ARTICLE / INVESTIGACIÓN

Is the Montreal Cognitive Assessment (MOCA) test better suited to cognitive impairment detection among Latino people than the Mini-Mental State Examination (MMSE)?

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Abstract: In a sample of 60 patients over the age of sixty and Spanish as mother-tongue, the Montreal Cognitive Assessment (MOCA) and the Mini-Mental State Examination (MMSE) tests were carried out to determine if they can be used equally in patients with cerebrovascular disease of small vessel and clinically perceptible affectations of cognitive impairment and Dementia; and obtain similarly valid results. The population with Dementia and cognitive impairment is increasing. Multiple tools and techniques have been perfected to study this health condition to measure mental problems and Dementia. To obtain the sample, we used the simple random method. A protocol of 30 questions focused on evaluating complex cognitive functions was used to apply the MOCA test. In the MMSE test, an 11-question protocol was used to evaluate essential cognitive functions. The results showed that the MOCA test correctly identified an actual positive rate of 89.6% and a true negative rate of 66.7%. The MMSE test had a false positive rate of 4.4%, having a higher probability of falsely identifying an individual with cognitive impairment. The tests help determine the degree of cognitive deterioration, but with different sensitivities according to their level of studies, which should be preferred over the MOCA.

Key words: Mental health, MMSE, MOCA, cognitive impairment, elderly.

Introduction

A growing population suffers from Dementia and cognitive impairment; this highlights the importance of establishing public health policies and plans to meet the needs of this group. Taking what was published in the "Estimation of the global prevalence of Dementia in 2019 and forecasted prevalence in 2050: an analysis for the Global Burden of Disease Study 2019"[1] at a worldwide level, the number of people with these conditions will increase, more severe in the geographic regions with a social stratification made up of older adults. This makes it necessary to adopt multidisciplinary approaches that include the expansion of interventions to address modifiable risk factors and investment in research to address the expected increase in the number of people affected by cognitive decline. There are multiple tools and techniques to measure cognitive problems and Dementia. Two of the most widely used are MOCA and MMSE. These instruments measure the variables of operational visual capacity, object recognition, short-term memory, attention, language, abstraction capacity, delayed memories, concentration, arithmetic calculation, and orientation[2-6].

The MOCA test (Montreal Cognitive Assessment) is a brief assessment that is commonly used to detect mild cognitive problems. Nasreddine *et al.*[2] described that this tool helps detect cognitive problems associated with normal aging, as well as degenerative cerebrovascular diseases such as Alzheimer's, Parkinson's disease, and multiple sclerosis, among others. It assesses different cognitive areas, including attention, memory, language, spatial orientation, and the ability to perform complex tasks. The interpretation of the results is based on factors such as the age and education of the individual evaluated, with a maximum result of 30 points, with values below 26 representing different levels of cognitive impairment.

Through the years, modifications and adaptations of the MOCA test have been made; Cheung and Gong[3] explored the variations in the versions and formats, especially those that integrate cultural aspects, with elements in common in all of them, even being adapted and used in different countries. In addition, Nucci, Mapelli, and Mondini[4] developed the Cognitive Reserve Index Questionnaire (CRIq) as a new tool to measure cognitive reserve that complements the MOCA. The MMSE test (Mini-Mental State Examination) is widely used to assess cognitive function. Developed by Folstein and colleagues[5], it has been widely used to evaluate mild and moderate cognitive problems associated with Alzheimer's disease and other neurodegenerative disorders, such as small vessel cerebrovascular disease.

The MMSE consists of questions and tasks that assess different cognitive aspects, such as memory, attention, and language. The maximum score is 30; lower values indicate

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more severe cognitive problems. In addition, different cut-off values have been established to determine whether the results indicate mild cognitive impairment or dementia[6].

Several studies have examined the utility of the MMSE test in different populations and settings. A study by Teng and Chui[7] examined this utility in evaluating Chinese-speaking individuals with Dementia. The authors found the MMSE useful for detecting Dementia in this population. On the other hand, a study by Galasko *et al.*[8] examined the utility of the MMSE in detecting Alzheimer's disease in a US population and found that it is a valuable tool for the early detection of the disease.

Despite its usefulness, some authors have criticized the MMSE test for its insufficient sensitivity and specificity, especially in populations with a low educational level[6]. Furthermore, some authors have argued that it is not sensitive enough to detect subtle cognitive changes[9].

In a study by Larner[10,11], the question was raised whether the MOCA test is a more useful tool than the MMSE for detecting cognitive problems. The author concluded that the MOCA is inferior to the MMSE in this task. On the other hand, Kavé *et al.*[12] evaluated the utility of the MOCA test as a predictor of results in real life. They found that it is better related to the ability to manage money and carry out daily tasks.

This study aimed to determine if both tests can be used equally in a Spanish-speaking population of Latino origin over sixty years of age with a suspected diagnosis of small vessel cerebrovascular disease. According to the Global Burden of Disease, this group coincided with the segment of countries with low and low-medium socio-demographic index (SDI)[1].

Because access to biomedical imaging is expensive and in a developing country, most of the population does not have access and through public health, it is not possible to obtain it due to delays and little availability; it is valuable to be able to determine with more excellent precision cases of Dementia due to cerebrovascular disease. This is an adjunct in delays in neurology and psychiatry services, representing a valuable tool for first-level care services. The MOCA and the MMSE can be used for screening in health facilities at the first level of care, but it must be clear that both tests can be used interchangeably, obtaining a similarly valid result.

For this paper, we define cerebral small vessel disease as a neurological disease in older people. It is difficult to identify this pathology; the diagnosis is relied on biomedical imaging with magnetic resonance imaging (MRI), including lacunar ischaemic stroke, white matter hyperintensities, microbleeds, lacunes, visible perivascular spaces, and many hemorrhagic strokes. The common symptoms can be Dementia, mood disturbance, and gait problems[13].

Materials and methods

A cross-sectional descriptive research design has been used because only patients with clinical suspicion have been selected for the sample, a working hypothesis has yet to be prepared with them, and there is no temporal continuity. The patients in the sample were classified taking into account their age as additional exclusion criteria to clinical suspicion[14-16].

The MOCA is a test of 30 points contained on one page, and its application time is around ten minutes. It is divided into sections, one corresponding to the short-term recall task (5 points); this involves two learning trials of five nouns and delayed recall after approximately 5 minutes. Visuospatial skills are assessed by drawing a clock (3 points) and a copy of a cube (1 point). Subsequently, multiple aspects of executive functions are assessed using a toggling task adapted from the Trail Making B task (1 point), a phonemic fluency task (1 point), and a two-item verbal abstraction task (2 points). Attention, concentration, and working memory are assessed using a sustained attention task (target detection by tapping; 1 point), a serial subtraction task (3 points), and digits forward and backward (1 point). each). Language is assessed using a three-item confrontational naming task with unfamiliar animals (lion, camel, rhinoceros; 3 points), repetition of two syntactically complex sentences (2 points), and the fluency task. Finally, orientation in time and place is evaluated (6 points)[2].

The MMSE consists of a range of questions that can be administered in 5–10 minutes and has a maximum possible score of 30 points. Typically, the questions have been divided into seven categories, each of which rationally represents a distinct cognitive function or domain: Time orientation (5 points), location orientation (5 points), three words registered (3 points), attention and calculation (5 points), three words retained (3 points), language (8 points), and one point for visual construction However, the visual building job was first categorized as one of the language items, and all of the orientation questions were placed into a single orientation category[6]. The term "mini" in the name is because it focuses only on the cognitive aspects of mental functions and excludes questions related to mood, abnormal mental experiences, and way of thinking[5].

They were using a sample obtained by a non-probability sampling by volunteers from a group of patients who arrived at the neurology service at the Center for Brain Research from January to December 2018 in Tegucigalpa, Honduras. Sixty patients, all over sixty years of age, were used in the sample, native speakers of Spanish. All of them were administered both MOCA and MMSE tests. Patients with suspected cognitive degeneration were evaluated in an office without visual and auditory distractions. They were allowed to always have the company of a family member or person in charge without their involvement. All procedures were approved by the National Autonomous University of Honduras ethics committee and were carried out in compliance with international standards of care and protecting patients' data.

For the application of the MOCA test, a 30-question protocol was used that included attention, memory, language, visuospatial tasks, executive capacity, and temporal and spatial orientation. A maximum score of 30 points was established, with a score below 26 points considered indicative of cognitive impairment. As for the MMSE test, an 11-question protocol included tasks of orientation, short- and long-term memory, attention, and language. A maximum score of 30 points was established, with a score below 24 points considered indicative of cognitive impairment.

The scores obtained in both tests were analyzed using descriptive statistics and the correlation of Spearman-Brown between the MOCA and MMSE scores. In addition, analyzes were carried out with methods such as the Kolmogorov-Smirnov distribution method, the Levene analysis of variance to compare the scores of both tests, a non-parametric comparison of Wilcoxon-Mann-Whitney and a comparison of results using the Bland-Altman method.

For statistical analysis, MedCalc version 19.7.1 (64bit)[17] has been used, combined with scripts developed on Python programming language version 3.10[18].

Results

A sample of 60 patients underwent the MOCA and MMSE tests. The results of the MMSE test have a mean of 23.88, a median of 25, a standard deviation of 6.28, and a range of 29. The MOCA has a mean of 21.5, a median of 23, a standard deviation of 7.34, and a range of 30. The behavior of the data can be observed in Figure 1.

The Spearman-Brown correlation between two parallel tests of MOCA and MMSE was calculated. The results revealed a significant Spearman-Brown correlation of 0.7381 ($p < 0.05$) and a critical value of 0.280. The coefficient obtained indicates a considerable positive correlation; however, it is not statistically significant, so there is not enough evidence in the sample used to demonstrate the relationship between the two tests because the critical value is higher than the p-value. Figure 2 shows the results of the tests for each patient in a scatter graph.

We conducted a Kolmogorov-Smirnov test to compare the distributions of two variables, MOCA and MMSE. The trial aimed to determine whether these variables were drawn from the same underlying distribution or if they differed significantly. Our analysis revealed a significant difference between the two variables, with a Kolmogorov-Smirnov statistic (D) of 0.606, exceeding the critical value at the 5% significance level. Therefore, we reject the null hypothesis that MOCA and MMSE are derived from the same distribution. These findings suggest that distinct patterns or characteristics are associated with each variable, and further investigation is warranted to explore the factors contributing to this divergence.

To compare cognitive studies, it must be verified if the variances of the medical results are equal. For this, a test of homogeneity of variances was carried out; in this case, we used the Levene test. The statistical value of the trial was 0.4005, and a p-value=0.5279. The data have sufficient behavior to show that both samples have heterogeneous variances.

Since the samples do not follow a normal distribution, we will not make any assumptions about the shape of the underlying distribution of the data. Using the non-parametric Wilcoxon-Mann-Whitney test, a value of statistical significance U=1548.50 and a p-value=0.009 was obtained. Because the p-value is less than the commonly used significance level (0.05), it is for this reason that we can reject that the two groups come from the same distribution. In other words, there is enough statistical evidence to say that there is a significant difference between the MOCA and MMSE scores in this data sample; this may result from the tests being differently sensitive.

Agreement between the two quantitative measures was assessed using the Bland-Altman method to assess the agreement between the two tests and detect any systematic bias or random error between them. With this method, it was possible to observe that the mean of the differences

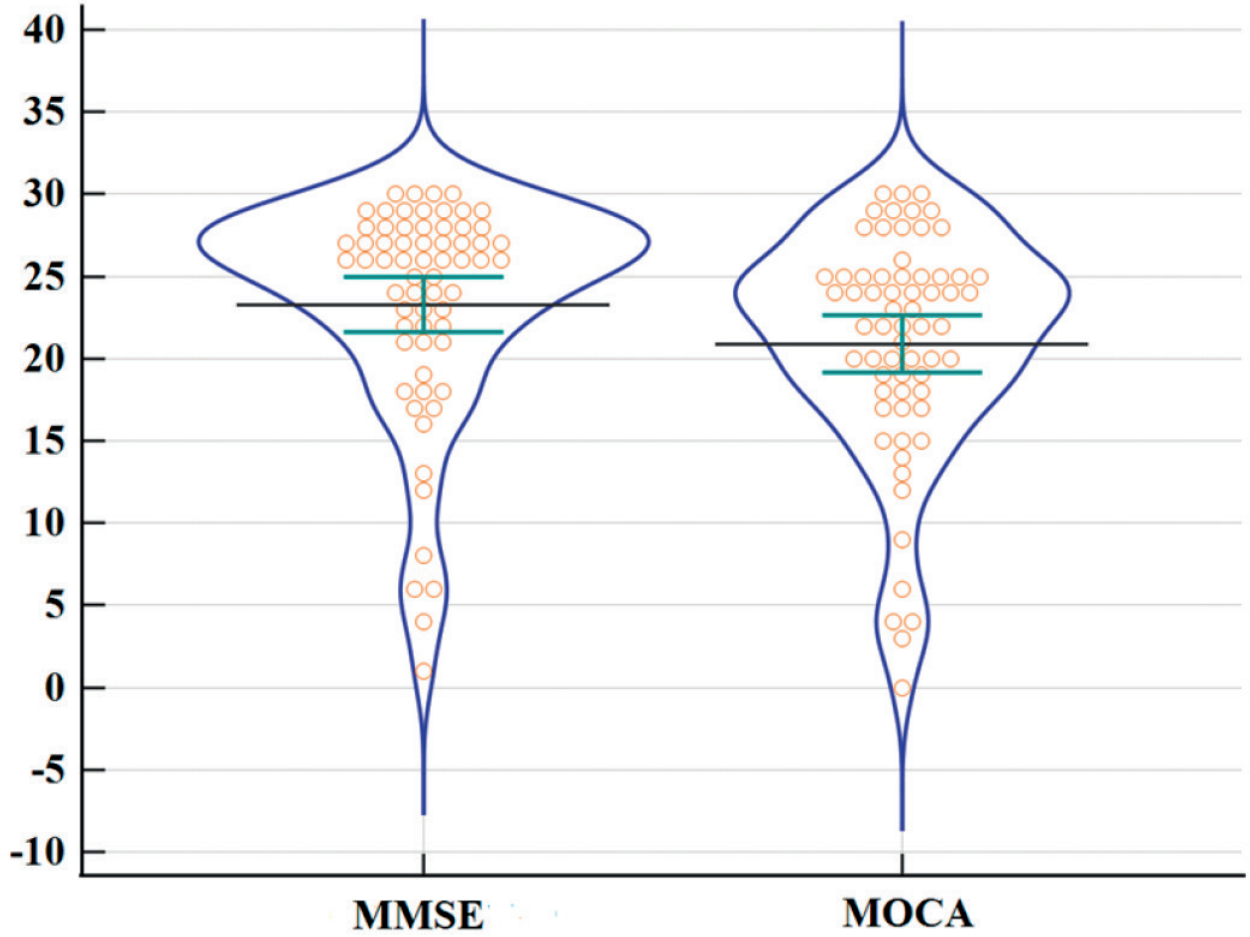

Figure 1. A violin graph shows the distribution and correlation of the results of both tests. They have a behavior that indicates a change together at a constant rate.

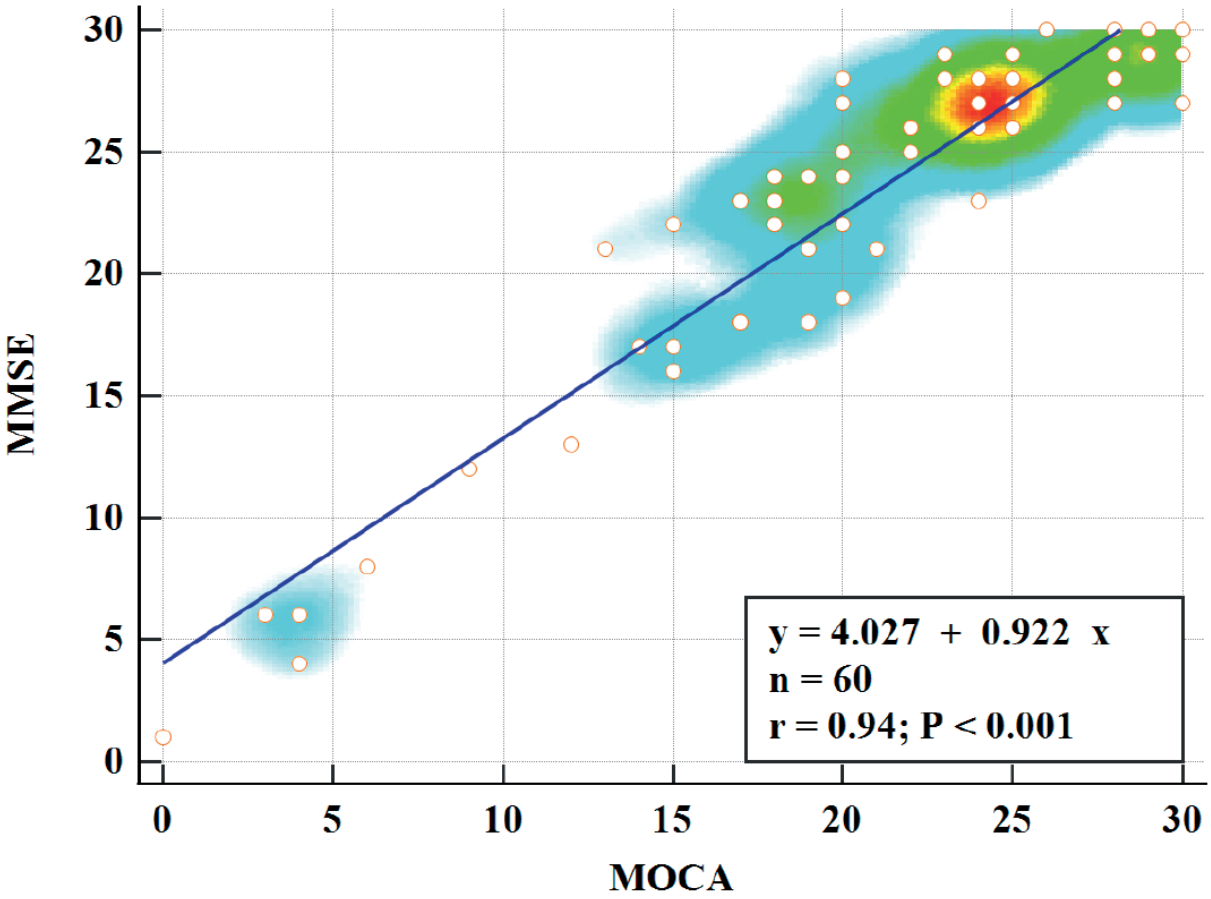

Figure 2. Scatter graph where the concentration of the values obtained around a score of twenty-five is observed.

between the MOCA and MMSE is 1.39, with a confidence interval of 95% that goes from -2.2 to 7.0.

Furthermore, it can be seen from the Bland-Altman plot that most of the differences are within the 95% limit of agreement, represented by the plot's dotted lines. This indicates that the MOCA and MMSE have a good agreement since most differences are within the acceptable range. However, some items are outside the 95% agreement limit, indicating that there are discrepancies between the two tests in some cases. It is important to note that these results are based on a sample of 60 people and could vary in different populations or larger samples. Figure 3 shows the plot.

A conclusion table was made to analyze the performance of both tests compared to each other regarding their ability to detect the presence or absence of cognitive impairment. The resulting confusion table is presented below:

The MOCA test correctly identifies 43 individuals with cognitive impairment and ten without cognitive impairment, resulting in an actual positive rate of 89.6% and a true negative rate of 66.7%. On the other hand, the MMSE test correctly identified ten individuals without cognitive impairment, resulting in an actual negative rate of 83.3%. However, the false positive rate for the MMSE was 4.4%, indicating that the test has a higher probability of falsely identifying an individual with cognitive impairment. These results suggest that the MOCA test has a higher sensitivity and specificity in detecting cognitive impairment than the MMSE test.

Discussion

The MMSE test is a widely used cognitive assessment tool that evaluates basic cognitive functions, memory, language, and attention span. It is like the MOCA test, a more comprehensive cognitive assessment tool that assesses more complex cognitive functions, such as sustained attention, visuospatial ability, executive function, and working memory.

The sample selection in this study was carried out using the subjective method by reasoned decision due to the specific characteristics of the target population and the limitations of time and resources. Given the heterogeneous nature of the people and the unavailability of a complete sampling frame, a subjective approach would be more appropriate to achieve adequate representation. For this, the research team's experience and expert knowledge were used in identifying and selecting, and expert knowledge of the research team was used in determining and selecting identifying and selecting the most relevant and representative sample. While acknowledging that this approach may carry certain risks of bias, we have sampled directly from people who were already attending a consultation with a neurologist to ensure that we consider multiple perspectives and minimize subjectivity in choice as much as possible. Possible.

The foregoing was preferred because, by any other method, the number of economic resources necessary to obtain the sample would be exponentially large and make the study impossible. This method reduced the time and economic factors necessary to reach interested patients. The experience of the experts was used, several of them with long experience in research. The complexity of neurological diseases makes it necessary to look at different approaches

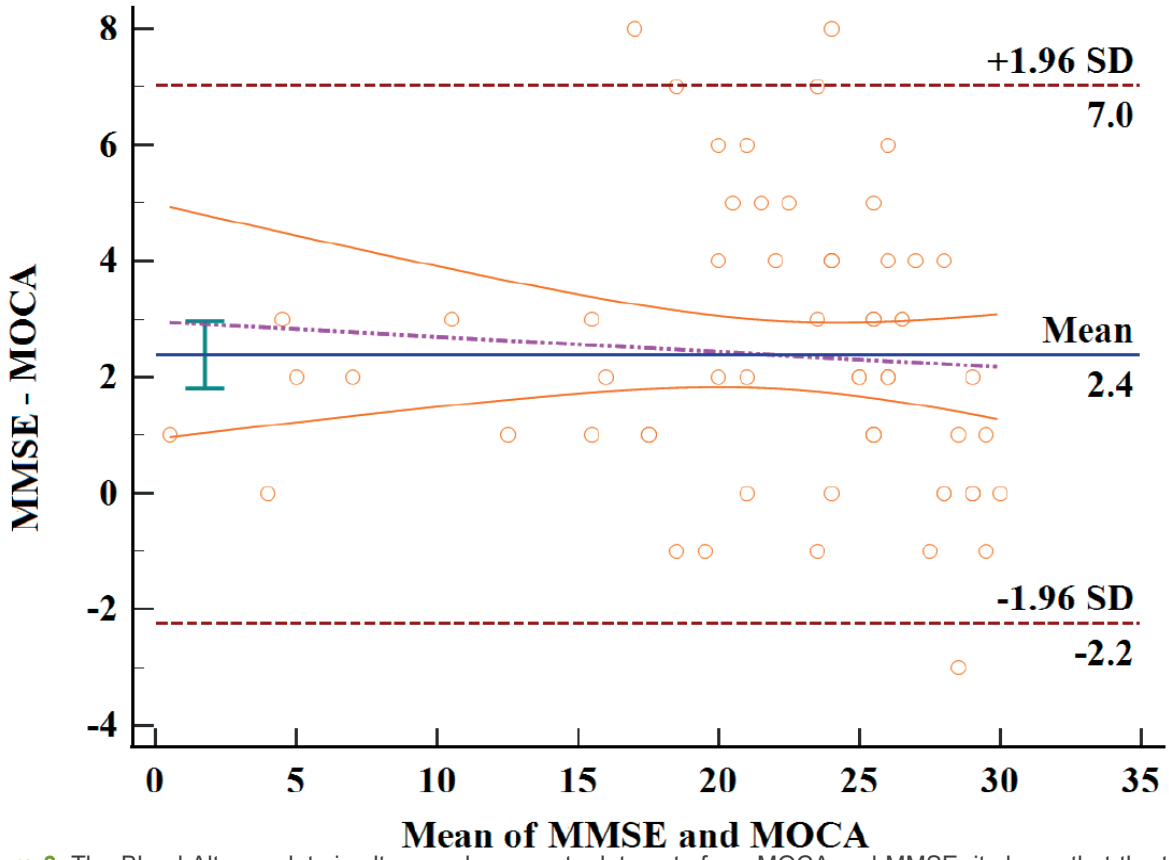

Figure 3. The Bland-Altman plot simultaneously presents data sets from MOCA and MMSE; it shows that the two test methods agree.

	MOCA Positive	MOCA Negative
MMSE Positive	43	2
MMSE Negative	5	10

Table 2. Conclusion table between MOCA and MMSE tests.

to find novel results.

Both tests have a maximum value of 30 points; values close to zero represent more severe cognitive impairment results. It is important to highlight that, although both tests share some aspects in common, such as the evaluation of memory and language, the MOCA test has a higher sensitivity for detecting mild cognitive deficits and evaluating more complex cognitive functions than the MMSE test.

The preceding coincides with those published by the Aiello study, in which encephalopathies and deficits at the functional level were evaluated in post-COVID-19 patients. The study method was to assess retrospectively one hundred people using the MMSE and MOCA tests; these patients were evaluated considering whether or not they presented a premorbid risk of cognitive risk. It was determined that the MOCA presents greater sensitivity to detect subclinical cognitive states and discriminate between the different levels of cognitive abilities[19]. This is consistent with our findings.

Therefore, the choice of a cognitive assessment test depends on the specific objectives of the assessment and the characteristics of the population being tested. The MOCA test is more suitable for evaluating cognitive function in people with mild cognitive deficits or in patients with neurodegenerative disorders. In contrast, the MMSE test is more suitable for general mental evaluation in the geriatric population. The data for this study reveal these qualitative differences between the individuals to whom the tests were applied since they were all older adults with a suspected diagnosis of small-vessel cerebral disease. Our results are like those of a cross-sectional study carried out in China in middle-aged and elderly patients, where it was shown that the MOCA is a better tool for the detection of mild cognitive impairment (MCI) because it presents a ceiling effect (performance range limited dynamic for normal individuals) lower compared to the MMSE[20].

It is essential to mention that, according to the perception of the health personnel who applied the MMSE, it was that they found that it was much more understandable for the patients who were perceived as having greater cognitive deterioration in a first impression when reviewing the data of these patients, a greater sensitivity. This differed from what was reported in a prospective investigation in older cancer patients to assess cognitive status, based on data obtained from the MOCA test, which was found to be more sensitive in detecting a cognitive decline in this patients[21].

Therefore, if both tests are used in a complete cognitive evaluation, obtaining a more comprehensive and accurate assessment of the individual's cognitive function is possible, thus bringing more robust conclusions. However, it is essential to bear in mind that the interpretation of the results of both tests must be made basis individually, considering other factors such as age, educational level, gender, and the presence of risk factors for cognitive diseases.

This is equal to a meta-analysis study that was developed to compare these two tools in the diagnosis of Dementia in patients older than 60 years, which found that the MOCA test compared to the MMSE, meets the requirements for the screening diagnosis of mild cognitive deficits, thus indicating better sensitivity in the MOCA assessment[22].

Conclusions

The MOCA test is a valuable tool for detecting mild cognitive problems in individuals of all ages. The interpretation of the results must consider factors such as the age and education of the individual evaluated. The MOCA test has also been used in different cultures, and other tools have been developed to assess cognitive reserve.

The MMSE test is a widely used tool to assess cognitive function and is useful in detecting Dementia and Alzheimer's disease. However, interpreting the results must consider factors such as the age, educational level, and culture of the individual evaluated. Although the MMSE test has been criticized for its insufficient sensitivity and specificity, it remains a valuable tool for evaluating mild and moderate cognitive problems.

The MOCA and the MMSE are two cognitive tests widely used to assess cognitive function in older adults and people with possible cognitive deficits. Both tests assess different aspects of cognitive function, such as memory, attention, language, and spatial orientation.

From the statistical analysis, the MOCA and the MMSE present a high sensitivity in detecting possible cognitive deficits since most of the scores obtained are below the maximum possible score. However, it is essential to highlight that some participants obtained scores close to the maximum values, suggesting a possible absence of cognitive deficits in such cases.

The results of the Kolmogorov-Smirnov test provided compelling evidence of a divergence between the distributions of MOCA and MMSE in our sample. This implies that the variables capture different aspects of cognitive function and may reflect separate underlying mechanisms. The statistically significant difference observed in the test underscores the importance of considering each variable independently when assessing cognitive abilities in research and clinical settings. Future studies could explore factors influencing these differences and investigate whether they are consistent across diverse populations. These findings contribute to a better understanding of cognitive assessment and pave the way for more nuanced interpretations of cognitive test scores.

While both tests can be useful in assessing cognitive function, it's important to note that each test has its strengths and limitations. For example, the MOCA is considered a more sensitive test for detecting mild cognitive deficits, especially around executive function, while the MMSE focuses more on short-term memory and orientation.

By calculating the Spearman-Brown correlation between two parallel tests of MOCA and MMSE, the results revealed a significant Spearman-Brown correlation of 0.7381 and p-value=0.280. These findings suggest a positive association between the measures obtained with both tests. The correlation is not statistically significant, so there is enough insufficient evidence in the sample used to demonstrate the relationship between the two tests. This will keep supporting the reliability and validity of both scales to assess cognitive impairment in the sample studied but measuring different things. These results have important implications for clinical practice and research, providing evidence of these tests' robustness and utility in assessing the cognitive function.

It is important to bear in mind that the sensitivity of cognitive tests does not depend solely on the scores obtained but also on other factors, such as age, educational level, gender, and the presence of risk factors for cognitive diseases. Additionally, each cognitive test has its strengths and limitations regarding sensitivity for detecting different cognitive deficits. Therefore, it is necessary to perform an individualized analysis of each case and use multiple cognitive tests to obtain a complete and accurate assessment of an individual's cognitive function. There must be a determining health criterion, the tests can indicate cognitive deterioration, but it must be chosen according to the criteria, especially in the aspect of deterioration sought to be measured. The ideal scenario in any clinical suspicion of Dementia due to small vessel cerebral disease is to use biomedical imaging in combination with other tools that are not so complex that have shown effectiveness, such as blood chemistry (homocysteine and vitamin B12), high blood pressure, and metabolic syndrome.

Supplementary Materials

They have not been provided.

Author Contributions

Conceptualization, Marco Tulio Medina and Isaac Zablah.; Methodology, Yolly Molina and Marcio Madrid; Validation, Melania Madrid and Jaffet Rodriguez; Formal analysis, Marco Tulio Medina.; investigation, Yolly Molina.; data curation, Antonio Garcia Loureiro; writing—original draft preparation, Isaac Zablah; writing—review and editing, Carlos Agudelo; supervision, Salvador Diaz; All authors have read and agreed to the published version of the manuscript.

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Conflicts of Interest

The authors declare no conflict of interest.

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