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Original Article

A Reliability of the Tele-Neuropsychological Assessment Using the Computerized Montreal Cognitive Assessment in Community-Dwelling Older Adults

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SUMMARY

Background: The Montreal Cognitive Assessment (MoCA) has been widely used to discriminate individuals with mild cognitive impairment (MCI). As a tele-neuropsychological service has become important due to Coronavirus Disease-19 (COVID-19), computerized neuropsychological assessments delivered by telehealth have recently been developed. However, to date, their reliability is unclear yet. Thus, this study was to investigate the reliability of the tele-neuropsychological assessment using the computerized MoCA (c-MoCA).

Method: Thirty-four community-dwelling older adults (age: 65–86 years, 17 females) participated in this study. While the primary assessor scored the participant's performance by telehealth, the secondary assessor independently scored the performance by directly observing face-to-face. To establish the inter-rater reliability of the c-MoCA by telehealth, the absolute agreement and the intra-class correlation coefficient (ICC) were analyzed.

Results: The inter-rater reliability of the c-MoCA by telehealth was high (ICC = 0.923; absolute agreement = 0.924, p 's < 0.001). In addition, there was no significant difference in the c-MoCA score between primary and secondary assessors.

Conclusion: This study demonstrated that the c-MoCA delivered as a tele-neuropsychological assessment was reliable. This finding suggests that the c-MoCA could be used as a tele-neuropsychological service in older adults who have a low accessibility to medical settings.

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1. Introduction

Early detection through neuropsychological assessments is a crucial component in rehabilitation for older adults with cognitive impairment.¹ The Montreal Cognitive Assessment (MoCA) is a typical screening tool for mild cognitive impairment (MCI) which is a pre-clinical stage of Alzheimer disease. The MoCA has been widely used in clinics with several advantages. For example, it takes only approximately 10 minutes to evaluate cognitive functions such as memory and attention.²

As the importance of neurocognitive assessment by a telehealth service called a tele-neuropsychological assessment has gained a lot of attention due to Coronavirus Disease-19 (COVID-19), conventional face-to-face health care delivery system has been altered.³ Considering that a tele-neuropsychological assessment could be used for older populations who have low accessibility to the health care system for early detection of MCI, it is urgent to investigate which type of neuropsychological assessment is suitable for tele-neurocognitive assessment.³

Computerized neuropsychological assessments have been developed due to advances in technology.⁴ Computerized neuropsychological assessments offer several advantages over paper-based

assessments. First, subjects might be able to self-administer without continuous attendance of a tester, thus reducing the care burden and financial costs for managing them. Second, computerized neuropsychological assessments can automatically score, save data, and analyze data, making it easy to use them.⁵ Third, computerized assessments are stable and reliable across a range of ages for individuals with or without cognitive impairment.^{6–8} With these advantages, previous studies have investigated clinical applications of computerized neuropsychological assessments.^{6–8} Moreover, computerized neuropsychological assessments could be self-administered with a relative lack of practice effects. These findings suggest that computerized neuropsychological assessments could be effectively delivered via a tele-neuropsychological service to monitor a subject's cognitive status for which paper-based neuropsychological assessments have been used.^{7,8}

Unfortunately, there is a controversy regarding the reliability of computerized neuropsychological assessments delivered by a telehealth service, compared to their reliability performed by a face-to-face service. Although computerized neuropsychological assessments have the same test items and scoring system as paper-based counterparts, performances of subjects might be affected by computerized administration by a telehealth service if they have less familiarity with a tablet computer.⁸ Indeed, previous studies have reported that an unpleasant feeling of computer-induced fear called computer aversion could be a main factor negatively affecting a

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subject's performance.⁹ Thus, the reliability of computerized neuropsychological assessments in the older population needs to be established before they are used for tele-neuropsychological assessments.⁴

Therefore, the purpose of this study was to investigate the inter-rater reliability of the computerized MoCA (c-MoCA) by a telehealth service for community dwelling older adults. This study hypothesized that there would be no significant difference in subject's score of the MoCA between telehealth and a face-to-face service.

2. Methods

2.1. Participants

Participants included community dwelling healthy older adults and they were recruited from local senior centers in South Korea. The inclusion criteria were as follows: (1) age 65 years or over, (2) intact global cognitive function confirmed as the Korean version of the Mini Mental Status Examination score ≥ 24 , (3) those who could fully understand simple instructions, and (4) those who agree to participate in this study. The exclusion criteria are as follows: (1) those who were diagnosed with dementia, (2) those who underwent treatment for neurological (e.g., stroke) or psychiatric disorders (e.g., schizophrenia), (3) those who had auditory or visual impairments diagnosed by a physician, (4) those who had a depressive symptom as determined by a score of ≥ 18 on the Korean version of the Geriatric Depression Scale, and (5) those who did not participate in any pharmacological or non-pharmacological treatment for cognitive function. All subjects were pre-screened by an independent occupational therapist with 3 years of clinical experiences according to the inclusion and exclusion criteria and were interviewed to determine how much experience they had with a table computer prior to participation, and they all were identified to have no experience of using a table computer.

The number of participants was calculated using G*Power version 3.1 (Informer Technologies, Dusseldorf, Germany). In accordance with a previous study,¹⁰ the correlation ρ was set at 0.84 with a power of 0.95 and α error probability of 0.05, resulting that a minimum of 11 subjects was required. This study was approved by the Institutional Review Board and registered at the Thai Clinical Trials Registry (ID: TCTR20210827003).

2.2. Procedure

The c-MoCA was implemented by the primary assessor in a remote room by using the videoconferencing equipment while the secondary assessor who was physically in the same room with a participant independently scored by observing the participant's response (Figure 1). All instructions were only delivered via the video-conference equipment whereas the secondary assessor was not allowed to help a participant in any form except for facilitating the implementation only for the purpose of proceeding it without technical issues.¹⁰ Each participant's performance was automatically recorded in real time, allowing the primary rater to check participant's score during or after the implementation.

Both assessors are occupational therapists with more than 5 years of clinical experiences. Prior to this study, both assessors were trained by using the c-MoCA's manual including administration, instructions, and scoring. In this study, 100 Mbps internet connection was used to connect two remote rooms, and a computer monitor with Logitech C922 USB web camera (HD 1080p) and Zoom video conferencing platform was used for the videoconferencing system.

2.3. Outcome measurement

The c-MoCA was installed as an app in a tablet computer (Android version) and administered by assessors. Administration and instructions were identically to those of the original Korean version of the MoCA. The c-MoCA consisted of seven cognitive domains (visuospatial/executive, naming, attention, language, abstraction, memory and orientation) including 12 test items. The total score was the sum of the scores for each item. It ranged from 0 to 30 with a higher score indicating better cognitive function. The cutoff score of the c-MoCA was 23 points indicating cognitive impairment.¹¹ If participant's education period was less than 6 years, one point was added to the total score within the maximum score. Its reliability was relatively high (Cronbach's $\alpha = 0.81$ to 0.84).¹² In the c-MoCA, both visual and auditory instructions were directly presented on the tablet computer. If participants could not use the tablet's stylus when performing the c-MoCA, they were instructed by the second rater to touch the tablet's screen to input their responses. Score for each test item was automatically calculated and stored in the same way as the original K-MoCA.

2.4. Statistical analysis

All data were analyzed using IBM SPSS Statistics version 22.0. Absolute agreement and the intra-class correlation coefficient (ICC) were analyzed to confirm the inter-rater reliability. Statistical significance was set at $p < 0.05$.

3. Results

3.1. Participants' characteristics

A total of 34 participants (17 females) were recruited and they all participated in this study. All participants implemented the c-MoCA and no data were missing. The age range of participants was from 65 to 86 years. The mean education level was 9.97 years and the mean MMSE score was 25.91 points (Table 1).

3.2. Inter-rater reliability

Regarding the inter-rater reliability of the c-MoCA, the ICC was 0.923 ($p < 0.001$) and the absolute agreement had an ICC of 0.924 ($p < .001$). There was no significant difference in the mean score of the c-MoCA between the primary assessor and the secondary assessors (23.41 vs. 23.26, $t_{(33)} = 0.669$, $p > 0.05$) (Table 2). These findings indicate that the inter-rater reliability of the c-MoCA delivered by a telehealth service is relatively high.

4. Discussion

As the older population continues to grow rapidly, early detection to manage individuals with cognitive impairment is attracting a lot of attention.¹³ Traditionally, paper-based neuropsychological

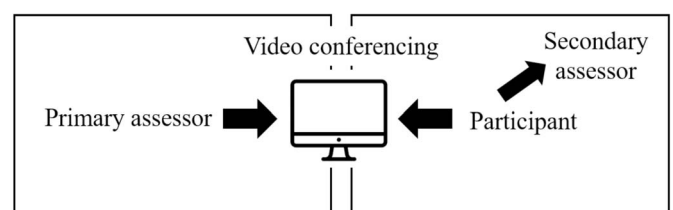


Figure 1. Tele-neuropsychological assessment procedure.

Table 1
Participants' general characteristics (N = 34).

Characteristics	Healthy older adults
Age (years)	73.53 (7.54)
Sex (male/female)	17/17
Education period (years)	9.97 (3.49)
MMSE-K (score)	25.91 (1.11)

Data were presented as mean (standard deviation). MMSE-K = Korean version of Mini Mental Status Examination.

assessments were administered face-to-face in clinical settings. However, due to the outbreak of COVID-19, alternative ways to conduct neuropsychological assessments for older adults in rural areas have been investigated as they have relatively low accessibility to clinical institutions.^{3,10} Accordingly, a tele-neuropsychological service has recently gained a considerable attention to overcome the low accessibility issue for older adults.¹⁰ A previous study has found that computerized neuropsychological assessments would be a more suitable method for a tele-neuropsychological service than conventional paper-based assessments as they could be self-administered.¹⁴ Consequently, it is urgent to confirm whether neuropsychological assessments could be implemented with high reliability by a telehealth service.

Findings of the present study suggested that the c-MoCA delivered as a tele-neuropsychological service in community-dwelling older adults was reliable, which is in line with previous studies.^{14,15} Specifically, the c-MoCA score assessed by the two independent assessors showed high agreement, indicating that cognitive function would not be considerably affected by a telehealth delivery. Therefore, this study shed new light on the importance of tele-neuropsychological assessments as an alternative way for people who have low accessibility to conventional face-to-face neuropsychological services, which is consistent with previous studies.^{14,16,17}

In this study, although the secondary assessor was allowed to provide only a technical assistance to the participants within the range which did not affect their performance, the c-MoCA was administered with minimal engagement of the secondary assessor as it could be easily implemented by touching a tablet computer screen, which is different from prior studies using paper-based assessments.^{10,15,17} Although any assistance might narrowly affect the inter-rater reliability, it could lead to more accurate c-MoCA by preventing technical issues that could potentially affect the participant's performance during cognitive testing. Indeed, in previous studies, it has been recommended to adapt a telehealth technician,^{11,18} which supports the tele-neuropsychological service delivery method in this study. These results imply that a technician could play a crucial role in tele-neuropsychological services.

On the other hand, in this study, all participants had no experience of using a table computer. It has been found that prior table computer experiences can negatively affect a participant's performance on computerized cognitive tests.⁹ Specifically, if a participant felt uncomfortable to use a computer called computer aversion because of no computer experience, it affects his/her performance. Since a tele-neuropsychological service includes the use of a computer and videoconference system, computer aversion needs to be considered in addition to one's experience of using a computer.⁹ However, in this study, since all participants had no experience of using a tablet computer, it is difficult to compare their performance on the c-MoCA based on their prior experience. Therefore, specific subjective information on a previous computer experience needs to be collected.

Table 2
Mean (SD) c-MoCA score agreement across assessors (N = 34).

c-MoCA	Score		ICC	Absolute agreement
	Primary rater	Secondary rater		
Score	23.41 (2.59)	23.26 (2.19)	0.923***	0.924***
$t_{(33)} = 0.669, p = 0.508$				

Data were presented as mean (standard deviation). c-MoCA = Computerized Montreal Cognitive Assessment; ICC = Interclass Correlation.

In sum, this study shed new light on the promising use of the c-MoCA delivered as a tele-neuropsychological service to monitor cognitive status of older adults. Specially, this finding has the clinical meaningfulness considering that the c-MoCA could be reliably delivered to more people without geographical restrictions while reducing time and costs by using a telehealth service.¹⁰ Furthermore, the c-MoCA could be administered in a non-face-to-face manner, which highlights that a tele-neuropsychological assessment is a safe way to deliver tele-health service during the COVID-19 pandemic with minimal physical contact.

Although this study revealed the clinical application of the c-MoCA as a tele-neuropsychological assessment, it has limitations. First, all participants had relatively higher levels of education than those reported in previous studies.^{14,16,17} Prior studies have shown people with lower levels of education are likely to have greater variability in performance in neuropsychological assessments.^{6,9} Thus, it is difficult to generalize the current results to less educated older adults. Second, this study was the cross sectional design and had small sample size. In addition, as only healthy older adults rather than individuals with cognitive impairment participated in this study, it is unclear whether tele-neuropsychological assessments could be reliably used in people with MCI or Alzheimer disease. Nevertheless, the findings of this study are not likely to be affected even if more participants were added considering that the results of previous studies involving more subjects or patients with cognitive impairment are consistent with the present study.^{14,16,17,19} Finally, although the promising results of this study, as some older adults might have low accessibility to technology, sometimes they need an assistance of a technician, which can impede non face-to-face delivery of tele-health service. In near future studies, discriminant power of tele-neuropsychological services using computerized screening tools with a larger sample size including a variety of levels of education and experiences of using a computer needs to be investigated.

5. Conclusion

The inter-rater reliability of the c-MoCA delivered by a telehealth service was high. The tele-neuropsychological delivery method did not considerably affect a participant's performance. Moreover, it was found that a tele-neuropsychological service could be efficiently delivered to older adults with a technician. Thus, a tele-neuropsychological service would be reliably implemented for older adults who have low accessibility to medical institutions.

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