Physiotherapy

Before surgery, we prepare the patient. In first, there are evaluations with scales, GABS and posturographic test. These scales allow the patient to be evaluated, but also to plan the specific planning of rehabilitation after surgery.

In second, we seek with the patient the irritating spines that can hinder the patient in the operating room (pain, cramps, osteoarthritis, dystonia, fears, anxiety).

Then we explain the positioning and the installation during the implantation of the electrodes, position, stereotactic frame, duration, unfolding, various participants.

All professionals involved in surgery repeat the same information, and answer the patient’s questions, it is very important that the patient receives all the information.

It is important that each of the actors of care reassures and gives confidence to the patient.

During surgery, when surgery is performed under local anesthesia, physiotherapists are present, from the patient’s installation to the end of the second side.

Many activities are the responsibility of the physiotherapist:
• accompaniment,
• Off Pain Prevention
• Articular mobilization
• Respiratory prevention
• Fighting cramps, ankyloses
• Reassure the patient, explain the surgical sequences
• Facilitate the patient’s well-being if possible

Every intervention of the physiotherapist must be rapid, so as not to delay the surgeon or the neurologist. It must be targeted and effective in a short time. No special techniques, but the relevance and control of his actions.

After surgery, the role of the physiotherapist is to highlight the various postural and locomotor alterations persisting in the patient.

The same assessments are revised to verify musculoskeletal benefits or degradations. The key points are posture, balance and walking. Generally, we are waiting for the phase of the optimum adjustments in postoperative (5 days), then the result of the evaluations is communicated to the neurologists to adapt the settings of the stimulation. These results will also determine the future rehabilitation of the patient, postural, balance or walking parameters.
A mail of advice and recommendations is given to the patient for his physiotherapist and to regain correct physical conditioning.

All these parameters will be re-evaluated during the 3-month and 1-year follow-up, corresponding to the patient follow-up visits by the entire team.

**Physiotherapy and gait analysis**

We always use the same walking and balance scales, GABS and MiniBest, as well as a posturological examination. This makes it possible to highlight the various abnormalities constituted by Parkinson's disease. Observation of movement disorders requires experience, and the most important is often what is hidden behind the evaluation score.

Before surgery, these tests validate a baseline assessment and can provide important information for the neurologist or neurosurgeon, such as a balance disorder, usually uncorrected by deep cerebral stimulation.

Each detail is important because it specifies the major points to monitor after surgery. But with experience and rigor, these details can also have a predictive character of future disorders and symptoms, such as a tendency to freezing or imbalance.

After the surgery, these scales of evaluation are redone in immediate postoperative, at 3 months postoperative and at 1 year. This information ensures the follow-up of the patient, facilitates the quality of the stimulation parameters and indicates the orientations of the rehabilitation or the sports activities to be practiced by the patient.

All the evaluations and observations are important, throughout the evolution of the disease and the follow-up of surgery, it is also a "data bank" to facilitate the understanding of the disease and to open paths to the clinical research and physiotherapy.
Clinical gait and balance scale (GABS): validation and utilization

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Abstract

Gait and Balance Scale (GABS) consists of historical information and examination of 14 different gait and balance parameters designed to assess the severity of these functional domains. Thirty-five patients with Parkinson’s disease (PD), Hoehn and Yahr stages 1–3, were tested during their “off” period. GABS items were compared to quantitative data from two computerized gait analysis instruments, GAITRite and Pro Balance Master. Intra-class correlation coefficients were calculated to establish reliability. Intra-rater test-retest reliability was determined using Cohen’s \textit{Kappa} statistic. Concurrent validity was derived using the Spearman’s \textit{rho} test with the items from GABS, GAITRite and Balance Master. Intra-rater reliability was high with \(k > 0.41\) (\(k = \text{kappa}\) statistic) for 17 items, 6 had \(k > 0.61\). When performing validity measurements, a number of items on the GABS had a correlation coefficient significant at \(p < 0.01\) (2-tailed). Posture, pull test, balance during stance, single limb stance, tandem stance, turning, toe walking and functional reach had significant correlation with Balance Master data (\(R = 0.46–1\)). Gait, arm swing, gait speed, steps/5 m, ‘up-and-go test’, modified performance oriented assessment of gait scale and provocative testing had significant correlation with the GAITRite items (\(R = 0.51–0.83\)). GABS is an easy-to-use comprehensive clinical scale with high intra-rater and internal item reliability. We have shown concurrent validity with two computerized gait analysis instruments. We expect GABS to have a particular utility in clinical trials designed to modify functional impairment associated with abnormalities in gait and balance.

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Keywords: Gait; Validation; Utilization

Gait is a highly complex function that requires integration of mechanisms of locomotion with those of motor control, musculoskeletal function, balance and posture [1]. Besides peripheral inputs and proprioceptive reflexes processed in the spinal cord, the cerebellum, basal ganglia, and cortical mechanisms contribute to the motor control necessary for normal gait and balance [2]. In primates automatic walking can be elicited by electrical stimulation of midbrain tegmentum, laterodorsal ponto-mesencephalic junction, including pendunculopontine nucleus and posterior subthalamus [3]. Postural control is highly dependent on proper maintenance of body alignment and stability in a gravitational field (quiet standing), reaction to external perturbations (pull, pushing, variations of base of support) and mechanical support for action (throwing, lifting, walking, etc.) [4]. In addition to the spinal and central mechanisms, visual, vestibular and somatosensory inputs contribute to a stable posture.

Several neurological disorders, including Parkinson’s disease (PD), stroke, cerebellar disorders and neuromuscular diseases, have been associated with alteration in the central and peripheral mechanisms resulting in specific patterns of gait and balance disturbance. In addition to tremor, rigidity and bradykinesia, postural instability and gait abnormalities, including freezing of gait (FOG), are common causes of disability in PD. The pathophysiology of FOG is poorly understood, but it has been attributed to brainstem or frontal cortical dysfunction, particularly the supplementary motor area [5]. This area has been implicated in the mechanism of the grasp phenomenon. Indeed, Denny-Brown suggested that foot grasp reflex is an important factor in FOG and the inability to lift the foot has been described as “magnetic apraxia” [6].
Although some measures of gait and balance have been included in a variety of clinical rating scales, there are currently no instruments that reliably assess functional impairment associated with abnormalities in ambulation. Highly sophisticated gait analysis techniques including kinematic analysis, computerized gait and balance methods and kinesiological electromyography (EMG) have been used in gait laboratories as research tools, but the utility of these techniques is limited by their inaccessibility and the time and expense involved in performing the testing.

We propose a comprehensive gait and balance scale (GABS) that is user-friendly and measures all the essential elements of gait and balance. This instrument can be used in an outpatient clinic setting and as such has potential utility in clinical trials, similar to the Unified Parkinson’s Disease Rating Scale (UPDRS) [7]. We administered GABS to patients with PD and validated the scale using two computerized instruments: Balance Master and GAITRite.

1. Methods

Thirty five subjects between ages 50 and 75 (15 men and 20 women) in various stages of PD, Hoehn and Yahr stages 1–3, were included in the study. All subjects signed an informed consent for participation in the study that was approved by the Institutional Review Boards of Baylor College of Medicine (BCM) and Texas Woman’s University (TWU). All subjects were capable of following simple instructions, ambulating independently, and had sufficient vision to read large print and view the video screen.

1.1. GABS

GABS, designed to assess gait, FOG, the gait cycle, balance and posture, consists of two parts: (1) historical information and (2) measurement of 14 gait parameters during examination of subjects including relevant items of the UPDRS, full and a half-turn, Romberg test, tandem stance, one limb stance, provocative tests for freezing, a modified Performance Oriented Assessment of Gait scale (POAG), foam posturography, timed tasks to assess gait speed and the ‘up-and-go’ test (Appendices A and B). The functional reach (FR) is defined as the maximal distance one can reach forward beyond arm’s length while maintaining a fixed base support in the standing position. Items 1 to 17 GABS are scored on a scale of 0 to 4 (0 being normal and 4 being the worst). Items 18–24 are scored on a scale 0 to 1 or 0 to 2 (0 being normal and 1 or 2 being abnormal). Historical information consists of questions related to walking, activities of daily living, falls and freezing. In addition to the items from the UPDRS related to freezing and falls [7], GABS captures items related to level of care, ambulation, limitation of activities due to fear of falling and the frequency of freezing. The examination part is divided into two categories, timed and untimed tasks. For assessment of balance, the tasks of balance during stance, tandem stance, Romberg and one limb stance are used. Previous studies found that performance on tandem stance, single limb stance, functional reach and postural stability tests differentiated between PD patients and controls, and PD patients with and without falls [8]. Some of these items are derived from the Berg balance scale [9,10]. Gait assessment items 15, 18–21 include walking on heels, toes and tandem gait. The items 11–14, 16, and 17 are derived from POAG scale [11] which is useful for analysis of step symmetry and height and path deviation while walking a distance of 10 m including a turn, by observing the subject both from the side and behind. Posture is assessed by using items 8–10 which are derived from the UPDRS [7]. Functional reach, is a useful and reliable test for balance and has predictive value in differentiating patients with and without a tendency to fall as shown in previous studies [12,13]. Freezing of gait is of particular importance in patients with parkinsonism. The items 16, 17, 22 including turning are very important to induce freezing in patients. Provocative testing is designed to induce freezing and motor blocks in patients while walking in a narrow space of 24 in. between two chairs. Foam posturography is used as a measure of body sway and the subject’s sensorimotor inputs for maintenance of balance. Timed tasks provide valuable information about the gait cycle by measuring speed of walking, variation between the normal and fast gait speed, stand–walk–sit time and cadence [14]. The ‘up-and-go’ test has been used for many years by physical therapists for objective assessment of ambulation [15,16].

Identical testing conditions were used at the two centers (TWU and BCM) while performing GABS. Ten patients were examined in their “off” period (at least 12 h after their last dose the night before the testing) on 2 consecutive days at TWU, and data collected by the same examiner (M.S.), was used to determine the test-retest reliability and intra-rater reliability. The GABS was administered by another examiner (M.T.) to 25 additional patients during their “off” periods and within 30 min their gait and balance were tested using GAITRite and Balance Master at TWU (see below). Patients then took their medication and GABS was repeated in those patients about 1 h after they turned “on”. Ten patients were, thus, examined in their “on” and “off” state based on the examiner’s observations.

1.2. GAITRite

The GAITRite system (CIR Systems, Clifton, NJ) was used to measure and record temporal and spatial parameters of gait in 20 subjects with PD. GAITRite is a portable computer based instrumented electronic roll-up walkway connected to a personal computer with application software for calculation of temporal and spatial parameters of gait. The walkway is 3 m long with a pressure sensitive mat (61 × 366 cm) composed of a series of sensors, organized in a 48 × 288 grid pattern, sandwiched between two layers of
As the subject walks across the mat, data from the triggered sensors is collected by on-board processors connected in series and fed to the computer through a serial port (19,200 baud).

The subject’s leg length was recorded bilaterally while standing (measured as the distance from the greater trochanter to the floor directly below the lateral malleolus). The subjects were then instructed to stand at the edge of the mat and begin walking across it at the word “go”, and walk off the other end of the mat. A therapist walked beside the patient off the mat to ensure subject safety. The subjects performed two trials at their normal walking speed. As the individual made contact with the walkway, footfalls were detected and electronically stored by the instrumental walkway’s software. Temporal and spatial parameters of gait including individual steps and strides are automatically calculated and organized in on-screen tables and printed out as hard copy after the subject completed a trail. Spatial parameters measured by GAITRite include step length, stride length, step/extremity ratio, toe in/toe out angle and H-H (heel-to-heel) base support. Temporal parameters measured by GAITRite include step time, gait cycle time, ambulation time, velocity, average leg length, single support time, double support time, stance time, swing time and functional ambulatory profile (FAP) [17–21]. The parameters of specific interest were stride length (m), step width (cm), velocity (m/min), cadence (steps/min) and the functional ambulation profile (FAP) score.

### 1.3. Balance Master

The Pro Balance Master system (Neurocom, Intl., Clackamas, OR) with software version 5.0b is comprised of two 9” × 18” dual force plates connected at the midline of the anteroposterior axis by a pin joint. Each force plate is mounted on a pair of symmetrically positioned force transducers. The four transducers measure vertical ground reaction forces, which form the basis of subsequent calculations of center of pressure (COP) and COG (center of gravity) sway angles. The ability to control the movement of the COG over the base of support is critical to normal balance. The region in space through which a normal person can move their COG without altering the base of support is called the limit of stability (LOS). The LOS test (performed at 75% of the subject’s maximum theoretical stability limits) is a dynamic standing balance test that measures the volitional control of the COG (the control of speed, direction and distance of COG movement). LOS test

### Table 1

<table>
<thead>
<tr>
<th>GABS assessment</th>
<th>Kappa statistic (k)</th>
<th>p-value</th>
</tr>
</thead>
<tbody>
<tr>
<td>Balance with stance</td>
<td>0.545</td>
<td>0.133</td>
</tr>
<tr>
<td>Rising from a chair</td>
<td>0.677</td>
<td>0.013</td>
</tr>
<tr>
<td>Posture</td>
<td>0.839</td>
<td>0.001</td>
</tr>
<tr>
<td>Postural stability</td>
<td>0.737</td>
<td>0.067</td>
</tr>
<tr>
<td>Romberg</td>
<td>0.315</td>
<td>0.107</td>
</tr>
<tr>
<td>Half turn</td>
<td>0.412</td>
<td>0.133</td>
</tr>
<tr>
<td>Heel walk</td>
<td>0.583</td>
<td>0.190</td>
</tr>
<tr>
<td>Toe walk</td>
<td>0.737</td>
<td>0.067</td>
</tr>
<tr>
<td>Arm Swing</td>
<td>0.756</td>
<td>0.022</td>
</tr>
<tr>
<td>Modified POAG</td>
<td>0.481</td>
<td>0.013</td>
</tr>
<tr>
<td>Foam posturography</td>
<td>0.800</td>
<td>0.048</td>
</tr>
<tr>
<td>Gait</td>
<td>0.593</td>
<td>0.036</td>
</tr>
<tr>
<td>Single limb stance</td>
<td>0.551</td>
<td>0.001</td>
</tr>
<tr>
<td>Tandem Stance</td>
<td>0.537</td>
<td>0.002</td>
</tr>
<tr>
<td>Full turn</td>
<td>0.693</td>
<td>&lt;0.001</td>
</tr>
<tr>
<td>Tandem walk</td>
<td>0.436</td>
<td>0.052</td>
</tr>
<tr>
<td>Number of steps (normal speed)</td>
<td>0.473</td>
<td>&lt;0.001</td>
</tr>
<tr>
<td>Number of Steps (fast walk)</td>
<td>0.542</td>
<td>0.003</td>
</tr>
</tbody>
</table>

Kappa statistic could not be computed for the timed tasks and functional reach. (Kappa: 0.93–1 = excellent; 0.81–0.92 = very good; 0.61–0.8 = good; 0.41–0.6 = fair; 0.21–0.4 = poor and <0.40 = very poor. POAG = Performance oriented assessment of gait scale.)
is designed to assess an individual’s ability to volitionally move the COG to eight predetermined positions in space. These positions are represented by an ellipse of square visual targets located on a video screen positioned at eye level and directly in front of the individual being tested (Fig. 1).

Each test was conducted with subjects positioned in a standardized foot position as recommended by the manufacturers of the equipment. A reference grid superimposed on the force plate ensured accurate placement of the feet on each testing occasion. Foot position was carefully monitored during each test and the feet were repositioned following a loss of balance or any other slight foot shift during leaning. The subjects were required to lean away from the midline/center target in the direction of each of the eight on-screen targets without stepping or moving their feet from the standardized foot position, with their arms by the side of the body. Subject height (i.e., subject’s predicted COG height) and previously determined maximum COG sway angles were used to determine the appropriate LOS values represented by the on-screen visual targets.

The concurrent visual biofeedback COG cursor remained at the center target in the direction of each of the eight on-screen targets without stepping or moving their feet from the standardized foot position, with their arms by the side of the body. Subject height (i.e., subject’s predicted COG height) and previously determined maximum COG sway angles were used to determine the appropriate LOS values represented by the on-screen visual targets.

The dependent variables calculated to provide specific information regarding the subject’s LOS performance for each of the eight targets associated with the test were maximum COG excursion (MXE), reaction time (RT), directional control (DCL) and movement velocity (MVL). MXE, DCL, RT and MVL values from all eight targets were averaged across the final LOS test for every subject [22].

2. Results

Data obtained from GABS, Pro Balance Master and GAITRite was analyzed in three separate steps. Intra-rater reliability was fair to good with kappa statistic \( k > 0.41 \) for several items. Six items have \( k > 0.61 \) and eleven items have \( k = 0.41–0.6 \) (Table 1). Posture testing had \( k = 0.83 \) (very good), items rising from a chair, arm swing, foam posturography and full turn had \( k = 0.61 \) and 0.8 (good). The rest of the items had \( k = 0.41–0.60 \) (fair). Romberg was the only item with \( k = 0.315 \) (poor).

Concurrent validity was determined using the Spearman’s \( \rho \) test with items from GABS tested against those from GAITRite and Balance Master. Gait items (walking, arm swing, timed tasks, provocative testing and modified POAG scale) were tested against items from GAITRite. Balance items (rising from a chair, posture, postural stability, balance during stance, Romberg test, stance, foam posturography and functional reach) were tested against procedures, subjects completed the LOS test. A 3-min rest interval was provided between each LOS test and a total of 3 tests were administered. In order to address the learning effect, only data from the final test was used for analysis. Data obtained from the Pro-Balance Master system was analyzed using the Smart Balance Master program Smart 5 and stored on a 486 PC.

Table 2

<table>
<thead>
<tr>
<th>Spearman’s rho</th>
<th>RT Right front</th>
<th>RT Right back</th>
<th>RT Left front</th>
<th>MVL_right</th>
<th>MVL_mean</th>
<th>MVL_back</th>
<th>MVL_right</th>
<th>MVL_mean</th>
<th>MVL_right</th>
<th>MVL_mean</th>
</tr>
</thead>
<tbody>
<tr>
<td>Rising from a chair</td>
<td>– 0.47</td>
<td>– 0.42</td>
<td>– 0.52</td>
<td>– 0.52</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Postural stability</td>
<td>– 0.60</td>
<td>– 0.56</td>
<td>– 0.61</td>
<td>– 0.61</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Balance with stance</td>
<td>– 0.46</td>
<td>– 0.51</td>
<td>0.48</td>
<td>0.48</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Single limb stance</td>
<td>– 0.47</td>
<td>0.48</td>
<td>0.48</td>
<td>0.47</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Tandem stance</td>
<td>0.50</td>
<td>0.48</td>
<td>– 0.47</td>
<td>0.46</td>
<td>0.46</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Half turn</td>
<td>0.48</td>
<td>– 0.47</td>
<td>0.51</td>
<td>0.44</td>
<td>– 0.51</td>
<td>0.45</td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Full turn</td>
<td>0.55</td>
<td>– 0.44</td>
<td>0.44</td>
<td>– 0.47</td>
<td>0.47</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Heel walking</td>
<td>0.48</td>
<td>– 0.44</td>
<td>0.51</td>
<td>0.44</td>
<td>– 0.51</td>
<td>0.45</td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Toe walking</td>
<td>0.50</td>
<td>0.48</td>
<td>– 0.47</td>
<td>0.46</td>
<td>0.46</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Functional reach</td>
<td>0.48</td>
<td>– 0.44</td>
<td>0.51</td>
<td>0.44</td>
<td>– 0.51</td>
<td>0.45</td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Foam posturography</td>
<td>0.44</td>
<td>– 0.47</td>
<td>0.47</td>
<td>– 0.47</td>
<td>0.47</td>
<td></td>
<td></td>
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</tr>
</tbody>
</table>

Correlation coefficient (Spearman’s \( \rho \)) for balance items of GABS and balance master items. Correlation coefficient significant at 0.05 level (2-tailed).

(Key: RT = reaction time, MVL = movement velocity, EPE = end point excursion, DCL = directional control.)
Table 2 (continued)

<table>
<thead>
<tr>
<th>MVL left</th>
<th>EPE_left</th>
<th>EPE_left</th>
<th>MXE_front</th>
<th>MXE_right</th>
<th>MXE_right</th>
<th>MXE_left</th>
<th>MXE_left</th>
<th>MXE_left</th>
<th>DCL front</th>
<th>DCL left</th>
</tr>
</thead>
<tbody>
<tr>
<td>0.44</td>
<td>-0.42</td>
<td>-0.42</td>
<td>0.55</td>
<td>0.55</td>
<td>-0.47</td>
<td>-0.47</td>
<td>0.55</td>
<td>0.55</td>
<td>0.55</td>
<td>0.55</td>
</tr>
<tr>
<td>0.52</td>
<td>-0.42</td>
<td>-0.42</td>
<td>0.55</td>
<td>0.55</td>
<td>-0.47</td>
<td>-0.47</td>
<td>0.55</td>
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<tr>
<td>0.43</td>
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<tr>
<td>0.53</td>
<td>0.46</td>
<td>0.51</td>
<td>0.55</td>
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<tr>
<td>0.54</td>
<td>0.46</td>
<td>0.48</td>
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<td>0.60</td>
<td>0.49</td>
<td>0.44</td>
<td>0.57</td>
<td>0.64</td>
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<tr>
<td>0.46</td>
<td>0.45</td>
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<td>0.65</td>
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</tr>
</tbody>
</table>

Objective assessment of gait and balance has been of great interest to investigators involved in designing clinical trials of therapeutic interventions targeted to improve ambulation as well as to clinicians who follow patients troubled with gait and balance problems. Several scales have been proposed in the past to objectively assess and monitor the degree of gait and balance impairment in PD. These include UPDRS [7], Berg balance scale [9,10], POAG scale [11] and the Webster scale [23]. However, these scales do not comprehensively evaluate gait and balance. Our study shows that GABS captures most of the clinically relevant parameters of gait and balance and provides a reliable, quantitative and objective assessment that can be used effectively in an outpatient clinic setting. We have shown high intra-rater and internal item reliability and concurrent validity using two computerized gait analysis and balance instruments.

UPDRS [7] has been traditionally used as a clinical instrument to assess motor symptoms and asigns associated with PD. There are, however, many limitations to this scale [24]. With respect to gait and balance, UPDRS relies mostly on historical information, and there are only two items pertaining to gait and balance (pull test) based on motor examination. In contrast, GABS is specifically useful in assessing the gait and balance problems, and the various items can identify abnormalities in either gait, or balance, and can be used in studies specifically evaluating progression gait and balance abnormalities in patients with PD.

Webster in his analysis of disability in PD has designed several clinical tests for assessment [23]. He described an objective assessment scale with scored items for bradykinesia, rigidity, posture, upper extremity swing, gait, tremor, facies, seborrhoea, speech and self-care. Relevant to this study is the timed gait analysis. Webster uses stand–walk–sit test over a 15 feet distance, and recorded the steps and the number of seconds taken to complete the task. He multiplied the number of steps and the number of seconds to give the index of walking ability expressed in step seconds. In normal subjects, the score was 50–100 step seconds, the scores for patients with mild PD were >100, moderate PD 200–400 and advanced disease >400. This test was even used in the recent studies [24–27]. However, the test is limited by the ability of a single-timed task of standing, walking and sitting at normal speed. GABS is more comprehensive in analysis of gait speeds during normal and fast walking in addition to the stand–walk–sit test.

Patients with PD were considered to be ideal subjects for this study designed to test the reliability and validity of GABS. Some aspects of the GABS, including rising from a chair, standing balance, postural stability, turning 360 and...
Table 3
Correlation between GABS and GAITRite

<table>
<thead>
<tr>
<th>Variable</th>
<th>Spearman’s rho</th>
<th>Mean On</th>
<th>Mean Off</th>
<th>Mean On</th>
<th>Mean Off</th>
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<th>Mean On</th>
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<tbody>
<tr>
<td>GAIT</td>
<td></td>
<td>0.53</td>
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<tr>
<td>ARMSWING</td>
<td></td>
<td></td>
<td></td>
<td>0.48</td>
<td>0.46</td>
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<td>GAIT SPEED NORMAL</td>
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<tr>
<td>Cadence (steps/min)</td>
<td></td>
<td>-0.51</td>
<td>-0.51</td>
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<tr>
<td>Fast gait speed</td>
<td></td>
<td>-0.46</td>
<td>0.61</td>
<td>0.63</td>
<td>0.53</td>
<td>0.56</td>
<td>0.56</td>
<td>-0.48</td>
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<tr>
<td>Up and Go test</td>
<td></td>
<td></td>
<td></td>
<td>-0.47</td>
<td>-0.51</td>
<td>-0.54</td>
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<td>-0.47</td>
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<td>Start hesitation</td>
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<tr>
<td>initiation of gait</td>
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<td>-0.55</td>
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<td>-0.45</td>
<td>0.46</td>
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<td>Step length and height</td>
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<tr>
<td>Step symmetry</td>
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<td>0.59</td>
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<tr>
<td>Step continuity</td>
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<td>0.55</td>
<td>0.53</td>
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<tr>
<td>Path deviation</td>
<td></td>
<td>-0.51</td>
<td>-0.45</td>
<td>0.57</td>
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<td>-0.50</td>
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<tr>
<td>Walking distance</td>
<td></td>
<td>-0.53</td>
<td>-0.46</td>
<td>-0.66</td>
<td></td>
<td>0.49</td>
<td></td>
<td>-0.45</td>
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<td>POAG score</td>
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</tbody>
</table>

Correlation coefficient (Spearman’s rho) for gait items GAITRite items compared to GAITRite.
Correlation coefficient significant at 0.05 level (2-tailed). Correlation is significant at the 0.01 level (2-tailed).

POAG scale were previously tested in elderly individuals [28–30]. Furthermore, several studies have tried to quantify temporal gait parameters such as gait cycle, gait speed, step length and step time [14,23]. Using gait analysis [31,32] and intermittent light photography on a walkway [33], a reduction in mean speed and stride length of gait and an increase in gait cycle were found in patients with PD compared to normal subjects [31–33]. Morris et al. [16] demonstrated reliability of the timed ‘up-and-go’ test in patients with PD and showed good correlation with improvements in performance noted after levodopa treatment [15]. We have assessed the validity of GABS against two computerized instruments: GAITRite and Balance Master. GAITRite has been designed to analyze the spatial and temporal parameters of gait by using an instrumented walkway with software to calculate the gait parameters. Previous study by Cutlip et al. [34] demonstrated a strong correlation for all kinematic variables at gait speeds investigated between the GAITRite and video-based kinematic analysis. Both systems had similar spatial parameters for step length and stride velocity, but the mean difference between the groups increased with increasing gait speed. The step period, stance duration and swing duration (temporal parameters) were more closely matched in both systems. In the study by McDonough et al. [35], the correlations between GAITRite and paper-and-pencil measures were excellent for spatial measures and walking speed, but poor for cadence. Comparison by video-based methods showed excellent correlation for step times, walking speed and for cadence, but weaker correlation for step length. In our study there was an excellent correlation between the timed tasks and items obtained on computerized analysis on GAITRite (Table 3). Gait speed (normal and fast gait speed) and up-and-go test have shown significant correlation (p < 0.01) with mean ambulation time and mean velocity on the GAITRite.

The Balance Master has been previously tested in various studies and has been shown to provide a reliable index of dynamic balance in various diseases including PD and progressive supranuclear palsy [36–39]. Reliability of the Balance Master was assessed in a study by Brouwer et al. [40]. They showed that, although there was variability between subjects, there was good intra-patient consistency in the mean position of the COG. They further suggested that balance performance must be based on the actual COG position and excursion since there is variability of sway and performance of weight shifts (direction and speed) between patients while reaching the target [40]. The most important component of the balance loss in PD relates to the
marked inability to execute effective responses to perturbation as well as failure of their proactive balance mechanisms [41–43]. In our study, there was excellent correlation between the balance items from GABS compared to the measurements from the Balance Master. The variables with significant correlation ($p < 0.01$, 2-tailed) were postural stability, balance with stance, single limb stance, tandem stance, full and a half turn, toe walking and FR (Table 2).

Freezing is a common symptom of PD, vascular parkinsonism, normal pressure hydrocephalus and other degenerative disorders. Freezing most frequently affects gait in the forms of start hesitation, blocks in the middle of motion, in turns, in approaching an obstacle and in narrow spaces [44,45]. GABS offers a reliable assessment of freezing by utilizing various turning tests and provocative tasks.

Duncan et al. [12,13] developed the functional reach (FR) as a measure of stability. They have shown a strong association between FR and risk category, suggesting that a high reach score may be useful as a screen for low fall risk. Weiner et al. [46] established the concurrent validity of FR comparing it to other measures including physical and instrumental activities of daily living, 10-ft walking speed, 10-item hierarchical mobility skills protocol, one foot standing, tandem walking and life space, a 3-point measure of social mobility. They concluded that FR correlated with physical frailty more than with age. In our study, using a slightly different grading system, FR highly correlated with Balance Master items, reaction time, mean velocity and maximum excursion ($p < 0.01$) (Table 2). As expected, patients with more severe balance problems tended to do worse on the FR testing, but a larger sample size is needed to determine whether FR correlates with the stage of the disease or other aspects of PD.

Although we tested a small number of patients both “on” and “off” their anti-parkinson medications, we were able to note specific differences in examination. The $p$-values are as shown in Table 4. It is important to note that there is a difference between the scores, which were better in the “on” state as compared to the “off” state. This shows that GABS is a very useful assessment tool to evaluate the response to medication, and can be valuable in future clinical trials in Parkinson’s disease.

In conclusion, in this study, we have demonstrated that GABS is a well-constructed, comprehensive, easy-to-use clinical scale, which reliably measures gait, balance, posture, freezing of gait and gait cycle. Items have high internal consistency and intra-rater reliability and good correlation with items from the Balance Master and GAITRite systems. Future studies are planned to include patients with a wide variety of neurological disorders associated with gait and balance impairment.

**Acknowledgements**

We thank Mike Almageur RN for his assistance with administration of GABS and the National Parkinson Foundation for their support.
Appendix A. Gait and balance scale (GABS)

A.1. Historical information

<table>
<thead>
<tr>
<th>(1) Level of care</th>
<th>0 = entirely independent</th>
<th>1 = requires minimal assistance in only a few activities</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>2 = requires moderate assistance in several activities</td>
<td></td>
</tr>
<tr>
<td></td>
<td>3 = requires assistance frequently with most activities</td>
<td></td>
</tr>
<tr>
<td></td>
<td>4 = entirely dependent on nearly all ADL’s, Nursing care</td>
<td></td>
</tr>
</tbody>
</table>

<table>
<thead>
<tr>
<th>(2) Walking environment</th>
<th>0 = able to walk anywhere, able to negotiate any terrain</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>1 = walks only in the immediate neighborhood, able to</td>
</tr>
<tr>
<td></td>
<td>walk up and down gentle hills</td>
</tr>
<tr>
<td></td>
<td>2 = walks only in the driveway, avoids uneven surface</td>
</tr>
<tr>
<td></td>
<td>and hills</td>
</tr>
<tr>
<td></td>
<td>3 = walks inside the house only</td>
</tr>
<tr>
<td></td>
<td>4 = unable to walk even at home</td>
</tr>
</tbody>
</table>

<table>
<thead>
<tr>
<th>(3) Ambulation</th>
<th>0 = normal</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>1 = mild difficulty, requires no assistance</td>
</tr>
<tr>
<td></td>
<td>2 = independent with a cane or walker</td>
</tr>
<tr>
<td></td>
<td>3 = severe limitation, requires assistance besides a cane</td>
</tr>
<tr>
<td></td>
<td>or walker</td>
</tr>
<tr>
<td></td>
<td>4 = unable to ambulate even with assistance, wheel-chair bound or bedridden</td>
</tr>
</tbody>
</table>

<table>
<thead>
<tr>
<th>(4) Falls (UPDRS, item 13)</th>
<th>0 = no falls</th>
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<tbody>
<tr>
<td></td>
<td>1 = rare falls ( &lt; 1 per month)</td>
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<tr>
<td></td>
<td>2 = falls ≥ 1 per month</td>
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<tr>
<td></td>
<td>3 = falls ≥ 1 per week</td>
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<tr>
<td></td>
<td>4 = falls ≥ 1 per day</td>
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</tbody>
</table>

<table>
<thead>
<tr>
<th>(5) Limitation of activity due to fear of falling</th>
<th>0 = no limitation</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>1 = able to ambulate independently, but with caution</td>
</tr>
<tr>
<td></td>
<td>2 = usually holds on during walking, shower, or dressing</td>
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<tr>
<td></td>
<td>3 = rarely ventures outside the house because of fear</td>
</tr>
<tr>
<td></td>
<td>of falling</td>
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<tr>
<td></td>
<td>4 = does not even attempt to stand or walk because of</td>
</tr>
<tr>
<td></td>
<td>fear of falling</td>
</tr>
</tbody>
</table>

<table>
<thead>
<tr>
<th>(6) Freezing (motor blocks) (UPDRS, item 14)</th>
<th>0 = no freezing</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>1 = occasional start hesitation</td>
</tr>
<tr>
<td></td>
<td>2 = freezes ≥ 1 per week</td>
</tr>
<tr>
<td></td>
<td>3 = freezes ≥ 1 per day, occasionally falls</td>
</tr>
<tr>
<td></td>
<td>4 = unable to ambulate due to freezing, frequent falls</td>
</tr>
</tbody>
</table>

<table>
<thead>
<tr>
<th>(7) Freezing (motor blocks)-modifying factors</th>
<th>0 = no freezing</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>1 = only occasionally when initiating gait, turning, walking through narrow passages, or reaching a destination</td>
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<tr>
<td></td>
<td>2 = more than 25% when initiating gait, turning, walking through narrow passages, or reaching a destination</td>
</tr>
<tr>
<td></td>
<td>3 = more than 50% when initiating gait, turning, walking through narrow passages, or reaching a destination</td>
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<tr>
<td></td>
<td>4 = most of the time (more than 75%)</td>
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</tbody>
</table>

SUB SCORE OF ITEMS 1–7

Appendix B. GABS: physical examination

B.1. Performance items

<table>
<thead>
<tr>
<th>(8) Rising from a chair (UPDRS, item 27): patient attempts to arise from a straight-back wood or metal chair with arms folded across chest</th>
<th>0 = normal</th>
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</thead>
<tbody>
<tr>
<td>(9) Posture (UPDRS, item 28)</td>
<td>0 = normal</td>
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<tr>
<td></td>
<td>1 = not quite erect, slightly stooped posture; could be normal for older person</td>
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<tr>
<td></td>
<td>2 = moderately stooped posture, definitely abnormal; can be slightly leaning to one side</td>
</tr>
<tr>
<td></td>
<td>3 = severely stooped posture with kyphosis; can be moderately leaning to one side</td>
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<tr>
<td></td>
<td>4 = marked flexion with extreme abnormality of posture</td>
</tr>
</tbody>
</table>

<table>
<thead>
<tr>
<th>(10) Postural stability (UPDRS, item 30): response to sudden posterior displacement produced by pull on shoulders while patient erect and prepared with eyes open and feet slightly apart</th>
<th>0 = normal</th>
</tr>
</thead>
<tbody>
<tr>
<td>(11) Balance during stance; feet close together with eyes open</td>
<td>0 = no impairment</td>
</tr>
<tr>
<td></td>
<td>1 = increased sway, but can stand with feet together</td>
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<tr>
<td></td>
<td>2 = cannot stand with feet together, but able to stand with widened stance</td>
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<tr>
<td></td>
<td>3 = balance is tenuous regardless of stance or foot position</td>
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<tr>
<td></td>
<td>4 = cannot stand&gt;10 s without assistance or support.</td>
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</tbody>
</table>

<table>
<thead>
<tr>
<th>(12) Romberg test (with eyes closed)</th>
<th>0 = no difficulty, &gt;20 s</th>
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<tbody>
<tr>
<td></td>
<td>1 = mild difficulty, 10–20 s</td>
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<tr>
<td></td>
<td>2 = moderate difficulty, 5–10 s</td>
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<tr>
<td></td>
<td>3 = severe, &lt;5 s</td>
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</tbody>
</table>
4 = unable to stand without support

(13) One limb stance
0 = no difficulty, > 20 s
1 = mild difficulty, 10–20 s
2 = moderate difficulty, 5–10 s
3 = severe, < 5 s
4 = unable to do single stance

(14) Tandem stance
0 = no difficulty, > 20 s
1 = mild difficulty, 10–20 s
2 = moderate difficulty, 5–10 s
3 = severe, < 5 s
4 = unable to do single stance

(15) Gait (UPDRS, item 29)-walking 5 m
0 = normal
1 = walks slowly, may shuffle with short steps, decreased arm swing
2 = walks with difficulty, but requires little or no assistance; may have some festination, short steps, or propulsion
3 = severe disturbance of gait, requiring assistance
4 = cannot walk at all, even with assistance

(16) Turning 180° after walking
0 = normal pivoting
1 = takes an extra step or two to turn, but no freezing or problems with balance
2 = turns en bloc, occasional freezing
3 = able to turn but requires minimal assistance
4 = unable to turn without full assistance

(17) Turning 360° (turn completely around in a full circle, pause, and then turn a full circle in the other direction)b
0 = able to turn 360° in both directions, 4 s per turn
1 = able to turn 360° safely only in one direction, 4 s per turn
2 = able to turn 360° safely but slowly, >4 s per turn
3 = needs close supervision or verbal cuing
4 = needs assistance while turning

(18) Walking on heelsb
0 = normal
1 = impaired
2 = unable

(19) Walking on toesb
0 = normal
1 = impaired
2 = unable

(20) Walking in tandemb
0 = normal
1 = impaired
2 = unable

(21) Arm swing (vertical wrist displacement)b
0 = normal
1 = reduced
2 = absent

(22) Provocative test for freezing, motor blocks (rise from a chair and walk 5 m, between two chairs spaced 24 in. apart, turn 180°, walk back and sit down)b
(a) Start hesitationb
0 = no
1 = yes
(b) Sudden transient blocks interrupting gaitb
0 = no
1 = yes
(c) Motor blocks on turningb
0 = no
1 = yes
(d) Motor blocks on reaching a target (chair)b
0 = no
1 = yes
(e) Motor blocks when walking through narrow spaces (24 in.)b
0 = no
1 = yes

(23) Functional reach (In in.)d
0 = normal (>10 in)
1 = Impaired (<10 in)

(24) Modified Performance Oriented Gait Assessment Scalec (Total score 0–12) Examine patient while walking a 10 m distance including a turn, from the side for items a–d and from the back for items e–g.
(a) Initiation of gait
Any hesitancy or multiple attempts to start = 1
No hesitancy = 0
(b) Step length and height
(i) Right swing foot
Does not pass left stance foot with step = 1
Passes left stance foot = 0
(ii) Right foot does not clear floor completely with step = 1
Right foot completely clears floor = 0
(iii) Left swing foot
Does not pass right stance foot with step = 1
Passes right stance foot = 0
(iv) Left foot does not clear floor completely with step = 1
Left foot completely clears floor = 0
(c) Step symmetry
Right and left step length not equal (estimate) = 1
Right and left step appear equal = 0
(d) Step continuity and rhythmicity
Stopping or discontinuity between steps = 1
Steps appear continuous = 0
(e) Path (estimated in relation to floor tiles, 12-in. diameter; observe excursion of one foot over about 5 m of the course)
Marked deviation = 2
Mild or moderate deviation or uses walking aid = 1
Straight without walking aid = 0
(f) Trunk
Marked sway or uses walking aid = 2
No sway but flexion of knees back or spreads arms = 1
No sway, no flexion, no use of arms, and no use of walking aid = 0

(g) Walking distance
Heels apart = 1
Heels almost touching while walking = 0

(25) Foam Posturography (stand barefooted with eyes closed on a 5 in., medium density foam pad for 15 s, with examiner next to the subject to prevent falls)\(^d\)

\(^a\) Modified from balance scale [Berg et al., 1992].
\(^b\) All items rated on a 0–4 scale: 0 = normal, 1 = mildly abnormal or rare, 2 = moderately abnormal or occasional, 3 = markedly abnormal or frequent, 4 = unable to perform or continuous, unless specified as UPDRS [Fahn et al., 1987].
\(^c\) Score each item on the following scale: 12 = worst, 0 = normal [Modified from Tinetti et al., 1986].
\(^d\) Detects vestibulospinal dysfunction, correlates well with moving-platform posturography [Weber and Cass, 1993].

Sub score of Items 8–25
TOTAL SCORE FOR ALL THE ITEMS 1–25

B.2. Timed tasks

(26) Timed walking at usual speed (5 m)
Time in seconds
Number of steps
Cadence = Number of steps per min with the subject walking at a normal speed

(27) Timed walking as fast as possible (5 m)
Time in seconds

(28) Stand–walk–sit time (total 10 m, in sec). (rise from a chair and walk 5 m, turn 180°, walk back and sit down).

\(^a\) Rise from armless chair, walk 5 m, turn, walk back and sit [Kempster et al., 1989].

Note for GABS

\(^d\) Functional reach (FR) evaluates the individual’s ability to reach forward without stepping and has been correlated with risk of falling in the elderly. The subject stands behind a line and is asked to reach as far forward as possible while maintaining his or her balance. The distance of the forward reach is measured along a yardstick that is placed at the level of the subject’s acromion and secured to a wall. FR is the distance from the start point to the end point of the reach [Duncan et al., 1992; Weiner et al., 1993].

References for items in GABS: (Note some items were modified from the original scale)


References


1. SIT TO STAND

**Instruction:** “Cross your arms across your chest. Try not to use your hands unless you must. Do not let your legs lean against the back of the chair when you stand. Please stand up now.”

(2) Normal: Comes to stand without use of hands and stabilizes independently.
(1) Moderate: Comes to stand WITH use of hands on first attempt.
(0) Severe: Unable to stand up from chair without assistance, OR needs several attempts with use of hands.

2. RISE TO TOES

**Instruction:** “Place your feet shoulder width apart. Place your hands on your hips. Try to rise as high as you can onto your toes. I will count out loud to 3 seconds. Try to hold this pose for at least 3 seconds. Look straight ahead. Rise now.”

(2) Normal: Stable for 3 s with maximum height.
(1) Moderate: Heels up, but not full range (smaller than when holding hands), OR noticeable instability for 3 s.
(0) Severe: ≤ 3 s.

3. STAND ON ONE LEG

**Instruction:** “Look straight ahead. Keep your hands on your hips. Lift your leg off of the ground behind you without touching or resting your raised leg upon your other standing leg. Stay standing on one leg as long as you can. Look straight ahead. Lift now.”

**Left:**
- Time in Seconds Trial 1:_____
- Trial 2:_____

(2) Normal: 20 s.
(1) Moderate: < 20 s.
(0) Severe: Unable.

**Right:**
- Time in Seconds Trial 1:_____
- Trial 2:_____

(2) Normal: 20 s.
(1) Moderate: < 20 s.
(0) Severe: Unable.

To score each side separately use the trial with the longest time.

To calculate the sub-score and total score use the side [left or right] with the lowest numerical score [i.e. the worse side].

4. COMPENSATORY STEPPING CORRECTION- FORWARD

**Instruction:** “Stand with your feet shoulder width apart, arms at your sides. Lean forward against my hands beyond your forward limits. When I let go, do whatever is necessary, including taking a step, to avoid a fall.”

(2) Normal: Recovers independently with a single, large step (second realignment step is allowed).
(1) Moderate: More than one step used to recover equilibrium.
(0) Severe: No step, OR would fall if not caught, OR falls spontaneously.

5. COMPENSATORY STEPPING CORRECTION- BACKWARD

**Instruction:** “Stand with your feet shoulder width apart, arms at your sides. Lean backward against my hands beyond your backward limits. When I let go, do whatever is necessary, including taking a step, to avoid a fall.”

(2) Normal: Recovers independently with a single, large step.
(1) Moderate: More than one step used to recover equilibrium.
(0) Severe: No step, OR would fall if not caught, OR falls spontaneously.

6. COMPENSATORY STEPPING CORRECTION- LATERAL

**Instruction:** “Stand with your feet together, arms down at your sides. Lean into my hand beyond your sideways limit. When I let go, do whatever is necessary, including taking a step, to avoid a fall.”

**Left:**
- Normal: Recovers independently with 1 step (crossover or lateral OK).
- Moderate: Several steps to recover equilibrium.
- Severe: Falls, or cannot step.

**Right:**
- Normal: Recovers independently with 1 step (crossover or lateral OK).
- Moderate: Several steps to recover equilibrium.
- Severe: Falls, or cannot step.

Use the side with the lowest score to calculate sub-score and total score.

7. STANCE (FEET TOGETHER); EYES OPEN, FIRM SURFACE

**Instruction:** “Place your hands on your hips. Place your feet together until almost touching. Look straight ahead. Be as stable and still as possible, until I say stop.”

**Time in seconds:**
- Normal: 30 s.
- Moderate: < 30 s.
- Severe: Unable.
8. STANCE (FEET TOGETHER); EYES CLOSED, FOAM SURFACE

Instruction: “Step onto the foam. Place your hands on your hips. Place your feet together until almost touching. Be as stable and still as possible, until I say stop. I will start timing when you close your eyes.”

Time in seconds:________
(2) Normal: 30 s.
(1) Moderate: < 30 s.
(0) Severe: Unable.

9. INCLINE- EYES CLOSED

Instruction: “Step onto the incline ramp. Please stand on the incline ramp with your toes toward the top. Place your feet shoulder width apart and have your arms down at your sides. I will start timing when you close your eyes.”

Time in seconds:________
(2) Normal: Stands independently 30 s and aligns with gravity.
(1) Moderate: Stands independently <30 s OR aligns with surface.
(0) Severe: Unable.

DYNAMIC GAIT

SUB SCORE: __________/10

10. CHANGE IN GAIT SPEED

Instruction: “Begin walking at your normal speed, when I tell you ‘fast’, walk as fast as you can. When I say ‘slow’, walk very slowly.”

(2) Normal: Significantly changes walking speed without imbalance.
(1) Moderate: Unable to change walking speed or signs of imbalance.
(0) Severe: Unable to achieve significant change in walking speed AND signs of imbalance.

11. WALK WITH HEAD TurnerS – HORIZONTAL

Instruction: “Begin walking at your normal speed, when I say “right”, turn your head and look to the right. When I say “left” turn your head and look to the left. Try to keep yourself walking in a straight line.”

(2) Normal: performs head turns with no change in gait speed and good balance.
(1) Moderate: performs head turns with reduction in gait speed.
(0) Severe: performs head turns with imbalance.

12. WALK WITH PIVOT TURNS

Instruction: “Begin walking at your normal speed. When I tell you to ‘turn and stop’, turn as quickly as you can, face the opposite direction, and stop. After the turn, your feet should be close together.”

(2) Normal: Turns with feet close FAST (< 3 steps) with good balance.
(1) Moderate: Turns with feet close SLOW (>4 steps) with good balance.
(0) Severe: Cannot turn with feet close at any speed without imbalance.

13. STEP OVER OBSTACLES

Instruction: “Begin walking at your normal speed. When you get to the box, step over it, not around it and keep walking.”

(2) Normal: Able to step over box with minimal change of gait speed and with good balance.
(1) Moderate: Steps over box but touches box OR displays cautious behavior by slowing gait.
(0) Severe: Unable to step over box OR steps around box.

14. TIMED UP & GO WITH DUAL TASK [3 METER WALK]

Instruction TUG: “When I say ‘Go’, stand up from chair, walk at your normal speed across the tape on the floor, turn around, and come back to sit in the chair.”

Instruction TUG with Dual Task: “Count backwards by threes starting at ___. When I say ‘Go’, stand up from chair, walk at your normal speed across the tape on the floor, turn around, and come back to sit in the chair. Continue counting backwards the entire time.”

TUG: ________seconds; Dual Task TUG: ________seconds

(2) Normal: No noticeable change in sitting, standing or walking while backward counting when compared to TUG without Dual Task.
(1) Moderate: Dual Task affects either counting OR walking (>10%) when compared to the TUG without Dual Task.
(0) Severe: Stops counting while walking OR stops walking while counting.

When scoring item 14, if subject’s gait speed slows more than 10% between the TUG without and with a Dual Task the score should be decreased by a point.

TOTAL SCORE: ________/28
**Mini-BESTest Instructions**

**Subject Conditions:** Subject should be tested with flat-heeled shoes OR shoes and socks off.

**Equipment:** Temper® foam (also called T-foam™ 4 inches thick, medium density T41 firmness rating), chair without arm rests or wheels, incline ramp, stopwatch, a box (9” height) and a 3 meter distance measured out and marked on the floor with tape [from chair].

**Scoring:** The test has a maximum score of 28 points from 14 items that are each scored from 0-2.

“0” indicates the lowest level of function and “2” the highest level of function.

If a subject requires physical assistance to perform an item, score “0” for that item. If a subject must use an assistive device for an item, score that item one category lower.

For Item 3 (stand on one leg) and Item 6 (compensatory stepping-lateral) only include the score for one side (the worse score).

For Item 3 (stand on one leg) select the best time of the 2 trials [from a given side] for the score.

For Item 14 (timed up & go with dual task) if a person’s gait slows greater than 10% between the TUG without and with a dual task then the score should be decreased by a point.

<table>
<thead>
<tr>
<th>Item</th>
<th>Description</th>
</tr>
</thead>
<tbody>
<tr>
<td>1. SIT TO STAND</td>
<td>Note the initiation of the movement, and the use of the subject’s hands on the seat of the chair, the thighs, or the thrusting of the arms forward.</td>
</tr>
<tr>
<td>2. RISE TO TOES</td>
<td>Allow the subject two attempts. Score the best attempt. (If you suspect that subject is using less than full height, ask the subject to rise up while holding the examiners’ hands.) Make sure the subject looks at a non-moving target 4-12 feet away.</td>
</tr>
<tr>
<td>3. STAND ON ONE LEG</td>
<td>Allow the subject two attempts and record the times. Record the number of seconds the subject can hold up to a maximum of 20 seconds. Stop timing when the subject moves hands off of hips or puts a foot down. Make sure the subject looks at a non-moving target 4-12 feet ahead. Repeat on other side.</td>
</tr>
<tr>
<td>4. COMPENSATORY STEPPING CORRECTION-FORWARD</td>
<td>Stand in front of the subject with one hand on each shoulder and ask the subject to lean forward (Make sure there is room for them to step forward). Require the subject to lean until the subject’s shoulders and hips are in front of toes. After you feel the subject’s body weight in your hands, very suddenly release your support. The test must elicit a step. NOTE: Be prepared to catch subject.</td>
</tr>
<tr>
<td>5. COMPENSATORY STEPPING CORRECTION - BACKWARD</td>
<td>Stand behind the subject with one hand on each scapula and ask the subject to lean backward (Make sure there is room for the subject to step backward.) Require the subject to lean until their shoulders and hips are in back of their heels. After you feel the subject’s body weight in your hands, very suddenly release your support. Test must elicit a step. NOTE: Be prepared to catch subject.</td>
</tr>
<tr>
<td>6. COMPENSATORY STEPPING CORRECTION- LATERAL</td>
<td>Stand to the side of the subject, place one hand on the side of the subject’s pelvis, and have the subject lean their whole body into your hands. Require the subject to lean until the midline of the pelvis is over the right (or left) foot and then suddenly release your hold. NOTE: Be prepared to catch subject.</td>
</tr>
<tr>
<td>7. STANCE (FEET TOGETHER); EYES OPEN, FIRM SURFACE</td>
<td>Record the time the subject was able to stand with feet together up to a maximum of 30 seconds. Make sure subject looks at a non-moving target 4-12 feet away.</td>
</tr>
<tr>
<td>8. STANCE (FEET TOGETHER); EYES CLOSED, FOAM SURFACE</td>
<td>Use medium density Temper® foam, 4 inches thick. Assist subject in stepping onto foam. Record the time the subject was able to stand in each condition to a maximum of 30 seconds. Have the subject step off of the foam between trials. Flip the foam over between each trial to ensure the foam has retained its shape.</td>
</tr>
<tr>
<td>9. INCLINE EYES CLOSED</td>
<td>Aid the subject onto the ramp. Once the subject closes eyes, begin timing and record time. Note if there is excessive sway.</td>
</tr>
<tr>
<td>10. CHANGE IN SPEED</td>
<td>Allow the subject to take 3-5 steps at normal speed, and then say “fast”. After 3-5 fast steps, say “slow”. Allow 3-5 slow steps before the subject stops walking.</td>
</tr>
<tr>
<td>11. WALK WITH HEAD TURNS- HORIZONTAL</td>
<td>Allow the subject to reach normal speed, and give the commands “right, left” every 3-5 steps. Score if you see a problem in either direction. If subject has severe cervical restrictions allow combined head and trunk movements.</td>
</tr>
<tr>
<td>12. WALK WITH PIVOT TURNS</td>
<td>Demonstrate a pivot turn. Once the subject is walking at normal speed, say “turn and stop.” Count the number of steps from “turn” until the subject is stable. Imbalance may be indicated by wide stance, extra stepping or trunk motion.</td>
</tr>
<tr>
<td>13. STEP OVER OBSTACLES</td>
<td>Place the box (9 inches or 23 cm height) 10 feet away from where the subject will begin walking. Two shoeboxes taped together works well to create this apparatus.</td>
</tr>
<tr>
<td>14. TIMED UP &amp; GO WITH DUAL TASK</td>
<td>Use the TUG time to determine the effects of dual tasking. The subject should walk a 3 meter distance. TUG: Have the subject sitting with the subject’s back against the chair. The subject will be timed from the moment you say “Go” until the subject returns to sitting. Stop timing when the subject’s buttocks hit the chair bottom and the subject’s back is against the chair. The chair should be firm without arms. TUG With Dual Task: While sitting determine how fast and accurately the subject can count backwards by threes starting from a number between 100-90. Then, ask the subject to count from a different number and after a few numbers say “Go”. Time the subject from the moment you say “Go” until the subject returns to the sitting position. Score dual task as affecting counting or walking if speed slows (&gt;10%) from TUG and or new signs of imbalance.</td>
</tr>
</tbody>
</table>
Is there a role for physiotherapy during deep brain stimulation surgery in patients with Parkinson’s disease?

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In our center, a physiotherapist is present in the operative room to bring relief to the Parkinsonian patient during subthalamic nucleus stimulation surgery under local anesthesia. This study searched to determine the causes of pain and suffering during bilateral electrode implantation and to assess the role of physiotherapy. Ninety-two consecutive patients operated on between 2001 and 2004 were included in this retrospective study. A questionnaire with eight items was developed and mailed to the patients. Seventy-five responses to questionnaires were available. All patients except one experienced physical pain and psychological suffering, alleviated by physiotherapy. These preliminary results need to be confirmed in a prospective randomized study.

Introduction

Subthalamic nucleus (STN) stimulation is an effective treatment for advanced Parkinson’s disease (PD) with severe levodopa-induced motor complications. Electrode implantation is carried out under local anesthesia and antiparkinsonian drugs are withdrawn 12 h before surgery for micorecording and assessing the stimulation-induced effects. This helps determine the precise site of implantation and necessitates patient’s cooperation [1]. In our procedure, a physiotherapist is present in the operative room, especially when patients exhibit severe off-motor periods, associated with painful off-dystonia [2]. In our center, the average duration for bilateral STN electrode implantation is 12 h. This lengthy surgical time is generally reported by the patients to be a difficult experience. The objective of this retrospective study was to validate, by means of a questionnaire, the importance of physiotherapy during surgery. We searched also to highlight the main reasons for physical pain and psychological suffering.

Patients and methods

We carried out this retrospective study from July to December 2004. The patients included in this study suffered from advanced PD with levodopa-induced motor fluctuations and dyskinesias. Surgery for bilateral STN stimulation took place between 2001 and 2004, a period with a physiotherapist present in the operative room. During this period, two physiotherapists were alternatively present and used the same techniques, principally mobilizations, muscular stretching, shaking, local massages and respiratory exercises for relaxation. A questionnaire was formulated with eight questions taking into account the complaints of the patients during the surgery. The patients were asked by mail, to evaluate the following items using a numeric pain scale from 0 to 10: level of pain; level of psychological suffering; importance of the physiotherapist’s treatment; the potential level of suffering expected if no physiotherapist had been provided. We have distinguished between physical pain (muscular cramps, dystonia, joint ankylosis and stiffness, back pain, fulcrums) and psychological suffering related to both surgery-induced stress and non-motor off-period symptoms such as apathy, depression, anguish or panic. We also asked the patients to rank the following five causes of suffering in a hierarchical order beginning with the one causing the greatest suffering and ending with the one causing the least suffering: (a) surgical procedure; (b) immobility; (c) length of operation; (d) fear, anguish or stress; (e) difficulty of communication. The following two questions required a yes or no answer: was a physiotherapist present? Did the physiotherapist provide relief? A last question asked about the duration of surgery-related suffering with a choice of time periods as follows: days, weeks, months, ongoing suffering.

We used a descriptive analysis. As the data distribution was non-parametric, the results were expressed as median values and percentiles. The Spearman non-parametric correlation test \((\rho > 0.65; P < 0.05)\) was used to determine the possible relation between physical pain or psychological suffering and the five causes of
suffering. The software used for the analysis of data was StatView for Windows 5.0 (SAS Institute Inc., Cary, NC, USA).

Results

Seventy-five (81.5%) of the 92 patients included in the study fulfilled the questionnaire (Table 1). The physiotherapist was present in 64 (85.3%) of 75 procedures and 58 patients (90.6%) estimated that its action during the procedure was effective. There were no differences amongst gender or year of implantation. All the patients appreciated the presence of the physiotherapist with a median score of 9 of 10. The median scores for physical pain, psychological suffering and level of expected suffering if no physiotherapist had been present are shown in Fig. 1. The rank ordering median score from the most to the least frequent for the five causes of suffering was b-immobility (1.5), c-length of operation (2.5), d-fear, anguish or stress (3), and in tied rank a-surgical procedure (4), e-difficulty of communication (4). The duration of suffering was related in days terms for 43 patients, in weeks for 18, in months for eight and ongoing suffering for five patients. No significant correlation was found in our study between the level of pain or suffering and the causes of suffering proposed by the questionnaire (0.061 < \( p < 0.132 \) for pain and 0.017 < \( p < 0.145 \) for suffering).

Discussion

This study retrospectively assessed the main factors of pain or suffering during bilateral STN implantation for PD and confirmed that patients experienced real physical pain and psychological suffering during the operation. Scoring for psychological suffering was higher than physical pain. Actually, local anesthesia can explain the low score of pain induced by the surgical procedure, and that other physical pains received good responses from the physiotherapy. The physiotherapy techniques aim at decreasing local pain and were not develop to manage psychological factors. In this field, the presence, experience and human qualities of the physiotherapist are more important factors. All patients except one experienced pain or suffering. Since these patients suffered from severe levodopa-induced motor complications, they exhibited marked off-periods with akinesia, rigidity, painful off-dystonia and anxiety. This profound disability of the patients justifies the risk of surgery, which improves off-period related motor symptoms and pain [3]. During surgical procedure all factors are intensified because the patients are awake in prolonged OFF-drugs periods. Thus it is not surprising that our patients expressed both pain and psychological suffering although moderate for most of them. Immobility and length of the procedure were the main causes of pain and suffering. Technically, we use a stereotactic frame fixed to the floor, which imposed a lying position without any possible neck movement over all the course of surgery. Immobility can be less distressing using mobilization techniques of arms and legs, muscular stretching, shaking or massages. We think also that respiratory exercises and relaxation exercises can considerably abate psychological suffering. We think that this excessive duration of surgery is justified, although stressful, because it may contribute to the satisfactory and longstanding results [4]. However, it may be difficult for the patients to distinguish physical pain from psychological suffering in the context of a retrospective analysis. With time, memory could have mixed all causes of pain. This may explain the high score of 8 of

Table 1 Base-line Characteristics of the 75 patients

<table>
<thead>
<tr>
<th>Characteristics</th>
<th>Value</th>
</tr>
</thead>
<tbody>
<tr>
<td>Sex (number of patients)</td>
<td></td>
</tr>
<tr>
<td>Men</td>
<td>48</td>
</tr>
<tr>
<td>Female</td>
<td>27</td>
</tr>
<tr>
<td>Age (years)</td>
<td>55.8 ± 7.9</td>
</tr>
<tr>
<td>Duration of disease (years)</td>
<td>11.6 ± 3.7</td>
</tr>
<tr>
<td>Off-dystonia (number of patients)</td>
<td>60</td>
</tr>
<tr>
<td>Sub-score III UPDRS (/108)</td>
<td>46.8 ± 14.2</td>
</tr>
<tr>
<td>Dose of levodopa (mg/day)</td>
<td>879.0 ± 422.1</td>
</tr>
<tr>
<td>Dose of levodopa-equivalent medication (mg/day) b</td>
<td>1266.9 ± 454.4</td>
</tr>
</tbody>
</table>

aPlus minus values are as means ± SD.
bThe dose of levodopa-equivalent medication was calculated as the dose of dopamine agonist plus levodopa.

Figure 1 Evaluation of pain, psychological suffering and expected pain by a numeric pain scale. Results are expressed as the median with 25th to 75th percentile for the box and 10th to 90th percentile for the tails, extreme points for values outside the 10th to 90th percentile.
10 reported by the patients to the question ‘expected pain if no physiotherapist was present’, whereas the pain score during surgery was moderate.

The long duration of our procedure is explained to the intraoperative used X-ray checking of electrode localization, robotized procedure, microrecording with five microelectrodes and precise evaluation of both stimulation induced anti-Parkinsonian effects and side effects related to increasing electrical intensities [1,5]. The action of the physiotherapist to bring relief was considered to be effective by the patients. These preliminary results underline the role of the physiotherapist during the electrode implantation procedure under local anesthesia but need to be confirmed in a prospective, randomized study with pre-, intra- and post-operative periods of assessment.

References