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Original Article

A Reliability of the Mobile Screening Test System for Mild Cognitive Impairment Using Telehealth in Rural Settings with Older Adults

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SUMMARY

Background: Tele-neuropsychological assessments have got a lot of attention as they can be available for older adults in rural areas who have difficulty in accessing medical services. However, to date, their reliability and validity are unclear yet. This study was to investigate the reliability of the tele-neuropsychological assessment using the newly developed Mobile Screening System for Mild Cognitive Impairment (mSTS-MCI).
Method: Sixteen older adults (age: 65–85 years, 11 females) in rural areas participated in this study and were allocated into three conditions. While a primary rater scored subjects' performances on the mSTS-MCI either face-to-face or by health, a secondary rater independently observed the primary rater's administration and scored subjects' performances on the mSTS-MCI in-person or by telehealth in accordance with the conditions. The inter-rater reliabilities across conditions were compared to test differences between in-person and telehealth methods.
Results: The inter-rater reliability of the mSTS-MCI score and reaction time across the three conditions was high, ranging from r = 0.987 to r = 1.000. There were no significant differences in reliability correlations among the conditions (*p*'s > 0.1). Moreover, the absolute mean difference between both the raters revealed no significant differences across the conditions, indicating acceptable accuracy (*p* = 0.324). On the other hand, all subjects were found to be positive about computer use.
Conclusion: These results indicated the reliability of administering the mSTS-MCI by telehealth, which suggests telehealth could be regarded as a beneficial way for older adults in rural areas.

1. Introduction

Mild cognitive impairment (MCI) can be regarded as a preclinical stage of Alzheimer's disease. MCI has gained a lot of attention with the high proportion of older people.[1] Older adults with MCI consistently show cognitive impairment compared with healthy older adults, which negatively affect daily activities.[2] Therefore, numerous studies have attempted to investigate beneficial efficacy of cognitive intervention.[3] Unfortunately, however, recent meta-analysis studies indicated that conventional cognitive intervention is not effective in improving cognitive function in people with MCI.[3] This is can be attributed by the fact that cognitive dysfunction has already progressed at the time when cognitive intervention is conducted, resulting in its ineffective results.[4,5] Thus, early cognitive intervention is crucial to improve its efficacy through early detection of MCI.

Even though, MCI can be classified into amnestic- or non-amnestic-MCI, majority of studies on MCI has focused on amnestic-MCI (a-MCI) because of minimal cognitive bias of a-MCI compared with other types of MCI.[6] Early detection of a-MCI needs to consider assessing episodic memory since one of hallmarks of a-MCI is atrophy in medical temporal structures responsible for episodic memory.[7] To date, the Montreal Cognitive Assessment (MoCA) is widely used in clinical setting to distinguish a-MCI from healthy older adults due to its brevity.[4] However, items for testing episodic memory in the MoCA are not weighted, which results in relatively low sensitivity and specificity.[6] To overcome these issues, the Mobile Screening Test System for Mild Cognitive Impairment (mSTS-MCI) was developed with weighted items for episodic memory. Indeed, the mSTS-MCI was identified to be more effective in differentiate older adults with MCI than MoCA.[6]

On the other hand, older adults living in rural areas have a low accessibility to medical care setting which tend to be located in urban areas.[8] Due to physical deteriorations with aging, such as loss of vision and decreased mobility, older adults living in rural areas face the difficulty of attaining early detection of MCI.[9] Furthermore, recently the outbreak of coronavirus-associated acute respiratory disease called coronavirus disease 19 (COVID-19) as a pandemic has altered conventional face-to-face health delivery system.[10] Therefore, minimizing obstacles to access health care is particularly crucial for older people in rural areas, indicating there is a need to use telehealth service for early detection of MCI.[8] Although screening tools including the MoCA and the mSTS-MCI are implemented in person, a few studies tried to investigate the reliability and validity when administered remotely.[8,11] In previous studies, the MoCA was

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used remotely via phone or video telehealth and the MoCA was found to had good reliability by using a test-retest design, which suggests screening tools for MCI via telehealth would be reliable way.[8,11]

However, in most studies, inter-rater reliability of screening tools for MCI via telehealth was not investigated. Moreover, given that the test-retest design is a methodology that introduces practice effects and time influences which have a potential effect on overall results, inter-rater reliability needs to be tested. Therefore, this study used simultaneously multiple raters to demonstrate the reliability and accuracy of the mSTS-MCI considering the mSTS-MCI is more appropriate tool to discriminate MCI compared with the MoCA.

2. Methods

2.1. Participants

16 older adults (11 female) over 60 years with a-MCI were recruited from local senior centers in Asan, South Korea and they all voluntarily participated in this study. Asymmetry of the sex ratio of the subjects is due to a tendency to not use senior centers in case of elderly males in Korea. a-MCI is defined with respect to a previous study.[6,12] Inclusion criteria were as follows: (a) subjective memory complaint, (b) objective memory impairment defined by score on the Seoul Verbal Learning Test for the elderly, (c) intact general cognitive function as confirmed by score on the Korean version of the Mini-Mental State Examination (MMSE-K) $\geq$ 24, and (d) intact activities of daily living as identified by score on Seoul instrumental activities of daily living score $\leq$ 7. Exclusion criteria were as follows: (a) dementia diagnosed by physicians, (b) presence of neurological or psychiatric disorders such as stroke and schizophrenia, (c) moderate to severe depressive symptom as determined by score on the Beck Depression Scale, and (d) presence of auditory or visual impairments. The number of subjects was calculated using G* Power (Informer Technologies, Dusseldorf, Germany). According to a previous study,[8] the effect size was set at 0.80, the α error at a probability of 0.05, and the power at 1.748. A minimum of 8 subjects was required for each group. All subjects provided informed consent before participating in the present study according to the Declaration of Helsinki (2004). This study was approved by the Institutional Review Board of Yonsei University.

2.2. Procedure

Subjects were randomly allocated to one of three conditions (Figure 1) and then performed the mSTS-MCI. Three conditions were derived from a previous study.[8] In the condition 1, the mSTS-MCI was conducted to subjects by the primary rater in the room while the secondary rater also scores the subject's performance independently by observing in the same room. In the condition 2, the mSTS-MCI performed face-to-face by the primary rater. The secondary rater independently scored subjects' performances by using videoconferencing equipment in a different room. In the condition 3, the mSTS-MCI was implemented by the primary rater in a remote location by using the videoconferencing equipment while the secondary rater scored subjects' responses face-to-face independently. All instructions were given using the videoconference system. The secondary rater physically in the room with subjects could facilitate the administration only for the purpose of ensuring that it proceeded without problems (i.e., holding subjects' written responses up to the camera). However, the secondary rater was not allowed to help subjects in any other way.[8] After the condition 3, the revised version of Computer Aversion, Attitudes, and Familiarity Index (CAAFI) was conducted to investigate subject's computer aversion. The primary rater and the secondary rater were occupational therapists with more than 5 years of clinical experiences.

2.3. Videoconferencing equipment

24 Mbps Internet connection was used to connect two non-adjacent rooms. The mSTS-MCI was conducted by telehealth system consists of a computer monitor equipped Logitech C922 USB Web camera with HD 1080p and Zoom video conferencing platform. Subjects in the non-adjacent room were seated 60 cm in front of the monitor.

2.4. mSTS-MCI

The mSTS-MCI, a kind of computerized cognitive test, involves 13 items for testing memory, attention, and executive function, with scores ranging from 0 to 28 points. The higher scores indicate the better cognitive function. The mSTS-MCI is administrated by a computer or mobile device. Its items were extracted through systematic reviews on paper-based or computerized screening tests for MCI and finally selected by expert panels. The mSTS-MCI shows higher sensitivity and specificity than the MoCA.[6] It takes about 15 minutes to complete all items. Subject's scores are automatically saved.[6] Since the mSTS-MCI is the newly developed tool, the user manual of the mSTS-MCI is provided.

2.5. Computer Aversion, Attitudes, and Familiarity Index

The CAAFI consists of 30 items with three domains (computer familiarity, computer attitudes, and computer aversion) to investigate experiences and feelings with respect to use of a computer. It has a seven-point scale from -3 (absolutely false) to 3 (absolutely true). Zero indicates subject's neutral response toward each item.

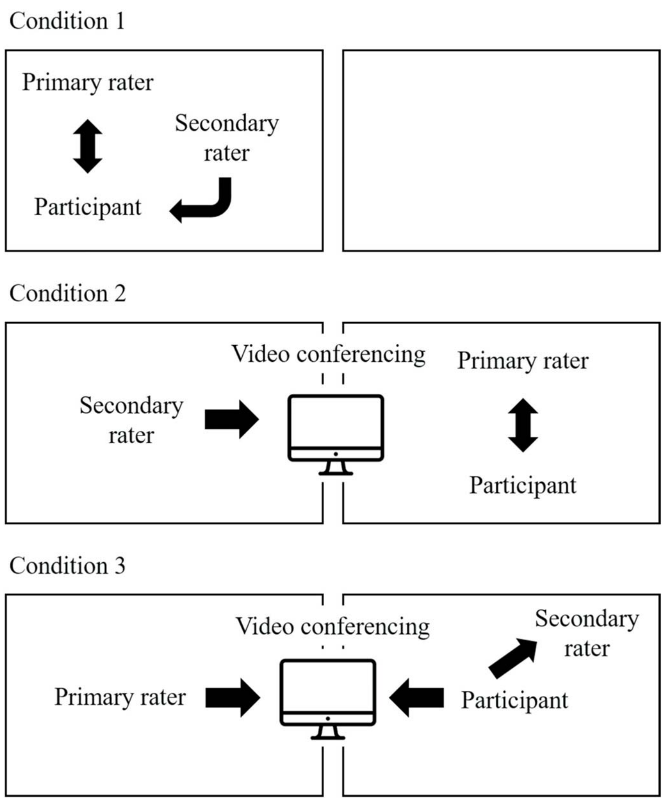

Figure 1. Characteristic of the three conditions.

The higher positive scores mean subject's favorable attitude toward a computer.[13–15]

2.6. Analysis

All data were analyzed using IBM SPSS Statistics version 22.0. The mean difference between the overall the mSTS-MCI score across the three conditions was computed and the absolute agreement was calculated using the intra-class correlation coefficient (ICC) to identify the inter-rater reliability.

3. Results

3.1. Participants characteristics

All 16 subjects (11 females) conducted the mSTS-MCI and no data were missing. The imbalance in the number of male and female subjects was due to a higher tendency of females to use senior centers in Korea. However, there was no significant differences in ages and education levels between male and female subjects. Subjects were allocated into one of the three conditions, and there were no significant differences in sex, age, and level of education (all p's > 0.05) (Table 1).

3.2. Inter-rater reliability

Each of the three conditions indicated very high ICC in both the mSTS-MCI score (ICC > 0.99) and reaction time (ICC > 0.98), suggesting high absolute agreement (Table 2 and 3). The inter-rater reliability of the mSTS-MCI score and reaction time across the conditions ranged from $r = 0.987$ to $r = 1.000$. Reliability across the conditions was compared using Fisher r-to-z transformations. As the results, there were no significant differences across the conditions (p's > 0.10).

3.3. Difference in performances across the conditions

Across all subjects, the mean mSTS-MCI score, based on the primary rater's rating, was 14.75, and there was no significant difference in the score ($F_{(13)} = 1.224$, $p = 0.324$) (Table 2).

3.4. Computer aversion

Computer familiarity (-1.8 ± .38) was found to be most negative toward into computer use. Nevertheless, subject's computer attitudes (2.1 ± .45) and computer aversion (2.3 ± .49) were positive (Table 4). These results suggest that subjects had little experience with computer use, but they though positively about computer use.

4. Discussion

The proportion of people with cognitive impairment is expected to rapidly increase in the next decade.[15] Therefore, in order to reduce enormous social cost of managing people with cognitive impairment, cognitive intervention necessary at an appropriate point through early detection using neuropsychological assessments.[6] Traditionally, paper-based neuropsychological assessments have been conducted face-to-face in specialized institutions.[15] However, telehealth services have recently been implemented for people who are unable to visit the institutions due to low socio-economic levels.[10] Moreover, the outbreak of coronavirus-associated acute respiratory disease called coronavirus disease 19 (COVID-19) causes the need for telehealth services.[10] Thus, it is important to establish which assessments could be used with high reliability and which conditions need to be met to provide early detection via tele-neuropsychology.[15]

The findings of this study showed that the screening tool implementation, the mSTS-MCI, via telehealth system is as reliable as a face-to-face implementation, which is consistent with previous studies.[16] Specifically, when the two independent raters scored subject's performance, very high agreement was observed across all the condition, suggesting there is no significant decrease in the agreement between both raters when the mSTS-MCI was observed remotely (Condition 2) or carried out by telehealth (Condition 3). In addition, no considerable decrease in subject's scores was observed across the conditions, which supports not only the its reliability and but also the validity of administering the mSTS-MCI by telehealth. Thus, telehealth is an alternative way to improve the accessibility of people who do not have access to neuropsychological assessments, which is consistent with previous studies on the use of telemedicine for people with cognitive impairment.[15,16,18]

On the other hand, in the condition 3, the secondary rater was allowed to help subjects perform the mSTS-MCI to facilitate the administration within the range that does not directly affect the performance. Even though, this might have affect agreement, this approach ensure a more accurate assessment by preventing tech-

Table 1
Subjects' general characteristics (N = 16).

Demographics	Condition 1	Condition 2	Condition 3
Sex (male/female)	2/3	1/4	2/4
Age (years)	72.00 (6.51)	69.80 (5.31)	71.67 (7.84)
Education period (years)	5.40 (5.36)	3.60 (5.36)	4.50 (3.67)
MMSE (scores)	25.40 (1.14)	26.40 (1.14)	25.83 (0.75)

Data were given as Mean (SD), MMSE = Mini-Mental Status Examination.

Table 2
Mean (SD) mSTS-MCI score agreement across the three conditions.

Condition	Score		Pearson correlation	ICC
	Primary rater	Secondary rater		
1 (n = 5)	14.00 (0.70)	14.00 (0.70)	1.000	1.000
2 (n = 5)	16.20 (2.58)	16.40 (2.88)	0.992	0.993
3 (n = 6)	14.17 (3.25)	14.33 (3.01)	0.994	0.996
	$F_{(13)} = 1.224$, p = 0.324			

ICC = intra-class correlation coefficient; mSTS-MCI = mobile screening test system for mild cognitive impairment; SD = standard deviation.

Table 3
Mean (SD) mSTS-MCI reaction time agreement across the three conditions.

Condition	Reaction time		Pearson correlation	ICC
	Primary rater	Secondary rater		
1 (n = 5)	16.74 (4.21)	17.01 (4.24)	1.000	1.000
2 (n = 5)	15.97 (1.29)	16.40 (1.31)	0.975	0.987
3 (n = 6)	16.48 (2.12)	16.76 (2.05)	0.995	0.997
All conditions	16.40 (2.60)	16.73 (2.59)	0.997	0.998

ICC = intra-class correlation coefficient; mSTS-MCI = mobile screening test system for mild cognitive impairment; SD = standard deviation.

Table 4
Subjects' CAAFI scores.

CAAFI	Computer familiarity	Computer attitudes	Computer aversion
Mean	-1.8	2.1	2.3
Standard deviation	.38	.45	.49

CAAFI = computer aversion, attitudes, and familiarity index.

nical problems during the procedure. Thus, it has been adapted as a telehealth technician at different levels in previous studies,[4,19] suggesting a secondary professional is required when telehealth is implemented for older people with MCI living in rural areas.

In this study, subjects in the condition 3 reported that they felt it was not uncomfortable to interact with a computer although they were not familiar with it. This result is beneficial given that telehealth mostly requires a videoconference system, it involves the use of a computer. Computer aversion, an unpleasant feeling of fear experienced by a computer, is found be a factor affecting subject's performance on neuropsychological assessments.[20] Therefore, this study confirmed subject's performances that were not affected by computer aversion and implied that even older adults who is not used to using a computer might not think negatively about the use of it.

Taken together, the current study highlights the promising use of tele-neuropsychological assessments, which can be used in areas of patient's diagnosis. Specially, given that tele-neuropsychological assessment could be used to enhance the capacity to reach more people living in multiple locations while reducing time and cost due to travel, the findings of this study has the clinical significance.

This study includes limitations. First is the cross sectional design and small sample size. Even though this limitation, the results are unlikely to be considerably affected even if more subjects were added. Second, considering only subjects who live in rural areas were included in this study, the external validity might be reduced. In the near future, studies with a larger sample size including a variety of levels of cognitive function need to be conducted.

5. Conclusion

The inter-rater reliability of the mSTS-MCI, a MCI screening tool, via telehealth across all the conditions is very high, and implementation of the screening tool using telehealth did not significantly affect its scores. Furthermore, telehealth system was identified to be well received by older adults with MCI with a technical professional. In the future, the performance of the mSTS-MCI using telehealth technology in people with different cognitive functions needs to be investigated.

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