Dementia
and Geriatric
Cognitive Disorders

Dement Geriatr Cogn Disord
DOI: 10.1159/000497743
Received: August 9, 2018
Accepted: February 5, 2019
Published online: July 16, 2019

Research Article

Validation of the Sinhala Version of the Addenbrooke's Cognitive Examination-Revised for the Detection of Dementia in Sri Lanka: Comparison with the Mini-Mental Status Examination and the Montreal Cognitive Assessment

Vindika Suriyakumara[a] Srinivasan Srikanth[b] Ruwani Wijeyekoon[c] Harsha Gunasekara[d] Chanaka Muthukuda[e] Dinalee Rajapaksha[a] Rasangi Weerasekara[f] Lakmal Gonawala[a] Nalaka Wijekoon[a] K. Ranil D. de Silva[a]

[a]Interdisciplinary Center for Innovation in Biotechnology and Neuroscience, Department of Anatomy, Faculty of Medical Sciences, University of Sri Jayewardenepura, Nugegoda, Sri Lanka; [b]Department of Neurology, Lanka Hospital, Colombo, Sri Lanka; [c]John van Geest Centre for Brain Repair, Department of Clinical Neurosciences, University of Cambridge, Cambridge, UK; [d]Department of Neurology, Sri Jayewardenepura General Hospital, Nugegoda, Sri Lanka; [e]University of Alabama at Birmingham, Birmingham, AL, USA; [f]Department of Neurology and ENT, Sri Jayewardenepura General Hospital, Nugegoda, Sri Lanka

Keywords
Cognitive assessment · Cognitive impairment · Cognitive screening test · Cultural adaptation · Dementia · Translation · Sri Lanka

Abstract
Background: Sri Lanka is a rapidly aging country, where dementia prevalence will increase significantly in the future. Thus, inexpensive and sensitive cognitive screening tools are crucial. ***Objectives:*** To assess the reliability, validity, and diagnostic accuracy of the Sinhalese version of the Addenbrooke's Cognitive Examination-Revised (ACE-R s). ***Method:*** The ACE-R was translated into Sinhala with cultural and linguistic adaptations and administered, together with the Sinhala version of the Montreal Cognitive Assessment (MoCA), to 99 patients with dementia and 93 gender-matched controls. ***Results:*** The ACE-R s cutoff score for dementia

K. Ranil D. de Silva
Interdisciplinary Center for Innovation in Biotechnology and Neuroscience
Department of Anatomy, Faculty of Medical Sciences
University of Sri Jayewardenepura, Gangodawila, Nugegoda (Sri Lanka)
E-Mail ranil@sjp.ac.lk

was 80 (sensitivity 91.9%, specificity 76.3%). The areas under the curve for the ACE-R s, Mini-Mental State Examination (MMSE) and MoCA were 0.90, 0.86, and 0.86, respectively. The ACE-R s had good interrater reliability (intraclass correlation = 0.94), test-retest reliability (intraclass correlation = 0.99), and internal consistency (Cronbach's α = 0.8442). ***Conclusions:*** The ACE-R s is sensitive, specific and reliable to detect dementia in persons aged ≥50 years in a Sinhala-speaking population and its diagnostic accuracy is superior to previously validated tools (MMSE and MoCA).

Introduction

Sri Lanka is a multiethnic, multicultural and multireligious country, which has one of the fastest aging populations in the world. The percentage of people aged 60 years or more will increase from the current value by 11–16% in 2020 and 29% in 2050, before peaking at 34% in 2080. By 2050, the 80+ year age group, who are most likely to be frail and dependent, will account for more than 5% of the overall national population [1]. As seen worldwide, this change in population demographic is associated with an increase in the prevalence of diseases associated with aging, of which dementia, especially that caused by neurodegenerative diseases (e.g., Alzheimer's disease [AD] and Parkinson's disease [PD]/Lewy body dementia), is one of the most devastating and resource draining. A previous human brain postmortem study completed by the principle author's group demonstrated a high prevalence of neurodegenerative (PD – 8.51% and AD – 4.25% related) pathology in 50 Sri Lankan subjects aged ≥60 years and increasing age, illiteracy, and apolipoprotein E ε4 allele were strongly associated with AD-related tau and/or Aβ pathologies [2]. Further, a comparative study between 47 Sri Lankan (Colombo) and 32 South Indian (Bangalore) aged brains demonstrated that age-related cytoskeletal pathologies are higher in elderly Sri Lankans than in South Indians [3]. Identifying those individuals with dementia at an early stage is one of the first steps in tackling this problem and the use of inexpensive, rapid and sensitive cognitive screening tools is essential for doing this in countries such as Sri Lanka, in the developing world.

A number of cognitive screening tests are currently available in Sri Lanka. The Mini-Mental State Examination (MMSE) [4] and the newer Montreal Cognitive Assessment (MoCA) [5] are the most widely used tests by physicians worldwide for general cognitive evaluation and have already been translated and validated for use in the Sinhala language [6, 7]. The Addenbrooke's Cognitive Examination-Revised (ACE-R) was developed as a brief test that is sensitive to the early stages of dementia and differentiates between dementia subtypes. The ACE-R examines key aspects of cognition and can be administered without special testing equipment or trained personnel in approximately 15 min [8]. This brief cognitive screening test incorporates elements of the MMSE, expanding the memory, language and visuospatial components and adding a verbal fluency component. The ACE-R involves 5 cognitive domains: attention/orientation (18 points), memory (26 points), verbal fluency (14 points), language (26 points), and visuospatial ability (16 points), adding up to a total score of 100. Higher scores indicate higher levels of cognitive functioning. It has been translated into several languages, adapted to suit different cultural settings and validated in several countries [9–18].

The aim of this study was to assess the reliability, validity, and diagnostic accuracy for dementia of the Sinhalese version of the Addenbrooke's Cognitive Examination-Revised (ACE-R s) in an urban Sri Lankan cohort and to compare it with the existing scales previously validated in Sri Lanka – the MMSE and the MoCA.

Table 1. Comparison between the original and the Sinhala-adapted version of ACE-R

Item	Original ACE-R	Sinhala adaptation
Orientation	Season Building County	What would be the time now? Location District
Registration	Lemon	Orange
Attention and concentration	"WORLD" spelt backward	Replaced with a commonly used Sinhala word of similar length
Memory-anterograde	Seven-word address	Seven-word address of local relevance.
Memory-retrograde	Name of current Prime Minister Name of the woman who was Prime Minister Name of the US President Name of the US President who was assassinated in the 1960s	Name of the current Prime Minister of Sri Lanka Name of the first female Prime Minister of Sri Lanka Name of the current President of Sri Lanka Name of the Sri Lankan Prime Minister who was assassinated in 1959
Verbal fluency	Letter "p" and animal	Sinhala equivalent of "p" and animal
Language-comprehension, writing	Read and follow an instruction Make up and write a sentence	Unchanged
Language-repetition	hippopotamus; eccentricity; unintelligible; statistician Above, beyond and below No ifs, ands or buts	Replaced with Sinhala words of comparable complexity and regularity Replaced with exact Sinhala translation as it brings a meaningful and grammatical complexity Replaced as in Sinhala version of MMSE [6]
Language-naming	Penguin, harp, barrel, accordion	Peacock, violin, candle, drum
Language-comprehension	Which is associated with the monarchy Which is a marsupial Which is found in the Antarctic Which has a nautical connection	Unchanged Which is used to write Which is found in the desert Unchanged
Perceptual abilities	Identifying the letters	Changed with Sinhala characters

Methods

Adaptation of the ACE-R from English to Sinhala

The ACE-R was translated into Sinhala – the language spoken by the majority of the Sri Lankan population, with the use of appropriate cultural and linguistic adaptations. The translation underwent numerous cycles of pilot administration and modification in patients and healthy individuals prior to the development of the final version, which was also reviewed by one of the authors of the original Addenbrooke's Cognitive Examination (Dr. P. S. Mathuranath) [19].

The modifications to the ACE-R are summarized in Table 1 and are as follows. In the orientation subsection, we changed season to "what would be the time now," which is identical to the Sinhala version of the MMSE [4]. "Building" was changed to "current location" and "county" to "district," as in Sri Lanka there is no county system. In the registration subsection, we changed "lemon" to "orange." In the attention and concentration subsection, we added "take away 3 from 20 for a total of 5 subtractions" for individuals with a formal education of 5 years or less. This change was also identical to the Sinhala MMSE. The word "WORLD" was replaced with a simple and commonly used Sinhala word of the same length. In the anterograde memory and recognition subsections, three sets of Sinhalese names and addresses were created, composed of 7 words of local relevance. In the retrograde memory test, we replaced "the woman who was Prime Minister" with "the first woman Prime Minister of Sri Lanka" and "the US president who was assassinated in the 1960s" with "the Sri Lankan Prime Minister who was assassinated in 1959."

In the verbal fluency test, we replaced the English letter "p" with the Sinhala letter "pa," as the Sinhala language has a fair number of words starting with this letter. Through a pilot study on 20 healthy individuals, we found a mean score of 10.9 for our Sinhala letter "pa," which was quite similar to the mean word count for the letter "p" (11.3 words) for cognitively normal individuals aged between 65 and 74 years in an urban American community [20]. In the word repetition test, words were selected considering the word length (number of syllables), frequency (familiarity according to how frequently the word is used), and articulation difficulty (e.g., clusters), which correspond to the original English ACE-R criteria (Table 1). The phrase "above, beyond and below" was replaced with the exact Sinhala translation as it brings meaningful and grammatical complexity. "No ifs, ands or buts" was replaced as in the Sinhala version of the MMSE.

In the naming subtest, we replaced the pictures of a penguin, harp, barrel, and accordion with pictures of a peacock, violin, candle, and drum, using pictures adopted from Snodgrass's line-drawings [21]. In the comprehension test, we replaced the instruction "which is a marsupial" by "which is used to write" (correct answer is pencil) and "which is found in the Antarctic" by "which is found in the desert" (correct answer is camel), based on their cultural familiarity. The reading subtest, which was designed to detect surface dyslexic reading errors, was adapted to maintain the irregularity of words similar to the original ACE-R. The Sinhala language does not have words with silent pronunciation. A range of "pili" are used (e.g., "හොදී"). A person needs to identify "ho" by reading all of හොඅ. Reading it partially suggests a "he" or a "haa". This pili concept is the closest to identifying surface dyslexia in Sinhala. In the perceptual abilities subtest, 4 Sinhala letters replaced English letters referring to the incomplete letters test of the Visual Object and Space Perception Battery [22].

A bilingual expert at the University of Sri Jayewardenepura, Sri Lanka, performed a back translation of the ACE-R s into English. Comparison of the original ACE-R English version with the back translation confirmed that they were similar, except for the modified items. The scoring system was not changed.

All subjects (dementia patients and controls) were also tested on the validated Sinhala version of the MoCA without repeating the items in common with the ACE-R.

Participants

This study was conducted at the Sri Jayewardenepura General Hospital (SJGH), Sri Lanka, from January 2014 to July 2016. SJGH is a tertiary care teaching hospital in the administrative capital of Sri Lanka with specialized clinics and serves as one of the country's main healthcare institutions in the state sector where free healthcare services are provided. In addition to catering to the local population as the first referral point, due to the specialized clinics it is also a referral hospital for a large adjacent population and may also see patients referred from all over the country.

Dementia patients aged 50 and above were recruited from the neurology clinic at SJGH. The diagnosis of dementia was established according to DSM-IV criteria by a consultant neurologist following appropriate clinical assessment, including patient and collateral history and general medical, neurological and psychiatric examination. Laboratory tests and brain imaging (MRI or CT), which would be required for the diagnosis of dementia subtypes, are not performed routinely in state sector hospitals in Sri Lanka unless there is a definite clinical indication to rule out serious or treatable conditions. Therefore, dementia subtypes were not included in this study and we considered all patients with dementia as one group.

Patients who had a history of major depression, schizophrenia, epilepsy, significant head injury, substance abuse, and alcoholism were excluded. Of the 180 patients reviewed during the period, 123 patients were eligible based on the criteria used and finally 99 dementia patients were able to complete participation in the study. The control group (n = 93) was recruited from among the spouses or friends of patients (n = 57) and individuals attending nonneurological clinics (n = 36) at SJGH. Spouses and friends of the dementia patients are likely to be of a relatively older age group, while controls from nonneurological clinics were of a relatively younger age, which provided wide coverage of age range in the control group on which the ACE-R s was tested.

As education level may contribute to the low scores in neuropsychological tests, they were screened with a functional screening instrument, the Sinhalese version of the modified Bristol Activities of Daily Living scale [23] and only individuals who scored 20 or more were included as controls. Subjects with neurological, cognitive or psychiatric complaints, history of significant head injury, substance abuse or alcoholism were excluded from the control group.

The ACE-R s was administered to both dementia patients and controls by trained researchers. In order to calculate interrater reliability, two researchers blindly scored 20 subjects (10 dementia and 10 control) and one researcher interviewed 10 subjects each. Following a 4-week interval, 15 subjects (10 dementia and 5 control) were interviewed for the second time to calculate test-retest reliability.

Table 2. Demographic data and test scores (mean ± SD)

	Controls (n = 93)	Patients (n = 99)	p
Male/female	42/51	48/51	0.64
Age, years	63.01±7.8	69.37±9.8	0.032*
Education, years	11.44±3.6	11.72±3.5	0.997
MMSE score, max. 30	27.97±2.3	22.51±4.6	<0.001*
MoCA score, max. 30	21.63±3.9	15.16±4.6	0.045*
Total ACE-R score, max. 100	84.54±10.2	61.98±16.4	<0.001*
Orientation/attention, max. 18	17.06±1.5	13.4±3.5	<0.001*
Memory, max. 26	21.42±4.1	13.11±5.8	0.004*
Verbal fluency, max. 14	9.92±2.4	5.82±3.4	<0.001*
Language, max. 26	22.08±2.6	19.48±4.1	<0.001*

Statistical Analysis

All statistical analyses were performed using either the Statistical Analysis system (SAS) or MedCalc Statistical software and a p value of <0.05 was considered statistically significant. The normative data scores were divided into three age groups (50–59, 60–69, 70 and above years) and analyzed using one-way analysis of variance (ANOVA). Post hoc pairwise comparisons between the age ranges were assessed using the Bonferroni correction.

Demographic variables (age and education), MMSE score, MoCA score, total and subscores of ACE-R s were compared using one-way ANOVA, followed by the Bonferroni correction. χ^2 tests were employed for categorical data (gender). A multiple regression analysis was carried out to investigate possible associations between the demographic variables (gender, age, and education) and scores on the ACE-R, MMSE, and MoCA.

Test-retest, interrater reliabilities, and internal consistency were calculated according to standard procedures. The diagnostic accuracy was assessed by receiver operating characteristic (ROC) analysis. The area under the ROC curve was calculated to determine cutoff scores that best differentiated dementia patients from control subjects. Sensitivity and specificity were calculated by comparing controls and dementia groups using a separate discriminant function analysis for each variable.

Results

Baseline Characteristics of the Study Sample

Demographic data and the MMSE, MoCA, and ACE-R s total and component scores in the dementia and control groups are presented in Table 2. Gender and education were not significantly different between the two groups while age was significantly different, with the patients being older overall (p = 0.032). MMSE (p < 0.001) and MoCA (p = 0.045) scores were significantly different between groups. ACE-R s (p < 0.001) and subscores for orientation/attention (p = 0.004), memory (p = 0.004), fluency (p < 0.001), language (p < 0.001), and visuospatial (p < 0.001) subscale scores were also significantly different between the groups. In our study, the average time taken within the research study is to administrate the scale for the dementia patients (22 ± 5 min) and for the controls (13 ± 5 min).

Reliability and Validity

Interrater reliability and test-retest reliability of the ACE-R s were very good, as evidenced by intraclass correlation values of 0.94 and 0.99, respectively. The internal consistency for ACE-R s (26 items) was also very good (Cronbach's α = 0.8442).

Table 3. Optimal cutoff scores and diagnostic utility of the ACE-R s, the MMSE and the MoCA for identifying dementia

	ACE-R s	MMSE	MoCA
Optimal cutoff score	80/100	26/30	18/30
Sensitivity	91.92%	80.81%	76.77%
Specificity	76.34%	80.65%	82.19%
Area under the curve	0.90	0.86	0.86
Positive likelihood ratio	3.89	4.18	4.13

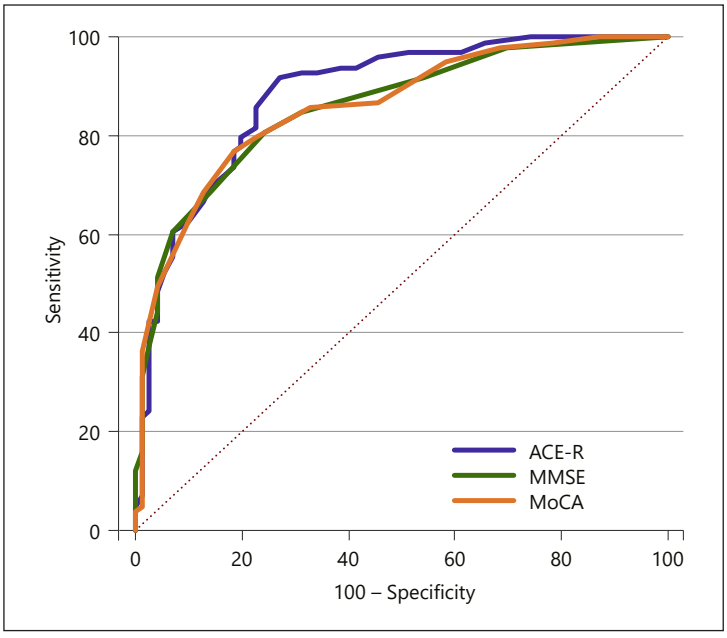

Fig. 1. ROC curves of ACE-R s, MMSE, and MoCA as tests for detecting dementia.

Assessment of Confounding Demographic Factors

In a multiple linear regression analysis, the MMSE, MoCA and ACE-R total scores were entered into the multiple regression model together with possible confounds that included age, education, and sex. With ACE-R s total score as the dependent variable and demographic data (age, education, and sex) as independent variables in the dementia sample, there was a significant effect of age ($p = 0.048$) and education ($p < 0.0001$) but not gender ($p = 0.98$) on the ACE-R s total score. The same analysis limited to the control sample revealed a significant effect of gender ($p = 0.035$) and education ($p < 0.0001$), whereas age ($p = 0.33$) did not show a statistically significant effect on ACE-R s score.

The MMSE score for dementia patients was significantly related to age ($p = 0.006$) and education ($p < 0.0001$), while in the control group only education ($p < 0.0001$) had a significant relationship with the MMSE. The MoCA score for dementia patients was significantly associated only with education ($p = 0.0048$), while the control group revealed no significant association with age, education or gender.

Diagnostic Accuracy of ACE-R s, MMSE, and MoCA for Dementia

ROC analysis was performed in order to determine optimal cutoff scores on the ACE-R s, MMSE, and MoCA for dementia. Table 3 shows the sensitivity, specificity, areas under the ROC curve (AUC), and positive likelihood ratios at the optimal cutoff scores of ACE-R s, MMSE, and MoCA. The AUC was 0.9 for the ACE-R s, 0.868 for the MMSE, and 0.864 for the MoCA (Fig. 1).

Although the AUC for the ACE-R s was slightly superior to that for the MMSE (p = 0.1402) and MoCA (p = 0.1879), this difference was not statistically significant. The optimal cutoff score of the ACE-R s in this sample was 80, which yielded a sensitivity of 91.2% and specificity of 76.34%. In this sample, the optimal cutoff score for the MMSE was 26, which yielded a sensitivity of 80.81% and specificity of 80.65%, while the optimum cutoff score for the MoCA was 18, yielding a sensitivity of 76.77% and specificity of 82.19% (Table 3).

Discussion

The present study demonstrates that the ACE-R s has very good test-retest and interrater reliability, internal consistency, and good diagnostic accuracy for detecting dementia in this sample, similar to other translations of the ACE-R into different languages [9, 11–14]. This test can be administered in a relatively short time period and these findings suggest that the ACE-R s is a reliable, valid and useful tool for the assessment of dementia.

The ACE-R, as well as the MoCA and the MMSE, have similar weaknesses to other practical tests utilized to rapidly assess cognitive function, such as being significantly influenced by demographic factors like age, education, and sex. In this study, we found that age and education significantly influenced the ACE-R s total score in the dementia group whereas in the control group, only gender and education showed significant influences on ACE-R s total score, which is consistent with many other validation studies using the ACE-R [8–10, 13, 15, 16, 18].

The ACE-R and MoCA are considered useful for screening for mild cognitive impairment and dementia subtypes when shorter tests are inconclusive [24]. In this study sample, the ACE-R s was superior to both the MMSE and the MoCA in identifying dementia (AUC of ACE-R s = 0.9, AUC of MMSE = 0.858, and AUC of MoCA = 0.857), while the MoCA and the MMSE showed similar diagnostic accuracy. Overall, at the optimal cutoff scores calculated in this study to detect dementia, sensitivity was highest with ACE-R s (91.92%), while specificity was highest with the MoCA (82.19%).

However, in assessing previous evidence of the superiority of the ACE-R over the MoCA, we were unable to find a direct comparison of these two scales in a heterogeneous dementia sample similar to ours. A Brazilian study done to screen for cognitive impairment in PD patients showed that the ACE-R and MoCA had similar diagnostic accuracy for detecting mild cognitive impairment (AUC of ACE-R = 0.53, AUC of MoCA = 0.50) and dementia (AUC of MoCA = 0.86, AUC of ACE-R = 0.84) [25]. Another study done with the Oxford Vascular Study participants in the UK showed that the ACE-R and MoCA showed similar diagnostic accuracy for detecting MCI in stable cerebrovascular disease [26]. Our finding on the diagnostic accuracy of the MoCA and the MMSE is consistent with two separate studies done in an AD dementia group, where it was shown that the MoCA had significantly increased diagnostic accuracy for detecting MCI compared to the MMSE [27, 28].

In comparison to the MMSE, the ACE-R covers a wider range of cognitive domains such as memory, verbal fluency, visuoperceptual and executive functions [8]. In comparison to the MoCA, the ACE-R contains more memory and language items, whereas the MoCA also includes abstraction and has more attentional tests [29]. Moreover, the 5 subscores available with the ACE-R extend its use in a range of neurological conditions. The fluency subdomain of the ACE-R appears to be as effective as the ACE-R total score in detecting PD/mild cognitive impairment with improved specificity at the expense of sensitivity [30]. The language subdomain of ACE-R has been demonstrated to be a satisfactory screening tool for aphasia in stroke compared to other screening tests [31]. Moreover, the availability of these subscores has even expanded possible employment of the ACE-R to the early assessment of cognitive

Table 4. Optimal cutoff scores for previously validated ACE-R in different languages and cultural settings.

Country	Language	Optimal cutoff score for dementia	AUC	Sensitivity, %	Specificity, %	Dementia sample description	Ref.
UK (original study)	English	82 88	– –	84 94	100 89	AD 67, FTD 55, DLB 20	8 8
UK	English	75	0.95	91	91	AD 33, FTD 8, VaD 2, DLB 1, other 2	33
Brazil	Brazilian	78	0.947	100	82.26	Mild AD 31	9
Korea	Korean	78	–	95	80	AD 30, SIVD 42	10
Germany	German	82/83 83/84	0.99 0.97	92 88	96 96	Mild AD 56 Mild FTLD 22	10 10
Argentina	Spanish	85	–	97.5	88.5	AD 46, bvFTD 41	12
Greece	Greek	85	0.963	97	82	AD 16, FTD 19	13
Japan	Japanese	80	0.98	94	94	AD 79, DLB 31, FTLD 9, PD with dementia 3, PSP 2, corticobasal degeneration 2	14
Japan	Japanese	82/83	–	99	99	AD 106, AD with CVD 7, VaD 3, FTD 8, DLB 6	15
Hong Kong	Chinese-Cantonese	73/74	0.92	88	84	AD 35, mixed 10, vascular 4	16
Belgium	French	83	0.89	92	68.6	dementia 128 (AD 13%, FTLD 2%, DLB 3%, VaD 18%, mixed dementia 5%, PPA 4%, PK 2%, other 55%)	17
Australia	English	84	–	85	80	AD 42, FTD 12, PSP, corticobasal degeneration and multiple-system atrophy 16, VaD or mixed AD/VaD 9, other 3	34

FTD, frontotemporal dementia; DLB, dementia with Lewy bodies; VaD, vascular dementia; SIVD, subcortical ischemic vascular dementia; FTLD, frontotemporal lobar degeneration; bvFTD, behavioural variant of frontotemporal dementia; PSP, progressive supranuclear palsy; CVD, cerebrovascular disorder; PPA, primary progressive aphasia; PK, progressive supranuclear palsy and parkinsonian dementia.

impairment in patients with cerebrovascular disease. For instance, in acute stroke patients, the ACE-R has been demonstrated to be useful in detecting visuospatial, attentional and executive impairments [32].

The optimal cutoff score of the ACE-R s was quite similar to the cutoff scores calculated in previous studies [8, 14, 15, 17]. This similarity was seen in studies which included a more heterogeneous dementia sample (Table 4), compared to the studies with less dementia subtypes and more mild dementia. Although the original ACE-R validation study suggested a cutoff score of 82 for dementia our study found a cutoff score of 80. These changes could be partially explained by the cultural difference of the study populations or by the effect of not being confined to particular dementia subtypes. Despite the AUC value of the ACE-R s for detecting dementia not being significantly higher compared to those observed in the MoCA and MMSE, the sensitivity of the ACE-R for detecting dementia subtypes such as frontotemporal lobar degeneration and dementia with Lewy bodies, where memory is relatively preserved, may be high. Furthermore, the performance of the ACE-R domain scores might differ between different subtypes of dementias and may aid in the differential diagnosis. Further larger studies are required to explore the possibility that the ACE-R differentiates different causes of dementia in Sri Lanka, to justify its use in day-to-day clinical practice as a screening tool for various dementia subtypes.

The low optimal cutoff score we obtained for the MoCA is consistent with the low cutoff value (MMSE score = 17) obtained in a previous study performed to validate the MMSE in a Sinhala-speaking population [6]. Interestingly, in our study, the optimal cutoff score for the MMSE was 26 and a previously done study to validate the MoCA in a Sinhala-speaking population was 24. All these scales were developed in the West in native English-speaking populations and despite the efforts towards accurate translation, there may be residual cultural and educational differences which may influence the overall score. This highlights the need for calculating cutoff scores specific to the translated version.

There are some limitations to our study. The assessment of ACE-R performance in different dementia subtypes was not possible in this study as comprehensive investigation and assessment of dementia subtypes was not undertaken in all patients. However, not confining the study to particular dementia subtypes may reduce the recruitment bias and increase the generalizability of the results to heterogeneous patients with both cortical and subcortical dementia in a clinic setting. We did not include the Clinical Dementia Rating scale to determine the severity of dementia. Therefore, we could not determine the concurrent and convergent validity of the ACE-R s in the assessment of the degree of dementia. Predictive values for dementia could not be determined in this study as patients and control groups were recruited independently and not from a population, thus leaving the prevalence unknown. Although we have performed comprehensive neurological assessments and used DSM-IV criteria as the gold standard for the clinical diagnosis of dementia, the clinical diagnoses are not always confirmed at autopsy. Therefore, due to possible erroneous clinical assessment, the diagnostic validity of the ACE-R s for dementia could be lower than our results suggest.

The patients were recruited from a neurology clinic setting, while the control group was recruited from healthy spouses or friends of patients and individuals attending nonneurological clinics. Therefore, the patients and the control group who attend tertiary care hospitals on a regular basis could be more motivated and better educated compared to the general community. In addition, our patient and control groups were relatively young (69.37 and 63 years), and it is unclear whether our findings can be extrapolated to more elderly subjects, who are rapidly forming a large proportion of the general population. Although this study was performed in a hospital in the capital city of Sri Lanka, a significant proportion of patients come to the specialist clinics from outside the city. Therefore, we cannot confirm that the cutoff value we obtained only applies to the local city population. Since Sri Lanka is a multicultural, multilinguistic and multireligious country with varying education levels, our cohort may also not be fully representative of dementia in Sri Lanka as a whole. Therefore, further larger community-based studies reflecting a variety of age, educational and geographical groups will be important in the further development of the ACE-R s as a tool to detect dementia in the Sinhala-speaking population.

Conclusions

The Sinhala version of ACE-R is a sensitive, specific and reliable bedside test to accurately detect dementia in persons aged 50 years or above in this Sinhala-speaking cohort and its diagnostic accuracy is superior to the commonly used tools such as the MMSE and the MoCA. Although administration of the ACE-R takes a few more minutes than the MMSE and MoCA, the ACE-R domains may provide a more detailed assessment of cognitive function. Future studies are required to establish the usefulness of the ACE-R s in detecting mild cognitive impairment, in order to enable early intervention, and in distinguishing the various dementia subtypes in a Sinhala-speaking population.

Acknowledgement

The authors wish to thank Prof. P. Mathuranath for his input and advice on the translation and cultural adaptation of the ACE-R into Sinhala and for his review of the manuscript. The authors would also like to thank Prof. Roger Barker and Prof. John Hodges for their initial support with this project.

Statement of Ethics

This study met the ethical guidelines of the local Sri Lankan institutional review board, which is in compliance with the Helsinki Declaration and informed consent was obtained from all participants.

Disclosure Statement

The authors declare that there are no conflicts of interest regarding the publication of this paper.

Funding Sources

This paper was funded by the University of Sri Jayewardenepura.

References

1 World Bank. Sri Lanka: Addressing the needs of an aging population [accessed 2018 Mar 31]. Available from: https://openknowledge.worldbank.org/handle/10986/8105.
2 Wijesinghe P, Shankar SK, Yasha TC, Gorrie C, Amaratunga D, Hulathduwa S, et al. Vascular Contributions in Alzheimer's Disease-Related Neuropathological Changes: First Autopsy Evidence from a South Asian Aging Population. J Alzheimers Dis. 2016 Oct;54(4):1607–18.
3 Wijesinghe P, Shankar SK, Chickabasaviah YT, Gorrie C, Amaratunga D, Hulathduwa S, et al. Cytoskeletal Pathologies of Age-Related Diseases between Elderly Sri Lankan (Colombo) and Indian (Bangalore) Brain Samples. Curr Alzheimer Res. 2016;13(3):268–80.
4 Folstein MF, Folstein SE, McHugh PR. Mini-mental state. A practical method for grading the cognitive state of patients for the clinician. J Psychiatr Res. 1975 Nov;12(3):189–98.
5 Nasreddine ZS, Phillips NA, Bédirian V, Charbonneau S, Whitehead V, Collin I, et al. The Montreal Cognitive Assessment, MoCA: a brief screening tool for mild cognitive impairment. J Am Geriatr Soc. 2005 Apr;53(4):695–9.
6 de Silva HA, Gunatilake SB. Mini Mental State Examination in Sinhalese: a sensitive test to screen for dementia in Sri Lanka. Int J Geriatr Psychiatry. 2002 Feb;17(2):134–9.
7 Karunaratne S, Hanwella R, de Silva V. Validation of the Sinhala version of the Montreal Cognitive Assessment in screening for dementia. Ceylon Med J. 2011 Dec;56(4):147–53.
8 Mioshi E, Dawson K, Mitchell J, Arnold R, Hodges JR. The Addenbrooke's Cognitive Examination Revised (ACE-R): a brief cognitive test battery for dementia screening. Int J Geriatr Psychiatry. 2006 Nov;21(11):1078–85.
9 Carvalho VA, Barbosa MT, Caramelli P. Brazilian version of the Addenbrooke Cognitive Examination-revised in the diagnosis of mild Alzheimer disease. Cogn Behav Neurol. 2010 Mar;23(1):8–13.
10 Kwak YT, Yang Y, Kim GW. Korean Addenbrooke's Cognitive Examination Revised (K-ACER) for differential diagnosis of Alzheimer's disease and subcortical ischemic vascular dementia. Geriatr Gerontol Int. 2010 Oct;10(4):295–301.
11 Alexopoulos P, Ebert A, Richter-Schmidinger T, Schöll E, Natale B, Aguilar CA, et al. Validation of the German revised Addenbrooke's cognitive examination for detecting mild cognitive impairment, mild dementia in alzheimer's disease and frontotemporal lobar degeneration. Dement Geriatr Cogn Disord. 2010;29(5):448–56.
12 Torralva T, Roca M, Gleichgerrcht E, Bonifacio A, Raimondi C, Manes F. Validation of the Spanish Version of the Addenbrooke's Cognitive Examination-Revised (ACE-R) [in Spanish]. Neurologia. 2011 Jul-Aug;26(6):351–6.
13 Konstantinopoulou E, Kosmidis MH, Ioannidis P, Kiosseoglou G, Karacostas D, Taskos N. Adaptation of Addenbrooke's Cognitive Examination-Revised for the Greek population. Eur J Neurol. 2011 Mar;18(3):442–7.
14 Dos Santos Kawata KH, Hashimoto R, Nishio Y, Hayashi A, Ogawa N, Kanno S, et al. A Validation Study of the Japanese Version of the Addenbrooke's Cognitive Examination-Revised. Dement Geriatr Cogn Disord Extra. 2012 Jan;2(1):29–37.

15 Yoshida H, Terada S, Honda H, Kishimoto Y, Takeda N, Oshima E, et al. Validation of the revised Addenbrooke's Cognitive Examination (ACE-R) for detecting mild cognitive impairment and dementia in a Japanese population. Int Psychogeriatr. 2012 Jan;24(1):28–37.
16 Wong L, Chan C, Leung J, Yung C, Wu K, Cheung S, et al. A validation study of the Chinese-Cantonese Addenbrooke's Cognitive Examination Revised (C-ACER). Neuropsychiatr Dis Treat. 2013;9:731–7.
17 Bastide L, De Breucker S, Van den Berge M, Fery P, Pepersack T, Bier JC. The Addenbrooke's Cognitive Examination Revised is as effective as the original to detect dementia in a French speaking population. Dement Geriatr Cogn Disord. 2012;34(5–6):337–43.
18 Rotomskis A, Margevièiûtë R, Germanavièius A, Kaubrys G, Petraðkaitë K, Bagdonas A. Validation of Addenbrooke's Cognitive Examination-Revised for the Differential Diagnostics of Frontotemporal Dementia and Alzheimer's Disease in Lithuanian-Speaking Population. Neurol Semin 2014;18(62):262–266.
19 Mathuranath PS, Nestor PJ, Berrios GE, Rakowicz W, Hodges JR. A brief cognitive test battery to differentiate Alzheimer's disease and frontotemporal dementia. Neurology. 2000 Dec;55(11):1613–20.
20 Ganguli M, Snitz BE, Lee CW, Vanderbilt J, Saxton JA, Chang CC. Age and education effects and norms on a cognitive test battery from a population-based cohort: the Monongahela-Youghiogheny Healthy Aging Team. Aging Ment Health. 2010 Jan;14(1):100–7.
21 Snodgrass JG, Vanderwart M. A standardized set of 260 pictures: norms for name agreement, image agreement, familiarity, and visual complexity. J Exp Psychol Hum Learn. 1980 Mar;6(2):174–215.
22 Warrington EK, James M. Visual Object and Space Perception Battery. Bury St. Edmunds: Thames Valley Test Company; 1991.
23 Umayal S, Kulathunga M, Somaratne S, Srikanth S, Kathriarachchi S, De Silva R. Validation of a functional screening instrument for dementia in an elderly sri lankan population: comparison of modified bristol and blessed activities of daily living scales. BMC Res Notes. 2010 Oct;3(3):268.
24 Velayudhan L, Ryu SH, Raczek M, Philpot M, Lindesay J, Critchfield M, et al. Review of brief cognitive tests for patients with suspected dementia. Int Psychogeriatr. 2014 Aug;26(8):1247–62.
25 Sobreira E, Pena-Pereira MA, Eckeli AL, Sobreira-Neto MA, Chagas MH, Foss MP, et al. Screening of cognitive impairment in patients with Parkinson's disease: diagnostic validity of the Brazilian versions of the Montreal Cognitive Assessment and the Addenbrooke's Cognitive Examination-Revised. Arq Neuropsiquiatr. 2015 Nov;73(11):929–33.
26 Pendlebury ST, Cuthbertson FC, Welch SJ, Mehta Z, Rothwell PM. Underestimation of cognitive impairment by Mini-Mental State Examination versus the Montreal Cognitive Assessment in patients with transient ischemic attack and stroke: a population-based study. Stroke. 2010 Jun;41(6):1290–3.
27 Trzepacz PT, Hochstetler H, Wang S, Walker B, Saykin AJ; Alzheimer's Disease Neuroimaging Initiative. Relationship between the Montreal Cognitive Assessment and Mini-mental State Examination for assessment of mild cognitive impairment in older adults. BMC Geriatr. 2015 Sep;15(1):107.
28 Freitas S, Simões MR, Alves L, Santana I. Montreal cognitive assessment: validation study for mild cognitive impairment and Alzheimer disease. Alzheimer Dis Assoc Disord. 2013 Jan-Mar;27(1):37–43.
29 Pendlebury ST, Mariz J, Bull L, Mehta Z, Rothwell PM. MoCA, ACE-R, and MMSE versus the National Institute of Neurological Disorders and Stroke-Canadian Stroke Network Vascular Cognitive Impairment Harmonization Standards Neuropsychological Battery after TIA and stroke. Stroke. 2012 Feb;43(2):464–9.
30 Komadina NC, Terpening Z, Huang Y, Halliday GM, Naismith SL, Lewis SJ. Utility and limitations of Addenbrooke's Cognitive Examination-Revised for detecting mild cognitive impairment in Parkinson's disease. Dement Geriatr Cogn Disord. 2011;31(5):349–57.
31 Gaber TA, Parsons F, Gautam V. Validation of the language component of the Addenbrooke's Cognitive Examination—Revised (ACE-R) as a screening tool for aphasia in stroke patients. Australas J Ageing. 2011 Sep;30(3):156–8.
32 Morris K, Hacker V, Lincoln NB. The validity of the Addenbrooke's Cognitive Examination-Revised (ACE-R) in acute stroke. Disabil Rehabil. 2012;34(3):189–95.
33 Larner AJ. Addenbrooke's Cognitive Examination-Revised (ACE-R) in day-to-day clinical practice. Age Ageing. 2007 Nov;36(6):685–6.
34 Terpening Z, Cordato NJ, Hepner IJ, Lucas SK, Lindley RI. Utility of the Addenbrooke's Cognitive Examination—revised for the diagnosis of dementia syndromes. Australas J Ageing. 2011 Sep;30(3):113–8.