definition it is the measurement of all the kinetic and kinematic indicators detected through the use of a dynamometric platform, in a standing post in a test post of the plumb line (which can be disturbed with thrusts or pull-tests), bipodalic with or without aids and orthoses.
It should be noted that differentiating between static and dynamic stabilometry can be an apparent paradox as well as an oxymoron.
From the neurophysiological and biomechanical point of view, in reality the living being although apparently immobile in our eyes has a certain instability linked to endogenous factors (muscle tone, respiration, cardiac ballistic movements, intestinal peristalsis, cognition) and exogenous factors (noises). , images, temperature, perturbations).

Clinically we can currently perform the following analyzes which are:

• static stabilometry in standard bipedal support at 30 sec. Open Eyes / Closed Eyes
• static stabilometry in bipodalic standard support 30 sec.OA / OC: with retroflexed head, with Messermann Test, with swallowing Test
• postural stabilometry in bipodalic support according to Gagey at 51 ”OA / OC
• Equitest in bi-breech support
• calibrated static stabilometry in bipodalic support with elevation to the right or left (5 mm, 1 cm, 1 cm ½, 2 cm, 2.5 cm, beyond; standard 30 sec. Open Eyes / Closed Eyes

For medical knowledge the parameters (indicators) studied for clinical purposes are the following:

• Kinetics: trace length, subtended area, eccentricity index, inclination of the axis, x and y mean, average speed in antero-posterior (AP), middle-lateral (ML); report v.media ML / AP; Romberg index, oscillation direction changes, ratio: vel.AP, vel LL OC => OA; radius permanence
• Kinematics: statokinesigram, stabilogram, radarbalance, ball rectangle, ellipse
• Quali-quantitative: frequency domain (Fourier transform or spectral density), ellipse, velocity diagram

For the study of the standing static station in monopodalic support we carry out:

• Monopodalic stability with raised limb against lateral, at 5 sec. or 10 sec. at OA / OC
• Monopodalic stability with limb against side leaning, at 5 sec. or 10 sec. at OA / OC

The indicators used in the clinic are: average right and left speed, track length, subtended area.

Usefulness and appropriateness of their use in the clinic: disturbances of the equilibrium of various origins, study of muscular kinetic chains in postural syndromes, study of heterometries, asynchlitisms, study of post-traumatic tibio-tarsal instabilities.

The posturographic study of the sitting position uses:
• Static distance with head in neutral position
• Dynamic Stability: with static-dynamic, sequential head-of-neck tests; open eyes (OA), eyes closed (OC); duration varying from 30 sec. at 50 sec.

The assisometry for the static sitting position is the measurement of all the kinetic and kinematic indicators detected through the use of a dynamometric platform, in a sitting position, through the use of a dynamometric platform.
The assisometry for the study of the perturbed sitting position is the measurement of all the kinetic and kinematic indicators detected through the use of a dynamometric platform, in a sitting position that is disturbed (thrusts), through the use of a dynamometric platform.
Practically a standard static is made at 30 sec. A OA / OC, and a postural at 51.2 sec. OA / OC.
The specific indicators are: kinetic (track length, subtended area, radius permanence). Kinematics (statokinesigram, stabilogramma). Quali-quantitative (frequency domain).

The assisometry calibrated at 30 sec. with calibrated rise to the right or left hemibacine, use the position of the center of pressure (CoP) with respect to the crurogram (graphic design of the seat on the platform), and the analysis of the loads as study parameters.

Crurography by definition is the evaluation of crested ischio pressures (crurogram) for selected area in seated position with or without aids (anti-decubitus cushions, other). Its specific indicators are:
• Kinetics or quantities: area or surface, pressure, percentage load
• Kinematics or qualitative: colorimetric analysis.

Usefulness and appropriateness of their use in the clinic: disturbances of the equilibrium of various origins, study of muscular kinetic chains in postural syndromes, study of heterometries, asynchlitisms, study of post-traumatic tibial-tarsal instabilities, of ischio-crural hyper-pressures (pressure ulcers).

Baropodometry

The posturographic study of the static and dynamic bipodalic support takes place through a standard static study, or in a free position with and without footwear, orthoses and aids. Or dynamic with and without footwear, orthoses and aids. Both with open or closed eyes.
The first method or static baropodometry is the measurement of all the kinetic and kinematic indicators detected through the use of a dynamometric platform, in standard or free standing bipodalic standing station, with or without aids and orthoses.
The parameters used for it are:

• Kinetics: Surface, load, foot angle, foot axis; Rear foot / forefoot ratio, Maximum pressure, average; support angle, barycentric angle, Distance: CoP-C.Geom (center of pressure, geometric center), CoF-breech axis (center of force of a foot, axis of the foot), CoF-beat, CoF-CoP, CoP position

• Kinematics: Areas; Analysis: point, isobar, numerical, Hi-Res (high resolution), Point M (point of maximum pressure)

Dynamic baropodometry is the measurement of all the kinetic and kinematic indicators detected through the use of a dynamometric platform, during walking with or without aids and orthoses. Its indicators are:

Kinetics: AP (forefoot) and RP (back foot) and% var. Surface, AP and RP load and% var., Max pressure, Mean pressure; Speed, rotation, half-step, cadence, step width; Foot angle, Breech axis; stride time; T.Appoggio; Double support; Resulting length dx / sx

Kinematics: temporal examination, Point M; Point analysis, isobar, numerical, Hi-Res; Resultants: average (CoM), partial (CoF), Graphs: surface, pressure, peak, speed, rotation.

The Tandem Gait Test by H.O. Digitized Barber or test of the walk of the tightrope walker where in patient he is invited to walk with his feet in line along a colored trace longitudinal to the direction of the platform, with eyes open and eyes closed, with duration based on the disability or capacity of the patient.
The parameters are relative to the table of H.O. Barber (The Otolaryngologic Clinics of North America, 1978. Symposium on Advances in Otolaryngologic Diagnosis).

Baropodographic treadmill

The posturographic study on sliding belt by definition is the measurement of all the kinetic and kinematic indicators detected through the use of a sliding belt (treadmill) on a dynamometric platform, during walking or running at various speeds adjustable with or without aids and orthoses.
For the baropodographic treadmill the indicators are obviously only dynamic, but always distinguishable in quantitative and qualitative.
For fingerprint analysis the quantitative indicators are:

• overall duration of the test in seconds
• number of analyzed fingerprints
• average speed in Km / h
• average length of the half-step in cm right and left foot
• average support time in msec right and left foot
• average time of double support / flight in msec right and left foot
• average oscillation time in msec right and left foot
• average ICP rockers in msec left and right foot
• average FFCP rockers in msec right and left foot
• medioFFP rockers in msec right and left foot
• Medium surface in cm2 right and left foot
• Medium avampodal load of the right and left foot

• Medium breech load of the right and left foot
• Medial average load of the right and left foot
• Breech axis in degrees

Of each imprint the qualitative indicators are:

• Colorimetric symmetry index
• partial result of the right and left foot
• the resulting butterfly or cyclogram
• the resulting mean or center of mass (CoM) right and left foot
• spot colorimetric analysis
• Hi-res colorimetric analysis (high resolution)
• 3D analysis
• numerical analysis
• level analysis

In biomechanical analysis the quali / quantitative indicator is the gait-cycle column chart.

Usefulness and appropriateness of their use in the clinic: study of alterations of static-dynamic foot support (flat foot, hollow, cavus, diabetic), of walking, running with and without aids (orthotics, sticks, crutches, shoes, spring Coldivilla).

Untenberger test (march in place) Digitized

The test, also known as the Fukuda test, is an important diagnostic test, commonly used in the field of neurology and otolaryngology to assess the presence of muscular hypertonia during a march carried out on the spot.
The doctor orders the patient to stand upright, positioned under a video camera (web cam) with the upper limbs extended and raised. The head is in a neutral position.
The doctor orders the patient to march in place for a few seconds with his eyes open (at least 3-4), then with his eyes closed for at least 1 minute, raising his knees but not excessively.
Normal test subjects rotate in place never more than thirty degrees. If instead the patient's body rotates over 30 degrees, the cause will probably be a labyrinthine suffering on the displacement side. A forward movement (walking) during the test is not a sign of pathology.
The test is repeated also under the influence of the nuchal reflex, that is with the head rotated on the right and left side of the body.

Usefulness and appropriateness of their use in the clinic: it is indicated in the evaluation of the subjects with: suspected peripheral vestibular dysfunction, balance instability, unspecified vertigo, postural alterations.

Three-dimensional reconstruction of the spine
It is the digital conversion of a photographic image using a specific algorithm, without the use of ionizing radiation in graphic images, using anatomical landmarks marked by markers on skin, and reconstructing the vertebral column with the triangulation system.
Its indicators are: Cobb degrees, limb lengths.
Usefulness and appropriateness of its use in the clinic: serious study of the spine in paramorphism, scoliosis in developmental age mainly in columns with Cobb degrees that are below 30 °, or above post-surgery.

One particular use of it occurs in association with the use of elevations placed under the feet in the heterometries (short limbs) or asynchronous (inclinations of the pelvis) that can be modified and which can at the time modify the deviations of the vertebral column.

Execution conditions of the examination: the patient only with briefs and bra (woman) is invited to stand still in a static standing station with the upper limbs along the trunk and well attached, and the lower limbs aligned for at least one minute.

Bibliography

Key words to type on Google, PuMed, Gait & Posture:

Posturology, Posturography, Stabilometry, Baropodometry, Baropodographic treadmill, Stabilometry in a sitting position, Three-dimensional reconstruction of the spine, Spinometry, Body Analysis Capture, Podoscopy, Equilibrium, Imbalance, Rasterstereography, Digital biometry, Biometry, Vertigo, Dizziness, Instability, Postural disorders, Postural biomechanical syndrome

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Rasterstereografia
Digital biometry
Biometrics
Vertigo, vertigo
Instability
Postural disorders
Postural biomechanical syndrome

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