Sensitivity and Specificity of Seven-Minute Screen (7MS) Thai Version in Screening Alzheimer's Disease

Somporn Sungkarat PhD*, Pised Methapatara MD**,
Khanittha Taneyhill PhD*, Reunthong Apiwong BSc***

** Faculty of Associated Medical Sciences, Chiang Mai University, Chiang Mai, Thailand*
*** Saunprung Hospital, Chiang Mai, Thailand*
**** Neurological Hospital, Chiang Mai, Thailand*

Background: *Diagnosis of Alzheimer's disease (AD) is often delayed due to lack of a simple and effective screening test in primary care settings.*
Objective: *To determine sensitivity and specificity of the validated 7 Minute Screen (7 MS) Thai version in screening elders with mild to moderate AD.*
Material and Method: *The original 7 MS was translated and modified to be appropriate for Thai elders. The validity and reliability of the test were obtained. The 7 MS was administered to community-dwelling elders in Chiang Mai province. AD was diagnosed by a neurologist based on NINCDS-ADRDA criteria. All AD cases were confirmed by MRI.*
Results: *One hundred forty nine elders (20 AD; mean age 79.10 $\pm$ 5.49 yrs and 129 non-AD; mean age 74.17 $\pm$ 6.88 yr) participated. The Thai version of 7 MS was valid (IOC = 0.96) and reliable (ICC = 0.99). It had a sensitivity of 100% and specificity of 89.9% in discriminating elders with mild to moderately severe AD from non-AD.*
Conclusion: *The Thai version of 7 MS has a high level of sensitivity and specificity for detecting elders with mild to moderate AD. The test is suitable to use in primary care settings since it is simple, can be rapidly administered by allied health professions with minimal training requirement.*

Keywords: *Seven minute screen (7MS) Thai version, Alzheimer's disease, Cognitive impairment, Dementia*

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Dementia is often undetected in primary care settings in both developed and developing countries. In Sweden and the U.S., approximately 60-70% of mild to moderate dementia were not detected in primary care settings[1,2]. In Finland, approximately 52% of mild to moderate dementia were not detected in primary care settings[3]. In Thailand, a study by Jitapunkul et al reported that 95.6% (22 of 23 persons) of dementia elders in the community have never received the diagnosis[4]. Alzheimer's disease (AD) is the most common form of dementia[5,6]. At present, although there is no cure for AD, recent evidence shows that early intervention can improve symptoms, slow down disease progression, and improve quality of life of both patients and care takers[7-9]. The very first step required for accomplishing the goal of early intervention is to successfully detect AD especially at an early stage. Thus, being diagnosed early is critical for individuals with AD and their care takers. Previous studies reported that less than half of the elderly with AD or other dementia types received medical diagnosis of their conditions[8,10,11]. One important barrier in identifying people with AD is a lack of a screening tool for AD that is simple to administer and score but gives an accurate outcome.

Although several methods have been developed and proven to be effective in identifying the AD-associated structural and molecular changes in the brain (*e.g.* MRI, PET) and biochemical markers in the cerebrospinal fluid[12], these tests are complex and costly. Thus, cognitive tests are more appropriate to use for a screening purpose. Among all cognitive tests, the Mini-Mental State Exam (MMSE) developed by Folstein et al[13] is considered the most widely used cognitive screening test. In Thailand, several research groups have developed cognitive assessments for individuals with dementia[14-16]. For example, Train the Brain Forum Committee at Siriraj hospital developed

Correspondence to:
Sungkarat S,Faculty of Associated Medical Sciences, Chiang Mai University 110 Intrawaroros Rd, Maung, Chiang Mai 50200 Thailand
Phone: 053-949-249, Fax: 053-946-042
E-mail: onlaor@chiangmai.ac.th

the Thai Mental State Examination (TMSE) in 1993[14]. Later the Institute of Geriatric Medicine Department of Medical Services, Ministry of Public Health developed the MMSE-Thai version 2002 in which the cut off accounted for subject's education level[15]. Similarly, Jitapunkul et al developed the Chula-Mental Test (CMT) to overcome the influence of literacy and education level on the test score for elders in less developed countries[16]. All these tests were modified from the original MMSE developed by Folstein and Folstein in 1975[13]. While the widely used MMSE is good for monitoring cognitive declines, it is, however, was not designed to screen for AD. Thus, its sensitivity and specificity in detecting AD especially at the early stage is low[17]. Several cognitive screening tests for AD were developed. These cognitive tests included the Memory Impairment Screen (MIS)[18], the Brief Alzheimer Screen (BAS)[19] and the 7 Minute Screen (7 MS)[20]. Among these tests, 7 MS has several attractive features that are suitable to use in primary care settings. First, the administered time is short (7-12 min). Second, it is simple to administer and score. Third, previous studies found that 7 MS both the English and translated version had a high level of sensitivity and specificity in screening AD. Finally, it is not affected by age, sex, education, and culture[21,22].

7 Minute Screen (7 MS) is a cognitive test battery developed by Solomon et al to detect AD in the elderly[20]. It consists of four brief tests, representing four cognitive areas typically compromised in AD. These four subtests are 1) Enhanced Cued Recall (memory test), 2) Category fluency (verbal fluency test), 3) Clock drawing (visuospatial and visuoconstruction test), and 4) Modified Benton Temporal Orientation (orientation of time test)[20]. These standard tests were chosen because they are shown to be sensitive to AD, can be rapidly administered and can be scored objectively. The 7 MS has been translated into several languages such as Dutch[23], Japanese[22], Malayalam[24], Greek[25], Norwegian[26] and Spanish[27]. The purpose of the present study was to validate the 7 MS Thai version and determine its sensitivity and specificity in detecting Thai elders with mild to moderate AD.

Material and Method

7 minute screen Thai version (7 MS)

The original 7 MS was translated into Thai. The draft version was then translated back to the source language (English) by a bilingual translator in order to make comparisons and adjustments in accordance with the original version. The Thai version of the MS was evaluated by three experts (cognitive neuroscientist, psychologist and neurologist) and modified to be appropriate for Thai elders. There were two modifications of the 7MS Thai version. First, some pictures in the Enhanced Cued Recall were changed to be those that Thai people are familiar with but belong to the same category as the original version. For example, a picture of grape (fruit category) was changed to be a banana and a screwdriver (tool category) was changed to be hammer. Second, in the clock drawing test, the time to draw the clock handset was changed from 03:40 to 11:10 AM, the same as the time commonly used in the standard clock drawing test. The validity and reliability of the final version of Thai 7 MS were obtained. The final version of 7 MS was then administered to the participants.

Participants

One hundred twenty nine community-dwelling, non-demented elders and twenty elders with AD participated in the present study. The inclusion criteria were age at least 60 years, independent in all activity of daily living, can read and write, and willing to participate in the present study. Those who have been diagnosed with neurological diseases such as Stroke, Parkinson's disease or psychiatric diseases such as Schizophrenia, Major Depressive Disorder (MDD) were excluded from the present study. The diagnosis of AD was based on the criteria of the National Institute of Neurological and Communicative Disorders and Stroke-Alzheimer's Disease and Related Disorders Association (NINCDS-ADRDA)[12]. All AD cases were confirmed by MRI. The severity of AD was rated using the Clinical Dementia Rating Scale (CDR). Only participants who were rated as CDR 1.0-2.0 (mild to moderate severity) were included into the present study[28,29].

Procedures

The study protocol was approved by the Human Ethical Review Board. All participants gave written informed consent prior to participation. The 7 MS was administered to each participant. They were then examined by a neurologist for AD using the NINCDS-ADRDA criteria[12]. The neurologist was blinded to the participant's 7 MS score.

Statistical analyses

Raw scores of the 7 MS were converted to probability scores using the algorithm of Solomon

et al[20]. This algorithm was derived from the following logistic regression model: Log (P/1-P) = 35.59 - 1.303 ECR - 1.378 CF + 3.298 BTO - 0.838 CD where ECR = score of the Enhanced Cued Recall, CF = score of the category fluency, BTO = score of the Benton orientation test, and CD = score of the clock drawing test. Statistical analyses were conducted to determine 1) the index of item objective congruence (IOC) of the 7 MS Thai, 2) inter-rater reliability (ICC) and 3) the sensitivity and specificity of the 7 MS comparing to the gold standard (*i.e.* the clinical diagnosis of AD). The receiver operating curve (ROC) was performed to identify sensitivity and specificity of the 7 MS. Participants' demographic data were expressed in mean and standard deviation.

Table 1. Index of item objective congruence of the 7 MS Thai version

Subtests of 7 MS	IOC*
1. Orientation (BTO)	0.93
2. Memory (ECR) (set 1, 2, 3, 4)	0.92 (0.92, 0.84, 0.92, 1.0)
3. Clock drawing	1.0
4. Categoty fluency (animal naming)	1.0

* IOC = index of item objective congruence greater than 0.5 is considered acceptable, BTO = the Benton Orientation Test, ECR = the Enhanced Cued Recall Test

Table 2. Participants' demographic data

	Non-demented elders (n = 129)	AD elders (n = 20)
Gender		
Men (%)	47 (36.4%)	4 (20%)
Women (%)	82 (63.6%)	16 (80%)
Mean age (years)	74.17 ± 6.88	79.10 ± 5.49**
60-64 years	12 (9.3%)	1 (5%)
65-79 years	84 (65.1%)	10 (50%)
80 years and above	33 (25.6%)	9 (45%)
Mean education (years)	6.71 ± 4.61	5.95 ± 4.22
1-4 years (%)	83 (64.3%)	14 (70%)
5-12 years (%)	30 (23.3%)	4 (20%)
13 years and above (%)	16 (12.4%)	2 (10%)
Depression (TGDS*)	3.43 ± 2.87	3.80 ± 3.08

* TGDS = Thai Geriatric Depression Score
** Independent student t-test showed significant difference between groups at $p < 0.05$

Results

Index of item objective congruence (IOC) of the 7 MS Thai version is shown in Table 1. Overall, the results showed that the modified version of 7 MS had high IOC. Intraclass correlation coefficient revealed that the 7 MS had high level of reliability between raters (ICC = 0.99, 95% CI 0.99-1.00).

One hundred forty nine elders (20 AD; mean age 79.10 ± 5.49 yr and 129 non-AD; mean age 74.17 ± 6.88 yr) participated in the present study. Participants' demographic information is shown in Table 2. Overall, there were more women than men in both groups. The majority of the participants was between 65-79 years of age and had four years of education.

Mean scores for each 7 MS subtests are shown in Table 3. Student t-tests revealed that participants with AD received significant poorer scores in all 7 MS subtests than participants without AD (p = 0.001).

The outcome of 7 MS is demonstrated in Table 4. Of the 149 participants, 34 participants were identified positive (AD) using the 7 MS, while the clinical diagnosis regarding as gold standard found 20 AD participants. The sensitivity, which is the ability of the 7 MS in identifying people with AD, was 100% while the specificity which is the ability of the 7 MS in identifying those without AD was 88.4%.

Table 3. Comparison of score for each 7 MS subtests between participants with and without AD

7 MS Subtests	Non-AD (n = 129)	AD (n = 20)	p-value
1. Orientation (0*-113)	1.88 ± 7.83	64.90 ± 38.21	0.001
2. Memory (0-16*)	15.32 ± 1.08	8.80 ± 4.07	0.001
3. Clock drawing (0-7*)	6.10 ± 1.31	2.25 ± 2.38	0.001
4. Animal naming (0-45*)	15.61 ± 4.39	9.05 ± 3.17	0.001

* Indicates best score

Table 4. Relation between the 7 MS results and the clinical diagnosis (Gold Standard)

	Gold Standard (NINCDS-ADRDA criteria)		
	AD	Non-AD	Total
7 MS			
Positive	20	14	34
Negative	0	114	114
Uncertain	0	1	1
Total	20	129	149

Table 5. Sensitivity and specificity for each 7 MS cut off score

7 MS cut off score	Sensitivity	Specificity
0.09	1.00	0.86
0.15	1.00	0.87
0.17	1.00	0.88
0.37	1.00	0.89
0.68	1.00	0.895
0.83	1.00	0.899
0.90	0.95	0.905
0.94	0.95	0.91
0.96	0.95	0.92
0.97	0.95	0.93
0.98	0.95	0.93
0.99	0.90	0.93
1.00	0.90	0.94

Sensitivity = [20 / (20 + 0)] x 100 = 100%
Specificity = [114 / (14 + 114+1)] x 100 = 88.4%

The sensitivity, specificity and area under ROC were also calculated (Fig. 1, Table 5). Result showed that the area under ROC was 0.962. Table 5 revealed that the best cut off score for 7 MS was 0.83, which gives sensitivity and specificity at 100% and 89.9%, respectively.

Discussion

The Seven Minute Screen (7 MS) has been validated and widely accepted as a practical psychological screening tool for detecting AD[20,22-25]. The present study aimed to validate the 7 MS Thai version. Despite the slight modification from the original version, the content validity of the 7 MS Thai version was high (IOC = 0.84-1.0), suggesting that its validity was not affected after modification. The inter-rater reliability of the Thai 7 MS was also high (ICC = 0.99). The level of sensitivity and specificity of the 7 MS Thai version was high, similar to that of the original version as well as those that were translated to other languages. Solomon et al[30] reported a sensitivity of the 7 MS at 92% and specificity at 96%. The sensitivity and specificity of the 7 MS Dutch version and Japanese version were 92.9% and 93.5%; and 90.5%, and 92.3%, respectively[22,23]. It should be noted that sample of the present study and previous studies[20,22,23] were recruited from both the community and hospitals. Using the clinically-based sample such as from the memory clinic or geriatric clinic may lead to an overestimation of the sensitivity and specificity of the test. It is likely that the level of sensitivity and specificity will be lower when administered solely in a primary care setting or community.

It was not unexpected that the accuracy of the 7 MS in differentiating elders with AD from non-AD was high given the combination of each subtest in the 7 MS. Solomon et al[20] took advantage of combining four cognitive subtests shown in previous studies to be sensitive and specific to AD in the 7 MS. For example, the original Enhanced Cued Recall test by Grober and Buschke had a sensitivity and specificity in discriminating elders with AD from non-AD at 94% and 99%, respectively[31]. The clock drawing test, widely used as a stand alone test for screening AD, had a high sensitivity (85%) and specificity (89%)[32]. Similarly, the category fluency and Benton orientation test also had a high degree of sensitivity and specificity to AD[33,34].

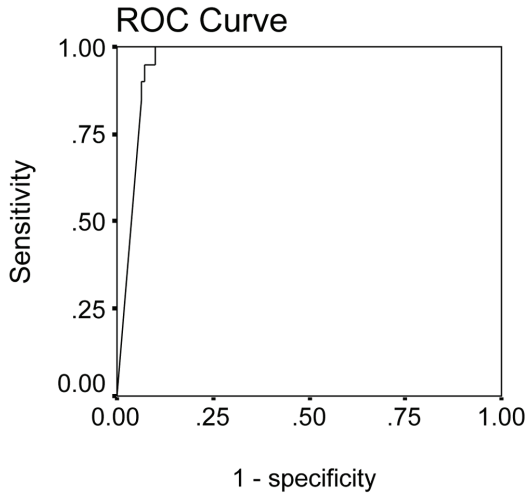

Fig. 1 Area under the curve of receiver operating characteristic (ROC)

Using the cut off point obtained from ROC curve (*i.e.* 0.83), resulted in a specificity at 89.9%, higher than that obtained from the original criteria by Solomon et al which in the present study gave a specificity at 84.4%. The two criteria, however, gave out the same level of sensitivity at 100%. Therefore, the cut off level of the 7 MS at 0.83 should be used in screening AD in Thai elders.

Solomon et al[20] reported that the mean duration of the 7 MS test administration was 7 minutes and 42 seconds (range from 6 to 11 minutes), which became the name of the test. Meulen et al[20] reported the mean administration duration at 15.6 minutes for AD and 12.4 minutes for intact subjects. Although the administration time in the present study was not recorded, the authors noticed that it could be as short as 5 minutes in some cognitive intact participants and as long as 20 minutes in some AD participants, suggesting an influence of the cognitive status on the administration time of 7 MS.

The present study has certain limitations. First, the eligible participants were only those who can read and write. In the process of recruitment, the authors found that several elders were not eligible to participate due to being unable to read and write. A future study should consider developing or modifying the test in such a way that this group can undergo the screening. Second, participants in the present study were recruited from both the community and hospital in order to have a reasonable number of elders with AD. Although, only mild to moderate AD participants were included in the present study, this sample was not a true representative of the community population. Thus, a future study should be conducted using all community based samples.

In conclusion, the 7 MS Thai version has a high level of sensitivity and specificity for differentiating elders with mild to moderate AD from non-AD. The test is simple to administer and score, thus required minimal training. The administer duration is relatively short. Together, the 7 MS is suitable to use in primary care settings for screening those who are at risk of AD.

Potential conflicts of interest

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ความไวและความจำเพาะของ Seven Minute ฉบับภาษาไทยในการคัดกรองโรคอัลไซเมอร์

สมพร สังขรัตน์, พิเศษ เมธาภัทร, ขนิษฐา ทานี่ฮิล, เรือนทอง อภิวงค์

***ภูมิหลัง**: การวินิจฉัยโรคอัลไซเมอร์มักล่าช้าเนื่องจากยังขาดแบบคัดกรองที่ใช้ง่ายและมีประสิทธิภาพ สามารถใช้ได้ในสถานพยาบาลระดับปฐมภูมิ*

***วัตถุประสงค์**: เพื่อทดสอบความไวและความจำเพาะของแบบคัดกรอง seven minute ฉบับภาษาไทยในการคัดกรองผู้สูงอายุอัลไซเมอร์ที่มีความรุนแรงน้อยถึงระดับปานกลาง*

***วัสดุและวิธีการ**: ทำการแปลแบบคัดกรอง seven minute ต้นฉบับเป็นภาษาไทยและปรับให้เหมาะสมในการนำมาใช้กับผู้สูงอายุไทย ทดสอบหาความความเที่ยงตรงและความน่าเชื่อถือของแบบคัดกรอง จากนั้นนำมาใช้คัดกรองผู้สูงอายุที่อาศัย ในชุมชนในเขตจังหวัดเชียงใหม่ การวินิจฉัยโรคอัลไซเมอร์ทำโดยแพทย์ด้านประสาทวิทยาตามเกณฑ์มาตรฐานของ NINCDS-ADRDA และผู้ป่วยทุกรายมีภาพถ่ายสมองด้วยวิธีเอ็มอาร์ไอยืนยัน*

***ผลการศึกษา**: ผู้สูงอายุจำนวน 149 คน เข้าร่วมการศึกษา แบ่งเป็นผู้ป่วยโรคอัลไซเมอร์ 20 คน (อายุเฉลี่ย 79.10 $\pm$ 5.49 ปี) และผู้สูงอายุที่ไม่เป็นโรคอัลไซเมอร์ 129 คน (อายุเฉลี่ย 74.17 $\pm$ 6.88 ปี) seven minute ฉบับภาษาไทยมีความเที่ยงตรง (IOC = 0.99) สามารถใช้แยกผู้สูงอายุที่เป็นโรคอัลไซเมอร์ในระดับน้อยถึงปานกลาง จากผู้สูงอายุที่ไม่เป็นโรคอัลไซเมอร์ที่ความไว100% และความจำเพาะ 89.9%*

***สรุป**: seven minute ฉบับภาษาไทยมีความไวและความจำเพาะในการคัดกรองผู้สูงอายุ ที่เป็นโรคอัลไซเมอร์ตั้งแต่ระดับความรุนแรงน้อยถึงปานกลาง แบบคัดกรอง seven minute เหมาะที่จะนำไปใช้ ในสถานพยาบาลปฐมภูมิ เนื่องจากใช้ง่าย ใช้เวลาประเมินน้อย และบุคลากรทางการแพทย์สามารถใช้แบบประเมินนี้ได้โดยฝึกอบรมการใช้เพียงเล็กน้อย*