

Functional Balance Assessment: review

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The aim of this study was to perform a literature review on different methods of postural balance assessment and to provide a theoretical framework for further study of this subject. Medline, PubMed and LILACS databases were used to find currently employed methods which show good reproducibility and reliability. Clinical examination and scale application or force platform testing, each one with their own advantages and limitations, can be used to assess postural balance. There is no common standard. The evaluator should be familiar with all available methods in order to be able to select the most appropriate for his specific requirements.

KEYWORDS: Postural Balance; Evaluation; Geriatric Assessment.

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■ INTRODUCTION

Postural balance is the ability to keep the body center of mass within the base of support, so that the rapid displacement of the body mass may occur coordinately in different directions. This requires constant adjustments of muscular activity and articular positioning.¹ To control balance, the postural control system depends on sensory information provided by vision, by proprioception, and by the vestibular system, which are integrated and centrally processed by different areas of brain.^{2,3}

Postural balance can be assessed subjectively by clinical examinations, can be classified by application of scales, and can be quantitatively measured by means of force platforms. Due to the diversity of methods to assess postural balance, there is some difficulty in choosing the best instrument applicable to clinical or academic practice according to the needs of the evaluator.⁴

The aim of this study was to review the different methods of measurement and/or assessment of postural balance.

■ METHOD

A literature review was performed, searching for studies published in scientific journals in the period 1990-2014 in English or Portuguese. Articles related to assessment and/or measurement of postural balance instruments, as well as its validation, were included. Articles describing treatments without the use of these instruments were excluded.

Procedures. Article search was performed in the electronic databases Medline, Lilacs and Pubmed with the following subject descriptors: balance assessment, postural balance, functional assessment, motor control, and proprioception.

To select the references relevant to the research topic, the initially simple combinations of these terms were used, and then the search was refined according to the options that each database offered for such a procedure.

After reading the titles and/or abstracts, articles were selected that met the inclusion criteria and were identified as relevant to the development of this work. 51 references were found in MEDLINE, 8,670 in PubMed, and 761 in LILACS. Thirty nine articles were finally selected based on established criteria.

■ RESULTS AND DISCUSSION

3.1 Clinical Assessment

Timed "Up and Go" Test (TUGT). The goal of this test is to determine how many seconds the individual takes to perform the task of rising from a standard chair (seat approximately 46 cm and arms 65 cm high), walking 3 meters, turning around, returning to and sitting back on the chair. In the test, patients are instructed to perform at their usual speed and not enter into dialogues. They should have their usual footwear and if necessary a cane. Ten seconds to run the test is considered as a normal healthy adult performance; between 10.01 and 20 seconds is considered normal for frail elderly or disabled; however, a period above 20 seconds indicates the need to observe the level of functional impairment of subject.⁵ Intra and inter-examiner reliability in the elderly population presents the intraclass correlation coefficient (ICC) - [ICC = 0.98].⁶ The test-retest

reliability of measurements obtained from a population of older adults without cognitive impairment was moderate [ICC = 0.56].⁷ Concurrent validity was evaluated by comparing this test with the Berg Balance Scale [$r = -0.81$], gait speed [$r = -0.61$] and the Barthel Index [$r = -0.51$].⁸

Unipodal Stance. This is a simple and good predictor of falls;⁹ the method evaluates the performance of the individual instructed to remain in single leg stance on each leg with eyes open or closed. The test starts with the legs parallel, maintaining a base of 10 cm away from the midline of each calcaneus, with the upper limbs hanging along the body. The subject is instructed to fix his gaze on a point that is at eye level and at a distance of one meter. Then, the examiner instructs the subject to take one foot from the ground, performing a hip flexion, and records the time during which the individual remains in position. The stay-in-position for more than 30 seconds is at low risk of falling, whereas a time shorter than 5 sec shows a high risk of falls.^{9,10} Inter-rater reliability for this unipodal stance test with eyes open [ICC = 0.994] and with eyes closed [ICC = 0.998].¹⁰

Romberg Test. This test is used in neurological examinations; it clinically evaluates the integrity of the dorsal column of the spinal cord providing an important clue to the presence of disease in the proprioceptive pathway. In this test, the patient is kept standing with feet together (side by side), arms by his/her side and eyes open; and postural sway is observed. The patient is then asked to close his/her eyes and postural sway is again observed and compared with that seen with open eyes. The degree of oscillation and its position should be considered (swinging from the ankles, hips and whole body)¹¹. The test is considered positive if there is significant imbalance with eyes closed or if the imbalance worsens significantly when eyes are closed. Study presented with unilateral vestibular lesions [ICC = 0.63] with eyes open and [ICC = 0.76] with closed eyes.¹²

Functional Reach Test. This test assesses the ability of anterior displacement within the limits of stability. The subject is instructed to lean forward starting from the standing position, perpendicular to a wall, shoulders flexed 90 degrees and elbows extended. The observed measurement is the distance traveled by the third metacarpal along the horizontal axis, which can be measured by a ruler or tape.¹³ The final test result is calculated as the mean value of three attempts. It is essential that the tested individual during the preceding movement of the tilt hold the support base stationary. If this does not occur a new measurement must be made.¹⁴ The functional reach test is validated and considered a to be a simple and precise clinical tool, with a coefficient of variation of 2.5% and¹⁴ inter-rater reliability [ICC = 0.98] and intra-examiner reliability [ICC = 0.92].¹⁵

3.2 Tests for Scales

Dynamic Gait Index. This is an assessment developed by Shumway-Cook *et al.*¹⁶ to assess deficiency balance during gait with excellent applicability for people with Parkinson's disease,¹⁷ stroke¹⁸, sclerosis,¹⁹ or vestibular dysfunction.²⁰ The test focuses on balance during gait including the eight most challenging pre-established functional tasks compared with other tests such as the timed "Up and Go" Test.⁵ These are (1) walk on a flat surface; (2) while walking introduce changes in gait velocity; while walking perform

(3) horizontal and (4) vertical head movements; (5) while walking rotate about own body axis; while walking pass (6) over and (7) circumvent obstacles; (8) walking up and down stairs. Tasks are scored from 0 to 3, so that "0" is severe impairment "1" moderate impairment, "2" mild impairment and "3" normal performance.¹⁶ The examiner's score is based on the subject's ability to maintain normal gait pattern, without detours or missteps. The ICC showed good interrater reliability [ICC = 0.96] and test-retest reliability [ICC = 0.98] when applied to the elderly.¹⁷

Berg Balance Scale. This evaluates functional balance during everyday situations using scores to evaluate different populations,^{22,23} such as elderly²⁴, stroke^{24,25} patients, and people with severe intellectual and visual disabilities.²⁵ This scale has been validated for the Brazilian version by Scalzo *et al.*²³ The maximum score is 56 points. A score between 0 and 20 represents balance deficit, 21-40 acceptable balance, and 41-56 good balance.²² It is highly reliable between observers [ICC = 0.98], and intra-observer [ICC = 0.98].

Postural Assessment Scale for Stroke Patients (PASS). This scale is used for evaluation of static and dynamic posture in lying, sitting, and standing positions²⁶ and has been validated for Brazilian subjects by Yoneyama *et al.*²⁷ The assessment consists of two parts: first is the evaluation of static balance, and second is the determination of the ability to change from a lying to sitting position and from a sitting to a standing position. Items are rated 0-3: zero is the impossibility to perform the requested task and three is the execution without assistance.²⁶ PASS has high reliability [ICC = 0.84] for both intra and inter examination²⁸ and shows a good correlation with the Berg Balance Scale [$r = 0.92$ to 0.95] in Stroke Patients.²⁹

Computerized Testing

Force Platform. The force platform is a plate under which are distributed four dynamometers to measure the three components of force and torque (anterior-posterior, medial-lateral and vertical) exerted by the body over the platform. The derivation of these forces is shown as a point representing the center of pressure, and the variation of these values through time is the movement of the center of mass and the effect of forces used to maintain balance. The signals are amplified and transmitted to a computer that manages the acquisition of data and can thus be used as an indicator for risk of falls.^{30,31} The reliability of the balancing test using the force platform is moderate to very high [ICC = 0.51 to 0.98] in the elderly population.³²

Biodex Balance System. The Biodex Balance System is a multiaxial platform system on which the stability of the platform can be adjusted by varying the resistance level of the springs located below it. It uses a circular platform which is able to move in the anterior-posterior and medial-lateral axes simultaneously with eight different levels, "eight" representing the most stable and "one" the most unstable. The Biodex Balance System measures, in degrees, the tilt relative to each shaft during dynamic conditions (it allows up to 20 degrees of tilt of the platform) and calculates the indexes, anteroposterior, mediolateral, and overall stability. Low levels indicate that the subject is stable, while high rates show that the subject is stability.^{33,34,35}

Equitest. Nashner³⁶ developed Equitest which is characterized as an assessment of computerized dynamic posturography. This system is able to isolate and quantify the contribution of vestibular information, visual and

Table 1 - Summary of methods of assessing balance.

Methods	Assessment	System	Characterization	Reference
Clinical Assessment	Timed Up and Go (TUGT)	Proprioception Visual Vestibular	Dynamic Balance; Quantifies the balance function to get up and walk through time.	5-8
	Unipedal Stance	Proprioception Vestibular	Unipedal Stance; Quantifies the balance over time.	9,10
	Romberg Test	Proprioception	Static bipodal Balance; Evaluates the integrity of the dorsal column of the spinal cord.	11,12
	Functional Reach Test	Proprioception Visual	Functional Balance; Quantifies balance versus functional range.	13-15
	Dynamic Gait Index	Proprioception Visual Vestibular	Dynamic Balance; forehead balance during gait with more challenging tasks.	16-21
Scale Assessment	Berg Balance Scale	Proprioception Vestibular Visual	Functional balance scale; Analysis of the performance of functional tasks with quantitative description.	22-25
	PASS	Proprioception Visual	Scale of postural control in patients after stroke	26-29
Computerized Testing	Force Platforms	Proprioception Visual	Gold standard for quantitative analysis of equilibrium by varying the mass center	30-32
	Biodex Balance System (BBS)	Proprioception Visual	Multiaxial platform that quantifies anterior-posterior and medial-lateral balance.	33-35
	Equitest	Proprioception Vestibular Visual	Computerized dynamic posturography. Quantifies the contribution of vestibular information.	36-39

proprioceptive and integrative, and maintenance or restoration of balance in a situation where the environment is disturbed by sensory or mechanical changes.³⁷ The subject tested is placed on top of a platform, which is surrounded by a cabin, both the platform and the cabin may exhibit parked or oscillating movement relative to the subject's^{36,38} own movement. Equitest features an [ICC = 0.66] for the elderly,³⁷ and an [ICC = 0.67-0.90] for elderly transtibial amputees.³⁹

Concluding Remarks

Postural balance is evaluated by several methods and tools (Table 1), all of which have their advantages and limitations. It is also necessary for a qualified and trained professional to interpret the data. Clinical tests and scales can be easily handled in clinical practice and are acceptable as assessment tools. Platforms are the most reliable methods, but they are expensive instruments and require evaluators with experience in the use of the equipment and the interpretation of results. It must be borne in mind that these are not the only available tests, but simply the most used ones. The vital point in selecting any one of them is that the evaluator is knowledgeable regarding the different methods so the best fit for any given clinical or academic practice be selected.

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RESUMO

O objetivo deste estudo foi realizar uma revisão de literatura sobre os diferentes métodos de avaliação do equilíbrio postural e para fornecer um quadro teórico para um estudo mais aprofundado deste assunto. Bases de dados MEDLINE, PubMed e LILACS foram usados para encontrar métodos atualmente empregados que mostram boa reprodutibilidade e confiabilidade. Exames clínicos, aplicativos de escala ou plataformas de força, cada um com suas próprias vantagens

e limitações, podem ser usados para avaliar o equilíbrio postural. Não há nenhum padrão comum. O avaliador deve estar familiarizado com todos os métodos disponíveis para ser capaz de selecionar o mais adequado para suas necessidades específicas.

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