

Mobile Posturography for the Assessment of Balance and Risk of Falling in Parkinson's Disease: A Review



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Abstract

Purpose: Conduct a review of clinical studies that applied balance tests and posturography in patients with Parkinson's disease and potential use of these tools for preventing falls.

Research Strategy: Integrative literature review guided according to Prisma protocol guidelines.

Selection Criteria: Clinical trials that evaluated the use of mobile posturography and platform posturography equipment and that performed the "Timed Up and Go" test was included. There were not any limits regarding language or year of publication.

Data analysis: The retrieved studies were submitted to the eligibility criteria and those included were read and analyzed. Results: Only seven studies were eligible and included in the final sample. They demonstrated that mobile posturography and platform posturography, although used in the assessment of several clinical situations, are still little explored in Parkinson's disease.

Conclusion: Mobile posturography performed with Vertiguard® using the Standard Balance Deficit Test proved to be one of the most efficient tools for predicting patients with Parkinson's Disease at greater risk of falling, and it is also useful for the rehabilitation of these patients.

Keywords: Gait analysis; Parkinson disease; Postural balance; Sensory; Neurofeedback

Abbreviations: PD: Parkinson's Disease; UPDRS Unified Parkinson's Disease Rating Scale; ABC: Activities-Specific Balance Confidence; CDP: Computer Dynamycs Posturograph; DHI: Dizziness Handicap Inventory; LOS: Limits of Stability; SBDT: Standard Balance Deficit Test; SOT: Sensorial Organization Test; TUG: Timed Up and Go

Introduction

Parkinson's disease (PD) is one of the most prevalent neurodegenerative diseases and causes progressive motor and non-motor impairments in the affected individual's movements [1]. Postural instability is one of the most debilitating motor symptoms [1] and it results from the loss of reflexes that maintain the orthostatic position, trunk rotation and flexed posture [2]. For this reason, it is associated with an increased risk of falling, which can result in complications such as fractures, reduced mobility and self-restriction of activities due to fear of falling and reduced quality of life [1]. Generally, postural instability presents itself in more advanced stages (from stage three onwards in the Hoehn and Yahr classification, which consists of stages from zero

to five, with three classified as moderate disability, and four and five classified as severe disability) of PD [1,3]. Patients known as "fallers", which are those who have had at least one fall in the last three to six months, usually have PD for a longer time and have severe disease [4].

In these patients, symptoms such as motor fluctuations, dyskinesia and freezing are also more common [4]. Bradykinesia and rigidity respond to dopamine treatment and affect balance and gait since the beginning of the disease [3]. However, impairment in kinaesthesia, lack of automatism and executive function dysfunction occur later in the disease and are not responsive to dopamine [3]. Changes in gait, which can impact on balance, such

as bradykinetic steps, result in increased dependence on vision to compensate for the postural movement [3,2]. The clinical assessment of postural instability in PD is usually carried out using the retropulsion test, but it is difficult to standardise [1] and its ability to predict the risk of falls is questioned [2]. It has been shown that the Unified Parkinson's Disease Rating Scale (UPDRS) and the body sway area are independent and important risk factors for predicting the risk of falling [4].

In PD, postural instability is evident both at rest and when performing activities [1]. As such, a quantitative assessment of postural instability can be made using posturography, which allows balance to be assessed both statically and dynamically [1]. Based on the premise that posturography helps assess balance and the risk of falls in PD patients and can be used to prevent falls, the aim of this study was to review clinical studies that applied balance tests and posturography in PD.

Methods

The review was based on the research question "Is assessing individuals with Parkinson's disease for balance and falls risk using balance tests and gait posturography effective for clinical guidance on falls risk and prevention?". The research protocol was registered in the International Prospective Register of systematic reviews (PROSPERO): CRD42023464490. The search was carried out in April 2023 on the CAPES Journal Portal (<https://www-periodicos-capes-gov-br.ez1.periodicos.capes.gov.br/index.php?>), which is a virtual library that gathers and makes available international scientific production to research institutions in Brazil, covering the main databases in the health area, such as Embase, PubMed, Scopus, ScienceDirect and Scielo. Two combinations of descriptors indexed on the Medical Subject Heading (MeSH), Health Sciences Descriptors (DeCS) and Embase Subject Headings (Emtree) platforms were used: "Parkinson AND Vertiguard" and "Parkinson AND mobile posturography".

Clinical trials that evaluated the use of gait posturography and platform posturography equipment and that carried out the "Timed Up and Go" test were included, with no limits as to language or year of publication. We excluded review articles, book chapters, letters to the editor and other types of scientific literature, studies that did not use posturography and studies in which the study population did not include Parkinson's disease. The studies retrieved were subjected to selection criteria and the elimination of duplicate articles and those that did not meet the eligibility criteria; the studies were read in full, and the information extracted and collated in a table for later analysis, in order to meet the proposed objectives.

Results

The search resulted in nine articles being retrieved and after applying the inclusion and exclusion criteria, the final sample consisted of seven articles (Figure 1). The results of the studies analyzed are shown in (Table 1).

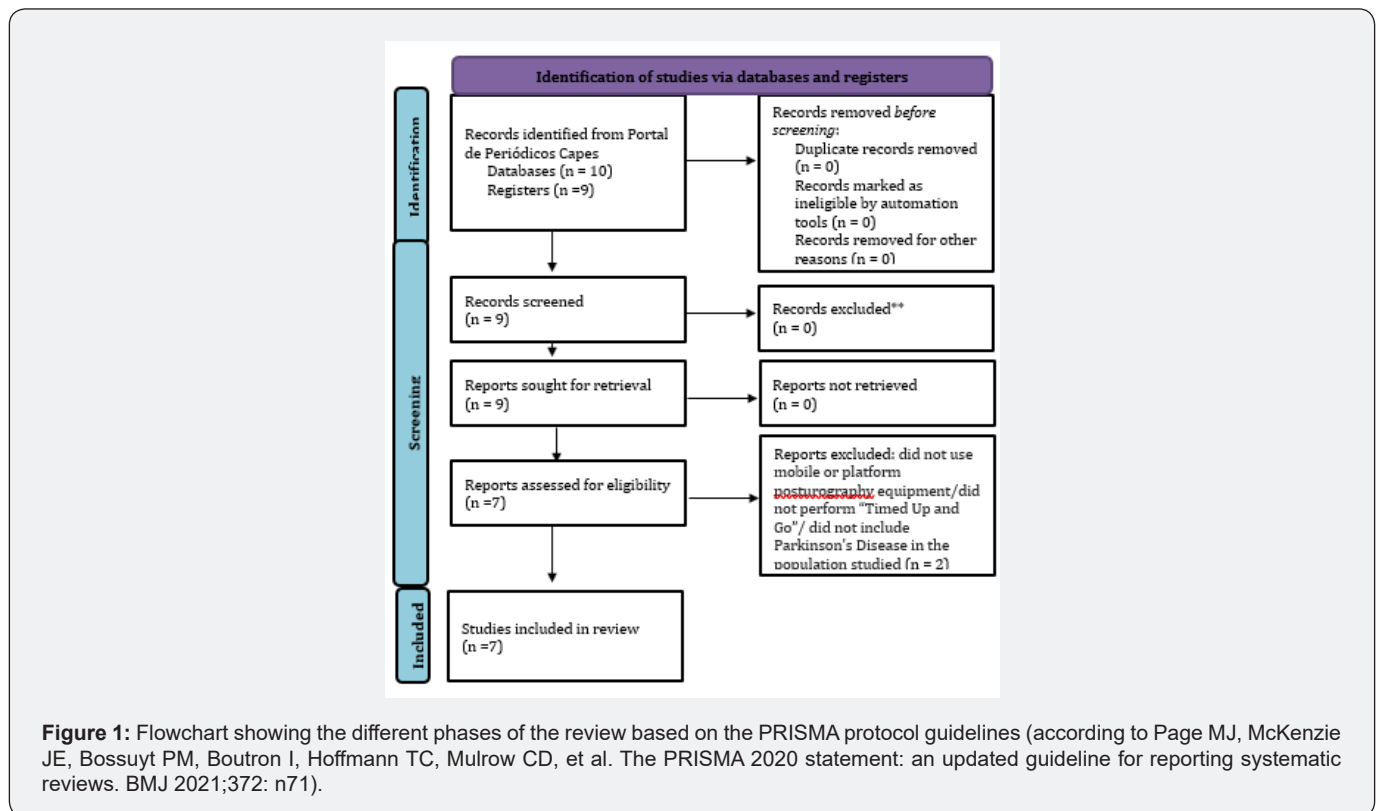


Table 1: Informations from the articles that make up the final sample.

Databases	Autores	População	Intervenção	Comparador	Desfecho	Tempo
Wiley Online Library	Chastan N, et al. [5]	9 individuals with PD in the early stages of the disease UPDRS posture score: <ul style="list-style-type: none"> · 4 patients: 0 · 5 patients: 1 UPDRS postural instability score: <ul style="list-style-type: none"> · 5 patients: 0 · 4 patients: 1 	Satel force platform® in static and dynamic conditions and with eyes closed and open	18 healthy individuals	Static posturography showed a greater area of body sway in PD patients with both closed and open eyes. Dynamic posturography did not show any difference in latero-lateral conditions, but the area of oscillation in antero-posterior conditions with eyes closed was greater for patients with PD. In the early stages, patients were able to regain their balance in unstable situations.	-
SCOPUS ScienceDirect Embase	Izquierdo MR, et al. [6]	32 patients with PD Fallers: · 1 in Hoehn-Yahr stage I, 3 in stage II, 7 in stage III e 2 in stage IV Non-Fallers: · 4 in Hoehn-Yahr stage I, 14 in stage II e 1 in stage III	DHI ABC scale, Number of falls in the last 6 months, Modified TUG test, CDP - SOT and LOS, Vertiguard® - SBDT	13 fallers (1 fall in the last 6 months) x 19 non-fallers	Fallers: <ul style="list-style-type: none"> · They took longer to complete the TUG and it took more steps; · They obtained worse scores on the ABC and DHI; · They performed worse in conditions 5 and 6 of the SOT; · They performed worse in all the LOS variables; · They had a higher risk of falling with Vertiguard® . DC (directional control) of the LOS and number of steps of the TUG had high accuracy. Vertiguard® is more efficient at identifying fallers than the SOT parameters. Fall risk indicator proved to be useful. 	-
SCOPUS	Ozinga SJ, Linder SM, Alberts JL [7]	14 patients with PD	Center of Mass (COM) acceleration - comparison between a mobile device and NeuroCom® force platform - during performing SOT	14 healthy individuals	NeuroCom® balance score was unable to identify patients with or without PD. Acceleration of the center of mass was the only measure capable of identifying deficits in postural stability in PD. The results of the acceleration of the center of mass obtained using the mobile device and NeuroCom® were similar. Latero-lateral and antero-posterior oscillation was greater in PD in conditions 5 and 6 of the SOT.	-

<p>SCOPUS ScienceDirect Embase</p>	<p>Izquierdo MR, et al. [8]</p>	<p>33 patients with PD Hoehn e Yahr stage 2,1 +/- 0,36</p>	<p>DHI ABC scale, CDP – SOT Vertiguard® - SBDT</p>	<p>Data from healthy patients</p>	<p>PD: · Antero-posterior sway was greater in all SBDT conditions (except sitting and standing); · Greater antero-posterior and latero-lateral sway in complex activities such as walking on foam. Mobile posturography was more accurate than platform posturography in assessing balance impairment. The re- lation of the posturo- graphy scores is greater between the ABC scale than between the DHI.</p>	<p>-</p>
<p>Embase Scopus</p>	<p>Basta D, et al. [9]</p>	<p>76 individuals with vestibular disorders (41 with unilateral semi- circular canal loss of function, 10 with acous- tic neuroma, 10 with Parkinson's disease, 8 with presbyvestigmus, 7 with unilateral otolith disorder)</p>	<p>Vertiguard® - SBDT Ankle oscillation during SOT – Balance Master force platform</p>	<p>246 healthy indivi- duals</p>	<p>The influence of vision on antero-posterior postural control in- creases with age. The influence of proprio- ception is not affected. Among patients with PD and chronic decomp- ensated neurovestib- ular disorder, 65 per cent of the patients who had falls obtained a pathological score on the SOT and 63 per cent of patients with altered balance were identified using this method. In addition, a pathological score on the SBDT was found in 82 per cent of patients with balance impairment and in 78 per cent of those who fell. The sensitivity of mo- bile posturography was greater than that of the SOT-platform posturog- raphy.</p>	<p>-</p>

<p>SCOPUS ScienceDirect Embase</p>	<p>Izquierdo MR, et al. [10]</p>	<p>10 patients with PD 6 Hoehn and Yahr stage III and 4 stage IV</p>	<p>Training function on Vertiguard® - vibrato- ry neurofeedback. Five repetitions of the 6 tasks with the greatest body sway detected, individually, in the initial assessment were car- ried out, lasting 20 seconds each. Evaluation of postural stability with SBDT, SOT, DHI, ABC.</p>	<p>9 fallers x 1 non- -fallers</p>	<p>Immediately after train- ing and 3 months later, there was a significant reduction in body sway. Immediately after training, there was a statistically significant improvement in the risk of falling (SBDT) and in the SOT score, which was maintained after 3 months. Number of falls reduced approximately 2-3 times after training. DHI results were significantly better im- mediately after training and were maintained 3 months later. A more significant improvement was seen in the SOT score using vibratory neurofeedback with Vertiguard® com- pared to CDP training.</p>	<p>10 days during a period of 2 weeks</p>
<p>SCOPUS Em- base</p>	<p>Basta D, et al. [11]</p>	<p>105 individuals with central balance and peripheral disorders (semicircular canal pa- resis, otolithic disorder, patients with acoustic neuroma removal with vestibular nerve resection, eighth cranial nerve microvascular compression syndrome, presbyvertigo, PD)</p>	<p>Vibratory Neurofeedback with Vertiguard®. Five repetitions of the 6 tasks with the greatest body sway detected, individually, in the initial assessment were carried out, lasting 20 sec- onds each. Evaluation with SOT, ankle-sway referenc- ed system platform, DHI and vestibular symptom score (VSS) before and after training and 3 months later.</p>	<p>14 patients ran- domly selected from the initial 105 individuals to receive random vibration stimuli</p>	<p>The test group showed statistically significant improvements, such as a reduction in both antero-posterior and latero-lateral, an in- crease in the SOT score, especially in conditions 5 and 6, as well as a reduction in the DHI questionnaire in PD patients. There was a tendency for the VSS score to improve in PD patients. Statistically signifi- cant differences were maintained 3 months later (only 60 per cent attended). A greater reduction in symptom scores and a greater statistically significant effect were observed in patients with PD. There were not statis- tically. There were not statistically significant differences in the con- trol group.</p>	<p>10 days during a period of 2 weeks</p>

Table Abbreviations: TI: Time not Informed; ABC: Activities-Specific Balance Confidence; CDP: Computer Dinamycs Posturography; DHI: Dizziness Handicap Inventory; LOS: Limits of Stability; SBDT: Standard Balance Deficit Test; SOT: Sensorial Organization Test; TUG: Timed Up and Go; UPDRS: Unified Parkinson's Disease Rating Scale.

Discussion

The evaluation of the application of posturography in Parkinson's Disease (PD) was the motivation for this review.

Posturography is a method for assessing the balance of individuals with Parkinson's disease, as well as predicting which patients are at greater risk of falling. In a study in which the intervention with nine patients involved Satel Force Platform posturography® in

static and dynamic conditions, with eyes closed and open, it was shown that postural instability is present since the early stages of PD, mainly at rest [5]. In the early stages of the disease, the ability to control balance during movement is not affected yet, apparently [5].

In a study of 32 participants with PD, 13 of them had fallen at least once in the last six months and were the worst performers in the modified Timed Up and Go (TUG) test, in conditions five and six of the Sensorial Organisation Test (SOT), in the Limits of Stability Balance Test (LOS), as well as they had the highest risk of falling in the Standard Balance Deficit Test (SBDT) with Vertiguard® [6,7]. Three studies have shown superior sensitivity in identifying the risk of falling using the SBDT- Vertiguard® compared to the SOT-platform posturography [6,8,9]. The SBDT identified 82 per cent of patients with balance disorders and 70 per cent of those who fell, while the SOT identified 63 per cent of patients with balance disorders and 65 per cent of those who fell [9]. The sensitivity of the SOT was 54.5 per cent and that of the SBDT was 93.9 percent [8].

In addition, a greater association has been shown between the result obtained with the Vertiguard® in relation to the Activities-specific Balance Confidence scale (ABC) than the Dizziness Handicap Inventory (DHI) - the last two tests are subjective scores that make it possible to assess the level of confidence in carrying out activities without losing balance and the impact of dizziness on quality of life, respectively [8]. SBDT through the use of the Vertiguard® makes it possible to assess body sway in the free field and in dynamic situations, situations in which falls occur in PD. It also makes it possible to assess lateral sway, which is common in PD, possibly due to rigidity [8]. In addition, the "risk of falling" indicator provided by the SBDT has proved useful for identifying individuals who have fallen [6].

The measurement of the acceleration of the center of mass can be assessed using the NeuroCom Smart Balance Master® or using a mobile electronic device with similar results during the SOT, and this parameter is capable of identifying postural stability deficits in PD, which the SOT balance score cannot [7]. Furthermore, it was observed that in conditions where vision was not available or somatosensory information was inconsistent, as in SOT activities five and six, individuals with PD showed greater postural instability compared to healthy individuals, reinforcing the proposal that individuals with PD rely more on vision to maintain balance in order to try to compensate for the loss of somatosensory feedback [7]. In addition, the larger body sway area with closed eyes in dynamic situations suggests that PD patients rely mainly on vision for postural control [5]. Postural instability in PD results from impaired visual and vestibular processing [10].

Another application of the Vertiguard® equipment, apart from its use in assessing balance and the risk of falling, is in the rehabilitation of PD patients through vibratory neurofeedback [10,11]. In one study [11], the test group showed statistically

significant improvements, such as a reduction in both antero-posterior and latero-lateral trunk sway, an increase in the SOT score, especially in conditions five and six, as well as a reduction in the DHI questionnaire result in PD patients. There was a tendency for vestibular symptom scores to improve in PD patients [11]. This is important since postural instability does not improve with the use of dopaminergic medication and, often, conventional rehabilitation with physiotherapy, for example, does not have significant and lasting results. Furthermore, vibratory neurofeedback allows for individualized training [10]. The two studies analysed showed an improvement in the risk of falling (SBDT) immediately after training and this was maintained three months later [10,11]. The number of falls decreased between two to three times and the DHI result remained well after three months [10]. Training with Computer Dynamic Posturography (CDP) did not produce results as significant as those of vibratory neurofeedback (Vertiguard®) [10].

Conclusion

Mobile posturography using Vertiguard®, applying the Standard Balance Deficit Test, has proved to be one of the most efficient tools for predicting which PD patients are at most risk of falling. It allows these patients to be assessed in a free field, better simulating how falls occur. In addition, the Vertiguard® can be used in the rehabilitation of PD patients using vibratory neurofeedback which, until now, has proved to be effective and quick to perform, with long-lasting results in postural stability. The limitations of this study include the limited number of studies published until the date on this subject, which were carried out with a small sample population. The applications of posturography have proved to be an area for further study in the future.

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