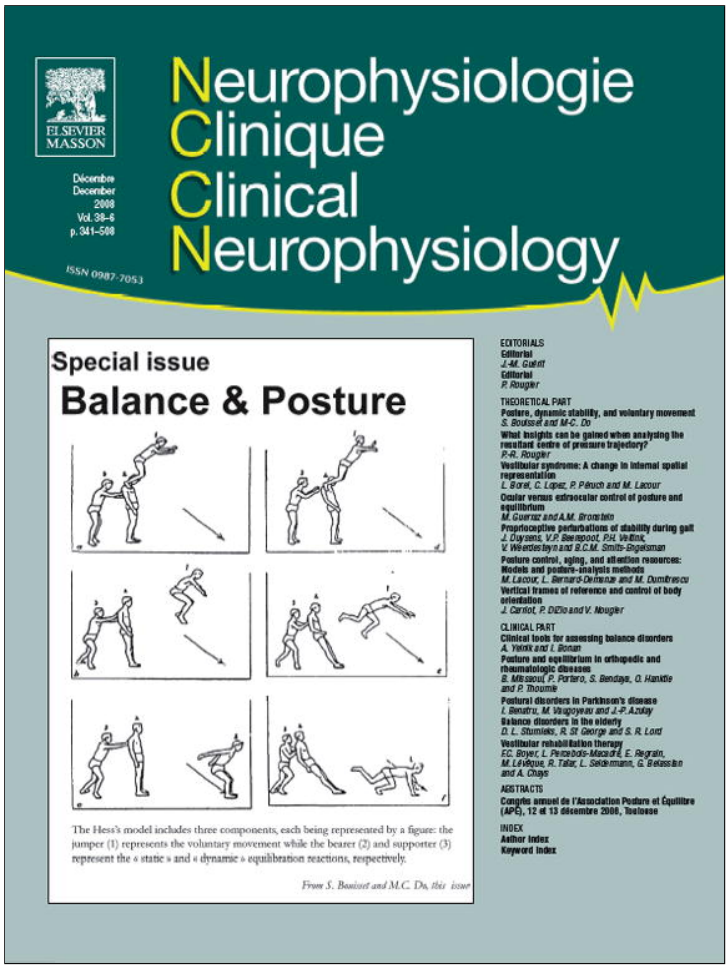

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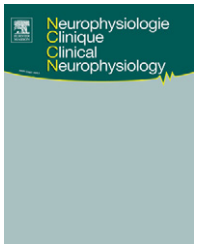

REVIEW/MISE AU POINT

Clinical tools for assessing balance disorders

Séméiologie et évaluation clinique des troubles de l'équilibre

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Evaluation;
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Berg Balance Scale;
Postural Assessment Scale for Stroke Patients;
Instrumental evaluation

Summary Three main issues have to be addressed by the examination of a patient complaining from balance disorders: physiopathology and aetiology, severity and consequences, and evolution. A precise clinical analysis must be then conducted, including close anamnesis and clinical examination, with scale measurements depending on the objectives. Daily consequences can be assessed by the Dizziness Handicap Inventory, which considers a large field of daily activities. The International Classification of Functioning evaluates activities and participation, influence of environmental factors, and quality of life. Then, patient's examination aims at objectifying and measuring the balance disorder. Quantified measurement is possible even in a simple doctor's office. Clinical scales for balance assessment should be used for a standardized assessment and to allow comparison of different subjects. Although the Tinetti test is the most-widely used in older people, it is quite approximate. The Berg Balance Scale has also been first validated in older people, it is rather easy to use, but uncertainty between two close scores is frequent. The Timed Up-and-Go Test is the simplest one and probably the most reliable. The Unipodal Stance Testing is also a simple test and a good predictor of fall. The Functional Ambulation Classification focuses attention on the physical support needed by the patient during walking. The Postural Assessment Scale for Stroke Patients (PASS) is easy to use after a recent stroke. Instrumental analysis by means of static and dynamic platforms, often coupled together with accelerometers or video, can be used to complete the clinical examination. Its main interest is to contribute to give insight into physiologic and pathologic mechanisms underlying the postural trouble.

MOTS CLÉS
Équilibre ;

Résumé Trois questions principales se posent à l'examinateur d'un patient se plaignant de troubles de l'équilibre : la physiopathologie et l'étiologie de ce trouble, sa sévérité et ses conséquences et enfin son évolutivité. Une analyse clinique rigoureuse doit être conduite, incluant un interrogatoire précis et l'examen clinique, aidé d'échelles d'évaluation selon les objectifs

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Évaluation ;
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Évaluation instrumentale

poursuivis. Les conséquences quotidiennes peuvent être évaluées par la ''Dizziness Handicap Inventory'' qui balaie un large champ des activités quotidiennes. Sur la base de la Classification internationale de fonctionnement, les activités et la participation à la vie sociale peuvent être évaluées ainsi que l'influence des facteurs environnementaux et la qualité de vie. L'examen lui même a pour but d'objectiver et de mesurer le trouble de l'équilibre. L'évaluation quantifiée est possible au cours d'une simple consultation médicale. Les échelles cliniques d'évaluation de l'équilibre doivent être utilisées pour une évaluation standardisée et permettre ainsi la comparaison de différents sujets entre eux. Bien que le test de Tinetti soit le plus couramment utilisé chez le sujet âgé, il est approximatif. La Berg Balance Scale, également validée chez les personnes âgées, est d'usage plus facile, mais des hésitations entre deux scores proches sont fréquentes. Le Timed « Up and Go Test » est le plus simple et sans doute le plus fiable. Le test de station unipodale est également un test simple et un bon indicateur de risque de chute. La « Functionnal Ambulation Classification » tient particulièrement compte du support physique dont le patient a besoin pendant la marche, aide technique ou aide humaine. La « Postural Assessment Scale for Stroke Patients » est adaptée à l'examen de l'équilibre après accident vasculaire cérébral récent. L'analyse instrumentale au moyen d'une plateforme d'équilibre statique ou dynamique, souvent associée à une analyse par accéléromètres ou caméra vidéo peut être utilisée pour compléter l'examen clinique. L'intérêt principal est de contribuer à une meilleure connaissance de la physiologie et des mécanismes pathologiques expliquant le trouble d'équilibre.

Introduction

Three main issues have to be addressed by the examination of a patient complaining from balance disorders: what is (or what are) the cause(s), i.e., physiopathology and aetiology, severity, i.e., the risk of falling down, and the evolution with or without treatment. A precise clinical analysis should then be conducted, including close interrogation and clinical examination, with the use of scales whose choice should depend on the objective, i.e., to compare a subject to himself or to analyse a whole population.

Anamnesis

Patient's interrogation should be close and comprehensive in order to orientate diagnosis and evaluate the consequences of the balance disorder. Past medical history should be collected.

Rotatory vertigo as the main symptom suggests a peripheral vestibular disorder. The characteristics of the vertigo (starting modalities, duration of symptoms, and other possible associated symptoms) are of invaluable help for diagnosing a vestibular neuronitis, benign postural paroxystic vertigo or tumoral disorders. More often, the patient complains from unsteadiness or dizziness without rotatory vertigo, in which case symptom description may sometimes be difficult and a central neurologic disorder is more likely to be the cause. The characteristics of unsteadiness sensations, triggering circumstances, their repetition, and the usual inefficacy of the tried treatment should be carefully recorded. Consciousness loss should be identified and detected, as it does not belong to the field of balance disorders and justifies urgent cardiologic and neurological examination.

In case of falls, circumstances must be clarified. Even when a mechanical cause is presumed, a pathological cause should be suspected. The distinction should be made between an external cause of balance perturbation (for instance, pushing) and an internal cause (for instance, turning around). However, very often, the fall cannot be explained by the patient. The rate of fall occurrence and their consequences (for example, fractures) should be recorded. Worth reminding is that one of the main consequences of falls is the fear of falling down, which leads to the fear of walking, a restriction of activity, care-giver dependency and loneliness.

The ''Dizziness Handicap Inventory'' is a useful tool to guide the interrogation, as it considers a large field of daily activities [20]. Though validated for vestibular disorders, this questionnaire can be included, whatever the aetiology of the dizziness, to the patient examination. For physiatrists who must pay special attention to patients complaints, activities and participation, involved environmental factors, and quality of life, we recommend the International Classification of Functioning [29].

Clinical examination

Patient's examination aims at objectifying and measuring the balance disorder. A quantified measure is possible even in a simple doctor's office. The sitting position should be assessed before the others in order to observe its stability, the need for support, the side of tilt if any, the ability to keep sitting despite internal destabilizations (self movements), and then external destabilizations (by pushing the patient in various directions). Important information can be gained from the examination of transfers and of the ability to rise from sitting to standing. The type of forces the physiatrist have to exert when the patient needs help to stand up can also provide relevant information: vertical in case of lower-limb weakness or pain, horizontal in case of equilibrium difficulties; sometimes a simple touch can help patient by providing sensory information.

When the standing position can be obtained, the following items are noted: spontaneous posture, laterally or posteraly tilted; need for support (number and type); spontaneous distance between heels and the minimal possible distance in centimeters; the ability to adopt the tandem position with each foot successively behind; the ability for unipedal standing. The minimum duration in seconds for each of these tests is recorded. Each test should be firstly conducted with eyes open and then with eyes closed. Equilibration will be then carefully evaluated after internally produced perturbations (head, trunk, and arm movements) and, lastly (and only lastly), firstly by expected, and then unexpected, externally produced perturbation (by pushing the patient in various directions).

When walking is possible, its stability and the need for device (single cane, crutch, tripod cane) or human support should be assessed. Both the distance between heels in the frontal plane and the ability of tandem walking should be evaluated. The normal double stance phase, during which both feet are in contact with the ground accounts for 20% of the gait cycle, and increases in case of balance disorder. Gait characteristics should be observed as they may give arguments for the cause of the instability: lameness, length and symmetry of steps, course of the step. Self-selected speed and then quick speed can be easily recorded over ten meters, although it is not directly related to the risk of fall. While turning round, the number of steps needed by the external foot is numbered, as a high number of steps is related to the risk of falling down. Lastly, some perturbation can be added in order to increase the balance disorder during walking: eyes closing; rotation and tilting head movements; simple or double tasks, which slow down or stop walking in older people with high risk of fall; then, possibly, external perturbation like playing with a ball.

At the end of this examination, a quantitative measurement of the balance disorder can be obtained. This will constitute a baseline for future examinations. Diagnostic hypotheses are put forward and will be tested by the remaining of examinations. In case of a lateralized destabilisation, a peripheral vestibular disorder should be suspected. The Romberg sign (patient standing, arms held in front, eyes closed) consists of a forefingers deviation toward the side of the lesion. It can be sensitized by head movements or unipodal standing. The Fukuda Test (stamping when eyes closed) can reveal an abnormal body rotation of more than 30° toward the lesion. A nystagmus is searched and hearing is examined. An ENT examination should complete this assessment by functional tests of the vestibular system: head manipulation for postural paroxystic benign vertigo, caloric testing, and otolithic myogenic evoked potentials.

A complete neurological examination should be performed: motor function and coordination (cerebellar ataxia), sensory examination (proprioceptive ataxia), muscle tone, cognitive testing. A complete examination of the locomotor system should include: measurement of the spinal static (scoliosis, kyphosis), pelvic static, lower-limb articular range of motion, length comparison of both lower-limbs, foot static with scopic sole examination. Vision examination includes visual acuity, visual-field examination, and visuospatial analysis. It should be completed by an ophthalmologic examination, systematically in the elderly, or whenever the cause of instability remains obscure. A cardiovascular examination should identify an orthostatic fall of blood pressure.

At the end of this assessment, which may require a long (or multidisciplinary) consultation, the examiner has enough data for quantifying the balance disorder, evaluating the risks of falls and, usually, putting forward diagnostic hypothesis.

Clinical scales for balance assessment (Appendix A)

Scales are used for a standardized assessment of balance and to allow comparison of different subjects or groups of subjects.

The Tinetti test [27] is certainly the widest used among older people. It consists of two parts. The first part is a static examination of standing that includes 13 items, all of them being close to those usually used and described above: standing position, ability to stand up and to resist external destabilizations. Each item is scored from 1 (normal) to 3 (abnormal). The second part is based on a gait observation with nine items, simply scored as normal or abnormal. Most of these items are difficult to assess. Despite being widely used in gerontology, this test is quite approximate and the second part is not in use.

The Berg Balance Scale (BBS) [2] consists of 14 items assessing the ability to stand up and to maintain standing position despite internally produced perturbations. Each item is scored from 0 (unable) to 4 (safely done) with a maximum score of 56. Inter- and intra-rater reliability is good. The BBS has been first validated among older people, in whom a score higher than 45 is related to a low risk of fall [5]. Nevertheless, a recent study showed that a change of eight points is required to reveal a genuine change in function among older people who are dependent in activities of daily living [9]. The BBS is rather easy to use and can be performed in only ten to 15 minutes, but uncertainty between two close scores is frequent. It has also been then validated among poststroke patients, but only for patients being able to walk [3], but in our experience its sensitivity in these patients is low.

The Timed ''Up and Go Test'': initially called Get Up and Go [22], it has been labelled on Timed up and Go after being validated with a timed score [24]. This quick test is the simplest one for an outpatient use, and probably the most reliable. The subject, sitting in an armchair, is called to stand up, to walk three meters, to about-turn, to retrace his step to the chair and to sit down. The score is the time in seconds and, during this test, it is possible to do the clinical analysis that was described above. This time score is reliable, correlates well with scores on BBS and appears to safely predict the patient's ability to go outside alone safely.

The unipedal stance testing [18] is another simple test and good predictor of fall. The subject has to maintain unipedal stance on the limb of his choice. For the authors, while a stance longer than 30 s was related with a very low risk of fall, a stance shorter than 5 s was, conversely, related with a high risk of fall.

The Functional Ambulation Classification (FAC) [8,16] has been designed to focus attention on the physical support that is needed by the patient during walking. This functional assessment consists of six classes, from Class 0 = no possible walk without at least two aides, to Class 5 = patient can walk independently anywhere. Classes 1 to 4 are related to the progression of the human assistance: continuous assistance, intermittent assistance, verbal supervision, aid for stairs only. Both validity and reliability of FAC have been established. It is simple for daily use to measure evolution from being immobile to walking. A French modified FAC, which is called *new FAC*, is a 9-class score that includes more details for stairs climbing [6].

The Postural Assessment Scale for Stroke patients (PASS) [1] has been built for patients after recent stroke. The PASS consists of two parts: the first part assesses the ability to maintain posture, with five items scored from 0 (not possible) to 3; the second part assesses in seven items the ability to change posture from the lying to sitting and then standing position, from 0 (not possible) to 3 (possible without help). The maximal score is 36. The PASS can be completed in 10 to 15 min. It has been validated within the first three poststroke months, with a good construct validity, an excellent predictive value for functional independence, and high inter-rater and test—retest reliabilities [1,21]. It is easily used and often quoted in the literature for patients with strong impairment.

The functional Reach Test [12] evaluates balance during a simple reaching task. The subject is standing along a wall, holding arms in front, and then has to lean forward. The observer measures the distance covered by the extremity of the major finger along a horizontal ruler. The score is calculated as the mean value of three trials. This test is easily conducted and looks test—retest and inter-observer reliable. Its score is related to the BBS score in stroke patients but it has no predictive value for the risk of falls [26].

The Hoehn and Yahr scale for parkinsonian patients [15] is still in use. It relies on the occurrence of balance disorders. It consists of five items, from 1 = unilateral parkinsonism without balance disorders to 5 = walking not possible without human assistance. The Unified Parkinson's Disease Rating Scale is more complex but includes items assessing falling, gait and postural stability.

Finally, for daily clinical evaluation, the Dizziness Handicap Inventory is a good tool for the assessment of the consequences of the balance disorder. The Timed ''Up and Go Test'' and the ''Unipedal stance testing'' are easy and probably the best to evaluate the risk of fall, although there is no validated threshold value. For standardized assessment, the BBS can be recommended in the elderly and chronic stroke patients, and the ''Postural Assessment Scale for Stroke Patients'' in recent stroke patients.

Postural Instrumental analysis

Instrumental analysis can be used to complement the clinical examination, to provide a baseline for a quantified follow-up of postural perturbations [11], and to evaluate therapeutic efficiency [17,25]. Its main interest is to contribute to give insight into the pathophysiology of the postural disturbance

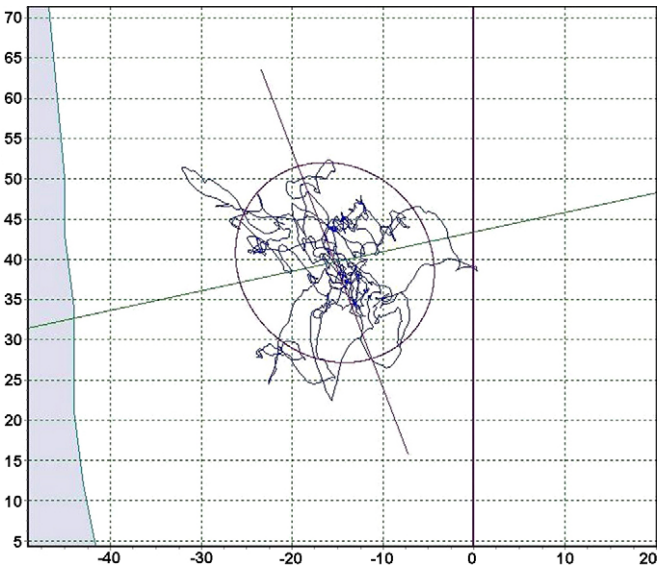

Figure 1 Statokinesigram (Technoconcept®): centre of pressure trajectory (length, surface, maximal amplitude of the displacement).

[14]. These tools that are used for the aetiological diagnosis, such as somatosensory evoked potential, EMG, and MRI, will not be described here.

Posturography

Static or dynamic posturography can be easily used in everyday practice, but is mainly used in research, eventually coupled together with other devices allowing analysis of the body movement and/or recording muscle activity. Posturography assesses the regulation of postural control by examining the trajectory of a force-plate centre of force. This technique uses force platforms, which contain strain gauges measuring the vertical forces exerted by the subject's feet with an acquisition frequency of more than 40 Hz. Several transducers on a supporting centre plate transform the force applied by the body in an electrical signal. One can use a single force platform, on which the subject stands with his feet placed in a fixed position. Two separate platforms can also be used, one under each foot, which allows recording separately the forces exerted by each foot. With these last devices, the position of the feet is not fixed and can vary. The parameters commonly studied from the analysis of the centre of pressure trajectory (length, surface [Fig. 1], maximal amplitude of the displacement, speed, frequency analysis of the postural sway [Fig. 1]) are described by Rougier in this issue.

Static posturography

Static posturography is conducted on a non movable forceplate, the subject standing on the force platform, commonly with the feet placed with an angle of 30° for 20 to 60 s. The subject is asked to maintain normal standing balance. Balance performance can be assessed in undisturbed stance, eyes opened or closed but dynamic balance can also be studied with dual tasks or while rising from a chair...

Dynamic posturography

Dynamic platforms allow analysing patient's abilities to maintain or recover his balance when balance is disturbed by sensory or mechanical perturbations.

To assess the sensory organization, i.e. subject's ability to integrate the sensory information that is relevant for balance control, patients can be tested during sensory perturbations. Vision can be altered by sway-referenced visual surround or optokinetic stimulation. Proprioception can be altered by a sway-referenced support or a foam rubber support. Vestibular cues can be altered by head movements or galvanic stimulation [23]. In other devices, balance can be tested in six sensorial conditions. The EquiTest® (Neurocom) is one of them. The subject stands on a force platform that is surrounded by a visual enclosure [13]. Both the platform and the visual surround can be stationary or sway-referenced to the subject's own motion. In sway-referenced conditions, shifts of the center of pressure in the anterior-posterior direction are accompanied by a forward or backward rotation of the force plate and/or visual surround. The sensory profile of the subject is given by analysing the ability of the subject to maintain his postural control in conditions in which sensory information is not present or erroneous. The outcome measures are derived from each sensorial condition. A computer generated equilibrium score (ES) is calculated as the angular difference between subject's calculated antero-posterior CP displacement and the theoretical maximum of 12.5°. The Balance Quest-MultiTest® (Framiral) consists of a similar device with a support force platform that is movable in any direction and a visual surround that is perturbed by horizontal optokinetic stimulation [19]. The outcome measure is calculated as the percentage of stability from the deviation in anterior-posterior and mediolateral direction. These devices allow understanding the sensory preferences of the subjects by comparing the results obtained in different conditions. The visual ratio compares the results of the condition [free vision and sway-referenced support] to [free vision-fixed support]. The vestibular ratio compares the results of the condition [eyes closed and sway-referenced support] to [eyes opened-fixed support]. A score of visual preference is also obtained by comparing the results of the two conditions in sway-referenced vision to the two conditions with eyes closed (Fig. 2).

Motor reactions to mechanical perturbations can be studied with these two platforms or with other devices. These platforms are dual force plates that are movable by rotation in the sagittal plane (toes up—down) or by translation in the horizontal plane (forward—backward). Although the movement of the plate is usually motorized, the movement of the platform can also be provoked by the spontaneous subject's movement on a laterally or antero-posterior rocking plate that is placed on a platform [4]. The plate movement provokes force excursion. The principle is to analyse the reaction to force-plate movement. The subject's reaction time to regain initial balance after sudden and unexpected perturbation is analysed. The reaction time is calculated and deviation of excursions can be normalized by subject's height to produce an assumed equivalent centre of gravity sway angle.

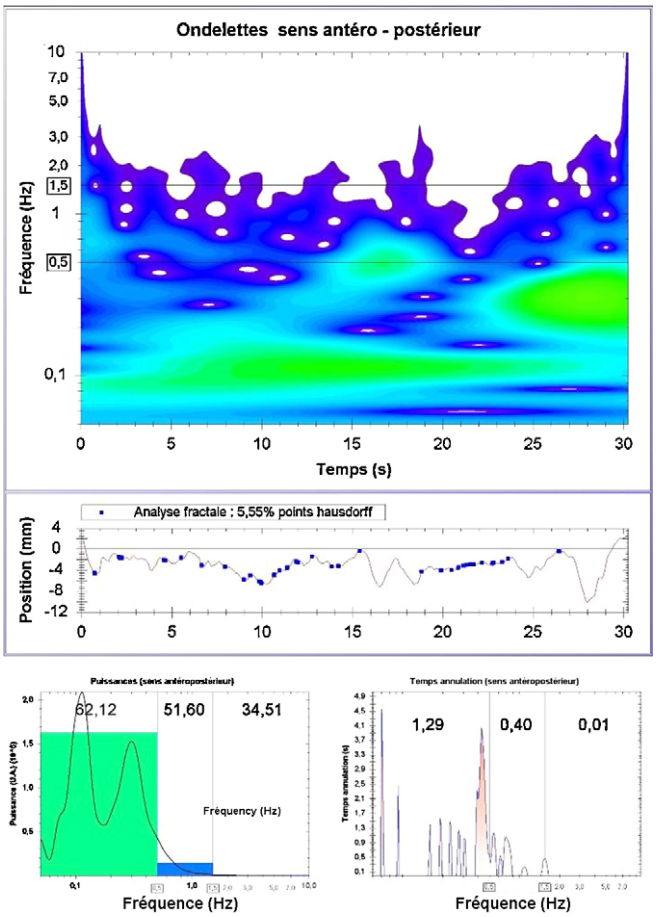

Figure 2 Normal frequential analysis of the postural sway with wavelet transform and power spectral density (Posturopro® Framiral®).

Another aspect of motor control is the adaptation to repeated perturbations, whose evaluation is provided by the analysis of subject's ability to modify motor reaction and minimize sway when support moves unpredictably. Repeated perturbations are performed and the decrease in the magnitude of the force of responses is quantified. Adaptation to sinusoidal movements can also be analysed [7]. The pattern of the responses is then provided.

However the limitation of posturography is to restrict body movement analysis to the examination of the CP excursion, which is assumed to represent the movement of the centre of gravity. Other devices are often added to explore the movement of the whole body and so complete the analysis: movement's captors, accelerometers, surface electromyogram, goniometry, or optoelectronic systems.

Gait analysis

Gait performance is often considered as another aspect of dynamic analysis of postural control. Gait analysis methods are based on several techniques. Gait kinematic and kinetic analysis (trajectory, angle, velocity, acceleration, stride analysis) are recorded by video systems, optoelectronic system, force-plates, electronic walkway carpet, footswitches, or a mechanical system called Locometre®.

Spatio-temporal variables provide information about balance control. Indeed, the double-support time and the gait velocity seem to be related to balance [28]. Electromyography and ground force reactions given by successive force platforms placed under the path can complete the analysis. Accelerometers that are placed on the subject during several hours in his proper environment can also be used to record the real daily activity [10].

Berg Balance Scale

Items

- Sitting to standing
- Standing unsupported for 2 min
- Sitting unsupported for 2 min
- Standing to sitting
- Transfers
- Standing with eyes closed for 10 s
- Standing with feet together for 1 min
- Reaching forward with an outstretched arm
- Retrieving an object from the floor
- Turning to look over shoulder
- Turning 360° in both direction
- Placing alternate foot on a stool
- Tandem stance for 30 s
- Unipedal stance for 10 s

See details for scoring in Berg K. et al Physiother Can 1989; 41:304-11

Timed ''Up and Go''

In seconds, time:

- To stand up from a standard armchair
- Walk a distance of 3 m
- Turn
- Walk back to the chair
- Sit down again

Functional ambulation categories

Nº	Category	Guidance
0	Nonfunctional (unable)	Patient cannot walk, or requires help of two or more people
1	Dependent — level 2	Patient requires firm continuous support from one person who helps carrying weight and with balance
2	Dependent — level 1	Patient needs continuous or intermittent support of one person to help with balance or co-ordination
3	Dependent — supervision	Patient requires verbal supervision or stand-by help from one person without physical contact
4	Independent — on level ground	Patient can walk independently on level ground, but requires help on stairs, slopes or uneven surfaces
5	Independent	Patient can walk independently anywhere

Postural Assessment Scale for Stroke Patients

Items

Maintaining a posture

1 Sitting without support (sitting on the edge of a 50-cm-high examination table [a Bobath plane, for instance] with the feet touching the floor)
2 Standing with support (feet position free, no other constraints)
3 Standing without support (feet position free, no other constraints)
4 Standing on nonparetic leg (no other constraints)
5 Standing on paretic leg (no other constraints)

Changing posture

6 Supine to affected side lateral
7 Supine to nonaffected side lateral
8 Supine to sitting up on the edge of the table
9 Sitting on the edge of the table to supine
10 Sitting to standing up
11 Standing up to sitting down
12 Standing, picking up a pencil from the floor

See details for scoring in Benaim et al. Stroke 1999;30:1862—1868.

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