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Methods of equilibrium assessment and use in non-healthy individuals: a systematic review

Métodos de avaliação do equilíbrio e o uso em indivíduos não saudáveis: uma revisão sistemática

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RESUMO | INTRODUÇÃO: A avaliação do equilíbrio é um assunto bastante conhecido e diversos testes foram elaborados com o intuito de identificar as alterações de forma precoce. Contudo, ainda existe divergência perante qual teste utilizar na prática clínica. **OBJETIVOS:** identificar os métodos de avaliação do equilíbrio mais utilizados em pesquisas publicadas nos últimos 4 anos e o uso em indivíduos não saudáveis. **MÉTODOS:** Este estudo é caracterizado como uma revisão sistemática da literatura e está em conformidade com as diretrizes do protocolo PRISMA. A busca dos dados foi realizada em 4 bases de dados PUBMed, Scielo, LILACS e PEDro. Foram incluídos Ensaios clínicos Randomizados publicados entre 2014 a 2018 que envolviam avaliação do equilíbrio estático e dinâmico em pacientes não saudáveis. **RESULTADOS:** A busca resultou em 151 artigos, dos quais 27 preencheram os critérios de inclusão. A Escala de Equilíbrio de Berg, *Time Up And Go, Balance Evaluation Systems Test* e o Teste do Alcance Funcional foram os métodos mais utilizados para avaliar o equilíbrio, o Acidente Vascular Encefálico e Parkinson foram os acometimentos mais evidentes. **CONCLUSÃO:** A Escala de Equilíbrio de Berg, *Timed Up and Go*, *Balance Systems Test* e Teste de Alcance Funcional foram as escalas mais utilizadas em pesquisas nos últimos quatro anos.

PALAVRAS-CHAVE: Equilíbrio postural. Fisioterapia. Revisão sistemática.

ABSTRACT | INTRODUCTION: The evaluation of the balance is a well-known subject and several tests were elaborated with the intention to identify the changes in an early form. However, there is still divergence over which test to use in clinical practice. **OBJECTIVES:** To identify the most used balance evaluation methods in published research in the last 4 years and the use in unhealthy subjects. **METHODS:** This study is characterized as a systematic review of the literature and is in compliance with the guidelines of the PRISMA protocol. The data search was performed in 4 PUBMed, Scielo, LILACS and PEDro databases. Randomized clinical trials published between 2014 and 2018 involving static and dynamic balance assessment in unhealthy patients were included. **RESULTS:** The search resulted in 151 articles, of which 27 met the inclusion criteria. The Berg Balance Scale, Time Up And Go, Balance Evaluation Systems Test and the Functional Reach Test were the most widely used methods for assessing balance, the Stroke and Parkinson were the most obvious complications. **CONCLUSION:** The Berg Balance Scale, Timed Up and Go, Balance Systems Test and Functional Reach Test were the most used scales in the last four years.

KEYWORDS: Postural balance. Physical therapy specialty. Systematic review.

Introduction

Body equilibrium can be classified as static and dynamic. The static equilibrium refers to the ability to maintain a posture with as little oscillation as possible. The dynamic equilibrium characterizes posture maintenance when performing activities that require a higher motor performance and that causes disturbances that the body needs to readjust[1].

The senescence process is marked by functional and motor alterations. Between these alterations: the reduction of visual acuity, the reduction of muscle mass, proprioceptive alterations and the increase of the walking time and body response time. These factors associated with a disease can result in loss of postural control, directly interfering with the performance of routine activities and quality of life of these individuals[2,3,4].

Some diseases, such as Stroke, Parkinson's disease (PD), Vertigo[5,6], Ankle Sprain[7], can modify the postural control system leading to a significant functional decrease that interferes with the performance of activities of daily living (ADL)[8]. The Stroke and PD are diseases with significant incidence and prevalence in Brazil and increase with advancing age. It generates high expenses for public coffers and social impact, one time that the individuals present the dependence on the realization of their activities[9,10].

The equilibrium training programs promote the improvement of the functional performance of individuals. However, for the correct construction of therapeutic plans, the professionals must choose effective and accurate tools for a correct evaluation. Over the years, many tests have been elaborated to the functional evaluation of the equilibrium with the idea of a search for parameters that establish effectively the early identification of any disorder[11,12].

However, there is still disagreement as to which test to use to evaluate certain unhealthier patients, whatever if they have higher rates of symptomatic or asymptomatic weaknesses. Analyze the use of equilibrium tools in clinical trials can be a reliable solution because these studies have important methodological quality. The study has a goal to identify the most commonly used equilibrium evaluation methods in research published in the last 4 years and their use in unhealthy individuals. We reviewed randomized studies that evaluated the characteristics, effectiveness, and in what diseases could be applied compared to the instruments between themselves and other equilibrium evaluation tools.

Methodology

Search strategy

The PRISMA recommendation was used to guide this systematic review. An embracing electronic search was performed by two independent authors from January to March 2019, with the last search performed on March 27 in the PubMed, Lilacs, SciELO and PEDro databases. The free descriptors used, combined with the Boolean operators, were: Evaluation AND Balance AND Methods AND Postural Balance And Clinical Trial. The strategy changed according to each database, an example presented by PubMed:

(((("Evaluation" OR "Evaluation " OR "evaluation") AND ("Balance" OR "balance")) AND (("methods" OR "methods" OR "method") AND ("Evaluation" OR "Evaluation " OR "evaluation") AND ("Balance" OR "balance"))) AND ("postural balance" OR ("postural" AND "balance") OR "postural balance") AND (ClinicalTrial AND ("2014/01/01": "2018/12/31") AND "humans" AND (English OR Portuguese OR Spanish) AND "adult") AND (ClinicalTrial AND ("2014/01/01": "2018/12/31") AND Humans AND (English OR Portuguese OR Spanish) AND adult).

Study Selection – Inclusion and exclusion criteria

Inclusion criteria were: Published randomized controlled trials involving static and dynamic balance evaluation in unhealthy patients; date of publication between 2014 and 2018 for the most current data acquisition; studies in any language. Exclusion criteria were: Studies related to muscle balance and performed in subjects under 18 years.

Analysis Procedures

The articles selection was independently realized by two authors, they evaluated the titles and abstracts in the first screening. For each suitable study, they examined the complete article and checked if the study had fit the inclusion rules. The obtaining of the included articles data was realized independently by two authors. The information extraction sheet was produced with the following variables: year,

country, study design, sample size, evaluated disease, equilibrium evaluation instrument. The disagreements regarding the inclusion of articles and completion of the extraction form were resolved by a third evaluator. A descriptive analysis of the data was performed.

Risk of bias

The risk of bias of the articles was evaluated using the Cochrane Collaboration tool. This tool consists of seven items: 1) random sequence generation; 2) allocation concealment; 3) blinding of participants and professionals; 4) blinding of denouement evaluators; 5) incomplete denouement; 6) report of selective denouement; 7) other sources of bias. Each item can

classify the risk of bias as "low risk", "uncertain risk" and "high risk". Two authors performed the evaluation independently. A third author was consulted in case of disagreement.

Results

The search in the databases, performed by two independent researchers, allowed us to identify 151 articles. After the investigation of titles, abstracts and references of the articles, 27 articles corresponding to the review eligibility criteria were considered (Figure 1).

Figure 1. Flowchart of the article selection process
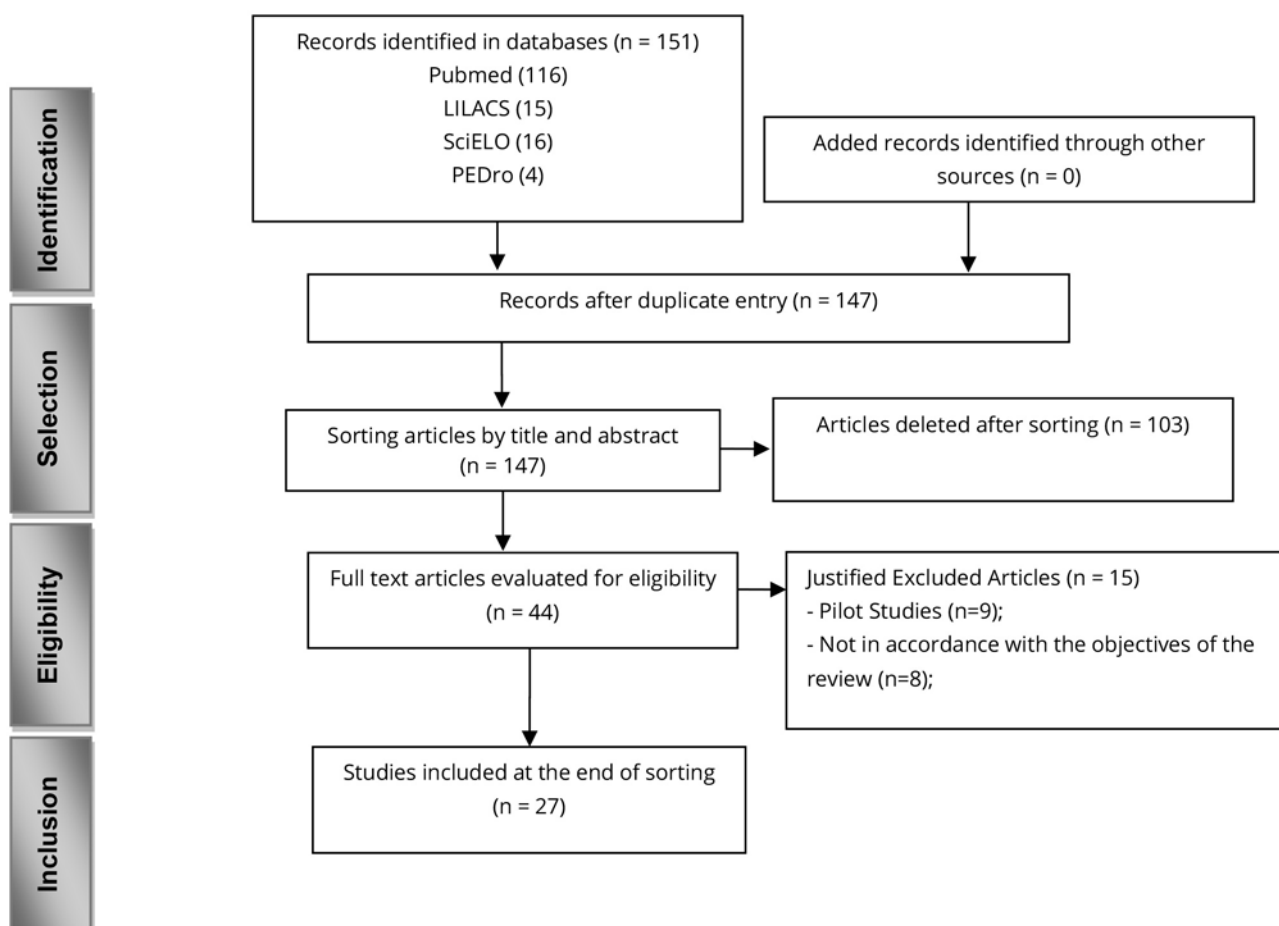
Studies were restricted to clinical trials with sample sizes ranging from 1 to 339 people per study, totaling 1,849 subjects. The studies identified in their entirety were in English, only three articles in Portuguese. The main characteristics of each study are reported in the chart 1.

**Chart 1.** Studies using balance assessment methods (to be continued)

Authors	Study design and sample	Instrument used	Disease
Furnari et al.[13]	Randomized controlled trial with blinded evaluator; 40 consultations with a mean age of 70 ± 6 years	Tinetti Test	✓ Stroke
Aydin et al.[14]	Randomized study; 36 subjects with a mean age of 32.83 ± 3.36	BBS	✓ Multiple sclerosis
Hung et al.[15]	Randomized controlled trial with blinded evaluator; 30 subjects over 18 years	BBS e TUG test	✓ Stroke
Taveggia et al.[16]	Randomized study; 27 subjects with a mean age of 72 ± 9 years	Dynamic Balance Platform	✓ Diabetes mellitus
Ordahan et al.[17]	Randomized study; 50 subjects with a mean age of 57.1 ± 9.2 years	BBS e TUG test	✓ Stroke
Ni et al.[18]	Randomized controlled trial; 41 subjects with a mean age of 72.2 ± 6.5	BBS , TUG test, functional reach test, single leg stance, postural sway test	✓ Parkinson's disease
Hagovská e Olekszyová[19]	Randomized study; 80 subjects with a mean age of 68.2 ± 6.7 and 65.7 ± 5.6	BESTest	✓ Cognitive deficit
Wong-Yu e Mak[20]	Randomized controlled trial; 70 subjects with a mean age of 61.2 ± 8.8 years	Mini-BESTest, functional reach test, five-time-sit-to-stand, one-leg-stance, TUG test.	✓ Parkinson's disease
Ricci et al.[21]	Randomized clinical trial; 82 subjects over 65 years old	TUG test, sit to stand test, multidirectional reach, and static balance test.	✓ Chronic Vertigo
Liao et al.[22]	Randomized controlled trial; 84 subjects with a mean age of 61 years	Mini-BESTest	✓ Stroke
Navega et al.[23]	Randomized study; 31 elderly women between 60 and 75 years old	Right and left unipodal test	✓ Thoracic hyperkyphosis
Callahan et al.[24]	Randomized controlled trial; 343 subjects with a mean age of 66 years	Multi-Directional Reach Test, timed single legstance	✓ Arthritis

Chart 1. Studies using balance assessment methods (conclusion)

| Authors	Study design and sample	Instrument used	Disease
Sparrow et al.[25]	Randomized crossover study; 23 subjects with a mean age of 66.7 ± 5.7	Mini-BESTest	✓ Parkinson's disease
Haruyama et al.[26]	Randomized controlled trial, 32 subjects with a mean age of 67 years	BESTest–brief version, functional reach test, TUG Test	✓ Stroke
Kargarfard et al.[27]	Randomized controlled trial; 32 individuals with average age 36.4 ± 8.2	BBS	✓ Multiple sclerosis
Wright et al.[28]	Clinical trial protocol; 6 individuals over 70 years old	TUG test, BBS, Balance Confidence Scale	✓ Stroke
Best et al.[29]	Randomized clinical trial; 47 subjects with a mean age of 24.77 ± 7.19 years and 27.32 ± 8.88 years	Balance platform	✓ Ankle sprain
Treleaven et al.[30]	Prospective and Randomized Study; 216 subjects with a mean age of 40.5 years	Romberg Test, Step test	✓ Vertigo
N. Byl et al.[31]	Randomized clinical trial; 24 subjects aged 30-75 years	BBS, TUG test, Five Times Sitto Stand Test	✓ Parkinson's disease
Ozgen et al.[32]	Randomized controlled trial; 40 subjects with a mean age of 41 years	Romberg Test, Posturografy, six-Meter Walktest, five times sit-to-standtest, BBS, TUG test;	✓ Multiple sclerosis
Hagovskà et al.[33]	Randomized controlled trial; 40 healthy subjects and 40 with cognitive impairment with a mean age of 67.1	BESTest	✓ Deficit cognitive
Bird et al.[34]	Randomized controlled trial; 78 subjects	Standardised sitting balance test, functional reach test, step test	✓ Stroke
Timmermans et al.[35]	Randomized clinical trial; 40 subjects aged ≥ 18 years	BBS; TUG test, Activities-specific Balance Confidence scale;	✓ Stroke
Vollmers et al.[36]	Randomized controlled trial; 36 individuals aged 18 to 75 years	Fullerton Advanced Balance Scale	✓ Breast cancer
Karthikbabu et al.[37]	Randomized clinical trial; 108 individuals aged 30 to 75 years	Brunel Balance Assessment, Tinettiscale	✓ Stroke
Batista et al.[38]	Randomized clinical trial; 39 individuals aged 50 to 80 years	BESTest;	✓ Parkinson's disease
Gomiero et al.[39]	Randomized controlled trial; 134 individuals aged 50 to 75 years	TUG Test, Tinneti Balance Scale	✓ Knee Osteoarthritis

Four scales were the most used among the studies. The Timed Up and Go (TUG) was used by eleven studies[15,17,18,20,21,26,28,31,32,35,39], of these five evaluated patients with Stroke, three evaluated Parkinson's Disease (PD) and evaluations in patients with vertigo, multiple sclerosis (ME) and knee osteoarthritis were reported each by an article. The Berg Balance (BBS) was used by 9 studies[14,15,17,18,27,28,31,32,33], four of these evaluated patients with Stroke, two evaluated people with ME and two evaluated the repercussions of PD. The Balance systems test (BEStest) was used in seven studies[19,20,22,25,26,33,38], three evaluated individuals with Stroke, 2 were performed on patients with PD and 2 in people with cognitive deficit. The Functional Reach Test (FRT) was used in four studies[18,20,26,34], two evaluated people with Stroke and two evaluated patients with PD. These along with the less reported scales are represented in figure 2.

Figure 2. Balance assessment methods used in studies
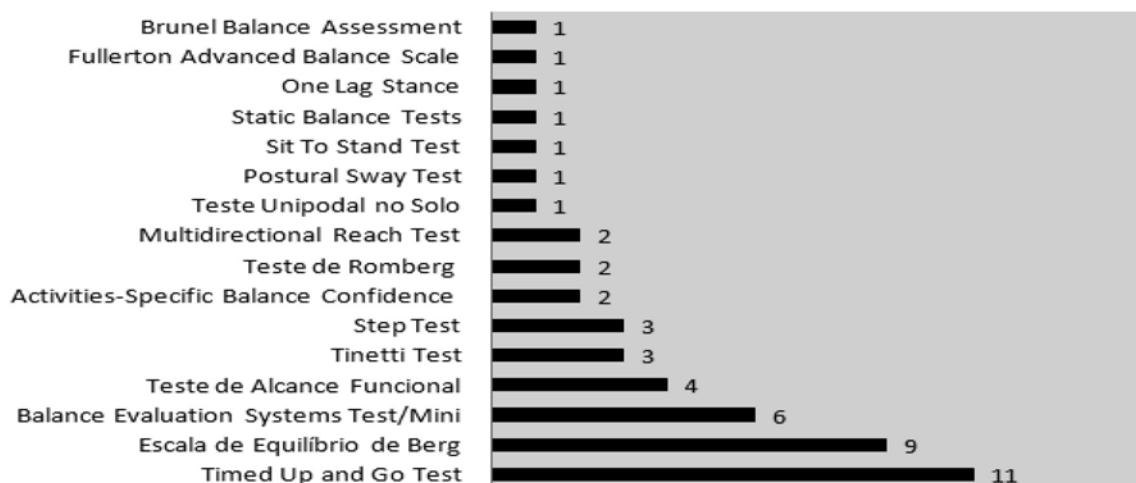
When dealing with the diseases, we observed an evaluation in 11 different types, in which Stroke appeared in 31% and PD in 17.2%. These and the others are characterized in figure 3.

Figure 3. Diseases evaluated in studies
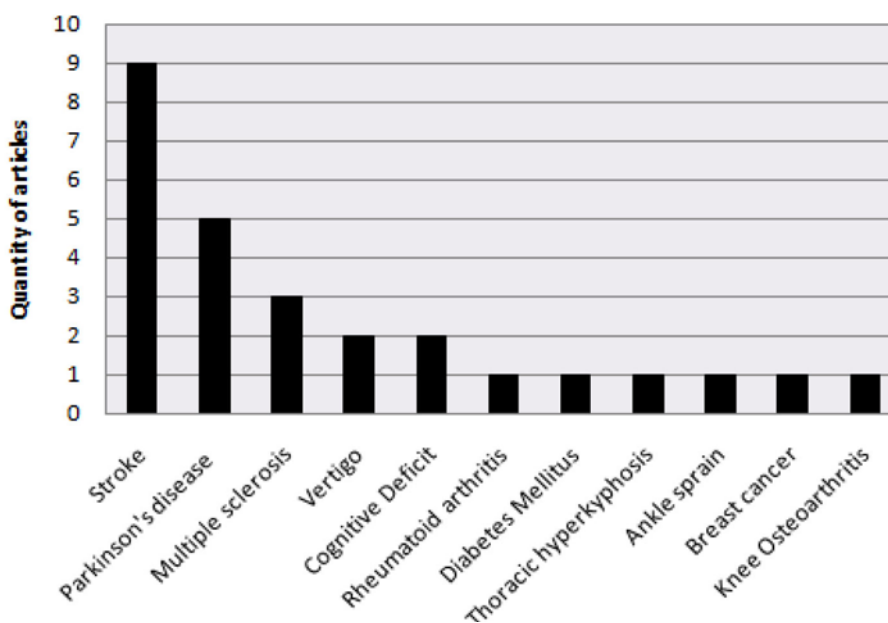
The bias risk assessment showed that 51.8% of the studies showed little detail related to allocation or blinding, thus receiving the classification "uncertain risk" for one or both of these domains. Only two articles were rated high risk in one of the domains evaluated. Chart 2 represents the evaluation of all articles.

Chart 2. Bias risk assessment

Studies	Random Sequence Generation	Allocation concealment	Blinding of participants and professionals	Blindness of outcome evaluators	Incomplete Outcomes	Selective outcome report	Other sources of bias
Furnari et al. [13]	UR	UR	LR	LR	LR	LR	LR
Aydin et al. [14]	LR	UR	UR	UR	LR	LR	LR
Hung et al. [15]	UR	UR	UR	UR	LR	LR	LR
Taveggia et al. [16]	LR	LR	LR	LR	LR	LR	LR
Ordahan et al. [17]	LR	UR	UR	UR	LR	LR	LR
Ni et al. [18]	LR	LR	LR	UR	LR	LR	LR
Hagovská e Lekszyová. [19]	LR	LR	LR	LR	LR	LR	LR
Wong-Yu e Mak. [20]	UR	LR	LR	LR	LR	LR	LR
Ricci et al. [21]	LR	LR	LR	LR	LR	LR	LR
Liao et al. [22]	LR	LR	LR	LR	LR	LR	LR
Navega et al. [23]	UR	UR	UR	UR	LR	LR	LR
Callahan et al. [24]	LR	LR	UR	UR	LR	LR	LR
Sparrow et al. [25]	LR	LR	LR	LR	LR	LR	LR
Haruyama et al. [26]	LR	LR	LR	LR	LR	LR	LR
Kargarfard et. al. [27]	LR	LR	LR	UR	LR	LR	LR
Wright et. al. [28]	LR	LR	LR	LR	LR	LR	LR
Best et al. [29]	UR	UR	LR	LR	LR	LR	LR
Treleaven et al. [30]	LR	LR	LR	LR	LR	LR	LR
N. Byl et al. [31]	UR	UR	LR	UR	LR	LR	LR
Ozgen et al. [32]	UR	UR	LR	UR	LR	LR	LR
Hagovskà et al. [33]	LR	LR	LR	LR	LR	LR	LR
Bird et al. [34]	LR	UR	UR	UR	LR	LR	LR
Timmermans et al. [35]	LR	LR	UR	UR	LR	LR	LR
Vollmers et. al. [36]	LR	LR	LR	HR	LR	LR	LR
Karthikbabu et. al. [37]	UR	UR	UR	UR	LR	LR	UR
Batista et al. [38]	UR	UR	HR	LR	LR	LR	LR
Gomiero et. al. [39]	LR	LR	LR	LR	LR	LR	LR

Subtitle: LR: low risk; HR: high risk; UR: uncertain risk; NA: not applicable (used for case studies).

Discussion

This systematic review was designed to identify the most commonly used balance assessment methods and in which pathologies. Overall, this study identified the TUG test as the most widely used balance assessment scale. This finding consolidates the value of using simple but capable tools to provide a good assessment.

TUG was proposed by Podsiadlo and Richardson[12] in 1991 to assess the functional mobility of frail elderly. This has shown good results in dynamic balance evaluation[40]. The test is performed by asking the patient to get up from a chair, walk a distance of 3 meters, turn around, return on the same path and sit back in the chair[12]. The validity of the TUG was determined by comparing the score obtained with the BBS, showing that the TUG time measurements were strongly related to the BBS score[12].

Dutra et al. (2016)[41] performed a study for translation and validation of the TUG in the Brazilian version. The study was conducted in elderly with a mean age of 72 years and showed an intra and inter-examiner correlation coefficient of 0.994 and 0.992. Unlike the study by Podsiadlo and Richardson[12], the validation of the Brazilian version was not performed on unhealthy individuals. A literature review study showed that the TUG is considered a reliable, valid and responsive test in people with stroke, however it does not allow the discrimination between healthy patients and individuals with the best performance in the test[42].

The BBS was the second most identified instrument in the study, proposed in 1989 by Berg et al.[11]. It evaluates the individual's balance in 14 items, representing some daily activities, for example: getting up, standing, walking, lean forward, transfer, turn around, among others. The BBS has been developed to meet various recommendations in clinical practice and research, with the aim of monitoring the patient's state of balance, the course of a disease, clarifying the risks of falls, selecting patients fit for rehabilitation and the patient's response in the patient treatment[43,44].

In institutionalized patients[43], the inter-examiner (ICC-0.98) and intra-examiner (ICC-0.99) reliability were classified as good with internal consistency of α Cronbach = 0.96. Similar values were found in a scale validation study for the Brazilian population[45]. Mao et al. (2002)[46] showed that BBS presents good reliability, validity and responsiveness in the evaluation of stroke patients, however this study suggests that the Postural Assessment Scale for Stroke Patients (PASS) is the instrument with better psychometric characteristics when compared to BBS in assessment of the patient with stroke. The validity of the Brazilian version of the scale was also tested in PD patients and the study concluded that BBS correlates with the severity of symptoms, disease stage and level of independence, and is suitable for evaluating PD patients[47].

BEStest was developed in 2009 by Horak et al.[48] and consists of a clinical assessment tool for balance divided into 27 tasks, for a total of 36 items arranged in 6 systems: "Biomechanical Restrictions", "Stability Limits / Verticality", "Anticipatory Postural Adjustments", "Postural Responses", "Sensory Orientation" and "Gait Stability". Cross-cultural adaptation and analysis of the psychometric properties of the Brazilian version was tested in elderly and PD patients. The test retest reliability through the interclass correlation coefficient was 0.98 for the elderly and 0.92 for patients with PD[49].

Bambirra et al. (2015)[50] evaluated the properties of BEStest in stroke patients. Test-retest and inter-examiner reliability were tested using the kappa coefficient that showed moderate to almost perfect agreement. This study demonstrated that there wasn't ceiling effect suggesting that the instrument is suitable for measuring the performance of these patients. However, two items ("hip and trunk lateral force" and "left lateral reach") showed erratic behavior, suggesting greater caution in the interpretation of the score.

The FRT was prepared in 1990 by Duncan et al.[51]. It is an assessment instrument that identifies dynamic changes in postural control. This is performed by measuring arm displacement during a trunk flexion. The test has good inter-examiner reliability (ICC 81)[51]. Analysis of the test-retest reliability of the three postural control measures suggests that the FRT is highly reproducible and of excellent accessibility compared to other assessment methods[51].

FRT is a reliable measure of balance that can be used to clinically evaluate instability because it is inexpensive, accurate, stable, age sensitive and clinically accessible. On the other hand, it may be difficult to perform in patients with severe dementia, extreme spinal deformity, severely restricted upper extremity function, and fragile individuals unable to remain unsupported[51].

The four identified scales have different characteristics and should be considered according to the objective and the clinical characteristics of the patient. The BBS, TUG and FRT are instruments developed mainly to assess the balance of the elderly and thus are able to predict the risk of falling individuals. Unlike these, BESTest, the most current instrument, was created with the aim of directing treatment by identifying changes in a specific subsystem. This is not directed to specific pathology or age.

The BBS and BEStest scales presented superiority when compared to the other scales because they allow evaluation in several ADL, which were more complete. Another study conducted with healthy elderly affirmed the superiority of BBS over TUG and FRT by evaluating various aspects of balance[52]. In the study by Almeida (2017)[53] BEStest and the BBS scale presented excellent correlation when applied to individuals with stroke.

However, when evaluating time and a simpler application format, the TUG and the FRT show superiority. Stroke was the most evaluated condition among studies. This fact can be attributed to this being the disease with high prevalence worldwide and being considered one of the main causes of adult acquired disability[42].

Conclusion

The results showed that the most used methods in most diseases associated with balance complications were BBS, TUG, BEStest and FRT thus characterizing four powerful assessment tools, while stroke and PD were the diseases most evaluated by these tools. By evaluating different aspects, these scales can be used together, in a complementary way for a better patient evaluation.

Author contributions

Rocha JVC, Araújo DRB e Cardoso VS participated in the conception, study design, search and analysis of the data and writing of the scientific article. Rocha RB participated in the analysis of the research data and writing of the scientific article.

Competing interests

No financial, legal or political competing, interests with third parties (government, comercial, private foundation, etc.) were disclosed for any aspecto of the submitted work (including but not limited to grants, data monitoring board, study design, manuscript preparation, statistical analysis, etc.).

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