Cross-cultural validity of the ABILOCO questionnaire for individuals with stroke, based on Rasch analysis

Patrick Roberto Avelino, Lívia Castro Magalhães, Iza Faria-Fortini, Marluce Lopes Basílio, Kênia Kiefer Parreiras Menezes & Luci Fuscaldi Teixeira-Salmela

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ABSTRACT
Purpose: The purpose of this study was to evaluate the cross-cultural validity of the Brazilian version of the ABILOCO questionnaire for stroke subjects.
Materials and methods: Cross-cultural adaptation of the original English version of the ABILOCO to the Brazilian-Portuguese language followed standardized procedures. The adapted version was administered to 136 stroke subjects and its measurement properties were assessed using Rasch analysis. Cross-cultural validity was based on cultural invariance analyses.
Results: Goodness-of-fit analysis revealed one misfitting item. The principal component analysis of the residuals showed that the first dimension explained 45% of the variance in locomotion ability; however, the eigenvalue was 1.92. The ABILOCO-Brazil divided the sample into two levels of ability and the items into about seven levels of difficulty. The item-person map showed some ceiling effect. Cultural invariance analyses revealed that although there were differences in the item calibrations between the ABILOCO-original and ABILOCO-Brazil, they did not impact the measures of locomotion ability.
Conclusions: The ABILOCO-Brazil demonstrated satisfactory measurement properties to be used within both clinical and research contexts in Brazil, as well cross-cultural validity to be used in international/multicentric studies. However, the presence of ceiling effect suggests that it may not be appropriate for the assessment of individuals with high levels of locomotion ability.

Introduction
Stroke is a leading cause of death [1] and the third leading cause of chronic disability worldwide [2]. The motor impairments observed after a stroke are disabling and interfere with the performance of daily life activities [3], such as locomotion. Locomotion refers to the individuals’ abilities to effectively move in their environment [4] and its recovery is one of the main goals for both patients and professionals, since higher locomotion ability will lead to greater independence and participation in community life [5]. Therefore, to implement effective interventions, appropriate assessment of locomotion ability is necessary.

Recently, for the evaluation of functional outcomes, great emphasis has been given to measures that collect information directly by patients, i.e., self-reported measures, because they improve communication with patients, which is essential to help professionals to plan effective interventions, based upon the patients’ perspectives [6]. The ABILOCO is a self-reported questionnaire, specific for individuals with stroke, for the assessment of locomotion ability [4]. It explores a representative repertoire of locomotion activities in the home and community environments [4]. The advantage of the ABILOCO over other questionnaires is that it was originally constructed based on the Rasch model, which allows for the conversion of ordinal scores into linear measures [4]. Linear measures offer more scientifically robust and clinically significant results, than ordinal measures and allow for correct inferences from direct inter- or intra-individual comparisons [7].

Previous studies reported adequate measurement properties of the ABILOCO, such as test–retest reliability, concurrent validity, linearity, unidimensionality, and reproducibility [4,8]. However, its cross-cultural validity has not yet been investigated. It is expected that a questionnaire should work in the same way, independent of the group being assessed [9]. This is particularly important for translated measures, because cultural differences could make some items more or less difficult [10]. When the objective is to compare patients across different countries in international studies, cross-cultural validity is required, to ensure that equivalent
scores will represent equivalent levels of the measured construct across different cultural groups [11].

Therefore, the aim of this study was to evaluate the cross-cultural validity of the ABILOCO, specific for individuals with stroke. First, the process of cross-cultural adaptation of the original English version of the ABILOCO was conducted to enable its application in Brazil. The Rasch analysis was performed to investigate if the adapted version showed adequate measurement properties, such as construct validity, reliability, sample targeting, and local independence for the intended application [12,13]. Lastly, the cross-cultural validity of the ABILOCO was investigated, based on cultural invariance analysis [9,14], followed by concurrent validity analysis.

**Materials and methods**

**Participants**

The participants were recruited from the general community of the city of Belo Horizonte, Brazil, by means of advertisements and by screening public rehabilitation services and lists of previous research projects. They were included if they were ≥20 years of age, had at least 3 months after the onset of the stroke, were able to walk with or without assistive devices, and had hemiparesis, i.e., weakness of the knee flexor/extensor and hip flexor muscles [15] and/or increased tone of the knee extensor or plantar flexor muscles, determined by scores different from zero on the Modified Ashworth Scale [16]. Individuals who had cognitive deficits, which were screened by the Mini-Mental State Examination cutoff scores [17], difficulties in expressing verbally, or any other disabling neuromusculoskeletal conditions, were excluded.

This study was approved by the ethical review committee of the Universidade Federal de Minas Gerais, Brazil, and all participants provided written consent, prior to data collection. Samples ≥100 are required to provide robust estimates of item parameters through Rasch analysis [18].

**The ABILOCO**

The ABILOCO is a stroke-specific questionnaire, which contains 13 items related to locomotion activities [4]. The ABILOCO is currently available in English and French, but its original version was developed in English. It is administered by interviews, during which the individuals are asked to estimate their ability to perform the activities, which are rated as 0 = Impossible or 1 = Possible. The activities, which were not attempted after the stroke, are not scored and are inserted as missing responses [4]. The responses are submitted to online Rasch analysis [4], which calibrates the locomotion ability of the individuals and the difficulty of the items in a linear continuum (scale) divided into equal units, or logits. The locomotion ability measure is equivalent to the individual’s position along a linear scale defined by the questionnaire’s items [19].

**Procedures**

**Cross-cultural adaptation:** The cross-cultural adaptation of the original English version of the ABILOCO to the Brazilian–Portuguese language was carried-out, as internationally recommended and was organized into five stages [10,20]. First, the ABILOCO was independently translated to the Brazilian–Portuguese language by two bilingual translators, whose native language was Portuguese. Second, a synthesis of the two translated versions was produced, followed by back-translation by two independent bilingual translators, whose native language was English. None of the translators had access to the original version of the questionnaire or prior knowledge of the objectives of the study. An expert committee composed of three physical therapists, one occupational therapist, one translator, and one back-translator discussed the clarity, relevance, and equivalence between the original and translated versions, to consolidate the pre-final version. This was applied to 10 stroke subjects [21], who responded to the questionnaire and were asked to interpret all the items. To clarify the intended motor activity, the following sentence “alternating the feet” was added to the item “going up stairs, putting each foot on the next step”. After this, the final version, named ABILOCO-Brazil was established.

**Application of the ABILOCO-Brazil:** First, all participants were screened to verify their eligibility. Then, demographic and clinical information, such as the time since the onset of the stroke, paretic side, previous lower limb dominance, lower limb motor recovery, which was determined by the Fugl–Meyer lower-limb motor section scores [22], and walking speed, which was measured by the 10-meter walk test [23], were collected for characterization purposes. Finally, the ABILOCO-Brazil was individually applied, following standardized procedures [4] of the application manual, which was also translated to Portuguese. All data were collected either in a research laboratory setting or in the subjects’ homes, by trained physical therapists.

**Statistical analysis**

The data were submitted to Rasch analysis, which evaluates the quality of the patterns of the responses to the items, according to a probabilistic model, in which the probability of choosing a response depends only on the individual’s ability and the difficulty of the items [19]. The analysis was carried-out with the WINSTEPS software, version 3.91.2. The rating scale model was used and the analyses were performed, as follows:

**Construct validity:** Construct validity was verified by the evaluation of the unidimensionality of the ABILOCO-Brazil. Goodness-of-fit statistics were used to determine the extent to which the ABILOCO-Brazil items contributed to a unidimensional construct [14]. Two formats of goodness-of-fit statistics were considered, infit and outfit mean square (MnSq), in combination with standardized Z values (Zstd) [14]. These were calculated for each item and each individual and indicated how well the items and the individuals fitted the model expectations [24]. Acceptable values for item fit are MnSq = 1.0 ± 0.4, associated with Zstd values ranging between −2 and +2 [14]. High MnSq values (>1.4) indicate that the scores on the item were highly variable or erratic (misfit) [25], i.e., individuals with low abilities scored high on difficult items or individuals with high abilities scored low on easy items [14,26]. If more than 5% of the total numbers of the items are erratic, it means that the items do not combine to measure a unidimensional construct [26,27]. The same criteria were used for the examination of the person fit, because individuals with erratic responses may affect the item fit [12].

Although goodness-of-statistics are useful to identify items and persons, whose patterns of responses deviate more than the model’s expectations, these statistics are imperfect to detect lack of adherence to the unidimensionality requirement of measurement, because no data will ever perfectly fit the model [14]. Mathematical models, such as the Rasch, do not hold exactly in the real world [14]. Thus, dedicated textbooks [14,24] recommend that fit statistics be followed by principal component analysis of the standardized residuals, to further investigate unidimensionality. Principal component analysis is used to identify if any common variance in the data is not accounted for the linear Rasch
good to excellent

From a list of 726 potential participants, 542 were excluded, due to the presence of more than one dimension being measured [14,24]. The criteria used to characterize unidimensionality were that the main dimension should explain at least 50% of the total residual variance and, after removal of this component, the second dimension should explain less than 5% of the remaining variance or have an eigenvalue lower than two [13,24].

Local independence: Local independence means that the success or failure in any item does not depend on the score on other items [14]. When there is high correlation between the residuals of two items ($r > 0.7$), this indicates that they are not locally independent, since the pair of items share more than half of the random variance ($V > 0.49$), suggesting that only one of them would be required for the test [24].

Reliability: The Rasch analysis provides errors associated with each item calibration and person measures, which are used to calculate the separation coefficients and estimate in how many ability levels the items divide the sample. To calculate the number of strata, the following formula was used: $(4G + 1)/3$, where $G$ is the separation coefficient [24]. It was expected that the individuals were stratified into at least two levels of locomotion ability (low and high) and the items into at least three levels of difficulty (low, medium, and high) [24]. The separation reliability index for persons and items, with variation from zero to one, is also provided.

Item-person map: This is a visual representation of the locomotion ability scale, in which both the items and individuals are displayed along the same linear continuum [13]. This map allowed for the verification of whether the ABILOCO-Brazil items targeted the ability levels of the sample and the presence of ceiling/floor effects and gaps, i.e., few or no items in certain ability level [13,14].

Cross-cultural validity: The cross-cultural validity of the ABILOCO-Brazil was based on cultural invariance analysis of both the estimates of the item difficulty and the persons’ abilities [14,28]. This procedure was based on the examination of differential item functioning (DIF) analysis, which allowed to examine if the items showed different calibrations (levels of difficulty), when applied to samples from Brazil and Belgium [12,14]. For this, the item calibrations of the ABILOCO-Brazil were plotted against those of the ABILOCO-Original, by means of a scatter-plot graph [14,29]. Then, a secondary analysis was performed to verify if the differences between the calibrations of the ABILOCO-Brazil and the ABILOCO-Original had significant impacts on the persons’ measures of locomotion ability. The responses of the sample of the present study were, then, anchored with the item calibration of the ABILOCO-Original. The locomotion ability estimates obtained by this anchoring were, then, compared with the estimates of the same sample obtained with the calibration of the ABILOCO-Brazil, also by means of a scatter-plot graph [14]. For the ABILOCO to be considered invariant, the differences should not be more than 5% [14].

Concurrent validity: The concurrent validity was evaluated by examining the relationship between the ABILOCO-Brazil scores and walking speed. Spearman correlation coefficient was calculated to examine the magnitude, direction, and significance of the relationship. The strength of the relationship was based upon the Portney and Watkins’s correlation descriptors [27] (little or none: $0-0.25$, fair: $0.26-0.50$, moderate to good: $0.51-0.75$, and good to excellent: $>0.75$).

Results

Participants’ characteristics

From a list of 726 potential participants, 542 were excluded, due to wrong contact information, refusals, absence of motor deficits, and death. From the 184 individuals, who were contacted via telephone and scheduled for evaluation, 48 were not included due to refusals and presence of cognitive deficits or other disabling conditions. Thus, 136 individuals, 80 men, who had a mean age of 61 years, participated. Their descriptive data are summarized in Table 1.

<table>
<thead>
<tr>
<th>Variable</th>
<th>$n = 136$</th>
</tr>
</thead>
<tbody>
<tr>
<td>Age (years), mean ± SD (range)</td>
<td>61 ± 12</td>
</tr>
<tr>
<td>Time since stroke (months), mean ± SD (range)</td>
<td>56 ± 63</td>
</tr>
<tr>
<td>Lower limb impairment, Fugl–Meyer scale classification, n (%)</td>
<td>64 (47.1)</td>
</tr>
<tr>
<td>Mild</td>
<td>37 (27.2)</td>
</tr>
<tr>
<td>Moderate</td>
<td>19 (14.0)</td>
</tr>
<tr>
<td>Severe</td>
<td>16 (11.7)</td>
</tr>
<tr>
<td>Walking speed (m/s), n (%)</td>
<td>0.71 ± 0.37 (0.15–1.54)</td>
</tr>
<tr>
<td>ABILOCO (logits), mean ± SD (range)</td>
<td>2.32 ± 1.87 (–3.25 to 5.35)</td>
</tr>
</tbody>
</table>

SD: standard deviation.

Measurement properties

Construct validity: Table 2 describes the calibrations and the fit statistics from the most difficult (hopping on the healthy foot) to the easiest (walking less than five meters, indoors, holding pieces of furniture) item. The analysis revealed that only the item “going up stairs putting each foot on the next step (alternating the feet)” showed infit ($\text{MnSq} = 1.4$, $\text{Zstd} = 3.2$) and outfit ($\text{MnSq} = 1.6$, $\text{Zstd} = 2.4$) values higher, than those acceptable. The principal component analysis revealed that the variance explained by the first dimension was 45%; however, the eigenvalue was 1.92, partially supporting the unidimensionality of the ABILOCO-Brazil.

Local Independence: No correlations $>0.7$ were identified between the items. This indicates that all items were locally independent, i.e., they did not incorporate features with common content.

Reliability: The person separation analysis indicated that the ABILOCO-Brazil divided the sample into approximately two levels of ability, leading to a person reliability index of 0.65. The item separation analysis indicated that the items were distributed into seven levels of difficulty, with an item reliability index of 0.96.

The item-person map: The item-person map (Figure 1) showed inadequate item/person targeting, due to a difference of 2.32 logits between the mean of the sample measures and the mean of the item calibrations. At the top of the continuum, there are several individuals without aligned items. In fact, 21 participants (15.4%) achieved maximum scores, i.e., they scored all items as possible to be performed, demonstrating ceiling effect. At the bottom of the continuum, there are very easy items, with no individuals in the sample with such low locomotion ability. Furthermore, there is on the top and at the bottom of the map the presence of two gaps without any items (Figure 1).

Cross-cultural validity: The DIF analysis showed that five items (2, 5, 7, 8, and 11) showed different levels of difficulty between the samples from Belgium and Brazil. However, the secondary analysis revealed invariance of the person measures, since the estimates were within the 95% confidence intervals (Figure 2). This result showed that the differences in calibrations across the
samples from Belgium and Brazil did not impact the measures of locomotion ability.

**Concurrent validity:** Significant and positive correlation of moderate to good magnitude was found between the ABILOCO-Brazil scores and walking speed ($r_s = 0.63$, $p < 0.0001$), indicating that people who walked faster, scored higher on the ABILOCO-Brazil. This supports the validity of the ABILOCO-Brazil in assessing locomotion ability in individuals with stroke.

### Discussion

The present study investigated the cross-cultural validity of the ABILOCO questionnaire, specific for individuals with stroke. The ABILOCO package includes the manual and the questionnaire in 10 random orders. The process of cultural adaptation of the ABILOCO to the Brazilian–Portuguese language followed all the recommendations proposed by Beaton et al. [10]. The inclusion of a sentence in one item was necessary to facilitate understanding. Regardless of the education or socioeconomic levels, all participants were able to answer the ABILOCO-Brazil in about five minutes, showing its fast and easy application. The evaluation of the measurement properties of the adapted version was carried out using Rasch analysis.

The goodness-of-fit analysis revealed that the item “Going up stairs, putting each foot on the next step (alternating the feet)” showed erratic pattern of responses, with fluctuations in both infit and outfit formats [30]. This means that some responses to this item were variable or unexpected. Further investigation showed that five individuals showed erratic responses, i.e., had residuals $>2$ on this item. Three of them had moderate to severe impairments and walking speeds below 0.4m/s (household ambulators). Thus, it was expected that they would not be able to climb stairs, alternating their feet. However, they scored this task as possible. Maybe, these individuals did not understand the question and only considered their ability to climb stairs, regardless of the adopted pattern. Concerning to the other two individuals, who had mild to moderate impairments and walking speeds $>0.8$ m/s, i.e., community ambulators, it was expected that they would perform the task, without problems. However, they scored it as impossible. It is possible that for safety reasons, they did not adopt the reciprocal pattern of alternating their feet, because they did not feel they were able to do so, although they had physical conditions to do it. The ABILOCO is a self-reported measure and, thus, is susceptible to under or overestimation of the actual performance [31].

<table>
<thead>
<tr>
<th>Items</th>
<th>Difficulty (logits)</th>
<th>SE (logits)</th>
<th>Infit</th>
<th>Outfit</th>
</tr>
</thead>
<tbody>
<tr>
<td>1) Hopping on the healthy foot</td>
<td>3.71</td>
<td>0.27</td>
<td>1.00</td>
<td>0.1</td>
</tr>
<tr>
<td>2) Going up an escalator alone</td>
<td>1.03</td>
<td>0.23</td>
<td>1.39</td>
<td>3.2</td>
</tr>
<tr>
<td>3) Walking while holding a fragile object (such as a full glass)</td>
<td>0.67</td>
<td>0.25</td>
<td>1.05</td>
<td>0.4</td>
</tr>
<tr>
<td>4) Going up stairs putting each foot on the next step (alternating the feet)</td>
<td>0.77</td>
<td>0.24</td>
<td>0.95</td>
<td>-0.4</td>
</tr>
<tr>
<td>5) Striding over an object with the paretic foot first</td>
<td>1.98</td>
<td>0.45</td>
<td>0.71</td>
<td>-0.9</td>
</tr>
<tr>
<td>6) Going up stairs putting each foot on the next step (alternating the feet)</td>
<td>-0.62</td>
<td>0.31</td>
<td>0.91</td>
<td>-0.4</td>
</tr>
<tr>
<td>7) Striding over an object with the healthy foot first</td>
<td>-1.19</td>
<td>0.36</td>
<td>0.75</td>
<td>-1.0</td>
</tr>
<tr>
<td>8) Striding over an object with the healthy foot first</td>
<td>-1.98</td>
<td>0.45</td>
<td>0.71</td>
<td>-0.9</td>
</tr>
<tr>
<td>9) Walking less than five meters without the help or supervision of a person</td>
<td>-4.38</td>
<td>1.05</td>
<td>1.19</td>
<td>0.5</td>
</tr>
<tr>
<td>10) Walking with the help of a person who guides but does not support</td>
<td>-4.38</td>
<td>1.05</td>
<td>1.20</td>
<td>0.5</td>
</tr>
</tbody>
</table>

Misfitting item is shown in bold. SE: standard error; MnSq: mean square; Zstd: standardized $Z$ value.
who scored maximum on the ABILOCO-Brazil, had the same level of locomotion ability. When analyzing the 21 individuals who showed ceiling effects, it was observed that 17 of them had walking speeds above 0.8 and were classified as community ambulators [34]. The original Belgium study [4] reported significant correlations between the ABILOCO scores and gait speed ($r = 0.83$), which was also measured by the 10-m walk test. In this sense, the ABILOCO may not be the most appropriate to evaluate individuals who walk fast, possibly because these individuals have higher locomotion ability. On the contrary, at the bottom of the scale, there are items that are too easy and there were not individuals with such low locomotion ability in the sample, who could not perform the tasks. However, beyond the difficulties in recruiting more disabled individuals, the participants of the present study were at the sub-acute and chronic phases after the stroke, different from the original ABILOCO study [4], which also included subjects at the acute phases. However, the characteristic of the sample of the present study was chosen because, in Brazil, after a stroke, usually the individuals do not start receiving rehabilitation right away, i.e., at the acute phases. Many subjects remain in their homes, waiting for placements in rehabilitation centers. This evidenced the cultural differences between Belgium.

Figure 1. Item-person map of the ABILOCO-Brazil. The left-side column locates the ability measures of the individuals along the continuum of locomotion ability. The right-side column shows the items. The letter “M” on the left indicates the mean of the individual’s locomotion ability and on the right, it indicates the mean of the item difficulty level.
measure and gaps implies in less precision.

The presence of these gaps indicates there were no items to evaluate locomotion ability with intermediate difficulties between these items. The presence of items evenly spaced along the scale, without large intervals, reflects the continuity of the measure and gaps implies in less precision.

This study investigated the cross-cultural validity of the ABILOCO-Brazil, by means of cultural invariance analysis. The results revealed that although DIFs between the samples from Belgium and Brazil were observed in five items, these differences did not impact the measures of locomotion ability. Measures of locomotion ability were similar using the calibrations of either the Brazilian or original versions, supporting the cultural invariance of the ABILOCO. This result suggests that the ABILOCO measures the same construct within different cultural contexts. Thus, the analysis (freely available at www.rehab-scales.org) [35], based on the ABILOCO-Original calibration, may be used for the conversion of the ordinal scores of the ABILOCO-Brazil into linear measures of locomotion ability. This, besides enabling the use of the ABILOCO within both clinical and research contexts in Brazil, also supports its use in international/multicentric studies. However, this study should be considered as a preliminary analysis of the cross-cultural validity of the ABILOCO. Future studies should include samples from other countries for the cumulative evidence of the cross-cultural validity of the ABILOCO.

Finally, the significant correlation of moderate to good magnitude \( r_s = 0.63 \) found between the ABILOCO-Brazil scores and walking speed supports the concurrent validity of the ABILOCO-Brazil, although the magnitude was lower than that found in the original study \( r_s = 0.83 \). This difference could be attributed to the characteristics of the samples. In the original Belgium study, the participants had walking speeds ranging from about 0.02 to 2.2 m/s, whereas those in the present study had walking speeds ranging from 0.15 to 1.54 m/s. It should be noted that correlation coefficient calculation is based on covariance and lower variation in the data would imply reduced correlation coefficient [27]. In addition, it was not expected to find a perfect correlation between these variables, since capacity and performance-based measures assess different constructs. Walking speed, as a measure of capacity, refers to the highest level of functioning within standardized environments, whereas the ABILOCO-Brazil, as a measure of performance, refers to functioning in real life situations [36]. Therefore, performance-based measures may encompass information, which is not obtained with capacity-based measures or vice versa. Rehabilitation professionals should not assume that abilities observed within clinical environments, such as walking speed, would perfectly match performance in real life. These potential mismatches should be considered, when establishing goals and planning interventions [37].

Although the sample was drawn from various settings, it was not randomly selected and, therefore, may not be fully representative of the Brazilian stroke population. Furthermore, although people were given the opportunity to be evaluated at home, many did not accept. Thus, most of the participants were evaluated at the university laboratory, i.e., they were able to get to the laboratory and, therefore, had better locomotion ability. This may have contributed to the lower than expected person reliability index and to the ceiling effect.

**Conclusion**

The results of the cross-cultural analysis showed that the ABILOCO-Brazil and ABILOCO-Original may be used interchangeably, since they provide similar measures of locomotion ability. The ABILOCO-Brazil demonstrated satisfactory measurement properties, but the presence of ceiling effect suggests that it may not be most appropriate to assess individuals with high levels of locomotion ability.
Disclosure statement

We certify that no party having a direct interest in the results of the research supporting this article has or will confer a benefit on us or any other associated organization.

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ORCID

Marluce Lopes Basilio http://orcid.org/0000-0002-1591-7140

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