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ASSESSMENT PROCEDURE

European Portuguese version of the Mini-BESTest: a cross-cultural adaptation and psychometric measurements in individuals with sensorimotor impairments

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ABSTRACT

Purpose: This study aimed to translate and cross-culturally adapt the Mini-BESTest into European Portuguese and to evaluate its psychometric properties in individuals with sensorimotor impairments.

Material and Methods: A cross-sectional cross-cultural adaptation and validation study was conducted according to the COSMIN guidelines and the STROBE statement. The study included 100 participants with sensorimotor impairments who were able to walk 6 m. Cronbach's alpha and item-total correlations were used to assess internal consistency. Interpretability was assessed by examining floor and ceiling effects and skewness. To investigate construct validity, Spearman correlation coefficients and Bland-Altman analysis were performed to compare the Berg Balance Scale and the Mini-BESTest Inter- and intra-rater reliability were assessed by calculating the ICC, SEM and MDC based on video recordings of the participants during the Mini-BESTest assessments.

Results: The European Portuguese Mini-BESTest showed good internal consistency (Cronbach's $\alpha = 0.892$) and no significant floor or ceiling effects. Excellent inter- and intra-rater reliability (ICC = 0.97) were also demonstrated, with MDC of 2.58 and 2.57, respectively. Furthermore, this instrument showed a significant correlation with the BBS ($r = 0.902$). Bland-Altman analysis showed small absolute differences.

Conclusion: The European Portuguese Mini-BESTest is comparable to the original English version in terms of validity and reliability and is therefore highly recommended for use by Portuguese-speaking professionals to assess postural control.

IMPLICATIONS FOR REHABILITATION

- The Mini-BESTest, increasingly recommended for addressing impaired postural control, has undergone its first comprehensive cross-cultural adaptation into European Portuguese.
- The Mini-BESTest may be a superior assessment tool compared to others because it can identify the specific postural control system that is impaired.
- In a clinical setting, the Mini-BESTest will aid in the development of appropriate intervention approaches, tailoring rehabilitation interventions to the specific needs of each patient.
- The Mini-BESTest is recommended for use by Portuguese-speaking professionals to assess postural control, as it has demonstrated good internal consistency, excellent inter- and intra-rater reliability, and significant correlation with the Berg Balance Scale.

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Cross-cultural adaption; Mini-BESTest; postural control; reliability; validity

Introduction

According to the Human Movement System Concept, postural control (PC) is a complex sensorimotor behavior mediated by the integration of multiple systems [1], which enables the ability to control the body's position in space concerning gravity, support surfaces, the visual environment, and internal references [2,3]. This control is essential for maintaining verticality and stability, which are fundamental for predicting and adapting motor control to successfully perform most activities of daily living (ADLs) [4,5].

Changes in PC are increasingly recognized and are associated with a significant decline in quality of life and clinical status in patients [2], including those with Parkinson's disease (PD) [6–8], stroke [9], multiple sclerosis (MS) [10,11], and older adults [12,13]. Currently, it is possible to assess PC in terms of postural performance regardless of the population studied (healthy or

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pathological), the goal of the postural task, and the environmental conditions [14]. Performance-based outcome measures (PerFOMs) can provide quantifiable and objective data to support clinical reasoning and are an essential component of evidence-based practice [15]. They are useful for identifying specific difficulties [16], allowing individualized adaptation of the intervention plan and monitoring the individual's progress toward achieving maximum functionality in ADLs [17].

Among the many different PerFOMs, the Mini Balance Evaluation Systems Test (Mini-BESTest) is a highly recommended and comprehensive standardized balance measure for the assessment of impaired PC [18–20]. In an expert review of the core outcome set recommendations for measuring standing balance in adults, 66 balance criteria systems were examined. However, consensus was only reached for the Mini-BESTest and the Berg Balance Scale (BBS) [18]. The Mini-BESTest addresses eight components of the PC construct, including static stability, underlying motor systems, verticality, reactive PC, anticipatory PC, dynamic stability, sensory integration, and cognitive influences [18,19]. It is an abbreviated version of the BESTest, based on the Systems Framework for PC theory [2,16]. The Mini-BESTest includes 14 items from the original version, selected by eliminating redundant and insensitive items using a Rasch analysis [16]. The short administration time of approximately 15 min [16,20] offers practical advantages over longer instruments, such as improved acceptability among study participants and increased feasibility for professionals administering the test [21].

The Mini-BESTest has been shown to have robust psychometric properties in a variety of populations. Many of its 14 items are drawn from well-established standardized PC assessments, supporting its content validity [2]. This instrument shows strong internal consistency, ranging from good to high levels (Cronbach's alpha = 0.7–0.98) [22–25], and exceptional inter-rater and test-retest (intraclass correlation coefficient [ICC] > 0,80) reliability when assessing individuals with chronic stroke, PD, and older adults [25–29]. Several studies have highlighted its effectiveness in predicting fall risk in different populations [7,30,31]. Compared with other dynamic balance assessment tools, the Mini-BESTest is one of the most responsive [22,32]. It is suitable for assessing individuals with superior functional abilities [33], unlike the BBS, which may have a ceiling effect [34].

The validity and reliability of the Mini-BESTest have been verified in Portuguese populations with chronic obstructive pulmonary disease [35], end-stage renal disease [36], elderly people and in the community [37]. However, considering that this instrument was developed in an English-speaking country, both linguistic translation and cultural adaptation are necessary to ensure content and face validity at the conceptual level across different cultures [38]. Although, to the authors knowledge, the Mini-BESTest has been translated into several languages [24–28,39–41], this instrument has not been formally translated into European Portuguese. Before its dissemination, it is necessary to analyze the validity and reliability of this useful tool for clinical practice in Portugal [42]. Therefore, the aim of this study was to translate and cross-culturally adapt the Mini-BESTest into European Portuguese and to evaluate its psychometric properties in individuals with sensorimotor impairments.

Methods

Study design and ethics

A cross-sectional, cross-cultural adaptation and validation study was conducted according to the criteria of the Consensus-based Standards for the Selection of Health Status Measurement Instruments (COSMIN) guidelines [43] and the Strengthening the Reporting of Observational Studies in Epidemiology (STROBE) statement [44]. The study was carried out in two phases. The first phase involved the translation and cultural adaptation of the Mini-BESTest and the assessment of its content validity, while the second phase aimed to evaluate the psychometric properties of the European Portuguese Mini-BESTest (Mini-BESTest_EP). Ethical approval for this study was obtained from the Ethics Committee of the Instituto Politécnico de Saúde do Norte (IPSN) (13/04/2023, reference 8/CE-IPSN/2023). Written informed consent was obtained from all participants prior to data collection.

Participants

The sample size was selected according to the COSMIN guidelines to ensure a good and adequate assessment of the psychometric domains [43].

A convenience sample of 100 participants was recruited from two outpatient rehabilitation units between January and May 2023. An experienced physiotherapist recruited participants according to the following inclusion criteria: 18 years of age or older, Portuguese nationality, ability to walk 6 m (walking aids allowed) [28], ability to perform tests without excessive fatigue [24], and clinical condition of sensorimotor impairments affecting PC (musculoskeletal problems, stroke, MS, PD, traumatic brain injury, cerebellar or encephalic inflammation, hydrocephalus, or pendent foot) [25,27]. Exclusion criteria included acute stages of any pathology, unstable health conditions, pregnant women [27] and individuals with a cognitive deficits on the Mini-Mental State Examination (MMSE), according to Portuguese normative data [45].

Data collection procedures

Sociodemographic (age, sex) and historical information about the participants was collected by completing an initial assessment form. Anthropometric measurements of body mass (in kg) and height (in m) were obtained using a Tanita® BC-601 scale (Tanita - Body Composition Monitor®, Tokyo, Japan).

Translation and cultural adaptation

The translation and cultural adaptation procedures followed the internationally recommended sequential methodology [15,38,43]. This included six stages: translation, synthesis, back-translation, expert committee review, pretesting, and final assessment, as shown in Figure 1.

Psychometric properties

Two experienced physiotherapists randomly assessed 100 participants, in two outpatient rehabilitation units. Prior to the study, both raters received two training sessions on the Mini-BESTest_EP and BBS items [29,39]. The training session included video demonstrations of the tests, scoring methods, and practice with administering the two balances scales on two patients [29]. Any doubts were clarified by the study author at the end of the session. The clinical instruments were administered in a randomized order during the same session and in the same environment to prevent the results from being influenced by fatigue [28,39].

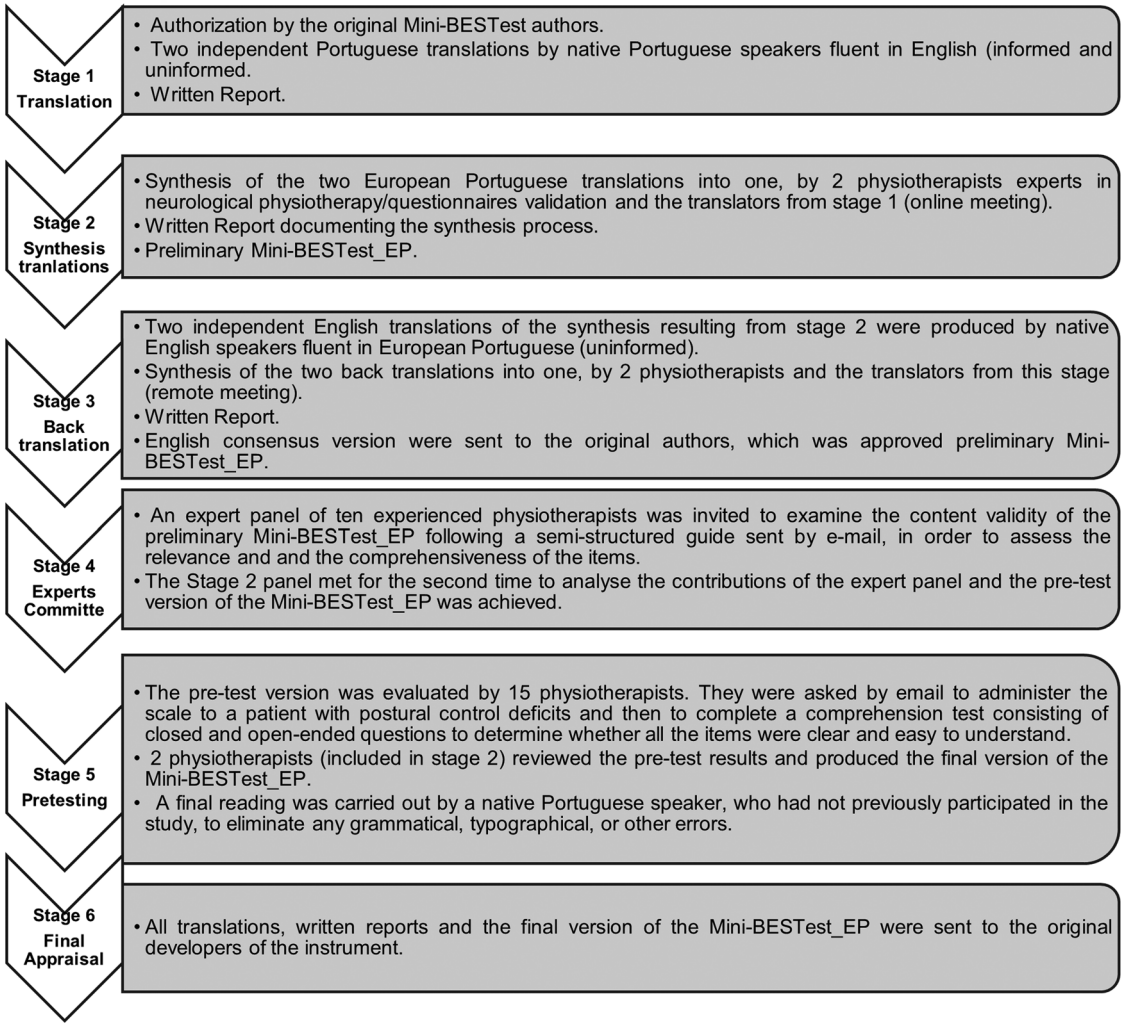

Figure 1. Stages of cross-cultural adaptation of the European Portuguese Mini-BESTest.

All participants were supervised during testing to ensure their safety and to prevent falls. A rest period was provided between the tests to prevent task-related fatigue [27,39]. Patients were instructed to wear comfortable clothes and flat shoes [27]. For the inter- and intra-rater reliability study, a sub-sample of the last 30 participants were videotaped performing the Mini-BESTest_EP test items [46]. The tests were administered by the same physiotherapist, and the participants' whole body was recorded using two stabilized iPhone 13 cameras from either the frontal or sagittal plane.

For inter- and intra-rater reliability, two physiotherapists, with more than 16 years or clinical experience, were asked to independently rate the performance of the 30 participants on the Mini-BESTest_EP using the video recordings (assessment 1). The same procedure was repeated 7 to 10 days after the initial assessment to assess intra-rater reliability, using the same videotape without the raters' knowledge (assessment 2). This was done to prevent raters from memorizing information and learning from test to retest [25].

Clinical scales

Mini-BESTest

The Mini-BESTest is proposed to measure dynamic balance using 14 items, divided into four sections: anticipatory postural adjustments, reactive PC, sensory orientation, and dynamic gait [16]. Each item is scored on a three-point scale (ranging from 0 to 2), with a total score of 28 points, representing optimal balance performance. Both the right and left sides are assessed for two items, with only the lower score being included in the total score [47]. In this study, if a participant chose not to perform one or more items, they were scored as 0. The assessment can be completed in approximately 10–15 min [47]. The equipment required for the experiment includes a standard chair with armrests, a 10-cm-thick Tempur® foam, a stopwatch, an inclined surface (10°), and two shoe-boxes [2].

Berg Balance Scale

The Berg Balance Scale (BBS) is a well-known assessment tool used to evaluate functional balance by assessing the performance of 14 tasks of varying difficulty, including balance during sitting and standing activities. The balance test consists of 14 items that are scored on a five-point scale (0–4), with a maximum score of 56 indicating better balance performance. A score below 46 points indicates a high risk of falling. The BBS has been shown to have high interrater and test-retest reliability in patients with balance disorders [22]. The test takes between 10 to 20 min to administer and requires a standard-height chair with armrests, a chair without armrests, a stopwatch, a ruler, appropriate footwear, and a 15-cm step [48].

Statistical analysis

Data analysis was performed using IBM SPSS Statistics version 29.0 (IBM Corporation, Armonk, NY, USA). The significance level was set at 0.05. Normality tests, including the Kolmogorov-Smirnov and Shapiro-Wilk tests, were performed on continuous variables. Descriptive statistics were used to present the data, including mean ± standard deviation, or median and interquartile range, or minimum or maximum values, when applicable, for quantitative variables, and absolute and relative frequencies for qualitative data.

Interpretability was calculated based on the frequency of total scores for the Mini-BESTest_EP and BBS to determine the presence of floor and ceiling effects. A significant effect was present if ≥15% of the highest or lowest possible score was achieved. The skewness of scores distribution, as a further estimator of ceiling and floor effects, was presented for total scores. A skewness value greater than 1 indicates a significant floor effect, while a value less than −1 indicates a significant ceiling effect.

Reliability was assessed using measures of internal consistency, inter-rater and intra-rater reliability, and measurement error [15]. Cronbach's alpha and Item-Total Correlation (ITC) were used to assess internal consistency. Items were scored according to the widely accepted guideline that Cronbach's alpha values should be between 0.70 and 0.95, and ITC values >0.30 [49].

As recommended for reliability studies, relative inter- and intra-reliability were analyzed using the intra-class correlation coefficient (ICC) with model 2,1 (two-way random effects or ICC2,1) and model 3,1 (two-way mixed effects or ICC3,1), respectively, and the 95% confidence interval (CI). Inter-rater reliability was calculated using the scores obtained by the two raters at the first assessment, and inter-rater reliability was calculated using the scores obtained by the two raters at the first and second assessments. To estimate an ICC with a 95% confidence interval of 0.65–0.95 and an expected value of 0.80, 30 participants with 2 repeated measurements are required, according to simulation studies [50]. The ICC was interpreted as excellent (>.75), moderate to good (0.5 to 0.75), or poor (<0.5) [51]. Bland-Altman plots and the Standard Error of Measurement (SEM) were used to assess absolute reliability [52].

The Bland-Altman approach is used to visually assess how well the measurements agreed between sessions. This method determines the degree of discrepancy between measurements by plotting the variations between two sets of values relative to their mean and the Limits of Agreement (LOA), which gives the mean difference between the two measures and its 95% CI [53].

The standard error of the mean (SEM) is a measure of the variability of a sample mean. It quantifies the amount of error in the sample mean and is expressed in the same units as the original measurement, making it more practical for clinical use [15]. The SEM was calculated based on the result of ICC from both inter-rater and intra-rater reliability, using the following equation:

$$\mathrm{SEM} = \mathrm{SD} \times \sqrt{(1 - \mathrm{ICC})} \quad (1)$$

where SD is the standard deviation of the scores obtained from all participants, ICC is the inter- or intra-rater reliability coefficient.

The MDC at the 95% confidence level (MDC_{95}) was calculated as follows:

$$\mathrm{MDC}_{95} = \mathrm{SEM} \times 1.96 \times \sqrt{2}$$

The MDC was also expressed as a percentage ($MDC_{\%}$), defined by the following equation:

$$\mathrm{MDC}_{\%} = (\mathrm{MDC}_{95} / \mathrm{mean}) \times 100$$

where mean is the mean of the scores obtained in the two assessment sessions. The $MDC_{\%}$ is unit independent and allows comparison of random measurement error between different measures. An $MDC_{\%}$ of less than 30% is considered acceptable and less than 10% is considered excellent [54].

Spearman's correlation coefficient (rs) was used to assess the construct validity (convergent validity) between the Mini-BESTest_EP and the BBS. The existence of a correlation ($r > 0{,}7$) between the two instruments was expected as they are both related to the construct they measure. According to COSMIN recommendations, construct validity is considered "positive" if the correlation coefficient is equal to or greater than 0.5 [49]. The strength of correlations was classified according to the British Medical Journal guidelines: very weak for correlation coefficients of 0–0.19, weak for 0.2–0.39, moderate for 0.4–0.59, strong for 0.6–0.79, and very strong for 0.8–1.0 (BMJ, 2021). The agreement between the total scores of the two instruments was assessed using Bland-Altman plot analysis [53].

Results

Participants

The study included 100 participants, consisting of 51 men and 49 women, with ages ranging from 19 to 93 years. The sub-sample of 30 participants selected for the inter- and intra-rater reliability study, comprising 16 men and 14 women, aged 20 to 93 years. Notably, a higher proportion of neurological conditions was observed in the sub-sample compared to the total sample (70% vs. 55%, respectively). Table 1 provides detailed demographic and clinical characteristics of all participants, along with their scores on the measurement instruments. No data were missing.

Translation and cultural adaptation

The translation and back-translation of the Mini-BEST were analyzed and all discrepancies, mostly related to synonymous grammatical and syntactical terms, were resolved by consensus. All units were converted to the international metric system (feet to m, inches to cm). The back-translated version of the Mini-BESTest was sent to the original authors (Horak, F.). Some changes were suggested, particularly in items 4 and 6, where the authors noted that 'what is being lost is going beyond your limits'. As a result, the phrases "beyond your forward limits" and "beyond your backward limits" were added to these two items, respectively. In item 10, it was suggested to change the instruction "walk slowly" to "walk very slowly." It was also recommended that the instruction descriptions for items 1, 3, 4, 5, 6, 8, and 12 be standardized and aligned with the terminology used in the item descriptions. These recommendations have been incorporated into the preliminary Mini-BESTest_EP.

The translation and back-translation panel analyzed the qualitative approach of the expert panel and, after reaching consensus, made linguistic changes to the terms most used by Portuguese physiotherapists. Regarding the content validity analysis, the expert panel unanimously agreed with all items of this instrument to quantify PC impairments, with no suggestions for deleting or

adding questions. The analysis of the pretest data for the Mini-BESTest_EP showed that the items were clear, understandable, and relevant, and that their content was appropriate. The final version of the Mini-BESTest_EP was therefore produced (available at https://www.bestest.us).

Table 1. Participant demographics and clinical characteristics.

Variable	Total ($n = 100$)	Sub-sample ($n = 30$)
Sex, (n; %)		
Male	51 (51%)	16 (53,3%)
Female	49 (49%)	14 (46,7%)
Age (years) Md (Q1; Q3)	69 (53,25; 76,00)	72 (63,75; 77,75)
BMI M (SD)	25 (3,40)	25,29 (3,06)
Clinical Condition (n; %)		
Neurological	55 (55%)	21 (70%)
Musculoskeletal	45 (45%)	9 (30%)
Sub-Clinical Condition (n; %)		
Stroke	20 (20%)	10 (33,3%)
Brain Vasculitis	12 (12%)	–
Parkinson's disease	1 (1%)	5 (16,7%)
Cerebral Palsy	4 (4%)	–
Traumatic Brain Injury	2 (2%)	1 (3,3%)
Multiple Sclerosis	2 (2%)	1 (3,3%)
Vestibular Syndrome	9 (9%)	1 (3,3%)
Polyneuropathy	4 (4%)	1 (3,3%)
Ataxy	2 (2%)	2 (6,7%)
Amyotrophic Lateral Sclerosis	8 (8%)	2 (6,7%)
Knee Ligamentoplasty	1 (1%)	–
Total Hip Prosthesis	3 (3%)	1 (3,3%)
Rheumatoid Arthritis	4 (4%)	–
Gonarthrosis	14 (14%)	5 (16,7%)
Meniscectomy	3 (3%)	–
Lower Limb Fracture	6 (6%)	–
Lower Limb Muscle Rupture	2 (2%)	–
Ankle Sprain	2 (2%)	1 (3,3%)
Walking Aids (n; %)	13 (13%)	5 (16,7%)
Mini-BESTest_EP Total Scores Md (Q1; Q3)	18 (13,00; 23,00)	–
BBS Md (Q1; Q3)	46 (38,25; 51,00)	49 (40,75; 52,25)

BBS: Berg Balance Scale; BMI: Body mass index; Q1: Quartile; Q3; Quartile 3; M: Mean; Md: Median; Mini-BESTest_EP: European Portuguese Mini Balance Evaluation Systems Test; SD: Standard deviation.

Psychometric properties

Interpretability

No floor or ceiling effects were found. The percentage of participants achieving the highest and lowest possible total scores was 3% and 2% on the Mini-BESTest_EP, and 2% and 5% on BBS, respectively. Slight negative skewness was found on the Mini-BESTest (-0.495) and the BBS (-0.719). The frequency distributions of the 14 item scores on the Mini-BESTest_EP are shown in Figure 2.

Construct validity

The correlation between the Mini-BESTest_EP and the BBS was significant, positive, and very strong ($r = 0{,}902$, $p < 0{,}001$). The Bland-Altman analysis for the mean differences between the two instruments scores is shown in Figure 3, showing a good agreement between the scores of the two instruments. The mean difference of the Mini-BESTest_EP total score between the two raters was 26.3 ± 4.48, representing a distribution of difference within the LOA.

Reliability

The Mini-BESTest_EP showed a good internal consistency, with a Cronbach alpha value of 0.892. For the ITC (Table 2), the correlations between the individual items ranged from 0.347 to 0.741, with most values above 0.5. The ITC scores for item 7 (standing position, feet together and eyes open, on a firm surface) and item 14 (Timed Up & Go test with dual task) were the lowest (0.35 and 0.45, respectively).

Table 3 shows excellent inter-rater reliability with an ICC of 0.97 (95% CI, 0.85–0.99) and intra-rater reliability with an ICC of 0.97 (95% CI 0.96–0.98) and an associated SEM value of 0.93. The MDC95 of the Mini-BESTest_EP was less than 3.

According to Figure 4, the systematic errors were close to zero, and the 95% LOA were narrow, indicating good agreement of the measurements. Figure 3A) shows the total score between the two raters. All data ($n = 30$) were within the LOA. The mean difference in the Mini-BESTest_EP total score between the two raters was 0.90 ± 0.995, showing a distribution of difference within the LOA. Similar results were found for the graphical representation of the

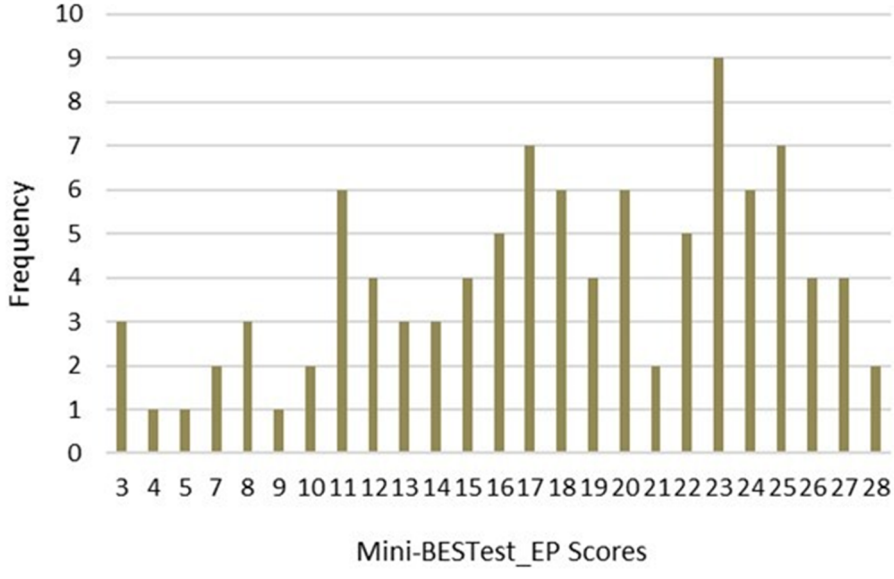

Figure 2. Distribution of sum scores on Mini-BESTest_EP.

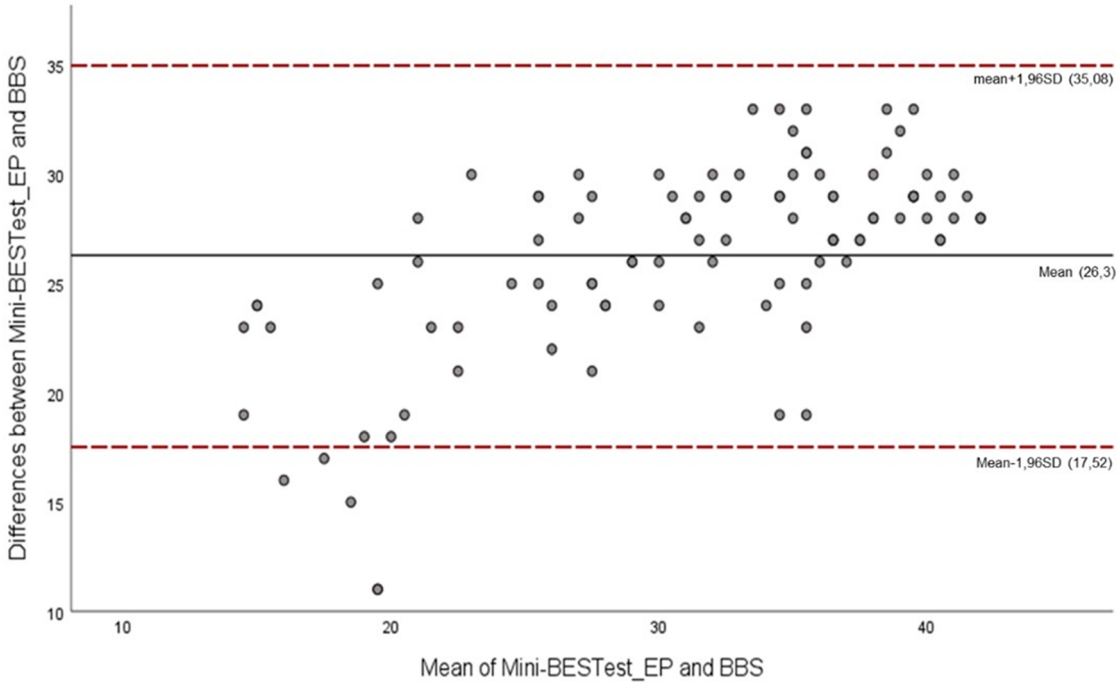

Figure 3. Bland–Altman analysis of differences between EP_Mini-BESTest and BBS. The solid line represents the mean difference between the two measures ($n = 100$) and the dotted line two standard deviations (95% LOA).

Table 2. Item-total correlation of Mini-BESTest_EP from $n = 100$.

Item	Item-Total Correlation	Cronbach's Alpha if Item Deleted
1	0.501	0.889
2	0.592	0.884
3	0.581	0.884
4	0.514	0.888
5	0.638	0.882
6	0.645	0.882
7	0.347	0.893
8	0.692	0.879
9	0.638	0.882
10	0.565	0.885
11	0.571	0.885
12	0.716	0.879
13	0.626	0.882
14	0.445	0.890

Table 3. Mean ± SD and intra and inter-rater reliability of Mini-BESTest_EP from $n = 30$.

	Rater	Mini-BESTest_EP Median (Q1; Q3)	Inter-Rater Reliability ICC2,1 (95% CI) *p*-Value	Intra-Rater Reliability ICC3,1 (95% CI) *p*-Value
First assessment	1	19.5 (13.00; 24.00)	0.97 (0.85–0.99) $p < 0.001$	0.97 (0.96–0.98) $p < 0.001$
	2	18 (11.75; 22.00)		
Second assessment	1	18 (11.75; 22.25)		
	2	18,5 (12.00; 22.00)		
SEM			0.93	0.93
MDC_{95}			2.58	2.57
% MDC_{95}			14.84%	14.91%

CI: Confidence interval; ICC: Intraclass correlation coefficient; ICC2,1: Two-way random effects; ICC3,1: Two-way mixed effect; MDC: Minimal detectable change; SD: Standard deviation; SEM: Standard error measurement.

difference between two ratings (Figure 3B)). Almost all data ($n = 28$) were within the LOA. The mean difference of the Mini-BESTest between the raters was −0.383 ± 0.795, representing a distribution of the difference within the LOA.

Discussion

To the best of our knowledge, this study is the first to translate and culturally adapt the Mini-BESTest into European Portuguese and verify its psychometric properties in individuals with sensorimotor impairments affecting balance. The results indicate that the BESTest_EP is a valid and reliable tool for assessing dynamic balance, consistent with previous reports [24–28,39,55].

When using the Mini-BESTest in a different context from its original development, factors such as culture, language, and geographical location must be considered [15,38]. The cultural and linguistic adaptation of the Mini-BESTest to the European Portuguese followed international guidelines, similar to other cross-cultural adaptations [24–26,28,39,55]. These guidelines, originally developed for the transcultural adaptation and translation of self-report outcome measures, where instructions are directed to the person being assessed [38]. PerFOMs, such as the Mini-BESTest, are primarily designed for use by clinical professionals, who rely on standardized language to score performance. This reliance on precise terminology may have influenced the translation process, leading to adjustments based on feedback from physiotherapists involved in the expert panel and pretest analysis. The Mini-BESTest_EP was well received by participants and physiotherapists for its clarity and comprehensibility, aligning with findings from other cross-cultural adaptation studies [25,26,28,39].

In a validation study, it is crucial that the study sample accurately represents the target population [15]. To ensure this, we included participants with diverse clinical conditions from two different rehabilitation centers, covering a heterogeneous population. The Mini-BESTest_EP scores ranged from 3 to 28 points,

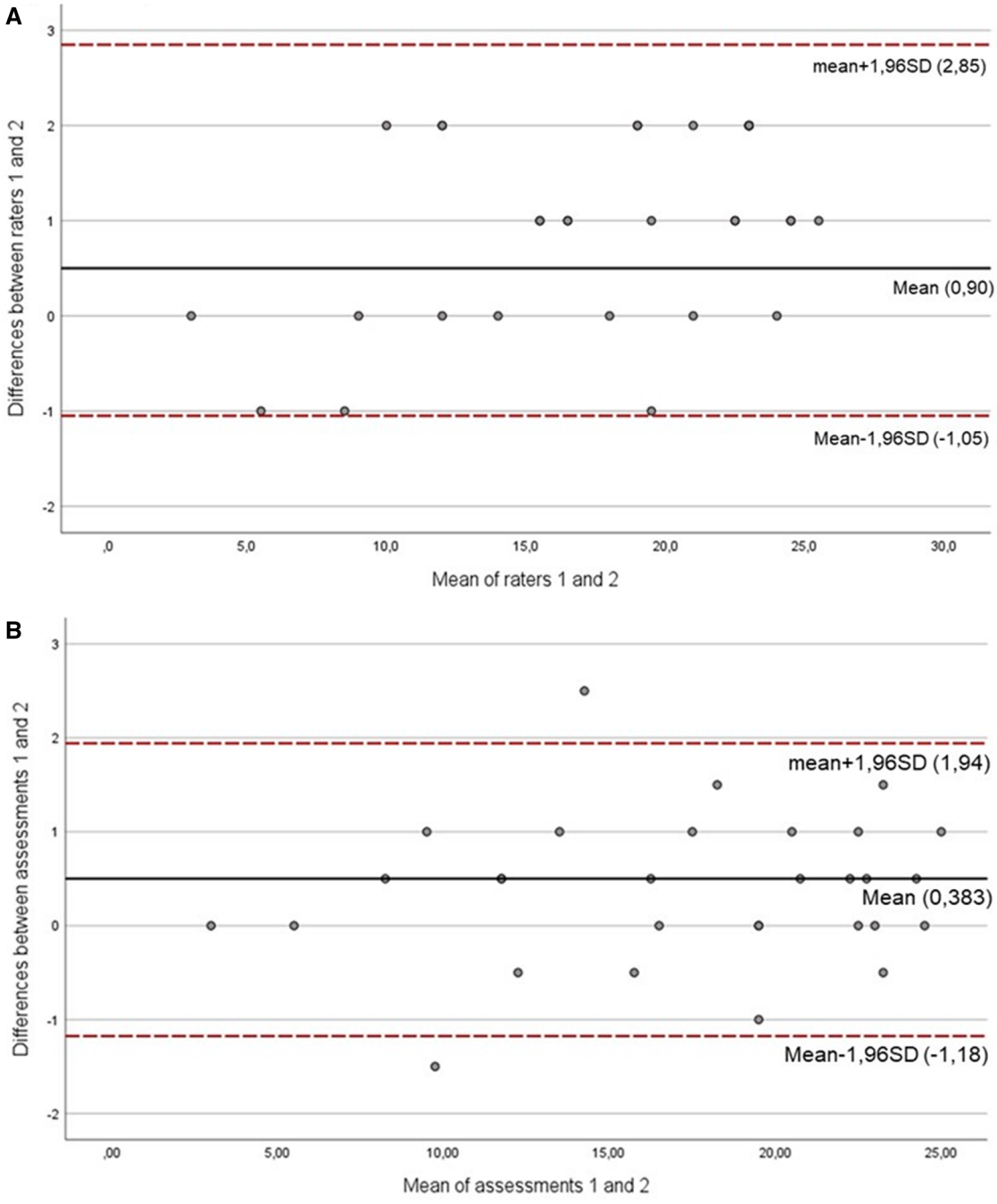

Figure 4. Bland & Altman graphs presenting the Mini-BESTest_EP for inter-rater A) and intra-rater B) reliability. A) The difference between rater A and B is plotted against the mean of rater A and B. B) The difference between assessments 1 and 2 is plotted against the mean of the two assessments (1 and 2). The solid line represents the mean difference between the two measures ($n = 30$) and the dotted line two standard deviations (95% LOA).

with participants presenting a variety of musculoskeletal and neurological conditions, some using walking aids and others walking independently. Consequently, the findings of this study are likely applicable to a broader population of individuals with sensorimotor impairments.

The presence of floor and ceiling effects can significantly impact the reproducibility and responsiveness of an instrument [49]. When more than 15% of the sample reaches the lowest or highest possible score, it indicates that a portion of individuals may not experience meaningful changes in their condition due to being at the extreme end of the scale [43]. In the case of the Mini-BESTest_EP, no floor or ceiling effects were observed, consistent with previous studies [16,24,25,27,29]. Additionally, the Mini-BESTest_EP demonstrates less skewness compared to the BBS, aligning with findings for individuals with sensorimotor impairments (-0.595 to −0,612) [25,27], and outperforming those reported for individuals with neurological disorders (−0.93 to −0.810) [30,56]. These results suggest that the Mini-BESTest_EP may be more effective than the BBS in distinguishing between different levels of balance performance. This advantage may be attributed to the inclusion of more challenging tasks and the comprehensive assessment of various aspects of PC in the Mini-BESTest_EP, which helps prevent score clustering at higher levels. In contrast, the BBS is more limited, lacking a thorough evaluation of anticipatory and reactive PC, sensory orientation, and dynamic gait, including dual-tasking [16].

As hypothesized, the high correlation between the Mini-BESTest_EP and the BBS confirmes its excellent construct validity, consistent with previous studies on the original [16,57] and cross-cultural adaptations [25,27,28,39]. However, it is important to note that high correlations do not necessarily imply agreement between PerFOMs. To further asses this, a Bland-Altman analysis [58] was conducted, which demonstrated strong agreement between the two instruments, as the lines of equality were within the LOA.

The Mini-BESTest_EP demonstrated excellent internal consistency with a Cronbach's alpha of 0.89, indicating that the measured variables consistently reflect the same construct [59]. This is consistent with previous studies across different populations, where Cronbach's alpha ranging from 0.79–0.93 [22,24–28,40]. Additionally, it is comparable with other translated versions, such as the French (Cronbach's α range from 0,895 to 0,929) [25], Greek (Cronbach's α of 0,883) [27], and German (Cronbach's α of 0,90) [28] versions. According to ITC analysis, correlations between each Mini-BESTest_EP item and its score are generally greater than 0.6. Although items 7 and 14 had the lowest scores, removing them would result in a lower Cronbach's alpha. The variation in clarity may be attributed to the fact that item 7 is the easiest and item 14 is the most difficult. In this study, 89% of respondents rated item 7 the highest, compared to only 14% for item 14. The ITC values indicate that the patients were effectively discriminated based on the construct under investigation [15].

The Mini-BESTest_EP also showed excellent inter- and intra-rater reliability (ICC = 0.97), consistent with findings in other populations, such as type 2 diabetic with peripheral neuropathy (ICC 0,93–0.95) [60], MS (ICC 0.80–0.88) [61], balance disorders (ICC 0,94–0,98) [22,25], DP (ICC = 0.91) [7,22] and stroke (ICC 0.94–0.98) [30,62]. It is important to note that ICC values tend to be higher when the sample includes a wide range of scores compared to a more limited range, so caution is advised when comparing results across different studies [63]. Since no single statistical analysis provides a complete picture of reliability, high ICC values should be interpreted alongside absolute reliability measures [52]. In this study, the SEM value of 0.93 indicates a low measurement error for the Mini-BESTest_EP, which is consistent with or slightly lower than previously reported SEMs ranging from 0.9 to 1.99 [22,23,27,30,64–66]. A critical aspect of a clinical tool is its ability to accurately identify true changes in a patient's condition and differentiate between patients based on their level of functionality. Estimates of the MDC and LOA are crucial for defining the threshold for detecting changes beyond measurement error [15]. Based on our findings, a score difference of at least 3 points on the Mini-BESTest_EP can be considered a significant change with 95% confidence, which is similar to other studies [24,29,30,60,67]. Some studies have reported higher MDC values, ranging from 3 to 4.4 [22,36,37], which may be due to differences in methodology and population studied. It is also important to note that in these studies the Mini-BESTest was not scored by video raters. The MDCs identified in our study are useful [54] for clinicians to detect real changes over time or in response to interventions in patients with sensorimotor impairments affecting balance. The absolute reliability of the Mini-BESTest_EP was further confirmed by Bland-Altman analysis, which showed good inter-rater and intra-rater agreement. These findings are consistent with previous studies on patients with PD, stroke or neurological disorders [23,64,67]. Overall, these results demonstrate the stability, consistency, and reproducibility of the scale when measured by different raters and at different times under the same conditions.

Clinical implications

This study provides the Portuguese clinical community with access to a reliable and valid balance assessment tool in their language. The Mini-BESTest may be a superior assessment tool compared to others because it can identify the specific postural control system that is impaired. In a clinical setting, this will aid in the development of appropriate intervention approaches, tailoring rehabilitation interventions to the specific needs of each patient.

Study limitations

This study used a convenience sample of participants from two outpatient clinics, providing a broad representation of the Portuguese population with balance problems. However, the lack of randomized sampling criteria could be considered a limitation of this study. Additionally, concerns may be raised about the inclusion of different balance conditions, as this might suggest a preference for a more homogeneous sample. However, the study deliberately selected a wide range of balance deficits to facilitate validation across a broader spectrum of clinical conditions.

Although identifying the MDC95% is clinically significant, this study did not provide a comprehensive investigation of the responsiveness of the EP_Mini-BESTest. Future studies could benefit from employing a fully randomized sampling method, focusing on evaluating responsiveness, predictive validity, and specificity across different patient populations. Furthermore, determining sensitivity and the minimal clinically important difference (MCID) is crucial, not only to establish the tool's utility as a measure of postural control in individuals with sensorimotor impairments but also to facilitate the clinical interpretation of changes in the health status of these populations over time. It is recommended that future research assess the MCID by combining effect size with clinical anchors, conducting longitudinal studies involving physiotherapy interventions, and utilizing both distribution-based and anchor-based methods. Additionally, testing hypotheses across different groups is essential for establishing construct validity, ensuring the tool accurately measures what it intends to across varied clinical contexts.

The reliability coefficients may have been strengthened by the assessments made by the two experienced physiotherapists. Additionally, a video-based scoring procedure was used to evaluate performance on the Mini-BESTest_EP. Therefore, this study did not account for various sources of variability, including those induced by protocol repetition or inherent biological variability, which may have contributed to an underestimation of the proposed measurement error. It is, consequently, important to use these values with caution in clinical practice, where assessments are often performed on multiple occasions compared to our protocol. To accurately estimate intra- and inter-rater reliability, a larger sample size and a methodological design with real-time observations would be required.

Conclusion

In conclusion, the study results suggest that the instructions and scoring descriptions of the Mini-BESTest_EP are equivalent to the original English version. This new adaption demonstrates excellent psychometric properties, including stability, reproducibility, and well-distributed score range, which is consistent with previous studies across different populations and languages. Based on these results, the Mini-BESTest_EP can be considered an effective tool for assessing dynamic balance within the scientific community.

We, therefore, encourage rehabilitation professionals and researchers who speak European Portuguese to adopt this tool for evaluating postural control in individuals with sensorimotor impairments.

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