Development of innovative training solutions in the field of functional evaluation aimed at updating of the curricula of health sciences schools

Module Biomechanics of Gait

Didactic Unit C: How do I assess gait?

C.2 What clinical scales exist to assess gait performance?

Index

1. Objectives

The objectives of this didactic unit are:

- To review the importance of the clinical standardized assessment of human gait.
- To identify the clinical assessment scales for gait performance in healthy, elderly or people with neurological disorders.
- To know the reliability and validity characteristics in the clinical assessment scales for gait performance.
- To learn the methodology of clinical gait scales and tests for human gait performance assessment.

2. Introduction

A rating scale is understood as a set of categories described to obtain information about a quantitative or qualitative attribute. It has been recorded throughout history that humans seek to quantify to understand reality, so, the conversion of values or value judgments on a useful scale of standardized mathematical quantification has been a great socio-cultural advance and scientific-technical. For this purpose, the values require adapting to a set of axioms, or model, that explain the relationship between its variables.

In the health field there is an important barrier that professionals have been dealing with for a long time: the multi-dimensionality of health-disease. This aspect cannot be ignored because, mentioning the definition of the World Health Organization (WHO), health is a state of complete physical, mental and social well-being, not just the absence of disease. Non-biological measurements are considered as soft or subjective indicators, but this is a clear bias due to the fact that the patient's social, cultural and environmental context cannot be ignored, and therefore, all their circumstances related to their health.

The psychometric and clinometric scales are used in research as in clinical practice and require an exhaustive creation process until they become available to specialized users. To be accepted as scientific tools they must have four fundamental properties: be valid, reliable, sensitive and useful. The validity represents the scientific utility of the scale itself, it is the ability of the instrument to measure the construct for which it has been designed; reliability, or its reliability, denotes the accuracy of the scale as a measuring instrument or utility in the scientific field, demonstrating its subsequent reproducibility in other cases or by different evaluators; The sensitivity of an instrument is the ability to detect changes over time; and the utility denotes its ease of execution to be able to reproduce again along with its low production cost. A more schematic explanation can be reviewed in Table 1.

Table 1 - Characteristics to a rating scale for being validated.

Criterion	Property	Definition	Stadistics	Satisfactory result
Reproducibility	Reliability	Variation or homogeneity in measurements	Cronbach's alpha	≥ 0,7
	Internal consistency	Correlation between the items of a dimension (applies to multidimensional scales and indexes)	Pearson, Spearman or Kuder-Richardson correlation	≥ 0,4 (if ≥0.9 would indicate measurements are equal)
	Discriminating power	Correlation between the items of a scale and the dimensions to which they do not belong (only in multidimensional scales)	Pearson or Spearman correlation	Less than the correlation of the items with their dimension (<0.3)
	Intra-rater reliability or test-retest	Instrument repeatability	Pearson correlation, Spearman or intraclass	≥0,80 or 0,85
	Reliability inter-rater	Concordance in different evaluators with the same subjects, same instrument and occasion	Pearson correlation, Spearman or intraclass	≥0,80 or 0,85
Validity	Face	Degree to which items logically measure a given construct	None. Applicability and Acceptability	Does not apply
	Content	The instrument items adequately represent the construct you intend to measure	Exploratory factor analysis	Coefficients λ or factor loads ≥0.3
	Criterion	Degree of similarity in scale scores compared to a standard or reference standard (criterion)	Pearson or Spearman correlation coefficients	≥0,80
	Convergent	Correlate scores obtained with different scales	Pearson or Spearman correlation	Between 0.4 and 0.70

	Construct	Degree to which the instrument adequately reflects the underlying theory of the phenomenon or construct to be measured	Confirmatory factor analysis. Or hypothesis tests to compare theoretically different groups	Coefficients λ ≥0.3, statistics of goodness of adjustment ≥0.05. In hypothesis tests Vp <0.05
Sensibility	Ability of an instrument to detect changes over time		Hypothesis testing	Vp <0,05
Utility	The scale is easy to apply, complex and low cost		None	Does not apply

The assessment scales are, today, essential to perform the scientific and clinical activity. If we focus on the clinical scales, these are accessible today to the vast majority of researchers and clinicians in the world, as long as there is no technical problem as highly specialized evaluation tools. In addition, evaluation scales require internationalization, referring to the fact that they must adapt to English and subsequently be adapted to the sociological conditions of each of the countries where they want to be used.

Below are some of the most commonly used clinimetric assessment scales in the field of biomechanics to determine gait disturbances in different populations of subjects: the Tinetti Mobility Test (TMT), the Time Up and Go Test (TUG), the 6 minutes Walking Test (6MWT), the Wisconsin Gait Scale (WGS), the Dynamic Parkinson Gait Scale and the Gait Assessment and the Intervention Tool (GAIT).

3. Tinetti Mobility Test (TMT)

The Tinetti Performance-oriented Mobility Assessment (POMA) or Tinetti Gait Scale (TGS) or Tinetti Mobility Test (TMT) scale, is a scale to analyze gait disturbances and balance in the healthy adult and geriatric population. However, it has also been used in the analysis of gait and balance disorders in populations with neurological disorders such as stroke or Huntington's disease (HD) and mostly in people with Parkinson's disease (PD)

The Tinetti scale is composed of 16 items in total, divided into two components to evaluate the functions of gait and balance independently. Each item evaluated can be assessed with a score of 0, 1 or 2 points. The answers are scored as 0 if the person fails to maintain stability in position changes or shows an inappropriate gait pattern according to the parameters described in the scale, which is considered as abnormal; the rating of 1 means that the person assessed achieved changes in position or gait patterns with postural compensations, which is called adaptive behavior; and finally the rating of 2 is scored when the person shows no difficulty to accomplish the different tasks of the scale and is considered as normal. In spite of everything, not all items are scaled up to 2 points (Table 2 and Table 3). The maximum balance score is 16 and that of March 12, totaling 28 points. People with scores between 19 and 24 points on the Tinetti scale are at moderate risk of falls and, people with scores below 19, have a high risk of falls.

For the evaluation of gait, the patient must walk down a corridor at a usual pace, while assessing the points in Table 2:

Table 1 - Gait evaluation of the Tinetti scale.

Item to evaluate	Score
1. Start the gait	
The way in which the patient starts walking is evaluated, that is, the phase immediately after the start indication by the evaluator.	Scaling as: • 0 if the patient hesitates or has difficulty starting. • 1 if the patient starts directly without hesitation.
2. Length and height of the right and left step	
The displacement of both lower limbs is evaluated on both the X axis (anterior displacement) and the Y axis (height).	2 items will be scaled per lower member: • 0 if the patient's foot when walking does not exceed the contralateral foot.

	• 0 if the patient drags the leg when walking. • 1 if the patient's foot when walking exceeds the contralateral foot. • 1 if you lift your foot completely when walking.
3. Step symmetry	
The length equity between steps within the gait phases is evaluated.	Scale as: • 0 if the step length of both feet is not equal. • 1 if the length of the step is the same or practically the same.
4. Continuity of the steps	
The constant rhythmic pattern between steps within the gait phases is evaluated.	Scale as: • 0 if there are stops in the steps. • 1 if there is fluidity in gait.
5. Path deviation	
The alteration of the rectilinear and stable trajectory during the gait phases is evaluated.	Scale as: • 0 if there is a marked deviation from the trajectory. • 1 if there is a slight / moderate deviation from the trajectory or if you have help to maintain the trajectory. • 2 if there is no deviation or help to maintain the trajectory.
6. Trunk mobility	
The performance of the spine is evaluated during the gait phases.	Scale as: • 0 if there is a marked trunk sway or the patient uses help. • 1 if there is no trunk swing, but the patient flexes the knees or trunk or separates the arms from the trunk. • 2 if you do not swing the trunk, do not flex your knees or trunk during walking or do not separate your arms from the trunk during walking.
7. Separation of the feet when walking	
The performance of the feet is evaluated, with respect to the other, during the gait phases.	Scale as: • 0 if there is heel separation during walking. • 1 if there is a great approach of the heels during the gait.

For the assessment of balance, the patient should be sitting in a chair, then get up and finally perform a couple of tests that assess the points in Table 3:

Table 2 - Balance evaluation of the Tinetti scale.

Item to evaluate	Score
1. Sitting balance	
Patient positioning in the chair is evaluated for a short period of time.	Scale as: • 0 if the patient fails to keep the trunk erect, leans or slips in the chair. • 1 if the patient maintains an erect, stable and safe, seated position.
2. Ability to get up	
The ability to rise from the sitting position to the upright bipodal is evaluated.	Scale as: • 0 if the patient is unable to get up without help. • 1 if the patient is able to get up, but use the arms for it. • 2 if the patient is able to get up without the use of their arms to help.
3. Attempt to get up	
The variation of attempts is evaluated during the survey phase. Direct relationship with item 2.	Scale as: • 0 if the patient is not able to get up without help. • 1 if the patient requires more than one attempt to get up. • 2 if the patient manages to get up on the first attempt.
4. Immediate foot balance	
The balance is evaluated immediately after the lifting phase (first 5 seconds of the test)	Scale as: • 0 if the patient moves the feet to stabilize, balances the trunk or wobbles. • 1 if the patient is stable standing, but with technical aids or is held to gain support for other objects. • 2 if the patient is stable without any help.

5. Foot balance	
The balance is evaluated as such during the bipodal phase of the patient.	Scale as: • 0 if the patient is unstable. • 1 if the patient is stable, but maintains a large support area with separate heels or uses technical aids to do so. • 2 if the patient stands stable with the feet together without difficulty.
6. Attempted destabilization	
The patient's stabilization capacity is evaluated by producing a destabilization on the sternum.	Scale as: • 0 if the patient does not stabilize and begins to fall. • 1 if the patient wobbles taking time to stabilize or holds to avoid falling. • 2 if the patient remains stable.
7. Balance with eyes closed	
The patient's standing balance is evaluated with the feet together and eyes closed for a few seconds.	Scale as: • 0 if the patient is not stable. • 1 if the patient is stable.
8. 360 ° turn over place	
The test is evaluated where the patient must make a complete turn on himself and return to the starting position looking at the evaluator.	Scale the continuity of steps as: • 0 if the patient has discontinuous steps. • 1 if the patient performs continuous steps. Scale stability as: • 0 if the patient is unstable, requires support or wobbles. • 1 if the patient is stable.
9. Balance while sitting	
The stabilization capacity is evaluated while the patient sits.	Scale as: • 0 if you do not control the distances or fall directly on the chair. • 1 if the patient uses the hands or does not have a fluid movement. • 2 if the patient manages to sit fluidly and safely.

The characteristics of the Tinetti scale studied on a population with PD are:

- Form and time of completion: administered by evaluator, 10-15 minutes.
- Reliability in population with PD:
    - Intra rater: ICC = 0.96 (24)
    - Inter rater: ICC = 0.88 ($p < 0.01$)
- Validity in population with PD:
    - Significant and positive correlation with comfortable walking speed: Pearson's statistic = 0.53 ($p < 0.01$)
    - Sensitivity of identifying the risk of falls (contrasted with clinical history) of 76%.

4. Time Up and Go Test (TUG)

The Timed Up and Go (TUG) test is a simple, rapid and widely used clinical test to measure the performance of lower limb function, mobility and risk of falling. The TUG test has proven useful for evaluating a variety of therapeutic interventions, both in the healthy older adult population, and in people with different neurological pathologies, including patients with PD.

The test is that the subjects should get up from a standard chair (chair with height between 44 and 47 centimetres), walk 3 meters forward (marked on the floor) in a comfortable space, turn, walk back to the chair and sit (Figure 1. Participants are allowed to use the usual technical aids they will use for the gait.

As indications, the subjects evaluated cannot use their arms to stand up and physical assistance should not be given to perform the test. The time to complete the task is measured with a stopwatch, begins with the "start" instruction and stops when the person sits down and finishes resting his back on the back of the chair. Several studies have adopted a modified version of the test in which subjects are asked to walk as fast as they can, a variation that was included in this study. It has been suggested in previous studies that the 13.5 second score is the threshold to identify the people most at risk of falling.

Reliability studies of the TUG test in groups of older patients indicate the following characteristics:

- Form and time of completion: administered by evaluator in less than 1 minute.
- Reliability in population with PD:
    - Repeatability (test-retest): ICC = 0.90
    - Intra rater: ICC = 0.97
    - Inter rater: ICC = 0.96
- Validity in population with PD:
    - Significant correlation with 6 Minute Walk Test: Spearman correlation index = -0.89 ($p < 0.05$)
    - Ability to identify people at risk of falls with a sensitivity of and specificity = 87%, when the test is performed only or when another task is included at the same time (cognitive or manual).

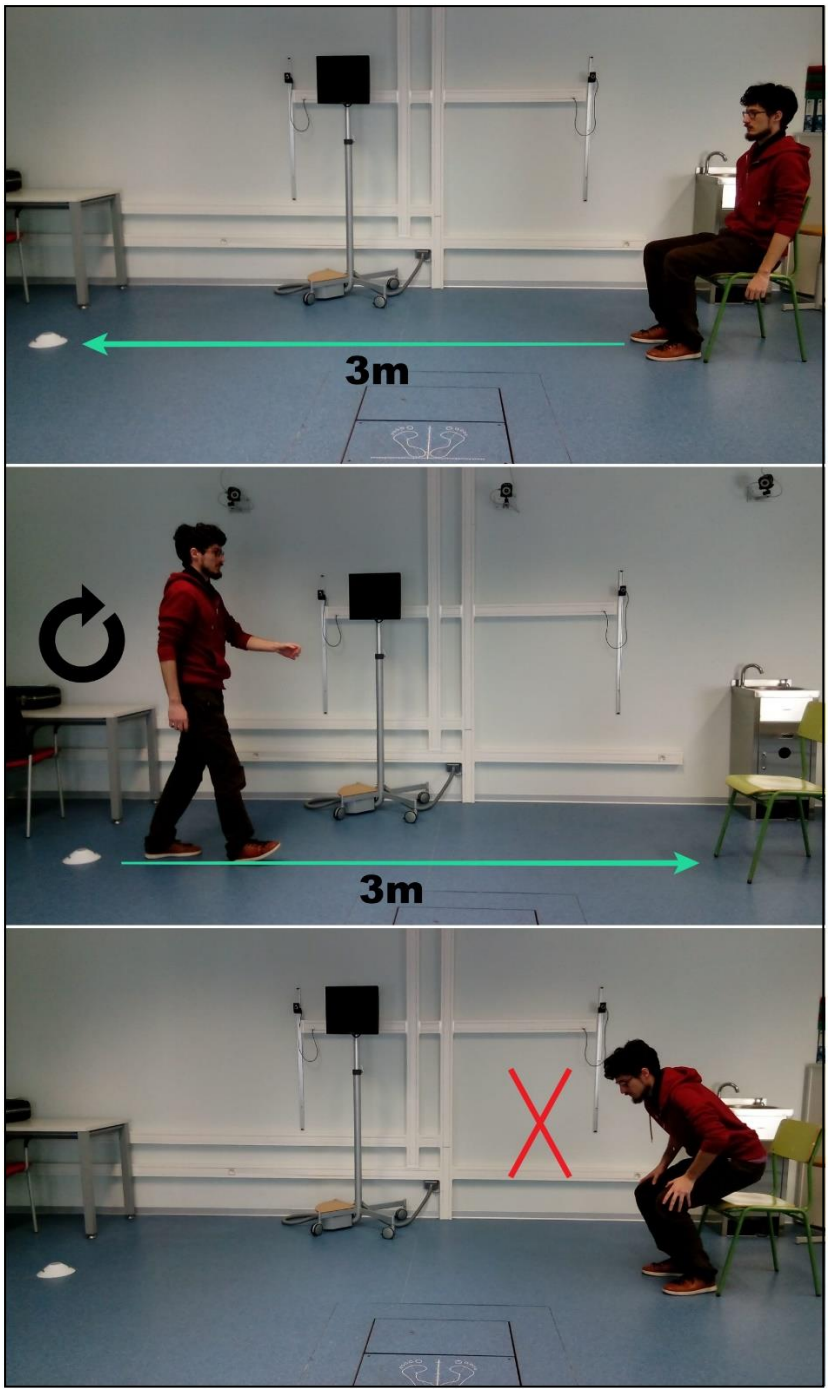

Figure 1: Time Up and Go Test performance. (Up) Test Starting. (Middle) Final line reached, turn around and return to start point to sit. (Down) Failure test. No hands allowed to standing up.

5. Six-Minutes Walking Test (6MWT)

The 6 Minute Walking Test (6MWT) is a common test in clinical practice, easy to use and high tolerance for patients due to its similarity to the usual walking action, which does not require specific instruments or prior training to perform. It is used in the analysis of gait disturbances and has been shown to be useful in populations of healthy adult patients and with cardio-respiratory pathology in chronic conditions.

The test is that the subjects must perform a rapid gait on a long, flat and rigid surface, with a minimum length of 30 meters signalled every 3 meters (10 markers), for a period of 6 minutes (Figure 2). However, it is also possible to use different lengths, such as 20m or 50m if the required space is not available. A multi-center study has confirmed that there are no significant differences by performing the test in lengths from 15m to 50m. It is not recommended to use a treadmill machine to perform the test because the subjects are not allowed to manage their own walking pace. Participants will be instructed to go to the test area with comfortable shoes and clothes and not to perform any sports activity 2 hours before the test. Neither will any warm-up be carried out prior to 6MWT.

The patient will begin the test sitting in a chair in the starting position, which will correspond to one of the two indicated ends of the catwalk, where it should be kept for 10 minutes before starting. Next, you should get up and graduate your level of effort according to the Borg scale (Figure 3) after the instruction of the “forward” assessor, the subject will walk agilely along the walkway for 6 minutes without performing any rest, once reached the opposite end will make a turn and return by the same walkway. Once the 6 minutes are over, he will stop and re-graduate his level of effort with the Borg scale. The patient will be told that during the test he cannot speak. The evaluator will remain standing at all times timing the time at one end of the catwalk and will not accompany the patient along it.

Reliability studies of the 6MWT test in groups of older patients indicate the following characteristics:

- Form and time of completion: administered by evaluator over 6 minutes.
- Reliability in healthy population:
    - Repeatability (Test-retest): ICC = 0.95
    - Intra-observer: ICC = 0.98
    - Inter-observer: ICC = 0.98
- Validity in healthy population:
    - Correlation with performance / clinical measures of chair lift: Spearman's correlation index: 0.67 ($p < 0.05$) (moderate)
    - Foot balance: Spearman's correlation index: 0.52 ($p < 0.05$) (moderate)
    - Running speed: Spearman's correlation index: 0.73 ($p < 0.05$) (moderate)

Figure 2: 6MWT in a 30m corridor. (Left) Starting point and moving forward direction. Red marks are assigned to the 4 proximal cones. (Right) Returning after final cone reached. 6-minute action repetition.

20-Grade Scale	
6	
7	Very, very light
8	
9	Very light
10	
11	Fairly light
12	
13	Somewhat hard
14	
15	Hard
16	
17	Very hard
18	
19	Very, very hard
20	

Figure 3 - Borg Scale for Rating Perceived Exertion (From Gerald F. Fletcher et al. 2001).

6. Wisconsin Gait Scale (WGS)

The Wisconsin Gait Scale observational scale (WGS) is designed for gait analysis in adults who have suffered stroke where lower limb motor skills have been affected due to deviations from hemiplegic marches. It has high reliability to assess gait patterns in patients with acute, subacute and chronic stroke, and it has been shown to have high validity in the correlation of motor performance and gait velocity in patients with acute, subacute and chronic stroke.

The WGS is that the subject walks four times along a flat surface 10 meters long at a comfortable speed. Two repetitions will be performed with the usual footwear of the subject and, subsequently, two repetitions will be performed with the subject barefoot. Between repetitions the subject has the opportunity to rest. The beginning and the end of the test will be delimited with markers (cones) and the test will be videotaped: the first videocamera will be located on one side covering the complete plane, head to toe of the subject, or the evaluator will follow the subject with a fixed camera on a moving surface; The second videocamera will be located 4 meters away at one end of the evaluation surface.

The WGS consists of 14 observational items that analyze the gait components: 13 of them analyze the MMII during the gait cycle and 1 of them the possible manual help. The scale of each item is between 1 (normal) to 3 (atypical), except for the 1st item that has a rating of 1 to 5, and the 11th item that has a rating of 1 to 4. The perfect WGS scale score is 14 points, while the maximum is 45 points. High scores represent severe gait deficits related to subjects who have suffered stroke.

The WGS scale has its items divided into four subscales that will observe the behaviour of the patient's affected side during the four phases of gait (Table 4):

Table 4 - Wisconsin Gait Scale (WGS)

Item to evaluate	Score
I. Use of manual aids	
1) Use of manual aids	Scale as: • 1 no use of help. • 2 a minimum use of help. • 3 a minimum use of support with large support base. • 4 high use. • 5 a high use of technical support with large support base.
2) Tempo of support on the affected side	Scale as: • 1 the same time on both sides respectively.

	• 2 as a different time between both supports. • 3 as a large decrease in support time on the affected side.
3) Step length on the healthy side	Scale as: • 1 when the foot of the healthy side clearly exceeds the big toe of the affected side. • 2 when it is not clear that the foot on the healthy side exceeds the big toe of the affected side. • 3 when the foot on the healthy side is at the same height or behind the big toe of the affected foot.
4) Displacement of loads towards the affected side with or without technical aids	Scale as: • 1 if during the gait there is a total displacement of the head and trunk loads on the affected side. • 2 if there is a decreased displacement. • 3 if there is no displacement.
5) Support Base Amplitude	Scale as: • 1 if there is an amplitude of one foot between the feet. • 2 if there is an amplitude of two feet. • 3 if there is an amplitude of more than two feet.
II. Affected leg takeoff	
6) Caution during the gait	Scale as: • 1 if the movement is decided without hesitation. • 2 if there is a hesitant movement. • 3 if there is a marked hesitation.
7) Leg hip extension affects	Scale as: • 1 if there is an equal extension in both legs during takeoff. • 2 if there is slight hip flexion. • 3 if there is a marked hip extension.
III. Affect Leg swing phase	
8) External rotation during initial swing	Scale as: • 1 if it is identical to that of the healthy leg. • 2 if external rotation increases with respect to the healthy leg.

	• 3 if there is a marked external rotation.
9) Circumduction during medium swing	Scale as: • 1 if the affected foot does not adduce more than the healthy foot during swing. • 2 if there is a moderate adduction. • 3 if there is a marked adduction.
10) Hip lift during medium swing	Scale as: • 1 if the pelvis descends slightly during swing. • 2 if the pelvis rises during the swing phase. • 3 if there is a large elevation of the pelvis during the swing phase.
11) Knee flexion from takeoff to medium swing	Scale as: • 1 if the knee affects denotes a flexion identical to that of the healthy side. • 2 if there is a decrease in knee flexion. • 3 if there is minimal knee flexion. • 4 if knee remains in extension throughout swing.
12) Separation of the big toe from the ground	Scale as: • 1 if the big toe rises completely from the ground during the swing phase. • 2 if there is a slight finger drag. • 3 if there is a marked finger drag.
13) Rotation of the pelvis in the final swing	Scale as: • 1 if the pelvis performs an anterior rotation to prepare for the heel impact. • 2 if the pelvis is in neutral position. • 3 if the pelvis is retracted or in subsequent rotation.
IV. Heel contact of the affected leg	
14) Initial foot contact	Scale as: • 1 if the heel makes the initial impact on the ground. • 2 if the impact is made with flat feet. • 3 if there is no contact with the heel.

The characteristics of the WGS studied on the population with stroke are:

- Form and time of completion: administered by the evaluator, 15 minutes.
- Reliability in stroke population:
    - Intra-observer: ICC = 0.961
    - Inter-observer: ICC = 0.945
- Validity in stroke population:
    - Correlation in acute phase with:
        - Functional Ambulatory Classificator (FAC - Holden et al. 1984): Spearman's correlation index = -0.773 (p <0.01) (moderate).
        - Berg Balance Scale (BSS - Berg et al. 1995): Spearman's correlation index = -0.676 (p <0.01) (moderate).
        - Postural Assessment Scale for stroke Patients (PASS) or Tinetti POMA: Spearman's correlation index = -0.657 (p <0.01) (moderate).
        - Barthel Index (BI): Spearman's correlation index = -0.657 (p <0.01) (moderate)
        - Functional Independence Measure (FIM): Spearman's correlation index = -0.592 (p <0.01) (moderate).
    - Correlation with the subacute phase:
        - (FAC): Spearman's correlation index = -0.878 (p <0.01) (excellent)
        - (BBS): Spearman's correlation index = -0.882 (p <0.01) (excellent)
        - (PASS): Spearman's correlation index = -0.847 (p <0.01) (excellent)
        - Barthel Index (BI): Spearman's correlation index = -0.842 (p <0.01) (excellent)
        - (FIM): Spearman's correlation index = -0.693 (p <0.01) (moderate)
    - Correlation with the chronic phase:
        - (FAC): Spearman's correlation index at 6 months = -0.905 (p <0.01) (excellent). Spearman's correlation index per year = -0.888 (p <0.01) (excellent).
        - (BBS): Spearman's correlation index at 6 months = -0.817 (p <0.01) (excellent). Spearman correlation index per year = -0.908 (p <0.01) (excellent).
        - (PASS): Spearman's correlation index at 6 months = -0.892 (p <0.01) (excellent). Spearman's correlation index per year = -0.890 (p <0.01) (excellent).

- Barthel Index (BI): Spearman's correlation index at 6 months = -0.867 ($p < 0.01$) (excellent). Spearman's correlation index per year = -0.810 ($p < 0.01$) (excellent).
- (FIM): Spearman's correlation index at 6 months = -0.801 ($p < 0.01$) (excellent). Spearman correlation index per year = -0.821 ($p < 0.01$) (excellent).

7. Dynamic Parkinson Gait Scale (DYPAGS)

The Dynamic Parkinson Gait Scale (DYPAGS) evaluates the performance of the gait in challenging tests, unlike most tests that analyze the performance of this function in baseline conditions. Each of the 8 items that make up the scale, have a score from 0 to 5, which is assigned according to the performance achieved in each item (Table 5).

At the "start" signal, the subjects must make the items as fluid and smooth as they can, that make the turns in the minimum number of steps possible, that during the obstacle tests perform the greatest possible stride, and during the cognitive double task name as many animals as possible. The total score of the DYPAGS scale is 40 points, high scores represent severe gait disorders related to PD.

Table 5 - Dynamic Parkinson Gait Scale (DYPAGS)

Item to evaluate	Score
1) Walking 7 m forwards	Scale as: • 0: Normal. • 1: Subtle start hesitation (<1 s) or slow gait or increased double-stance time. • 2: Start hesitation >1s or destination hesitation or impaired feet clearance. • 3: Block or accelerated short steps. • 4: Unable to perform the entire distance or near fall. • 5: Unable to initiate a step backward or fall.
2) Walking 3 m backwards	Scale as: • 0: Normal. • 1: Subtle start hesitation (<1 s) or slow gait or increased double-stance time. • 2: Start hesitation >1s or destination hesitation or impaired feet clearance. • 3: Block or accelerated short steps. • 4: Unable to perform the entire distance or near fall. • 5: Unable to initiate a step backward or fall.
3) Turning 360º on the same place to the right	Scale as: • 0: Normal. • 1: Subtle start hesitation (<1 s) or 8 or >8 steps. • 2: Start hesitation >1s or 10 or >10 steps. • 3: 15 or >15 steps or block. • 4: Unable to complete 360º turning or near fall.

	• 5: Unable to initiate turning or fall.
4) Turning 360º on the same place to the left	Scale as: • 0: Normal. • 1: Subtle start hesitation (<1 s) or 8 or >8 steps. • 2: Start hesitation >1s or 10 or >10 steps. • 3: 15 or >15 steps or block. • 4: Unable to complete 360º turning or near fall. • 5: Unable to initiate turning or fall.
5) Stepping over an imaginary obstacle with the right leg	Scale as: • 0: Step amplitude > 0.5 x patient's height. • 1: Step amplitude = 0.4 x patient's height - 0.5 x patient's height. • 2: Step amplitude = 0.3 x patient's height - 0.4 x patient's height. • 3: Step amplitude = 0.2 x patient's height - 0.3 x patient's height. • 4: Step amplitude < 0.2 x patient's height. • 5: Unable to initiate a step forward.
6) Stepping over an imaginary obstacle with the left leg	Scale as: • 0: Step amplitude > 0.5 x patient's height. • 1: Step amplitude = 0.4 x patient's height - 0.5 x patient's height. • 2: Step amplitude = 0.3 x patient's height - 0.4 x patient's height. • 3: Step amplitude = 0.2 x patient's height - 0.3 x patient's height. • 4: Step amplitude < 0.2 x patient's height. • 5: Unable to initiate a step forward.
7) Passing through tight quarters	Scale as: • 0: No hesitation. • 1: Subtle hesitation (<1 s) or shuffling of first step. • 2: Start hesitation = 1-2 s or impaired feet clearance within tight quarters. • 3: Start hesitation = 2-5 s or accelerated short steps within tight quarters. • 4: Start hesitation = 5-10 s or block within tight quarters or near fall. • 5: Start hesitation > 10 s or unable to initiate a step forward or fall.
8) Walking while performing a cognitive dual-task (quoting animal names)	Scale as: • 0: Normal. • 1: Subtle start hesitation (<1 s) or slow gait or increased double-stance time. • 2: Start hesitation >1 s or destination hesitation or impaired feet clearance or <6 items quoted. • 3: Block or accelerated short steps. • 4: Unable to perform the entire distance or near fall. • 5: Unable to initiate a step forward or fall.

The characteristics of the DYPAGS scale are:

- Form and time of completion: administered by the evaluator, 4 to 8 minutes.
- Reliability in PD population:
    - Inter observer: Alpha coefficient of krippendorff = 0.83; Kendall's W coefficient = 0.90; CCI = 0.94
    - Internal consistency: global Cronbach's alpha coefficient = 0.95
- Validity in PD population:
    - Correlation with Freezing of Gait Questionnaire (FOG-Q) test: Spearman's correlation coefficient = 0.74 ($p < 0.01$)
    - Correlation with the mobility index of the PD Questionnaire test (PDQ-39 gait): Spearman's correlation coefficient = 0.58 ($p < 0.01$)
    - Correlation with motor part of the Unified Parkinson's Disease Rating Scale (MDS-UPDRSgait) scale: Spearman's correlation coefficient = 0.81 ($p < 0.01$)
    - Correlation with the progress assessment part of the Tinetti Mobility Test (TMTgait): Spearman's correlation coefficient = -0.71 ($p < 0.01$).

8. Gait Assessment and Intervention Tool (GAIT)

The Gait Assessment and Intervention Tool (GAIT) is an observational scale assesses the coordination of movements during the gait phase and the associated deficits in adult populations with stroke. It consists of an evaluation of 31 items divided into 3 different sections: 4 items evaluate the upper limbs (MMSS) and the trunk, 14 items evaluate the trunk, pelvis, hip, knee and ankle during stance phase and finally 13 items evaluate the trunk, pelvis, hip, knee and ankle. Each of the items is rated between 0 (normal) to 3 (altered) having a perfect maximum score of 0 and a maximum deficit score in the gait of 62. Not all items have a maximum score of 3 (Table 6) there are also items that have different types of evaluation that must be described and noted in the subsequent analysis (Table 6). Not only the scores will be noted, but also the type of alteration observed in each of the items, such as the laterality of the alteration.

The test is that the subject walks a minimum of 6 steps along a flat surface of 3 meters, the distance not being specific being able to use more travel if required, nor the speed at which the test is developed. It will be necessary to make a video recording of the entire body (head to foot) first of the sagittal plane on both sides, of the frontal plane starting with an approach and then a distance, and finally the recording of the stance phase in the frontal plane . A recording of the transverse plane (top view) will also be required to perform the evaluation of item 23 (Rotation of the pelvis in anterior oscillation). Intermediate steps will be evaluated by skipping the first and last of each test to avoid acceleration and deceleration of the gait phase. The patient must wear short, non-bulky clothing, and must adjust the shirt inside the pants. A contrasting color tape will be placed over the waist and two pieces of color that contrast over the anterior superior iliac spines.

If for any reason the patient requires follow-up by the evaluator or a contact, the test will be considered as “supervised”.

The perfect GAIT scale score is 0 points, while the maximum is 62 points. High scores represent severe gait deficits related to subjects who have suffered stroke.

Table 6. Gait Assessment and Intervention Tool (GAIT)

Item to evaluate	Score
I. Stance and swing phases	
1) Shoulder position	Scale as: • 0 if there is a normalized position. • 1 if there is an altered position (depressed, raised, retracted or anteposed shoulders).
2) Elbow flexion	Scale as: • 0 if there is an elbow flexion of <45º (normal +/- 10º). • 1 if there is an elbow flexion between 45 and 90º. • 2 if there is an elbow flexion of >90º.

3) Arm swing • Dynamic	Scale as: • 0 if there is a normalized roll. • 1 if it is an altered swing (reduction or absence of swing).
4) Trunk alignment • Static	Scale as: • 0 if there is a normal erect position (without flexion, extension or lateral trunk flexion). • 1 if there is a flexion or extension of the trunk. • 2 if there is a latero-flexion to the right or left of the trunk. • 3 if there is a combined pattern of flexion or extension with latero-flexion to the right or left.
II. Stance phase	
5) Posture / trunk movement • Dynamic • Sagittal plane • Lateral view	Scale as: • 0 if there is a normalized position (static alignments maintained). • 1 if there is flexion or extension of <30º. • 2 if there is flexion or extension of 30 or >30º.
6) Posture / trunk movement • Dynamic • Front plane • Anterior / posterior view.	Scale as: • 0 if there is a normalized position (static alignments maintained). • 1 if there is latero-flexion of <30º. • 2 if there is latero-flexion of 30 or >30º.
7) Displacement of charges • Lateral displacement of head, trunk and pelvis. • Front plane. • Anteriorposterior view.	Scale as: • 0 if there is a normalized displacement of loads (+/- 25mm over the MI in stance). • 1 if there is a reduced displacement of loads. • 2 if there is practically no displacement of loads. • 2 if there is excessive displacement of loads.
8) Position of the pelvis • Front plane. • Anterior / posterior vision.	Scale as: • 0 if there is normality (there is no sign of Trendelenberg. • 1 if there is a pelvic fall on the contralateral side. • 2 if there is a severe contralateral pelvic fall.
9) Hip extension • Sagittal plane. • Lateral vision.	Scale as: • 0 if there is normality (movement of up to 30º of hip flexion at the start of heel contact, neutral in the middle stance and up to 20º of extension in the final stance). • 1 if there is a hip extension in the middle stance but no

	extension in the final stance. • 2 if there is an abnormality during stance. Maintains hip flexion or there is a marked hip extension).
10) Hip rotation • Front plane. • Antero / posterior vision.	Scale as: • 0 if there is normality (remains neutral). • 1 if there is an alteration with internal rotation. • 1 if there is an alteration with external rotation.
11) Knee during the initial contact phase (heel shock) • Sagittal plane • Side view	Susceptible to choose model (A or B): A) Scale knee flexion as: • 0 if there is normality (neutral / non-hyperextended position) • 1 if there is 5-15º of knee flexion. • 2 if there is> 15º and <30º of knee flexion. • 3 if there is> 30º knee flexion. B) Scale knee extension as: • 0 if there is normality (neutral / non-flexed position) • 1 if there is 5-15º of knee hyperextension. • 2 if there is> 15º and <30º of knee flexion. • 3 if there is 30 or> 30º knee flexion.
12) Knee during the load response phase • Sagittal plane • Side view	Susceptible to choose model (A or B): A) Scale knee flexion as: • 0 if there is normality (up to 15º of knee flexion). • 1 if there is> 15º and <30º of knee flexion. • 2 if there is 30 or> 30º knee flexion. B) Scale knee extension as: • 0 if there is normality (up to 15º of knee flexion). • 1 if there is no knee flexion, but if hyperextension up to 15º. • 2 if there is 15 or> 15º of knee hyperextension.
13) Knee during the medium stance phase • Sagittal plane • Side view	Susceptible to choose model (A, B, C or D): A) Knee flexion • 0 if there is normality (knee in 4th flexion at heel shock, increasing to 15º flexion at 14% of the walking cycle). • 1 if there is 5-15º of flexion during medium stance; does not reach the neutral position. • 2 if there is> 15º and <30º of knee flexion. • 3 if there is 30 or> 30º knee flexion. B) Knee extension • 0 if there is normality (knee in 4th flexion at heel shock, increasing to 15º flexion at 14% of the walking cycle). • 1 if there is an extended knee during the medium

	stance phase, not hyperextended. • 2 if there is up to 15º of knee hyperextension during the middle stance phase. • 3 if there is> 15º of knee hyperextension during the middle stance phase. C) Flexion step to knee extension • 0 if there is normality (knee in 4th flexion at heel shock, increasing to 15º flexion at 14% of the walking cycle). • 1 if there is normal knee flexion during the beginning of the middle stance, then the knee extends to the neutral position. • 2 if there is knee flexion during the beginning of the middle stance, then the knee extends to the maximum range (neutral position or beyond) in an uncontrolled manner but without blocking. • 3 if there is knee flexion during the beginning of the middle stance, then the knee extends abruptly and energetically to the maximum range uncontrollably. D) Extension step to knee flexion • 0 if there is normality (knee in 4th flexion at heel shock, increasing to 15º flexion at 14% of the walking cycle). • 1 if the knee remains in extension at the beginning of the middle stance, then flexes late but maintains control. • 2 if the knee remains in extension at the beginning of the middle stance, and then flexes losing control and regaining it later. • 3 if the knee remains in extension at the beginning of the middle stance, then it is blocked in hyperextension with the impossibility of regaining control, and requires the use of compensatory strategies.
14) Knee during the final stance phase • Sagittal plane • Side view	Scale as: • 0 if there is normality (flexion of 35-45º in the sagittal plane) • 1 if there is an altered knee flexion of <35º or> 45º. • 2 if there is a normalized flexion of 35º-45º and suddenly it extends. • 3 if the knee remains fully extended in the process.
15) Ankle movement • Sagittal plane • Side view	Susceptible to choose model (A or B): A) Plantar ankle flexion • 0 if there is normality (from the neutral position of the ankle at the initial contact of the heel, it goes to 10º of plantar flexion before the middle stance, and then at 10º of the dorsal flexion at the heel takeoff). • 1 if there is normality from the initial contact (heel shock) to the middle stance, but in plantar flexion after

	the middle stance. • 1 if there is flat foot in the initial contact, moving to a slight plantar flexion before the middle stance, but in plantar flexion after the middle stance. • 2 if there is flat foot in the initial contact with plantar flexion until heel takeoff. • 3 if there is no heel contact, with excessive plantar flexion until heel takeoff. • 3 if there is contact or not with the heel, followed by excessive and / or early plantar flexion (medium stance). B) Dorsal ankle flexion • 0 if there is normality (from neutral ankle position at the initial contact of the heel, it goes to 10º of plantar flexion before the middle stance, and then to 10º of dorsal flexion at the heel takeoff). • 1 if there is normality just before the middle stance, but> 10º of dorsal flexion after the middle stance. • 2 if there is 15-20º of dorsal flexion in the middle stance until the final stance (heel takeoff). • 3 if there is excessive dorsal flexion (> 20º) during the entire stance phase.
16) Ankle inversion • Front plane • Anterior / posterior vision.	Scale as: • 0 if there is normality (slight inversion / supination in the initial stance; then eversion / pronation until heel takeoff). • 1 if there is an excessive inversion / supination of the ankle present at the initial contact. • 2 if there is an excessive inversion / supination of the ankle present in the initial contact and in the middle stance. • 3 if there is an excessive inversion / supination of the ankle during the entire stance phase.
17) Plantar flexion during final stance / pre-oscillation (from heel takeoff to forefoot takeoff) • Sagittal plane • Lateral view	Scale as: • 0 if there is normality (adequate propulsion in the pre-oscillation to go from dorsal flexion to 10º of plantar flexion). • 1 if there is partial / weak propulsion when moving to plantar flexion in the forefoot takeoff. • 2 if there is no plantar flexion; There is no propulsion.
18) Finger position • Sagittal plane • Lateral view	Scale as: • 0 if there is normality (fingers in neutral position) • 1 if there is excessive finger extension. • 1 if there are claw fingers.
III. Swing phase	
19) Posture / trunk movement	Scale as: • 0 if there is normality (maintains the static alignment of

• Dynamic • Sagittal plane • Lateral view	the trunk). • 1 if there is flexion or extension of the trunk of <30º. • 2 if there is flexion or extension of the trunk of 30 or> 30º.
20) Posture / trunk movement • Dynamic • Front plane • Anterior / Posterior View	Scale as: • 0 if there is normality (maintains the static alignment of the trunk). • 1 if there is lateral flexion of the trunk to the right or left <30º. • 2 if there is lateral flexion of the trunk to the right or left of 30 or> 30º.
21) Position of the pelvis - frontal • Front plane • Anterior / Posterior View	Scale as: • 0 if there is normality (pelvis level or slightly lowered on the oscillating side). • 1 if there is a slight elevation of the pelvis. • 2 if there is moderate or severe elevation of the pelvis.
22) Position of the pelvis - sagittal • Sagittal plane • Lateral view	Scale as: • 0 if there is normality (neutral position with respect to an anterior or posterior inclination). • 1 if there is anterior inclination of the pelvis (anteversion). • 1 if there is posterior inclination of the pelvis (retroversion).
23) Rotation of the pelvis in anterior oscillation • Transverse plane • Top view	Scale as: • 0 if there is normality (from 5º of subsequent rotation in the initial oscillation to 5º of previous rotation in the final oscillation) • 1 if there is a decrease in pelvic rotation. • 1 if there is excessive pelvic rotation. • 2 if there is no pelvic rotation.
24) Hip flexion • Sagittal plane • Lateral view	Scale as: • 0 if there is normality (from 0° of hip flexion in the initial oscillation, up to ~ 35º° in the maximum flexion, then decreases to ~ 25° in the final oscillation; neutral hip with respect to abduction / adduction) • 1 if the hip starts the flexion oscillation, but reaches the maximum normal flexion. • 1 if there is> 10°, but <30° of maximum hip flexion in the sagittal plane. • 2 if there is> 10°, but <30° of maximum hip flexion, and with hip abduction • (eg = circumduction). • 2 if there is> 10°, but <30° of maximum hip flexion, and with hip adduction • (eg = scissor gear). • 3 if there is between 0 to 10° of hip flexion during the entire oscillation.

	• 3 if there is> 35° of hip flexion (excessive hip flexion).
25) Hip rotation • Front plane • Anterior / Posterior View	Scale as: • 0 if there is normality (remains in neutral position). • 1 if there is alteration, internal rotation. • 1 if there is alteration, external rotation.
26) Knee - initial swing • Sagittal plane • Lateral view	Scale as: • 0 if there is normality (40 -60° knee flexion). • 1 if there is at least 15º of knee flexion, but <40º of knee flexion. • 2 if there are <15º of knee flexion. • 3 if the knee never flexes.
27) Knee - medium swing • Sagittal plane • Lateral view	Scale as: • 0 if there is normality (60° ± 4 knee flexion). • 1 if there is a 45º - 55º knee flexion. • 2 if there is a 25º - 45º knee flexion. • 3 if there is a 0º - 25º knee flexion.
28) Knee - final swing • Sagittal plane • Lateral view	Scale as: • 0 if there is normality (from knee flexion to full extension). • 1 if from the knee flexion position, it remains in flexion throughout the phase. • 1 if from the knee extension position, it remains in extension throughout the phase.
29) Ankle movement • Sagittal plane • Lateral view	Scale as: • 0 if there is normality (from initial plantar flexion in the final support (forefoot take off), it goes to the neutral position in the middle oscillation, and then slight dorsal flexion just before the initial contact). • 1 if there is a neutral position in the middle swing but there is no dorsal flexion in the final swing. • 2 if it does not go to neutral position in the middle oscillation nor is there dorsal flexion in the final oscillation, plantar flexion during the whole phase.
30) Ankle inversion • Front plane • Anterior / Posterior View	Scale as: • 0 if there is normality (the ankle remains in neutral position with respect to the investment / eversion) • 1 if there is an ankle in inversion during the swing.
31) Finger position • Sagittal plane • Lateral view	Scale as: • 0 if there is normality (fingers in neutral position). • 1 if there is an inadequate extension of fingers. • 1 if there are claw fingers.

The characteristics of the GAIT scale are:

- Form and time of completion: administered by the evaluator, 20 minutes.
- Reliability in population with stroke:
    - Repeatability (test-retest): ICC = 0.996
    - Intra observer: ICC = 0.98
    - Inter observers: ICC = 0.83
- Validity in population with stroke:
    - Significant correlation between the score of item 26 (knee flexion in the initial oscillation) and the motion capture information of the knee flexion in the initial oscillation: Spearman's correlation index = 0.65 (p = 0.001).
    - Significant correlation between the score of item 27 (average knee oscillation) and the motion capture information of the mid knee oscillation: Spearman's correlation index = 0.75 (p = 0.001).

9. Key ideas

- Tinetti Mobility Test (TMT) is used to analyze changes in gait and balance. Used in adult population, mayor, healthy and with neurological disorders; specifically in Parkinson's disease and Stroke. Determine the risk of falls.

- Time Up and Go Test (TUG) is used to analyze the performance of the lower limb function, mobility and fall risk. Used in adult population, mayor, healthy and with neurological diseases.

- Six-minute walk test (6MWT) is used in the analysis of gait disturbances. Used in adult population, healthy and with cardio-respiratory diseases. It is used together with the Borg scale.

- The Winsonsin Gait Scale (WGS) is used in the analysis of gait disturbances. Used in adult population and with neurological alterations, more specifically strokes, in subjects with hemiplegic marches. With high reliability in acute, subacute and chronic neurological patients.

- The Dynamic Parkinson Gait Scale is used to evaluate the motor performance of the gait during challenging tests. Used in adult population, elderly, healthy and especially in Parkinson's disease.

- The Gait Assessment and Intervention Tool (GAIT) is used to assess the coordination of movements during the gait phases and deficits associated with it. Used in adult population with stroke.

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