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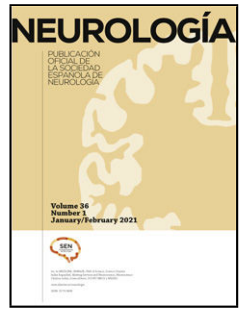

Transcultural adaptation and validity to Spanish population with acquired brain injury of the Balance Evaluation Systems Test (BESTest) and their reduced versions (Mini-BESTest and Brief-BESTest)

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Adaptación transcultural y validación a la población española con Daño Cerebral Adquirido de la Prueba de Sistemas de Evaluación del Equilibrio (BESTest) y sus versiones reducidas (Brief-BESTest y Mini-BESTest)

Transcultural adaptation and validation in the Spanish population with acquired brain injury of the Balance Evaluation Systems Test (BESTest) and its short forms (Brief-BESTest and Mini-BESTest)

Running title: Adaptation and validation of the BESTest, Mini-BESTest, and Brief-BESTest to the Spanish population with ABI

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Highlights

- Balance involves a complex integration of systems, which is impaired in ABI. (75 characters with spaces)
- We adapted the BESTest, Mini-BESTest, and Brief-BESTest to the Spanish population with ABI. (90 characters with spaces)
- The BESTest, Mini-BESTest, and Brief-BESTest present good psychometric properties and are clinically viable. (107 characters with spaces)
- The BESTest evaluates balance alterations and intervention outcomes. (67 characters with spaces)

- Sensitivity to change constitutes a promising line of research in this field. (76 characters with spaces)

RESUMEN

Introducción: Las medidas de evaluación de equilibrio suelen estar validadas en población general o en personas mayores, y escasas veces en población con afectación neurológica. El objetivo de este estudio es la adaptación transcultural y validación de la prueba de sistemas de equilibrio (BESTest) y sus versiones reducidas Mini-BESTest y Brief-BESTest en población española con daño cerebral adquirido.

Métodos: El estudio se dividió en tres fases: 1) Traducción y adaptación de las pruebas, 2) prueba piloto de la versión adaptada, y 3) evaluación de propiedades psicométricas (fiabilidad y validez). Se utilizó como variable criterio la escala de equilibrio de Berg; la validez de constructo se evaluó mediante el análisis factorial exploratorio de todos los ítems de cada prueba; y la fiabilidad se comprobó mediante Alfa de Cronbach e intervalo de correlación intraclase.

Resultados: Participaron 108 personas en fase subaguda y crónica tras sufrir daño cerebral. El análisis psicométrico de las tres pruebas mostró buena validez convergente, consistencia interna, acuerdo inter-evaluador (0,998-0,969) y reproductibilidad (0,985-0,989). Se detectó validez convergente con la escala de equilibrio de Berg (r=0,901, p<0,001; r=0,977, p<0,001; r=0,852, p<0,001 respectivamente) y otras escalas de marcha y equilibrio. No se ha encontrado efecto techo ni suelo en las adaptaciones a población española con daño cerebral adquirido de BESTest, Mini-BESTest y Brief-BESTest.

Conclusiones: Las tres pruebas son válidas y fiables, siendo BESTest la mejor opción para evaluar el equilibrio en personas con daño cerebral adquirido, tanto en fase subaguda como crónica, puesto que incluye dominios que otras herramientas no evalúan.

Palabras clave: Disability evaluation; Validation study; Outcome Assessment; Postural Balance; Brain injuries.

ABSTRACT

Introduction: Balance assessment measures are often validated in the general population or older adults, but rarely in individuals with neurological impairment. This study reports the transcultural adaption and validation of the Balance Evaluation Systems Test (BESTest) and its short forms, the Mini-BESTest and Brief-BESTest, in a Spanish population with acquired brain injury (ABI).

Methods: The study was conducted in 3 stages: 1) translation and adaptation of the tests, 2) pilot test of the adapted version, and 3) assessment of psychometric properties (reliability and validity). The Berg Balance Scale was used as the criterion variable; construct validity was assessed by exploratory factor analysis of all items of each test; and reliability was tested by calculating Cronbach's alpha and the intra-class correlation coefficient.

Results: A total of 108 patients with subacute and chronic ABI participated in the study. Psychometric analysis of the 3 tests demonstrated good convergent validity, internal *consistency, inter-rater reliability (0.998-0.969), and test-retest reliability (0.985-0.989). Convergent validity was observed with the Berg Balance Scale ($r = 0.901$, $P < .001$; $r = 0.977$, $P < .001$; $r = 0.852$, $P < .001$, respectively), as well as other gait and balance scales. No ceiling or floor effects were found in the adapted versions of the BESTest, Mini-BESTest, and Brief-BESTest for the Spanish population with ABI.*

Conclusions: All 3 tests are reliable and valid, with BESTest being the best option for assessing balance in people with ABI, both in the subacute and chronic phase, as it includes domains that other tools do not assess.

Keywords: Disability evaluation; Validation study; Outcome Assessment; Postural Balance; Brain injuries

INTRODUCTION

Acquired brain injury (ABI) is defined as a lesion to the brain that is not degenerative, hereditary, congenital, or induced by birth trauma. Regardless of its aetiology (stroke, head trauma, encephalitis, tumours, anoxia, central nervous system infections), patients with ABI frequently report motor, sensory, and cognitive alterations resulting from neuronal damage.[1] ABI is the leading cause of disability worldwide, with a global incidence of 12.2 million cases in 2019.[2] In Spain, over 435 000 people live with sequelae of ABI.[1] Gait and balance alterations result from motor, sensory, and cognitive alterations, and constitute one of the most limiting factors for independence.[3] Assessment of static and dynamic balance is therefore essential to minimise the risk of falls and to design appropriate rehabilitation protocols aimed at improving the quality of life of patients with neurological diseases.[4] As a result of impaired postural control, between 36% and 73% of individuals with ABI are estimated to present at least one fall within 6 months after hospital discharge, and the prevalence of falls continues to be high at one year after the cerebrovascular event.[5]

Balance alterations, caused by altered or decreased postural control, represent a great challenge for the rehabilitation team aiming to improve the patient's physical and mental status.[6] Postural control requires a complex integration of the neuromuscular (motor, sensory, and cognitive processing) and musculoskeletal systems (biomechanical relationships, muscle performance, range of motion, and flexibility).[7]

The above suggests that thorough assessment of balance, including the activities and participation listed in the International Classification of Functioning, Disability and Health,[8] is essential for both diagnostic and treatment purposes, as balance disorders may have negative consequences for both physical and social functioning.[9]

Several scales are currently available for assessing balance.[10] The Berg Balance Scale (BBS)[11] is considered the gold standard. However, like most balance assessment scales, it focuses on evaluating the risk of falls, and does not detect isolated deficits in the systems involved in balance.[12] The Postural Assessment Scale for Stroke (PASS) is of limited value in patients with

ABI of aetiology other than stroke.[13] As a result, the data provided by these scales is insufficient for proper planning of rehabilitation therapy for patients with ABI.[14]

The Balance Evaluation System Test (BESTest)[15] is a complete tool that evaluates 6 dimensions related to different postural control systems. The results of this assessment serve as guidance for the therapeutic intervention, according to the balance deficits detected. Furthermore, this is the only balance assessment scale that tests postural response to external perturbations and perception of verticality. Two short versions have been developed: the Mini-BESTest,[16] which evaluates 4 of the 6 dimensions, and the Brief-BESTest,[17] which evaluates all 6 dimensions using the most relevant item for each of them. The ability of the BESTest, Mini-BESTest, and Brief-BESTest to detect patients at risk of falls has been assessed in elderly individuals, but not in patients with ABI,[18] as these tools have not been adapted to that population.

The original English-language versions of the BESTest and its short forms have previously been used to evaluate balance in patients with neurological lesions. In the Spanish population, however, they have only been validated and adapted to elderly individuals[19] and patients with Parkinson's disease,[20] showing good psychometric properties. Furthermore, Spanish is the second most widely spoken language worldwide, and one of the 6 official languages of the United Nations.[21] The purpose of this study is to translate and adapt the BESTest and the short forms Mini-BESTest and Brief-BESTest to the Spanish population with ABI, and to verify their usability, reliability, and validity.

MATERIAL AND METHODS

We conducted a cross-sectional validation study of the translation and adaptation to the Spanish population with ABI of the BESTest, Mini-BESTest, and Brief-BESTest. The authors of the original version authorised the translation of the tools. Our study was approved by the clinical research ethics committee of Universidad de Alcalá in Madrid (CEID/HU/2019/38), and is registered on ClinicalTrials.gov (NCT04052087).

Study population

According to the recommendations of the COSMIN initiative, our sample size should ideally include ≥ 100 participants (4-10 for each item evaluated).[22,23] The selection criteria were as follows: adults who had presented ABI at least 2 months prior, aged 18-65 years, without severe functional impairment before the ABI (modified Rankin Scale score ≤ 3), Mini–Mental State Examination score > 24, no history of disorders affecting balance, being clinically stable, and being able to walk either independently or with walking aids.

We excluded individuals with medical contraindications for physical tests (acute musculoskeletal or peripheral nervous system disorders), those unable to understand instructions (severe aphasia), patients with acute processes of any kind, and individuals who were scheduled to receive treatment with botulinum toxin or to undergo treatment changes in the following 2 months.

Balance assessment scales

The BESTest[15] comprises 27 items, scored from 0 (worst performance) to 3 points (best performance), and has been shown to be valid and reliable in detecting the risk of falls in elderly individuals and patients with neurological disorders. Administration time ranges from 20 to 30 minutes. The Mini-BESTest[16] comprises 14 items, scored from 0 (worst performance) to 2 (best performance), and takes approximately 15 minutes to administer. This version has shown adequate reliability and validity in elderly individuals. The Brief-BESTest has not been validated in the Spanish population, but the English-language version, including 6 items scored 0-3, has been shown to be reliable and takes 10 minutes to administer.[17]

In addition to the BESTest, Mini-BESTest, and Brief-BESTest, we administered the BBS[11] as the main criterion variable, as well as other dynamic balance tests, as the BBS does not evaluate stability limits, reactive postural response, or dynamic gait; subsequently, correlations were calculated for scores in similar sections. These tests were the Performance-Oriented Mobility Assessment (POMA),[24] the Timed Up and Go (TUG),[25] and the Community Balance and Mobility Scale (CB&M).[26]

Translation, adaptation, and validation

Following the recommendations of the World Health Organization on the development and use of standardised health indicators,[27] the validation of the scales comprised 3 stages (Fig. 1):

Stage 1: transcultural adaptation. To ensure the methodological quality of the process of cultural adaptation, we followed the principles established by the International Society for Pharmacoeconomics and Outcomes Research and the ISOQOL Translation and Cultural Adaptation Special Interest Group.[23] Four experts participated in the consensus focus group. Fig. 1 describes the process and the professionals involved.

Stage 2: pilot test of the adapted version. In this stage, 7 independent physiotherapists administered the scales at the time of the first assessment to gather information on the scale's viability and administration time.

Stage 3: assessment of psychometric properties. All participants received the same verbal instructions and were allowed to rest if they experienced fatigue. Patient performance was filmed for subsequent review and analysis. If the assessment could not be completed in one day, it was continued the following day. The scales were administered at baseline by raters 1 and 2, to evaluate inter-rater reliability, together with the BBS, POMA, TUG, and CB&M. At 3 weeks after the baseline evaluation, rater 1 re-administered the scales (Fig. 1).

Statistical analysis

Sample characteristics, including sociodemographic data, are summarised using descriptive statistics.

For the inferential analysis, the threshold for statistical significance was set at $P < .05$ for all cases. For the analysis of items, we calculated the Pearson correlation between item score and total scale score excluding that item, as well as the Pearson correlation matrix between all items. Values > 0.80 were considered to indicate a strong correlation for this sample size.[28] To confirm whether the Spanish-language version of the questionnaires had a one-dimensional structure, as in the original versions, we conducted an exploratory factor analysis, using the Kaiser-Meyer-Olkin test and considering values 0.70-0.79 as acceptable and values > 0.80 as satisfactory for demonstrating that the results were not coincidental.[29] Once the validity of the scales was confirmed, reliability was estimated through internal consistency analysis using Cronbach's alpha (values of 0.70-0.90 indicate acceptable internal consistency).[30] Test-retest and inter-rater reliability were determined using the intraclass correlation coefficient (ICC); values > 0.75 were considered to be appropriate and values > 0.9 to be excellent.[31]

If ≥ 15% of participants present the highest or the lowest possible score, this would point to a possible ceiling or floor effect.

Statistical analysis was conducted using the SPSS software, version 28.0.0.

RESULTS

Of a total of 108 participants, 37% reported left hemiparesis, 47.2% reported right hemiparesis, and 15.7% presented bilateral paresis. Only 13% of participants were not receiving any pharmacological treatment.

Table 1 summarises the demographic and clinical characteristics of the study sample.

None of the participants presented the lowest (0) or the highest possible score on the BESTest (108/108) or the Mini-BESTest (28/28). Three participants achieved the highest possible score on the Brief-BESTest (24/24). However, in the balance assessment scales used for comparison, 11.1% and 16.7% of participants achieved the highest possible scores on the BBS (56/56) and the balance section of the POMA (16/16), respectively.

Usability

Mean (standard deviation) administration times were as follows: BESTest, 23.42 (3.74) minutes; Mini-BESTest, 15.05 (2.4) minutes; and Brief-BESTest, 10.54 (2.32) minutes.

During the pilot test, untrained examiners reported difficulty administering the scales. Some examiners had difficulty understanding items 16-18 (compensatory stepping correction) and 24 (walk with pivot turns) of the BESTest during the pilot test; therefore, these items were rephrased in the definitive version.
In section II (stability limits) of the BESTest and Brief-BESTest, participants with hemiparesis of either side presented greater limitation in lifting the arm to reach out; therefore, instructions had to be adapted. Furthermore, the term "inestabilidad" (instability) and its definition were highlighted in the scoring sheet to prevent misinterpretation.

During the pilot test, 8% of items were not completed, corresponding to section IV (reactive postural response). However, no incidents were observed in stage 3.

Validity

Comparison with the BBS showed that the BESTest, Mini-BESTest, and Brief-BESTest present good convergent validity ($r = 0.901$, $P < .001$; $r = 0.977$, $P < .001$; $r = 0.852$, $P < .001$; respectively). Section II of the BESTest and Brief-BESTest was correlated with BBS item 8 ($r = 0.734$, $P < .001$; $r = 0.757$, $P < .001$; respectively); section III of the BESTest, section I of the Mini-BESTest, and section III of the Brief-BESTest were correlated with BBS items 1-4 and 8-14 ($r = 0.840$, $P < .001$; $r = 0.852$, $P < .001$; $r = 0.737$, $P < .001$; respectively); and section V of the BESTest, section III of the Mini-BESTest, and section V of the Brief-BESTest were correlated with BBS items 6 and 7 ($r = 0.755$, $P < .001$; $r = 0.680$, $P < .001$; $r = 0.595$, $P < .001$; respectively). Correlations between the total scores in the 3 scales are presented in Fig. 2. Regarding correlations between common sections, section III of the BESTest (anticipatory postural adjustment) was found to be correlated with the homonymous sections of the Mini-BESTest ($r = 0.869$, $P < .001$) and the Brief-BESTest ($r = 0.910$, $P < .001$), as well as between the 2 short forms ($r = 0.786$, $P < .001$). Section IV of the BESTest (reactive postural response) was correlated with section II of the Mini-BESTest and section IV of the Brief-BESTest (r = 0.663, $P < .001$ and r = 0.890, $P < .001$; respectively); the latter 2 were correlated with one another (r = 0.658, $P < .001$). Section V of the BESTest (sensory orientation) was found to be correlated with section III of the Mini-BESTest and section V of the Brief-BESTest (r = 0.889, $P < .001$ and r = 0.836, $P < .001$, respectively); the latter 2 were observed to be correlated with one another (r = 0.832, $P < .001$).

Table 2 shows the correlation between the dynamic gait section of the 3 scales and the gait section of other scales frequently used for the assessment of patients with ABI.

Regarding construct validity, the Kaiser-Meyer-Olkin test revealed good sampling adequacy for the BESTest (0.874), Mini-BEST (0.897), and Brief-BESTest (0.855). The model detected the 6 sections by grouping the items into division components of the BESTest, as well as 3 sections of the Mini-BESTest that do not correspond to the item grouping. However, it did not detect the 6 components of the Brief-BESTest, as each includes a single item.

Reliability

The BESTest displayed a Cronbach's alpha coefficient of 0.956; the discrimination index showed no significant changes after removal of any item.

The Mini-BESTest also showed good internal consistency ($\alpha = 0.898$), without changes according to the discrimination index; this was also the case for the Brief-BESTest, which presented a Cronbach's alpha value of 0.878.

The ICC shows the stability of the scales over time (lowest value-highest value; Table 3). The adapted versions of the BESTest, Mini-BESTest, and Brief-BESTest show very good test-retest reliability.

Analysis of the reproducibility of the scales by ABI aetiology revealed excellent agreement between total BESTest, Mini-BESTest, and Brief-BESTest scores in individuals with cerebrovascular accidents (ICC = 0.996-0.999), head trauma (ICC = 0.987-0.990), encephalitis (ICC = 0.999), and tumours (ICC = 0.998).

In patients with ABI in the subacute (ICC = 0.992) and chronic stage (ICC = 0.997), the BESTest showed excellent agreement with the short forms.

Table 4 shows the total and section scores of the 3 scales, recorded by each examiner. All 3 adaptations showed excellent inter-rater reliability.

By ABI aetiology, inter-rater reliability values for the 3 scales were 0.957-0.998 for stroke, 0.974-0.997 for head trauma, 0.979-0.998 for encephalitis, and 0.986-0.997 for tumours.

By ABI stage, inter-rater reliability values were 0.986-0.997 for subacute ABI and 0.953-0.998 for chronic ABI, in all 3 scales, with the lowest values corresponding to the Mini-BESTest and the highest values to the BESTest, in both stages.

DISCUSSION

Our results show that the BESTest, Brief-BESTest, and Mini-BESTest present good validity, internal consistency, and test-retest and inter-rater reliability in individuals with subacute or chronic ABI.

A review analysing 66 standardised measures for the assessment of standing balance concluded that such widely used scales as the BBS, TUG, and POMA omit components that are relevant for assessing the risk of falls. Only the BESTest included domains essential for the assessment of patients with neurological disorders: stability limits, reactive postural response, cognitive effects, and verticality.[10] In this respect, we may consider changing the use of certain scales, as choosing one balance assessment scale or another may have a significant impact on our perception of a patient's balance.

BESTest and Brief-BESTest provide data on biomechanical constraints and stability limits that are not analysed in the Mini-BESTest, which suggests that, of the 2 short forms, the Brief-BESTest may have higher sensitivity, with half as many items as the Mini-BESTest and including all the sections of the BESTest.[17]

Regarding usability in the population with ABI, no ceiling effect was observed in the BESTest or the Mini-BESTest, and only 3 participants achieved the highest possible score on the Brief-BESTest, a percentage far below the established threshold (20%) in studies of balance in patients with stroke.[32] The lack of ceiling or floor effects supports the use of these instruments in individuals with both mild and severe balance alterations following ABI.[33] Our findings regarding administration times are in line with those reported in the literature.[15,16] In the absence of time constraints and in patients without fatigue, experts recommend using the BESTest, both to assess balance alterations and to measure the results of an intervention.[34] The Brief-BESTest and Mini-BESTest, on the other hand, may be useful for evaluating alterations in postural control in patients with ABI when there are time constraints and/or the patient presents fatigue.

The results of the pilot study, which reveal difficulties in the administration of the tests by untrained examiners, underscore the need to train the professionals administering the scales.[15] Regarding the difficulty of administering the scales, the pilot study found that examiners with little experience administering scales had difficulty understanding and evaluating some items, and some patients with hemiparesis had difficulty executing certain items.[15,35]

We also observed problems with the assessment of reactive postural response items in patients with ABI. This may be related to compensatory corrections (forward, backward, and lateral stepping) as a protective mechanism when the examinee is unable to complete a task, especially backward stepping, as this requires more involvement of supraspinal control mechanisms than forward stepping; therefore, this protective mechanism may be more impaired in patients with ABI.[34,36] Participants may fear falling during the execution of these items. In fact, some studies suggest that balance assessment in patients with severe cognitive or physical deficits should be performed by 2 examiners.[37,38]

Furthermore, we should highlight the adaptation of the final item in the gait section, which includes a dual task, to the examinee's cognitive abilities. Patients with ABI and cognitive deficits (eg, dementia, aphasia) may find this task difficult to perform, since cognitively demanding tasks while walking have a destabilising effect, increasing the risk of falls.[39] Therefore, some studies recommend using less demanding dual tasks (eg, backward spelling of a 5-letter word) when the scale is administered to patients with cognitive difficulties[35,40]; this modification was incorporated in our adaptation.

The convergent validity analysis of all 3 scales showed good correlation with the BBS. However, as in previous studies,[41] the BBS showed a significant ceiling effect, and evaluates fewer domains than the BESTest and its short forms.[10] The ceiling effect of the BBS may constitute a limitation in the assessment of individuals with less impaired balance; therefore, studies in the literature recommend combining it with other tools, explaining the usefulness of analysing convergent validity with such other scales as the POMA, 10-Metre Walk Test, TUG, and CB&M in patients with ABI.[42]

The BESTest, Mini-BESTest, and Brief-BESTest are comprehensive balance assessment scales with potential to challenge even patients with only mild balance impairment. In patients with neurological disorders, however, the Mini-BESTest should be complemented with other scales assessing the risk of falls and specific diagnostic data.[37] In any case, this scale has been validated in populations with other neurological disorders, such as Parkinson's disease,[20] and has also been used to assess balance in patients with multiple sclerosis.[43] The BESTest[44] and its short forms[34,45] have also shown good reliability in patients with chronic stroke.

Our results suggest that the BESTest, Mini-BESTest, and Brief-BESTest are reliable tools when administered by different examiners. All sections of the BESTest, Brief-BESTest, and Mini-BESTest showed good reproducibility. These findings are consistent with those of other studies including patients with neurological disorders.[34,35,44] One of the limitations of this study is the clinical variability between the participants with ABI. Furthermore, the administration time of the BESTest in patients with ABI is longer, and also depends on the examiner's experience, which constitutes a limitation in clinical practice. This is due to the resting time needed as a result of the fatigue that these patients often present, which further increases administration times.[46] We recommend using this scale when there are no time constraints, as has also been suggested in other studies with subacute stroke patients.[34]

In conclusion, we recommend using the adaptations of the BESTest and its short forms to the Spanish population with ABI to identify balance alterations in these patients. These adaptations are adequate for assessing balance in individuals with ABI, as they include more domains than other balance assessment scales. Furthermore, they are useful in both subacute and chronic stages, and can therefore be used to assess treatment outcomes and for clinical decision-making. In the research setting, the adaptation to and validation of these 3 scales for the Spanish population will enable better design of experimental studies. Future studies should aim to evaluate the sensitivity to change of these adaptations to the Spanish population with ABI.

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Ethics approval

This study complies with the ethical principles of the Declaration of Helsinki. All participants were informed about the study and confidentiality of personal data was guaranteed. All participants gave written informed consent prior to inclusion.

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Conflicts of interest

None.

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Table 1 Demographic and clinical characteristics of the participants.

	n = 108
Age in years, mean (SD)	45.59 (12.47)
Women, n (%)	43 (39.8)
Aetiology of ABI, n (%)	
Stroke	80 (74.1)
Head trauma	16 (14.8)
Encephalitis	6 (5.4)
Tumour	6 (5.4)
BMI, mean (SD)	23.42 (4.15)
Patients with falls in the last 6 months, n (%)	56 (51.9)
Need for walking aids, n (%)	34 (31.5)
Subacute ABI, n (%)	35 (32.4)
Currently receiving rehabilitation, n (%)	78 (72.2)
Botulinum toxin in the last 6 months, n (%)	23 (21.3)
BBS score, mean (SD)	45.68 (11.45)
POMA score, mean (SD)	21.73 (6.66)
TUG score in seconds, mean (SD)	15.29 (11.79)
CB&M score, mean (SD)	47.44 (26.13)

ABI: acquired brain injury; BBS: Berg Balance Scale; BMI: body mass index; CB&M: Community Balance and Mobility Scale; POMA: Performance-Oriented Mobility Assessment (POMA); TUG: Timed Up and Go.

Table 2 Spearman correlation coefficients between the dynamic balance section of the BESTest, Mini-BESTest, and Brief-BESTest and other scales.

	BESTest section VI	Mini-BESTest section IV	Brief-BESTest section VI	POMA-G	10MWT	TUG	CB&M
BESTest section VI	-	0.918	0.793	0.749	0.683	0.794	0.829
Mini-BESTest section IV	0.918	-	0.707	0.670	0.559	0.728	0.747
Brief-BESTest section VI	0.793	0.707	-	0.677	0.676	0.795	0.743
POMA-G	0.749	0.670	0.677	-	0.778	0.834	0.858
TUG	0.794	0.728	0.795	0.834	0.823	-	0.877
CB&M	0.829	0.747	0.743	0.858	0.811	0.877	-

*P < .001.

10MWT: 10-Metre Walk Test; BESTest: Balance Evaluation System Test; CB&M: Community Balance and Mobility Scale; POMA-G: Performance Oriented Mobility Assessment-Gait; TUG: Timed Up and Go.

Table 3 Inter-rater reliability for each section.

	Cronbach's alpha	Single measures ICC (95% CI)	Average measures ICC (95% CI)
BESTest			
Section I: biomechanical constraints (%)	0.987	0.970 (0.911-0.990)	0.985 (0.953-0.995)
Section II: stability limits/verticality (%)	0.941	0.889 (0.710-0.961)	0.941 (0.831-0.980)
Section III: anticipatory postural adjustments (%)	0.975	0.952 (0.866-0.983)	0.975 (0.928-0.992)
Section IV: reactive postural response (%)	0.994	0.989 (0.969-0.996)	0.995 (0.984-0.998)
Section V: sensory orientation (%)	0.958	0.914 (0.766-0.970)	0.955 (0.868-0.985)
Section VI: stability in gait (%)	0.997	0.995 (0.985-0.998)	0.998 (0.993-0.999)
Total BESTest score (points)	0.987	0.974 (0.926-0.991)	0.987 (0.961-0.995)
Mini-BESTest			
Anticipatory	0.955	0.915 (0.772-0.970)	0.955 (0.871-0.985)
Reactive postural control	0.997	0.994 (0.982-0.998)	0.997 (0.991-0.999)
Sensory orientation	0.905	0.800 (0.486-0.929)	0.889 (0.654-0.963)
Dynamic gait	0.998	0.995 (0.987-0.998)	0.998 (0.993-0.999)
Total Mini-BESTest score (points)	0.990	0.978 (0.930-0.993)	0.989 (0.964-0.996)
Brief-BESTest			
Section I: biomechanical constraints	0.893	0.811 (0.533-0.932)	0.896 (0.695-0.965)
Section II: stability limits/verticality	0.874	0.788 (0.471-0.924)	0.881 (0.641-0.960)
Section III: anticipatory postural adjustments	0.994	0.986 (0.960-0.995)	0.993 (0.980-0.998)
Section IV: reactive postural response	0.989	0.978 (0.939-0.993)	0.989 (0.969-0.996)
Section V: sensory orientation	0.918	0.841 (0.599-0.943)	0.914 (0.749-0.971)
Section VI: stability in gait	0.981	0.961 (0.888-0.987)	0.980 (0.941-0.993)
Total Brief-BESTest score (points)	0.986	0.971 (0.916-0.990)	0.985 (0.956-0.995)

BESTest: Balance Evaluation System Test; CI: confidence interval; ICC: intraclass correlation coefficient.

Table 4 Inter-rater reliability.

	Rater 1 (median [p25-p75])	Rater 2 (median [p25-p75])	Cronbach's alpha	Single measures ICC (95% CI)	Average measures ICC (95% CI)
BESTest					
Section I: biomechanical constraints (%)	80 (60-93.33)	76.67 (60-91.67)	0.992	0.984 (0.976-0.989)	0.992 (0.988-0.994)
Section II: stability limits/verticality (%)	90.48 (76.19-90.48)	90.48 (76.19-90.48)	0.975	0.951 (0.928-0.966)	0.975 (0.963-0.983)
Section III: anticipatory postural adjustments (%)	69.44 (50-83.33)	69.44 (50-83.33)	0.995	0.990 (0.985-0.993)	0.995 (0.993-0.997)
Section IV: reactive postural response (%)	66.67 (40.28-83.33)	66.67 (44.44-83.33)	0.987	0.974 (0.962-0.982)	0.987 (0.981-0.991)
Section V: sensory orientation (%)	83.33 (68.33-93.33)	80 (73.33-93.33)	0.987	0.973 (0.961-0.982)	0.986 (0.980-0.991)
Section VI: stability in gait (%)	66.67 (42.86-84.52)	66.67 (42.86-80.95)	0.995	0.990 (0.986-0.993)	0.995 (0.993-0.997)
Total BESTest score (points)	83.88 (61-91)	82.5 (60.25-91)	0.998	0.995 (0.993-0.997)	0.998 (0.996-0.998)
Mini-BESTest					
Anticipatory	4 (2.25-4)	4 (3-4)	0.965	0.930 (0.899-0.952)	0.964 (0.947-0.975)
Reactive postural control	4 (3-5)	4 (3-5)	0.839	0.722 (0.618-0.801)	0.838 (0.764-0.889)
Sensory orientation	5 (4-6)	5 (4.25-6)	0.941	0.888 (0.840-0.922)	0.941 (0.913-0.959)
Dynamic gait	6 (3.25-7)	6 (4-8)	0.926	0.831 (0.674-0.903)	0.908 (0.805-0.949)
Total Mini-BESTest score (points)	19 (12.25-21)	20 (13-22.75)	0.969	0.926 (0.851-0.958)	0.961 (0.919-0.979)
Brief-BESTest					

Section I: biomechanical constraints	2 (1.25-2)	2 (1.25-2)	0.983	0.966 (0.951-0.977)	0.983 (0.975-0.988)
Section II: stability limits/verticality	3 (2-3)	3 (2-3)	0.974	0.950 (0.928-0.966)	0.974 (0.963-0.982)
Section III: anticipatory postural adjustments	2 (1-4)	2 (1-4)	0.996	0.993 (0.990-0.995)	0.996 (0.995-0.998)
Section IV: reactive postural response	4 (1-5)	4 (1-6)	0.982	0.964 (0.948-0.976)	0.982 (0.973-0.988)
Section V: sensory orientation	2 (1-2)	2 (1-2)	0.975	0.950 (0.928-0.966)	0.974 (0.963-0.983)
Section VI: stability in gait	2 (2-3)	2 (2-3)	0.991	0.981 (0.973-0.987)	0.991 (0.986-0.994)
Total Brief-BESTest score (points)	15 (10-18.75)	15 (9.25-19)	0.995	0.990 (0.986-0.994)	0.995 (0.993-0.997)

BESTest: Balance Evaluation System Test; CI: confidence interval; ICC: intraclass correlation coefficient; p25-p75: 25th and 75th percentiles.

Fig.1. Fases de adaptación y validación de la prueba de sistemas de evaluación de equilibrio (BESTest) y sus versiones reducidas (Mini-BESTest y Brief-BESTest).

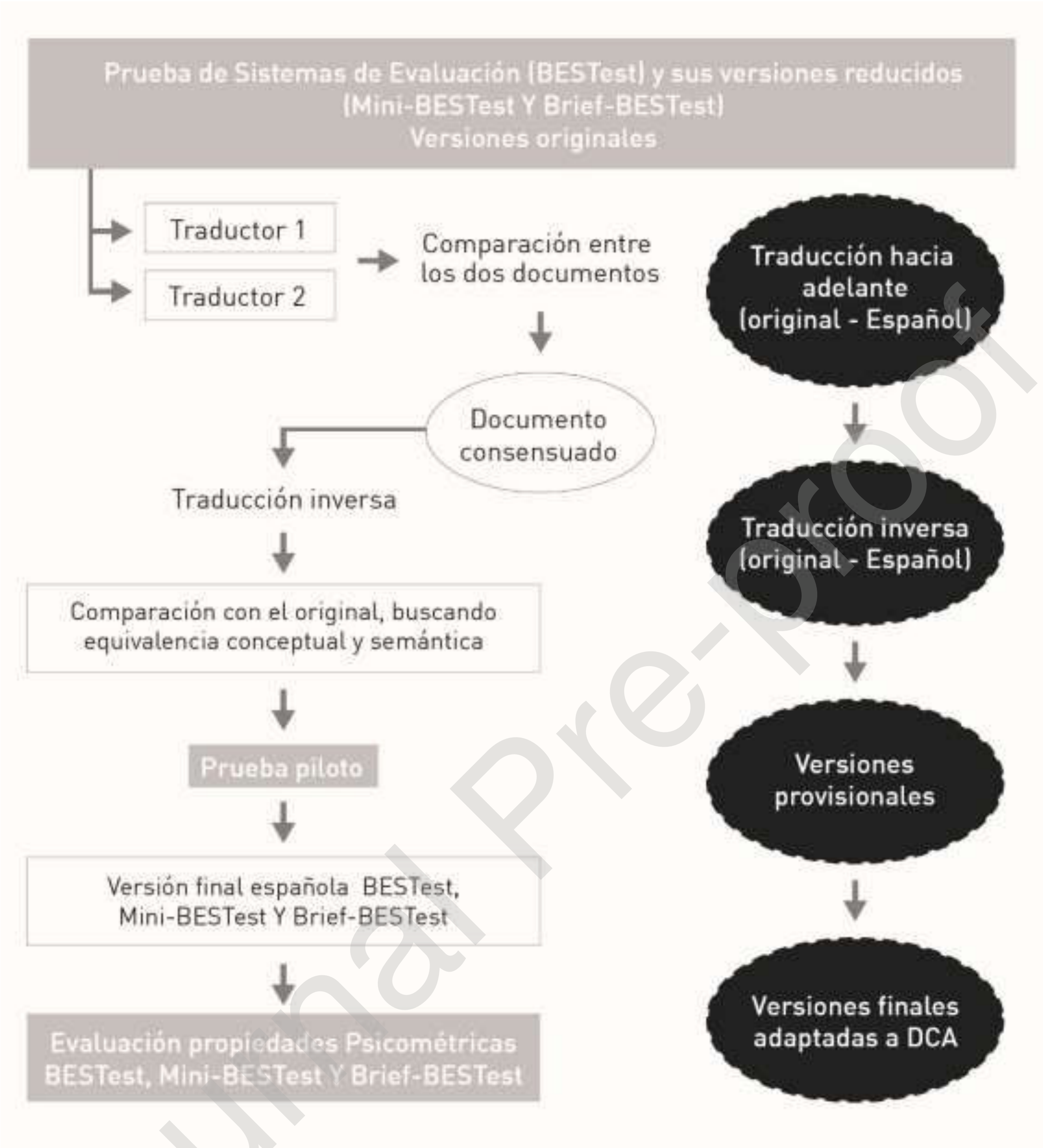
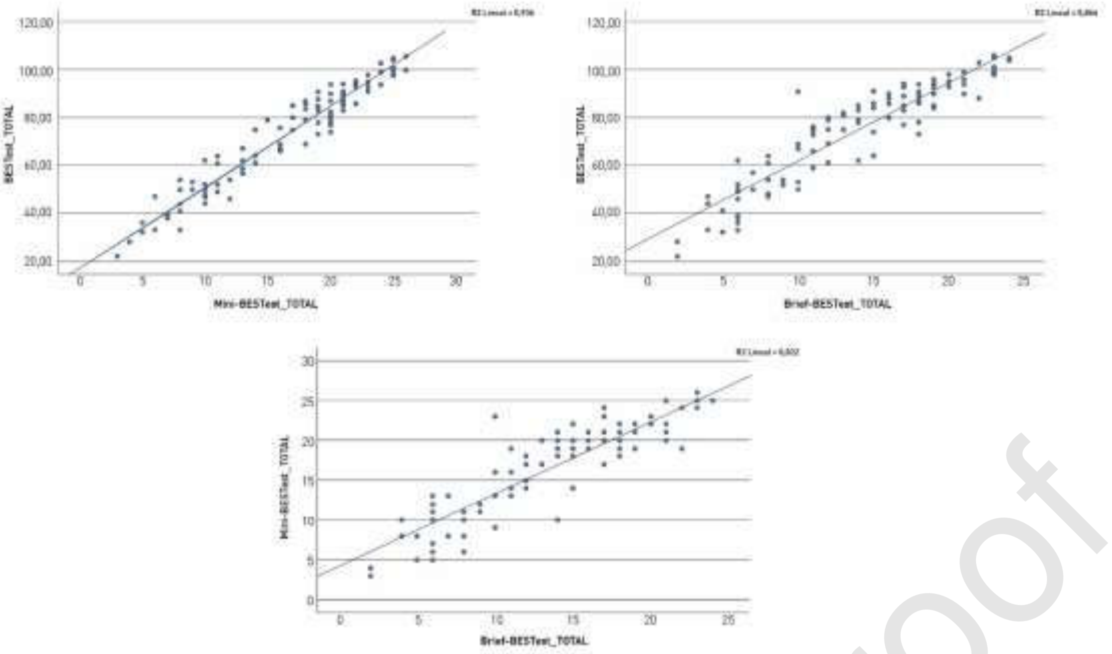
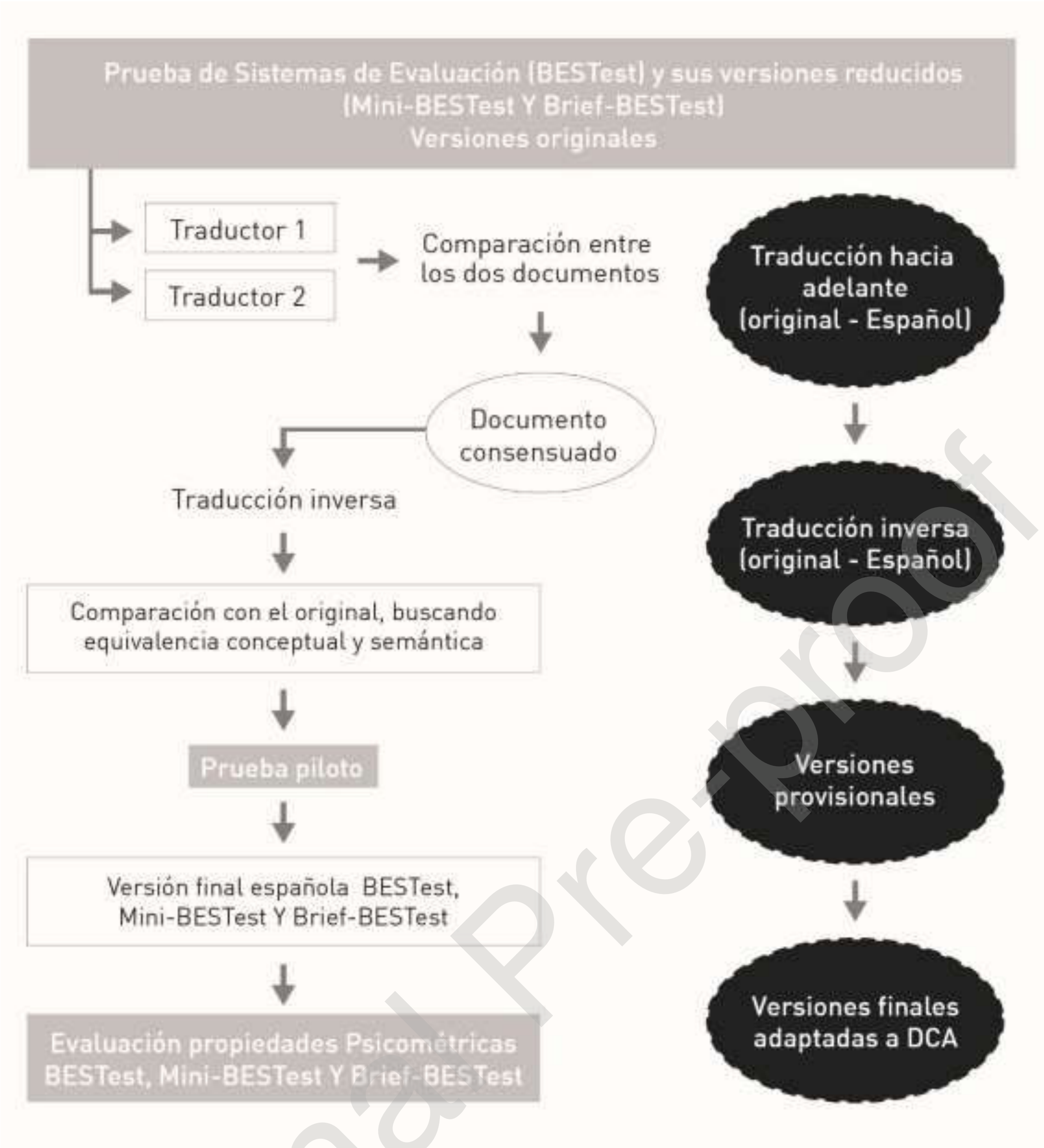


Fig.2. Correlación en puntuación total de las adaptaciones de la prueba de sistemas de evaluación de equilibrio (BESTest) y sus versiones reducidas (Mini-BESTest y Brief-BESTest).

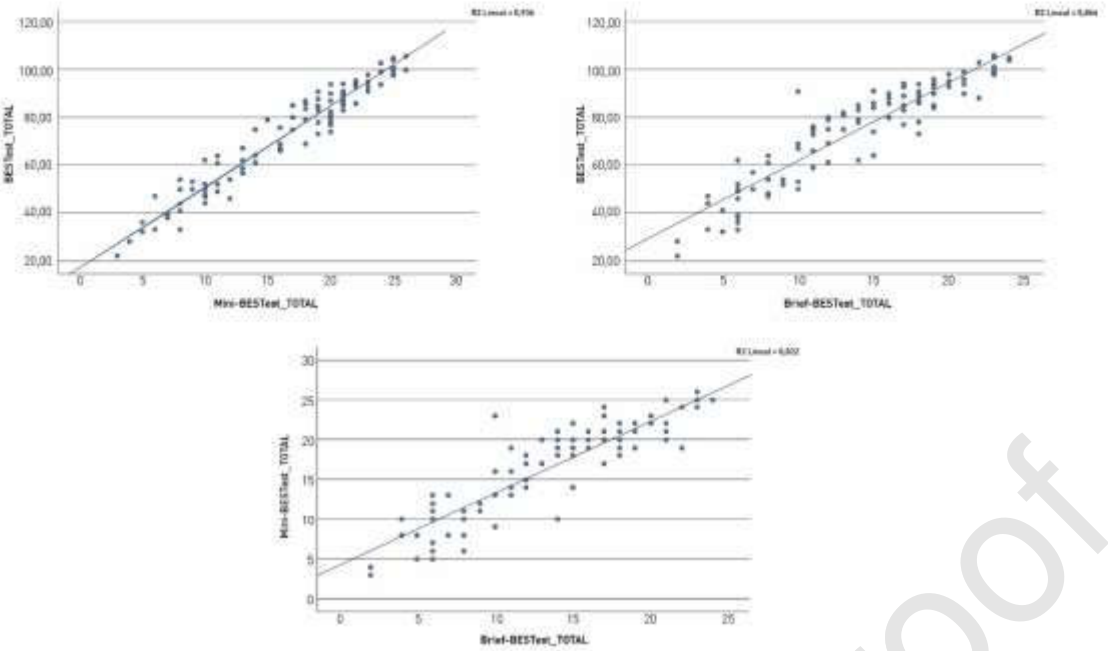

BESTest_TOTAL
120,00
100,00
80,00
60,00
40,00
20,00
0
5
10
15
20
25
30
Mini-BESTest_TOTAL
BESTest_TOTAL
120,00
100,00
80,00
60,00
40,00
20,00
0
5
10
15
20
25
Brief-BESTest_TOTAL
Mini-BESTest_TOTAL
30
25
20
15
10
5
0
0
5
10
15
20
25
Brief-BESTest_TOTAL



Prueba de Sistemas de Evaluación (BESTest) y sus versions reducidos (Mini-BESTest Y Brief-BESTest) Versiones originales	BESTest and its short forms Brief-BESTest and Mini-BESTest Original versions
Traductor 1	Translator 1
Traductor 2	Translator 2
Comparación entre los dos documentos	Comparison between the 2 translations
Documento consensuado	Consensus version
Traducción inversa	Back-translation
Comparación con el original, buscando equivalencia conceptual y semántica	Comparison with original scales to verify conceptual and semantic equivalence
Prueba piloto	Pilot test
Versión final española BESTest, Mini-BESTest Y Brief-BESTest	Definitive Spanish-language version of the BESTest, Mini-BESTest, and Brief-BESTest

Evaluación propiedades Psicométricas BESTest, Mini-BESTest Y Brief-BESTest	Assessment of the psychometric properties of BESTest, Mini-BESTest, and Brief-BESTest
Traducción hacia adelante (original – Español)	Forward translation (original > Spanish)
Traducción inversa (original – Español)	Back-translation (translated version > English)
Versiones provisionales	Provisional versions
Versiones finales adaptadas a DCA	Final versions adapted to patients with ABI

Figure 1 Stages in the adaptation and validation of the Balance Evaluation Systems Test (BESTest) and its short forms (Mini-BESTest and Brief-BESTest). ABI: acquired brain injury; BESTest: Balance Evaluation Systems Test.



R2 Lineal = 0,936	Linear R^2 = 0.936
R2 Lineal = 0,866	Linear R^2 = 0.866
R2 Lineal = 0,822	Linear R^2 = 0.822
120,00	120.00
100,00	100.00
80,00	80.00
60,00	60.00
40,00	40.00
20,00	20.00

Figure 2 Graphical representation of the correlation between total scores on the original BESTest, Mini-BESTest, and Brief-BESTest, and the adapted versions.

Resumen gráfico	Graphical abstract
Adaptación y validación a población española con DCA de BESTest, Mini-BESTest y Brief-BESTest	Adaptation and validation of the BESTest, Mini-BESTest, and Brief-BESTest in the Spanish population with ABI
FASE 1 Adaptación transcultural 2019-2020	STAGE 1 Transcultural adaptation (2019-2020)
FASE 2 Pilotaje 2021 n=30	STAGE 2 Pilot study (2021) n = 30
FASE 3 Propiedades psicométricas 2021-2023 n=108	STAGE 3 Psychometric properties (2021-2023) n = 108
RESULTADOS	RESULTS
CONCLUSIONES	CONCLUSIONS
BESTest	BESTest
Brief-BESTest	Brief-BESTest
Mini-BESTest	Mini-BESTest
Restricciones biomecánicas /15 x 100 = Límites estab./Verticalidad /21 x 100 = Transiciones/Anticipación /18 x 100 = Respuesta Post. Reactiva /18 x 100 = Orientación sensorial /15 x 100 = Estabilidad en la marcha /21 x 100 = Total 108 puntos Tiempo 23’42” 27 items	Biomechanical constraints 15 × 100 = Stability limits/verticality 21 × 100 = Anticipatory postural adjustments 18 × 100 = Reactive postural response 18 × 100 = Sensory orientation 15 × 100 = Stability in gait 21 × 100 = Total 108 points Time 23 min 42 s 27 items
Restricciones biomecánicas /3 x 100 = Límites estab./Verticalidad /3 x 100 = Transiciones/Anticipación /6 x 100 = Respuesta Post. Reactiva /6 x 100 = Orientación sensorial /3 x 100 = Estabilidad en la marcha /3 x 100 = Total	Biomechanical constraints 3 × 100 = Stability limits/verticality 3 × 100 = Anticipatory postural adjustments 6 × 100 = Reactive postural response 6 × 100 = Sensory orientation 3 × 100 = Stability in gait 3 × 100 = Total 24 points

24 puntos Tiempo 10’52” 6 items	Time 10 min 52 s 6 items
Transiciones/Anticipación /6 Respuesta Post. Reactiva /6 Orientación sensorial /6 Estabilidad en la marcha /10 Total 28 puntos Tiempo 15’05” 14 items	Anticipatory postural adjustments 6 Reactive postural response 6 Sensory orientation 6 Stability in gait 10 Total 28 points Time 15 min 05 s 14 items
La adaptación a la población Española con DCA tanto en fase subaguda como crónica, de BESTest y sus versiones reducidas (Mini-BESTest y Brief-BESTest) son instrumentos de medición válidos y fiables. Uso como medida de resultado del tratamiento, toma de decisiones y diseño de estudios experimentales.	The adaptations of the BESTest, Mini-BESTest, and Brief-BESTest to the Spanish population with subacute and chronic ABI are valid, reliable tools. They may be used to measure treatment outcomes, and in clinical decision-making and experimental studies.