Stabilometry indicators

General definition of stabilometry
Stabilometry is an instrumental assessment of the individual's stability in standing. Static and dynamic stabilometry are distinguished. It is also performed in a sitting position.
The first one evaluates the individual on a dynamometric platform (force meter) with both open and closed eyes.
The second, always evaluates above a dynamometric platform which has movements on the anteroposterior plane to evoke reflex responses and is called Equi-Test and will not be treated in this work.

In both cases, the measurements on the platform always take place by reference to the Cartesian axes, where on each platform, to orient ourselves we must know that:

- The sagittal plane corresponds to the antero-posterior (AP) and is proper to the Y axis (ordered)
- The frontal plane corresponds to the mid-lateral one (ML) and is proper to the X axis (abscissa).

The clinical definition, definitive practice tells us that it is the measurement of all the kinetic and kinematic indicators detected through the use of a dynamometric platform, in an upright position in the test posture of the bipodal, monopodalic plumb line or in a sitting position with or without aids and orthoses.

Clinical indicators (parameters)

The postural indicators (parameters, variables) used in the clinic for evaluation can be divided into two categories

• kinetic or quantitative or functional
• kinematic or qualitative or structural

The first concern the numerical values of the linear dimensions (they are expressed in mm or cm) and give us information on the function, the second concern the geometric or graphic aspects of the analysis, and give us information on the structures.

And I'm:

Kinetics or functional quantities

1. Track length
2. Underlying area
3. Analysis in the frequency domain according to Fourier and Prieto
4. Index of cervical interference
5. Chieti index

Kinematic or qualitative structural
1. Statochinesigramma
2. stabilogram

3. Drift or radar balance

Specific analysis of stabilometric indicators

Premise

In the human body, balance is maintained through a complex neuromuscular control system. In an upright position, the support polygon is given by the area between the two podograms, which in normal conditions is relatively little extended. The center of gravity is located at a fairly high altitude, varying between L3 and S1.

This entails an intrinsic instability: even small movements of the body can move the vertical passing through the center of gravity outside the support polygon. For example, when we stand on tiptoe, the support polygon is further reduced, and it is therefore difficult in this position to stay in balance for a long time, also spending a lot of energy.

If you bend the trunk forward, the center of gravity tends to move forward out of the support polygon and the vertical line passing through the center of gravity tends to exit the support polygon.To counteract this fact and avoid falling, there is a concomitant movement of legs and buttocks backwards (compensation) in normal conditions.

This is the reason why it is impossible to push forward while keeping the squeegee leaned against the wall of the room, for example.

Given the intrinsic instability of the human body even when standing still, we know that various afferent and efferent neuromuscular mechanisms intervene, which we will discuss later, necessary to maintain the balance of the human body as a whole and in its parts .

In static standing position with monopodalic support, the projection on the ground of the center of gravity must always pass within the area of the podogram, either right or left, if this situation is not fulfilled, given the instability there may be a tendency or fall to the ground .

In a seated position (raised on a chair), the support polygon is given by the femoral "vu" (femurs), part of the pelvis and feet on the ground. The projection on the center of gravity support polygon (forward the D11 spine and inside the trunk), and the CoP (center of pressure), must be in normal conditions well positioned within this area.

This occurs when the subject, for example, is seated with the support of the upper limbs on both femurs, the trunk is erect, with the head and neck aligned and the gaze is infinite. The femoral "vu" is open to 30 °, the shins are 90 ° with respect to the femurs.

For example, if the subject crosses his legs (tailor's position), the balance situation obviously changes.

In all cases, however (standing position, sitting position), a necessary and sufficient condition for a body resting on a horizontal plane to be in balance is that the vertical lowered from its center of gravity passes internally to the support base.

It therefore appears that:

• the balance is more stable the wider the support base. In fact, by widening the base, the radius of the arc that the center of gravity must travel to extend vertically out of the same
• the balance is all the more stable the lower the center of gravity. In a sitting position, it approaches the support base.

Here a very important neurophysiological clarification on the affirmation that "the balance would be more stable the greater the weight of the body" is useful. As the weight increases, according to physics, the force necessary to produce displacement in the body increases that makes him fall. But this is true in serious inanimate.
In the human body there is a central driver (central nervous system: brain, cerebellum) and a peripheral one (peripheral nervous system: spinal cord and nerves) that intervene in the gesture and posture continuously. Both in normal and pathological conditions albeit in a reduced way. think of the stability between two healthy subjects: one 1 meter and ninety tall and 50 kg heavy, one short of 1 meter and sixty tall and 80 kg (obese). Both if without pathologies to the nervous and osteoarticular system, there are no changes in balance. Things change if, for example, the low fat person is affected by diabetes mellitus with involvement of the peripheral nervous system (polyneuropathy). Although low and heavy, neurological tests will present pathological and evident postural oscillations, which can be recorded with stabilometry.

Balance is a form of sensitivity that does not significantly contribute to determining the state of consciousness, but is essential for the coordination of motor responses, eye movements, posture.
In order to have an appropriate balance and posture, continuous information on the position and movement of all parts of the body, including the head and eyes, must be available.
By definition, posture is defined as the orientation of the body and its parts with respect to the vertical, while the position is the orientation of one part of the body with respect to the other.

The skeletal system effectively supports body mass when posture is normal.
The amount of energy spent on the muscle contractions required to maintain posture is very low and in this situation the muscles exhibit a certain contractile activity that is identified with the basic muscle tone.
Posture is an active neuromuscular process that depends on the centers of the brain stem, on stimuli coming from proprioception, on labyrinthine and visual impulses that affect to make straightening and other more complex reflexes suitable.
Measuring the average position of the center of gravity and its dispersion means measuring stability, which is the property of a disturbed body in its balance of returning to its state (Gage, 2000). Equilibrium is an ideal limit state towards which we tend and can be quantified by measuring it (Thomas, 1940) for example with a stabilometer.

Man has less stability than other animals, because he has a relatively small base of support and a rather high center of gravity. Standing on two feet, the man is well balanced, but resting on one foot, his balance becomes difficult to maintain; it becomes even more difficult if he tries to walk on a rafter or on a rope, in which cases the support base is very narrow. If, due to impact (perturbation), the center of gravity is moved laterally so that the vertical line passing through it leaves the support base, it may fall to the ground.
To prevent this danger, it is evidently appropriate that the base is wide and the center of gravity as low as possible.
In humans, in the event of collisions in a static upright position that move it forward, sideways or backwards, under normal conditions, reflex mechanisms take over (supraspinal, labyrinthine-kinetic) which ultimately activate the safeguard postures (parachute reflexes), same thing in a sitting position.
In the patient with pathology of the central or peripheral nervous system (stroke outcomes, polyneuropathies, etc.) we observe that the maintenance of the static upright position is obtained by widening the support base, abduction of the upper limbs, with overall posture in slight flexion of the hips, knees and perhaps a continuous search for points of support. Same thing, we can observe it in the sitting position.

In the patient with degenerative pathologies affecting the locomotor system even in the absence of pathologies of the central nervous system, peripheral nervous system, since there are alterations of the body axes (arthritic bone modifications, tendinopathies, etc.) the vertical gravity not passing through the centers of the joints, create moments (flexions, rotations, inclinations) that biomechanically cause instability and at the same time an increase in energy expenditure which can indirectly be measured by stabilometry with analysis of the track length.
We can end by stating that in the pathologies of the balance and posture system, strategies and compensation attempts are implemented which to a greater or lesser extent lead the human organism to have a posture that has a lowering of the center of gravity towards the support surface and a enlargement of the support polygon.
All this always occurs with an increase in energy expenditure.

In summary: heights are reduced, surfaces are enlarged.
The balance system in humans allows you to switch, under normal conditions, from stable to unstable and indifferent equilibrium situations with exchange from one situation to another, without the individual being aware of it. Under pathological conditions all this can be altered to varying degrees.

In the normal subject, there is a basic or physiological instability, determined by intrinsic and extrinsic factors that are the first:

• muscle contractions necessary to maintain the anti-gravity posture and not taken at that moment (muscle tone)
• continuous functioning of the cardio-respiratory systems (cardiac activity, in-exhalation)
Bowel movements
• type of preferential sensory channel used by the individual to achieve balance through reflex responses (vision, proprioception)
• unwanted movements (tics, tremors, dyskinesias)
• Intentional patient movements (cognitive: simulation, dissimulation, recall of symptoms)

For extrinsic factors:
• various external perturbations (acoustic, visual, mechanical, cognitive, other)

In humans, a series of signals from peripheral receptors that send visual, labyrinthine, auditory, proprioceptive information compete for spatial orientation.
The three main systems, visual, vestibular, proprioceptive, are linked together, even if the integration at the central level (cerebral cortex, cerebellum, vestibular nuclei, reticular substance) is not yet well known. This allows you to organize the reflex motor responses appropriate to the situation which results in compensatory eye movements to maintain the fixation of an object during movements and various postures (vestibular-ocular reflex), and body movements to maintain balance (vestibular-spinal reflex).
We know by now that when one of the sensory channels is damaged or does not provide information or provides incorrect and discordant information from that provided by other channels, therefore there is an erroneous sensation of movement, a hallucination of the spatial sense, dizziness.
The feeling of vertigo can be accompanied by anguish, vegetative reactions such as nausea, cold sweats, vomiting.
If it is perceived as a rotating movement of the surrounding environment, it is referred to as objective, if as rotation of one's own body, subjective.

It must be kept distinct from other conditions variously indicated by the patient such as: feeling of empty head, confusion, uncertainty, sense of heeling, instability which are instead pseudo-overtime or dizzying type disorders, included in the generic term of dizziness.

For the visual system, during the bipodal static standing station for the execution of open eye stabilometry, for every second of eye opening, in fixing an image we are blind for 250 milliseconds, i.e. 1/4 of the time of our opening eyes: about 30 seconds, about 7.5 seconds we don't see, we are blind. It is saccadic suppression.
During eye movements our brain "switches off" vision, to avoid the effect of sliding images or camera effect, very annoying. A saccade lasts on average 50-100 milliseconds, while the fixation pauses (the eye sees perfectly) do not exceed 400 milliseconds. The brain corrects the image by bringing it into focus thanks to the continuous saccades of exploration of the environment.
We cannot fix our gaze even if we make an effort; at the most, after 400 milliseconds, the eye performs small corrective saccades, and deviates by a few fractions of a millimeter and then perhaps returns to its original position. The signal for controlling rapid eye movements is retinal error. The single image that is processed in 100 milliseconds by the retina and brain is very poor.
The conjugate error perceived by the cerebral cortex causes the production of signals that are sent to the paramedian pontine reticular formation (PPRF) triggering corrective eye movement and reducing the error to zero. The image we get is mediated by memory and compared with mnemonic processes. We see clearly why memory reconstructs the entire retinal image giving the illusion of sharpness. The eye is a continuous scanner. The minimum temporal distance for two images to be considered separate from our eye is 80-100 milliseconds (1/10 of a second), the cinematography effect occurs above this value.
If the image of an object on the retina does not move, it vanishes. When looking constantly at an object, the image must be enlivened by gently moving the eyes, making small and quick shots (saccades) (1).

There are several theories for framing the rules governing the balance and posture system, and they are cybernetic, cognitive theories and complex nonlinear systems.

According to Ashby (1952), a system is any set of variables that the experimenter selects from all those available, and any measurable quantity is defined as variables which at any instant has a numerical value (e.g. pressure, temperature, angles, etc.).

Grodins (1963) further develops this concept by defining the common system a connection of arranged and interconnected components in a defined way. Such components can be physical, chemical, biological or a combination of the three. Milsum (1966) in turn defines the system as any set of communicating structures and processes that together perform a function.
The behavior of the system is determined by the inputs to the system, or variables, by the characteristics of the components or subsystems; the structure of the communication between the components, communication that usually requires feedback.
Each system can be considered as a white box or as a black box.
The white box is a system built in such a way that a certain relationship between input and output is guaranteed.
On the contrary, in the black box only the input and output functions are known but not the processes that determine the input-output relationship, and therefore all the processes and structures that give rise to a given operation.
The system of balance if considered a black box, means that it is not correct to predict the functioning of the structures inside the box, being able to evaluate (and not necessarily know) only

the inputs and outputs of this box. You can overcome this difficulty by setting a cybernetic model representative of the function of this box on the basis of the model provided by complex systems.
The balance system can therefore be interpreted as a complex, circular, time varying and causal system. This system will comply with the laws that regulate complex systems of this type.

According to neurocognitive theories, the equilibrium system would in fact be considered a white box and therefore the modules between input and output would be studyable and processable.
The information coming from the environment, visual (remote space) and domesticated (next space), passing through the visual and domesticated cortex respectively, would reach the posterior parietal cortex where specific areas (area 5 and 6) process visual, tactile, kinesthetic stimuli vestibular, coding the spatial coordinates centered on the head, on the body (egocentric coordinates: midline) and on the environment (allocentric coordinates).
Through the premotor cortex (spatial orientation) and the additional motor cortex (programming of motor sequences), the outputs are sent to the motor cortex for the execution of voluntary movement useful for the purpose of maintaining balance.
The midline is a particular coordinate that helps define the anatomical and functional lateralization of the body and the environment.

In recent years, the notion that the postural system and the equilibrium system are to be considered as complex nonlinear systems has made headway. The emerging properties of which is never given by the simple sum of each component.
The vast majority of physical systems are nonlinear, making the search for solutions on an elementary basis very difficult and sometimes impossible.
And it is in this statement that the drama of the instrumental analysis of movement in its aspects related to balance and posture is currently taking place.
For linear systems, a minimal variation in its initial state (physical, chemical, biological, economic) causes a correspondingly minimal variation in its final state.
For example, if I hit a ball a little more, or less with the cue, on the pool table, its impact against another will cause it to move a little more or less on the cloth.
Unlike for a nonlinear system, small differences in initial conditions produce unpredictable differences in subsequent behavior.
For example, a subject who underwent stabilometric analysis with his eyes open if he inhales deeply or swallows before starting the test, we do not know how much (numerically: length of the trace, subtended area) and how (qualitatively: status kinesigram, stabilogram) his behavior will vary movement on the platform in seconds of the duration of the test.
It is impossible to predict the behavior that a chaotic system will have after even a short interval of time.
The epistemology of complexities is a branch of epistemology that studies complex systems and associated emerging phenomena. Living organisms are complex systems, consisting of elements that undergo continuous changes, individually foreseeable, but of which it is not possible, or is very difficult to predict a future state.
The objects of complex systems interact, adapting and evolving, developing a form of self-organization that allows the system itself to have collective properties that are not specific to individual agents and are called emerging properties. These properties never represent the sum of the individual elements.
These systems are located in the region known as the edge of chaos. That is, placed between stability and chaos.
If we relate the terms of balance with genotype, posture with phenotype, motor behavior with emerging properties, we can confirm that if the organization of the molecules of an organism confer the vital essence to it, this is due to the genotype.

The organization of the components of an organism can make it take on computational skills. Therefore, the implementation of a series of basic rules (genotype) through computation, produces a structure (phenotype-posture) from which behavior derives.
The rules may in turn have been predefined or learned, and unless they are trivial, it will be impossible to predict the results and behaviors except at a statistical level.
Then, in defining the complexity of the system where its objective intrinsic properties are not understood, but the properties of the whole constituted by the observer subject (who creates the model) and the model itself, another problem arises which adds to one of the many issues fundamentals of movement analysis such as: model theory, and the stochastic aspect.

In today's contemporary thinking, complexity from an epistemological point of view means that there is a new collaboration between science and philosophy. A renewed way of doing scientific research using computers, simulation, using the bottom-up approach.
In this sense, evolutionism is placed in a new light, trying to abandon the idea that progress favors evolution.
Returning to the equilibrium system, it is also more complex, the greater the arbitrary constants to describe it.
As said, the complexity of a system is not an intrinsic property, but always refers to a description of it and therefore depends on the model used and its accredited variables (indicators).
The goal of complexity theory is to understand the behavior of complex systems characterized by numerous and different elements, with multiple and nonlinear connections.
Man is a complex adaptive system capable of adapting, changing by experience, with the ability to evolve. It is ultimately an unstable aggregate of self-organized agents and connections, and to ensure adaptation, it constantly redefines its relationship with the environment (co-evolution).
By adopting systems theory, balance can be considered as an identity that can be analyzed and broken down as it has variable or constant characteristics.

If we represent it as a box with inputs (e.g. posturographic signals, U), we also think of it with outputs (Y). Its state will therefore be described by a set of variables, called status (X).
The inputs (input), visual, proprioceptive, auditory, cognitive, act on the state of the system and modify its characteristics which are recorded and processed by the state variables (neuroendocrine system, cardiorespiratory system, musculoskeletal system, CNS, SNP).
The values of the outputs (Y), the only measurable variables (for example: surface of the ellipse, length of the trace, half-step, Fourier etc.) depend on the status variables and the inputs, giving us ultimately information on the various organs and systems .
In the study of balance and posture, time (T) is always fixed and analyzed. Over a period of time (ordered set of instants), a series of particular instants is considered.
By order it is meant that taking any elements, it can be established with certainty which of the two precedes the other.
In summary, the elements to study the balance-posture system can be represented by a sixfold of data such as: S = (T, I, U, X, f, g).
Where is meant by:

• T = {t0, t1 …… .ti} ordered set of time (eg measurement time at OA or OC at 30 "or 51")
• I = {i0, i1 …… .ii} set of input variables (sight, hearing, proprioception, cognition)
• U = {u0, u1 …… .ui} set of the output variables (motor behavior on the platform: sagitto-frontal or lateral-lateral oscillations, strategies, compensations)
• X = {x0, xi …… .xi} set of state variables (neuroendocrine, cardiorespiratory, musculoskeletal system, CNS, SNP)

• f = {T, I, U, X} equation of state (correlates the internal state of the system with a specific moment: eg Cervical Interference Index, Romberg Index, Postural Biomedical Index); X (ti) = f [X (t0), I, (t0, ti)]
• g = g (T, I, U, X) output equation; calculate the output over time ti. Semi-quantitative Romberg, classification of instability; U (ti) = g [X (ti), in (ti)]

The importance of the epistemology of complexities derives from the conflict in the science-philosophy relationship. Through cognitive science, in the second half of the 19th century, neuroscientists, computer scientists, philosophers of the mind, linguists, psychologists, anthropologists, began to build behavioral models of psychic activity to answer complex questions.
Research institutes where neurobiologists, philosophers of the mind, computer scientists, epistemologists and chemists work together to elaborate the theory of complexity.
There is talk of the birth of a third culture, alternative to the humanistic and scientific-technological one.
To give examples, according to these scholars a classification of systems could be:

• minimal complexity (non-living)
• medium complexity (computer)
• maximum complexity (living)

Cognitive science has used behavioral models that proceed from top to bottom. The model is built on the global knowledge of the system itself, how it behaves, which laws it obeys.
A system is studied starting from its competences, initially neglecting the details of the performances of the single parts.
The complexity theory proceeds from the bottom to the top. The system model is built on the basis of local knowledge, how and how many its components are, how they interact, which laws they obey.
For complex systems, the measurement of their variables implies that since their distribution is very asymmetric, their average value never provides satisfactory information on the variation in complexity. Is the modal value and not the average value that measures the main trend (in a frequency distribution, fashion is the value of the independent variable which corresponds to the highest frequency).
The practical implications are important. In the meantime, the choice of indicators cannot be random but derive from their careful choice that obeys the following requirements:

1. their statistically reliable calculation
2. chosen according to the type of application in use
3. they must allow the formulation of a hypothesis and its remote control over time
4. must allow to modify the therapeutic choice
5. must give added value to the whole journey
6. must not be an end in themselves (2)

Track length

The length of the trace is the linear measurement (in mm or cm) of how far the center of pressure does during the test (CoP), due to the postural oscillations of the individual in the sagittal-frontal plane. It is an indicator of energy expenditure.
CoP is in practice the point where the resultant vector of the constraint reaction of the surface on which the body is resting is located. It is totally independent of COM. If only one foot is resting on the ground, the CoP will be in a point inside the foot itself; if, on the other hand, both feet are

resting on the ground, the position of the CoP will vary and will be in an unspecified point between the two feet, however, shifted to the right or left in relation to the weight distribution.
In the sitting position, with the trunk erect, the upper limbs resting on the knees, the pelvis in contact with the sitting with both femurs 30 ° apart and the lower limbs 90 ° at the knees with the feet adhering to the ground, the CoP must be inside the trunk, in front of the vertebral column and projected inside the crurogram obtained as per posture described above.

The status kinesigram is the digitized graphic of the actual displacement of the pressure center with reference to the plantar support, it is also called postural ball. Quantities directly related to the kinesigram state are the surface parameters and the length.

The control of the upright posture can be described referring to a reverse pendulum type model. The variables involved in the phenomenon are:

• Center of mass (COM) whose position in the anteroposterior direction is indicated by y
• Center of pressure (COP) whose position in the anterior-posterior direction is indicated by u
• Gravity force (applied to COM)
• Ground reaction F (applied to COP)
• mτ Ankle muscle couple

COM is never perfectly immobile, but subject to acceleration. The acceleration of the COM is proportional to the difference u-y: where the constant k depends on the physical characteristics of the subject and the acceleration of gravity. Instability derives from the fact that u and y never coincide perfectly. The acceleration of the COM generates an inertia force which is balanced by the horizontal component of the soil reaction FH.
Even during the maintenance of the upright posture in quiet conditions, there are continuous oscillations of the COM and the COP on the support base. The displacements of COM imply an effective movement of the whole body mass. The displacements of the COP are determined by the muscular pair of the ankle and therefore do not imply any movement.
The control of the upright posture continuously requires a mutual pursuit of COM and COP. To bring COM and COP together, two main control strategies can be implemented:

• Act on COP by modulating the activation of the ankle muscles (ankle strategy)
• Act on COM through relative movements of body parts (hip strategy)

In the ankle strategy, the modulation of the ankle muscle couple directly and quickly controls the COP; action on COM is less important. It allows you to compensate for minimal balance disturbances. Requires good muscle capacity.
In hip strategies, the displacement of the pelvis and trunk directly controls the position of the COM. It allows you to compensate for moderate balance disturbances. It requires less muscle effort.
To compensate for greater disturbances of the balance in a static standing position, the so-called compensations such as the enlargement of the base of support, of the upper limbs with search for support can be implemented.

There are three possible stabilization mechanisms, which intervene simultaneously:

• physical mechanism, linked to muscle stiffness
• reactive mechanism, it is a closed-chain or feedback control, which acts in reaction to different types of reflexes acting independently

• anticipatory mechanism, it is an open chain or feedforward control mechanism based on an internal model of sensory fusion and dynamic prediction

Muscle stiffness is the elastic stiffness KA typical of muscle tissues. It produces a torque proportional to the oscillation angle: CA = KA □
You can compare the torque provided to the ankle by muscle stiffness with the static gravitational torque (reference value): CG = mgh □ (where h is the height of the COM).
Indicatively, the torque produced by the stiffness of the ankle muscles is about 50% lower than the reference value. Muscle stiffness is therefore not sufficient to stabilize erect posture alone.

Feedback control is a mechanism that tries to maintain balance based on sensory information (afferents) regarding the position of the various parts of the body. Muscle actions are thus generated on the basis of visual, vestibular, proprioceptive and tactile information.

In feedforward control, sensory afferents are not directly sent to the neuromotor system but to an associative neural center that is based on an internal model of biomechanics and physics of the external world. The different muscle actions are generated in advance of the events, in anticipation of the presumed effects. It is a control based on learning and memory mechanisms and is adaptable to different environmental conditions. Prediction is effective only if the disturbances are foreseeable and their dynamics (experience) has already been learned by the subject.

The control of the upright posture, as well as the sitting position and any other motor function, requires the intervention of three physiological systems:
• sensory system
• central control system
• muscle drive system

The three systems are complex and interfaced. In the elderly, the functionality of the three systems degrades causing various difficulties.
As we age, the functionality of the three fundamental systems in postural control tends to decrease:
1) vision decreases in acuity, sensitivity of contrast and perception of depth
2) the vestibular system undergoes changes that cause dizziness and instability
3) there may be a decrease in proprioceptive capacities;
4) sensory information has slowed down
5) the speed of nerve conduction is slowed down
6) muscle strength decreases
7) increases the rigidity of the connective tissues
8) decrease joint mobility (3)

Clinically, the track length (4,5,6) allows us to graduate the energy expenditure according to a classification as per the attached table to measure instability in a static standing position.

__Tab.1 Classification of instability in static standing position at 30 ", detection frequency 20 Hz__

	SAEO Degree of precision / compensation	**TLOE Degree of energy expenditure**	SACE	**TLCE**	SAOERH	**TLOERH**	SACERH	**TLECERH**
Normal	<117	**<306,72**	<136,92	**<342,5**	<93,15	**<349,65**	<193,53	**<894,51**
Borderline	117,01-175,59	**306,73-460,17**	136,93-206	**342,6-513,82**	93,16-140,44	**349,66-524,52**	193,54-291,80	**894,52-1350,78**
Mild	175,6-288,9	**460,18-763,11**	206,1-338,97	**513,83-1027,78**	14045-231,25	**524,53-966,42**	291,81-480,48	**1350,79-2488,17**
Average	289-405,135	**763,12-1066,77**	338,98-594,19	**1027,78-1707,36**	231,26-321,16	**966,43-1421,91**	480,49-667,30	**2488,18-3660,41**
Serious	405,136-463,05	**1066,78-1219,23**	594,2-679,14	**1707,37-2081,55**	321,17-367,06	**1421,91-1649,7**	667,31-762,67	**3660,42-4296,59**
Very serious	463,06-oltre	**1219,24-oltre**	679,15-oltre	**2081,56-oltre**	367,07-oltre	**1649,8-oltre**	762,68-oltre	**4296,6-oltre**

Legend: SA = subtended area in mm2, TL = track length in mm OE = open eyes CE = closed eyes CR = retroflex head

__Tab.2 Classification of instability in static standing position at 51.2 ", detection frequency 20 Hz__

	SAEO Degree of precision / compensation	**TLOE Degree of energy expenditure**	SACE	**TLCE**	SAOERH	**TLOERH**	SACERH
Normal	<44,25	**<527,16**	<169,28	**<677,82**	<35,19	**<600,96**	<239,26
Borderline	44,25-66,33	**527,17-790,97**	169,29-254,68	**677,83-1016,88**	35,19-53,05	**600,97-901,53**	239,27-360,76
Mild	66,34-109,14	**790,98-1311,67**	254,69-419,08	**1016,89-2034,08**	53,06-87,36	**901,54-1661,11**	360,77-594,04
Average	109,15-153,05	**1311,68-1833,65**	419,09-734,64	**2034,09-3379,03**	87,37-121,32	**1661,12-2444,07**	594,05-825,02
Serious	153,06-174,93	**1833,66-2095,63**	734,65-839,66	**3379,04-4119,57**	121,33-138,66	**2444,08-2835,65**	825,03-942,92
Very serious	174,94-oltre	**2095,64-oltre**	839,67-oltre	**4119,58-oltre**	138,67-oltre	**2835,66-oltre**	942,92-oltre

Legend: SA = subtended area in mm2, TL = track length in mm OE = open eyes CE = closed eyes CR = retroflex head

Clinical use

The length of the trace is one of the fundamental indicators in use in stabilometry. It must always be measured.
It is an indirect index of the energy expenditure implemented to maintain posture and balance.
The balance of our body in its multiple joints depends on a fine neutralization of the force of gravity by the work of opposing forces.
Standing, energy consumption occurs when the vertical line of gravity passes through an inactive bone support pillar. The human body is approaching this ideal situation with discontinuity. In the human body, bones are a series of segments connected by joints and held in a straight position by muscles, ligaments, capsules. If these are arranged in such a way that the line of gravity passes directly through the center of each joint, the mechanical stresses on the muscles and ligaments, capsules will be minimal.
It has been established (Steindler, 1955) that a complete passive equilibrium is impossible since the center of gravity of the segments and the movement of the centers between them cannot be such that all coincide perfectly with a common line of gravity. If the barycenters of each body segment are aligned one on top of the other and these, in turn, are in line with their respective joints, the force required to maintain this position is zero. If the line of gravity passes through the supporting joints, the lever arm should be zero without moments, but only a linear downward force. However,

a little that the center of gravity of the segment moves from this line, a moment is determined. The greater the displacement, the greater the moment. To stay in balance, one must exert a force that creates an equal moment in amplitude and in the opposite direction. The muscles must actively contract and the ligaments are subjected to tension to balance the bad position of the body segments. To maintain stability, the line of gravity of the entire body must be in the support base. In the seated position, the support base is given by the so-called crurogram.

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