Research Report

Journal of INTERNATIONAL MEDICAL RESEARCH

Journal of International Medical Research
41(4) 1098–1110

DOI: 10.1177/0300060513484433
imr.sagepub.com
SAGE

Reliability and validity of a self-reported measure of medication adherence in patients with type 2 diabetes mellitus in Korea

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Abstract

Objective: This study examined the psychometric properties of the Korean version of the eight-item Morisky Medication Adherence Scale (MMAS-8) to measure adherence to diabetes medication in patients with type 2 diabetes mellitus.

Methods: The English version of the MMAS-8 was translated into Korean and administered to patient with type 2 diabetes mellitus via face-to-face interviews, conducted by an independent interviewer. Patient characteristics and glycosylated haemoglobin (HbA_{1c}) levels were assessed at the same clinic visit. A proportion of patients was randomly selected for 2-week test-retest reliability via telephone interviews. Convergent validity of the MMAS-8 against a four-item MMAS, correlations with HbA_{1c} levels and construct validity of the MMAS-8 were evaluated.

Results: In total, 317 patients were included; 70 completed the 2-week test–retest interview. Internal consistency reliability was moderate and test–retest reliability of the MMAS-8 was excellent, although a ceiling effect was detected. Good convergent validity was shown by the high correlation of the new scale scores with the original MMAS-4. A significant association was found between MMAS-8 scores and HbA_{1c} levels. Using glycaemic control as a gold standard, sensitivity was 74.1% and specificity was 38.3%. Explanatory factor analysis identified three dimensions of the scale.

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Conclusions: In light of acceptable reliability and validity, the MMAS-8 is a simple and quick method for the assessment of medication adherence among patient with type 2 diabetes mellitus, in a busy clinic setting.

Keywords
Eight-item Morisky Medication Adherence Scale, MMAS-8, medication adherence, self-report questionnaire, psychometrics, type 2 diabetes mellitus

Date received: 24 January 2013; accepted: 10 February 2013

Introduction

Nonadherence to prescribed medications for diabetes is associated with poor glycaemic control, which can lead to microvascular and macrovascular complications.[1] While effective oral hypoglycaemic agents and insulin have been developed, nonadherence to medical regimens is still a major behavioural problem in the management of patient with type 2 diabetes mellitus. For example, in some developed countries, adherence rates to therapy with oral hypoglycaemic agents (defined by the proportion of doses taken as prescribed during the follow-up period of 12, 24 or 36 months) ranged between 36% and 93%.[2] In some low- and middle-income countries, the proportion of persons self-reporting regular medication use ranged between 35% and 98%.[3] According to the Korean National Health and Nutrition Examination Survey in 2008, the mean diabetes medication adherence rates, measured by self-report of regular medication use, was 58%.[4]

Inadequate adherence with diabetes medication can be partly due to the complexity of the regimen, the frequency of dosing and the adverse events associated with treatment.[5] Physicians should be aware of medication adherence in their daily practice, in particular in chronic conditions such as type 2 diabetes mellitus. A simple, reliable and validated self-report instrument that can be used in routine clinical practice could lead to a better understanding of nonadherence and lay the groundwork for interventions aimed at increasing adherence to therapies.[6] In particular, in a busy practitioner's office and in many research settings, simplicity is essential for inclusion of an assessment of adherence as part of the provider–patient interaction.[7] It was for this purpose that the eight-item Morisky Medication Adherence Scale (MMAS-8) was developed. Although a self-report measure could have disadvantages such recall bias and overestimation,[8] this could be offset by its potential to modify barriers to medication adherence, and its simplicity (which makes it easy to administer in busy clinic settings).

The present study assessed the psychometric properties of a Korean language version of the MMAS-8 in type 2 diabetes mellitus; the MMAS-8 has already demonstrated good validity and reliability in primarily low-income, minority patients with hypertension.[9] The MMAS-8 has been validated in some studies in patients with type 2 diabetes mellitus,[10,11] postmenopausal osteoporosis,[12] hypertension[9,13] and those taking warfarin.[14] The psychometric examination of the Korean version of the MMAS-8 in a sample of patient with type 2 diabetes mellitus will contribute to the validation of the MMAS-8 and constitutes the first trial to validate the patient-reported medication adherence measure in Korea.

Patients and methods

Study population and design

The study was undertaken in the diabetes clinic of a large teaching hospital, Chung-Ang University Yongsan Hospital, Seoul, Republic of Korea, between May and September, 2010. Eligibility criteria were: age >30 years; ability to communicate in the Korean language; had received prescriptions for type 2 diabetes mellitus at the clinic more than once before the study began; had no indication of severe health problems such as cancer or chronic heart failure.

The study design for patient screening, selection, interview and data collection is outlined in Figure 1. During a normal clinic visit, patients were screened for eligibility by two physicians and patient with type 2 diabetes mellitus who met the eligibility criteria were selected. Eligible patients then underwent a face-to-face interview, conducted by an independent interviewer, who administered the study questionnaires and explained aims of this study and asked for their consent to participate. All interviews were conducted by the same interviewer.

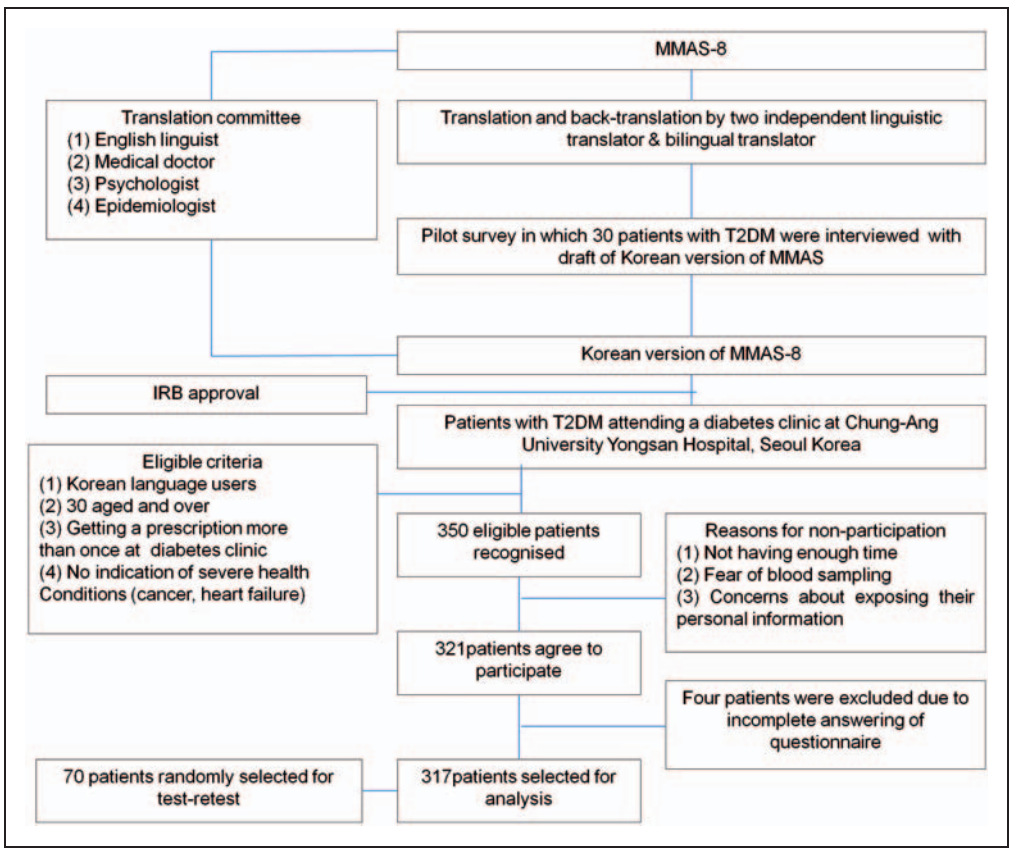

Figure 1. Study design for the development and psychometric testing of the eight-item Morisky Medication Adherence Scale (MMAS-8) in Korean people with type 2 diabetes mellitus (T2DM). IRB, Institutional Review Board.

The Institutional Review Board of Chung-Ang University Yongsan Hospital approved the protocol, survey instruments, and consent documents (IRB No. 10-023-04-07). Verbal informed consent was received from all patients.

Data collection

On the same day as the interview, blood samples were collected for immediate measurement of glycosylated haemoglobin (HbA_{1c}) levels. The HbA_{1c} level was measured using High-Pressure Liquid Chromatography Variant II analyzer (BioRad, Hercules, CA, USA) and levels were reported in accordance with recommendations of the National Glycohemoglobin Standardization Program (which is internationally recognized for its work in standardizing the HbA_{1c} assay) at the Department of Laboratory Medicine, Chung-Ang University Yongsan Hospital . Patient medical records provided clinical information, such as duration of type 2 diabetes mellitus, number of hypoglycaemic medications administered, whether or not the patient received insulin and the presence of diabetic complications. In addition, about one-fifth of the patients were selected by generating a random sample using SPSS® version 17,0 statistical software (SPSS Inc., Chicago, IL, USA), to participate in a 2-week reliability test–retest interview was undertaken via telephone, by the same interviewer who conducted the face-to-face interviews.

Instrument and translation

The MMAS-8 was developed from a previously validated four-item scale and supplemented with additional items addressing the circumstances surrounding adherence behaviour.[7,9] The theory underlying this measure was that failure of adherence to a medication regimen could occur due to several factors such as ''Do you sometimes forget to take your medication?'', ''Do you stop taking medications when feeling worse?'' and ''Do you feel hassled about sticking to a treatment plan?'' Each item measures a specific medication-taking behaviour and not a determinant of adherence. Items 1 to 7 were recorded as a yes/no dichotomous response and the last item was recorded using a 5-point Likert scale. MMAS-8 scores can range from 0 to 8 and have been trichotomized previously into three levels of adherence, to facilitate use in clinical practice: high adherence: MMAS score, 8; medium adherence: MMAS score $\geq$6 to <8; low adherence: MMAS score <6.

For this study, the 8-item MMAS, in which the term 'diabetes' was placed in each item, was translated into Korean using a forward and backward translation, as recommended for translation and adaptation of patient-centred outcomes measures (Figure 1).[15] First, the forward translation of the original English version of the MMAS-8 into Korean was undertaken by two qualified independent linguistic translators, who were both native speakers of Korean and proficient in English. Researchers reviewed the two primary versions and reached a consensus on a Korean draft version. Secondly, a bilingual expert, who is Korean–Canadian, translated the draft back into English. Translators and researchers compared the backward-translated English version with the original one in terms of conceptual equivalence. Thirdly, the translated questionnaire was distributed to 30 Korean people with type 2 diabetes mellitus, who completed the questionnaire and commented on the questions. These individuals were not included in the present study. The patients' comments were discussed by the researchers, and a final Korean version was completed and made available for the reliability and validity assessment.

Statistical analyses

A target sample size of 160 patients was estimated by a ratio (sample size : number of items) of 20 : 1, to provide good precision for the explainable factor analysis of a scale.[16] To overcome potential biased results and to increase outcome validity, the target size was doubled, resulting in a final sample size of 350 patients, allowing for 10% missing or incomplete responses.

The sociodemographic characteristics, clinical characteristics and MMAS-8 scores of the patients in this study were evaluated according to the MMAS-8 category (high, medium, or low adherence) that the patients obtained. The statistical significance of the characteristics and scores across the three adherence groups were calculated using a one-way analysis of variance, followed by Tukey's post hoc test and χ^2- test for continuous variables and categorical variables, respectively. Potential ceiling and floor effects, which may affect reliability and validity, were considered if >15% of respondents achieved the lowest and highest possible total scores (0 and 8, respectively).

Internal consistency of the MMAS-8 was assessed using Cronbach's α with corrected item-total correlations, and intraclass correlation (ICC) was used to assess test-retest reliability. Newly developed measures can be accepted with Cronbach's α of >0.5, otherwise 0.7 should be the threshold.[17] When a corrected item-total correlation coefficient value is <0.2, it indicates that the item contributes very little to the homogeneity of the scale.[18] ICCs were interpreted using the following criteria: ICC <0.4, poor; $0.4 < \text{ICC} < 0.75$, fair or good, $\text{ICC} > 0.75$, excellent.[19]

Convergent validity was evaluated using Pearson's correlation coefficient to assess the association between the MMAS-8 and the MMAS-4.[20] Three items from the MMAS-8 that are the same items as those of the previous 4-item scale were used to represent the original scale, because of concern regarding learning effect after the first administration resulting from the sequential administration of both scales looking like each other. These three items included, "Do you sometimes forget to take your diabetes pills?", "Have you ever cut back or stopped taking your medication without telling your doctor because you felt worse when you took it?" and "When you feel like your blood glucose is under control, do you sometimes stop taking your medicine?" Correlations were interpreted using the following criteria: 0–0.25, little or no correlation, 0.25–0.5, fair correlation, 0.5–0.7, moderate to good correlation and >0.75, very good to excellent correlation.[21]

The known-groups validity was assessed through the association of the MMAS-8 categories (high, medium, and low adherence) and HbA_{1c} levels ($\geq$7% and <7%) using the χ^2-test. Additionally an odds ratio (OR) adjusted by sex, age, education, duration of diabetes, presence of diabetic complications and the number and type of medication, for the association between MMAS-8 categories and HbA_{1c} levels was calculated using multiple logistic regression analysis. To provide helpful information in clinical practice, the following were also determined: (i) the sensitivity, as true positive : poorly controlled ($HbA1c \geq 7\%$) indicates low adherence ($MMAS < 6$); (ii) the specificity, true negative : well controlled ($HbA1c < 7\%$) indicates medium to high adherence ($6 \leq MMAS \leq 8$); (iii) the positive (patients with low adherence are poorly controlled) and negative (patients with medium to high adherence are well controlled) predictive values.

Both confirmatory factor analysis (CFA) and explanatory factor analysis (EFA) were used to examine the structural validity of the Korean version of the MMAS-8. First, CFA was employed to evaluate the absolute and relative fit of the scale that was a one-factor model in previous studies. Indices that were

used to assess the fit of the model included: (i) χ^2-value/degree of freedom (df); (ii) the goodness-of-fit index (GFI); (iii) the root mean square error of approximation (RMSEA); (iv) the normed fit index (NFI); (v) the non-normed fit index (NNFI); (vi) the relative fit index (RFI); (vii) the comparative fit (CFI). The goodness-of-fit criteria[22] for each index are as follows: $\chi^2/df < 5$, GFI, NFI, NNFI, RFI and CFI > 0.9 and RMSEA < 0.05. Secondly, EFA was applied to identify any factors unique to Korean patient with type 2 diabetes mellitus sample data. EFA-principal component analysis (PCA) with varimax rotation was used and only factors with eigenvalue >1 were considered to contribute significantly to explaining the variance. Factor loading >0.3 on each item was considered to belong to the corresponding factors.[23] All analyses were performed using IBM® SPSS® Amos™ software, version 20.0 (IBM Corporation, Somers, NY, USA) for Windows. A P-value <0.05 was considered statistically significant.

Results

Demographic and clinical characteristics

A total of 350 patients with type 2 diabetes mellitus were eligible and 321 (91.7%) of the patients who were approached agreed to participate (Figure 1). The reasons 29 patients did not agree to be involved were: not having enough time to get involved in the survey ($n = 19$); fear of blood sampling ($n = 3$); being unwilling to expose their personal information ($n = 2$); other reasons ($n = 5$). Of the 321 patients, 98.8% (317) were selected for analysis and 70 were randomly selected (and agreed to) the test–retest telephone interview. The characteristics of the total sample and adherence groups are shown in Table 1. There were no significant differences across the three adherence groups in terms of sex, education, duration of diabetes, number of diabetic complications, and the number, type and use of fixed combination types of hypoglycaemic drugs. Significant differences were observed only between the high- and low-adherence groups for age and HbA_{1c} levels ($P < 0.05$); older patients and those with lower HbA1c were more adherent to their diabetes medication.

MMAS-8 scores

As shown in Figure 2, the MMAS-8 scores were skewed, with a median of 6.75 (range 0.75 – 8.0). A ceiling effect was observed, as almost one-third ($n = 98$) of the subjects achieved a maximum score of 8. The distribution of responses to each question of the MMAS-8 is shown in Table 2. Just over half of the patients did not forget to take their diabetes medications and had no days when they had not taken their medications in the previous 2 weeks. Additionally, >90% of the respondents had taken their diabetes medications the day before the interview, did not stop or reduce their diabetes medication of their own free will when they felt worse or better, and most of the respondents 'never' or 'rarely' (92.7%) had difficulty remembering to take their diabetes medications.

Reliability

Cronbach's α (for indicating internal consistency) was 0.66 for the Korean MMAS-8, which is slightly below the generally acceptable value 0.7 but much higher than 0.5: item-total correlation coefficients ranged between 0.230 and 0.658, with all of them being above 0.2 (Table 2). For test–retest reliability, however, the MMAS-8 showed an excellent ICC of 0.79 ($P < 0.001$).

Table 1. Demographics and clinical characteristics of patients with type 2 diabetes mellitus who completed the Korean version of the eight-item Morisky Medication Adherence Scale (MMAS-8) questionnaire, stratified according to level of adherence.

Characteristics	Total sample $n = 317$	High adherence, MMAS = 8 $n = 98$	Medium adherence, 6 ≤ MMAS < 8 $n = 87$	Low adherence, MMAS < 6 $n = 132$
Age, years[a]	59.3 ± 11.2 (28–90)	62.3 ± 11.1 (30–87)	59.8 ± 11.7 (33–84)	56.8 ± 10.3 (28–90)
Sex				
Male	195 (61.5)	57 (58.2)	57 (65.5)	81 (61.4)
Female	122 (38.5)	41 (41.8)	30 (34.5)	51 (38.6)
Education,				
None	16 (5.1)	5 (5.1)	7 (8.0)	4 (3.0)
6th grade or lower	63 (19.9)	26 (26.5)	17 (19.5)	20 (15.2)
7th ~ 12th grade	135 (42.6)	30 (30.6)	36 (41.4)	69 (52.3)
College 2–4 year	87 (27.4)	33 (33.7)	23 (26.4)	31 (23.5)
Graduated from college	16 (5.1)	4 (4.1)	4 (4.6)	8 (6.1)
Duration of diabetes, months	49.4 ± 48.6 (0.8–280.5)	56.7 ± 53.7 (0.9–280.5)	46.5 ± 47.7 (0.8–257.7)	45.8 ± 44.8 (0.9–255.5)
Number of diabetic complications,				
0	283 (89.3)	89 (90.8)	82 (94.3)	112 (84.8)
1	30 (9.5)	9 (9.2)	4 (4.6)	17 (12.9)
2	4 (1.3)	0 (0)	1 (1.1)	3 (2.3)
Number of hypoglycaemic drugs[b]	2.0 ± 0.9 (1–5)	1.9 ± 0.8 (1–5)	1.9 ± 0.8 (1–4)	2.1 ± 0.9 (1–5)
Type of hypoglycaemic drugs,				
Only oral drugs	278 (87.7)	84 (85.7)	76 (87.4)	118 (89.4)
Oral drug plus insulin	39 (12.3)	14 (14.3)	11 (12.6)	14 (10.6)
Use of fixed combination drug				
Yes	24 (7.6)	4 (4.1)	6 (6.9)	14 (10.6)
No	293 (92.4)	94 (95.9)	81 (93.1)	118 (89.4)
HbA_{1c}, %[a]	7.5 ± 1.2 (5.6–11.9)	7.2 ± 1.1 (5.6–11.4)	7.4 ± 1.2 (5.7–10.6)	7.8 ± 1.4 (5.8–11.9)

Data presented as mean ± SD (range) or *n* (%) patients.

[a]Statistically significant differences just between high and low adherence groups were found using Tukey's post hoc test for one-way analysis of variance ($P < 0.05$).

[b]Hypoglycaemic drugs (prescription rates are the percentage of patients receiving each drug [total of 317 subjects]): metformin ($n = 274$; 86.4%), sulphonylurea ($n = 179$; 56.5%), dipeptidyl peptidase-4 inhibitor ($n = 79$; 24.9%), alpha-glucosidase inhibitor ($n = 38$; 12.0%), thiazolidione ($n = 21$; 6.6%), glinide ($n = 9$; 2.8%).

MMAS-8, eight-item Morisky Medication Adherence Scale; HbA_{1c}, glycosylated haemoglobin.

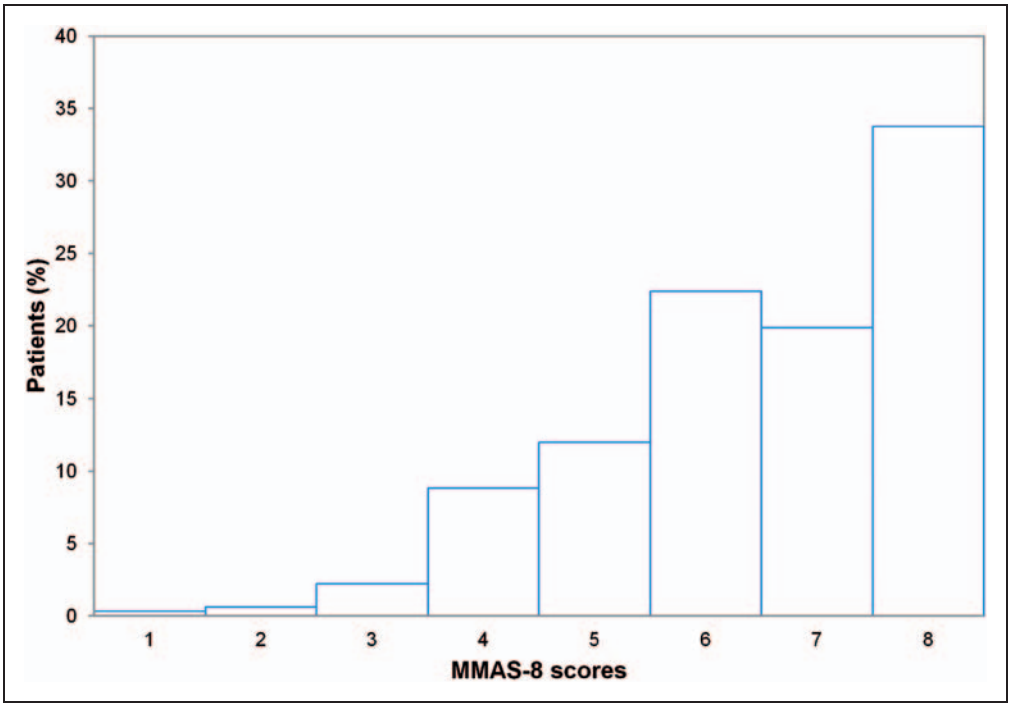

Figure 2. Distribution of the eight-item Morisky Medication Adherence Scale (MMAS-8) scores in 317 Korean patients with type 2 diabetes mellitus, who completed the questionnaire as part of psychometric evaluation of the scale.

Convergent validity

The MMAS-8 was positively associated ($r = 0.88$; $P < 0.01$), and had excellent correlation with, the original MMAS-4.

Known-groups validity

As shown in Table 3, the χ^2-test showed a significant relationship between the adherence levels, as determined by the MMAS-8, and glycaemic control ($\chi^2 = 10.05$, $P < 0.01$). Poor glycaemic control (HbA1c $\geq$7%) was twice as prevalent in the low-adherence group (MMAS-8 score < 6) compared with the high-adherence group (MMAS-8 ≥ 6; adjusted OR 2.00, 95% confidence interval [CI] 1.21, 3.36).

Sensitivity and specificity

The MMAS-8 showed poor or moderate sensitivity and specificity. As the cut-off point was 6 (low adherence = MMAS-8 score < 6), sensitivity, specificity, positive predictive and negative predictive values of the MMAS-8 were 48.6%, 68.8%, 69.7%, and 47.6%, respectively. This sensitivity means that 92 (48.6%) of 189 diabetic patients who had poor glycaemic control had low adherence, while the specificity indicates that 88 (68.8%) of 128 patients with good glycaemic control were moderately ($6 \leq$ MMAS-8 score < 8) or highly (MMAS-8 score = 8) adherent to their medication. The positive predictive value indicates that 92 (69.7%) of 132 subjects with

Table 2. Responses, internal reliability and exploratory factor analysis for items from the eight-item Morisky Medication Adherence Scale, administered to 317 patients with type 2 diabetes mellitus.

	Patient responses[a]					Internal reliability[b]		Exploratory factor analysis[c]		
Items 1 to 7	No				Yes	Corrected item –total correlation	Cronbach's α if item deleted	Factor 1	Factor 2	Factor 3
1. Do you sometimes forget to take your diabetes medications?	168 (53.0)				149 (47.0)	0.526	0.572	**0.858**	0.013	−0.062
2. Over the past 2 weeks, were there any days when you did not take your diabetes medicine?	186 (58.7)				131 (41.3)	0.433	0.607	**0.581**	0.255	−0.039
3. Have you ever cut back or stopped taking your diabetes medicine medication without telling your doctor because you felt worse when you took it?	294 (92.7)				23 (7.3)	0.230	0.653	0.021	**0.808**	0.008
4. When you travel or leave home, do you sometimes forget to bring along your diabetes medications?	256 (80.8)				61 (19.2)	0.374	0.621	**0.657**	−0.064	0.150
5. Did you take your diabetes medicine yesterday?	26 (8.2)				291 (91.8)	0.251	0.649	0.297	**0.335**	−0.699
6. When you feel like your blood glucose is under control, do you sometimes stop taking your diabetes medicine?	298 (94.0)				19 (6.0)	0.292	0.643	0.113	**0.760**	−0.022
7. Taking medication every day is a real inconvenience for some people. Do you ever feel hassled about sticking to your diabetes treatment regimen?	243 (76.7)				74 (23.3)	0.280	0.650	0.331	0.279	**0.740**
Item 8	Never	Rarely	Sometimes	Often	Always	0.658	0.607	**0.835**	0.157	−0.019
How often do you have difficulty remembering to take all your diabetes medications?	145 (45.7)	149 (47.0)	21 (6.6)	−0 (0.0)	2 (0.6)					

[a]Data presented as *n* (%) of patients.

[b]Cronbach's α was 0.659 for the total scale.

[a]Factor loading in 317 patients. Bold-faced numbers indicate factor loadings > 0.3.

Table 3. Relationship between the eight-item Morisky Medication Adherence scale (MMAS-8) and glycaemic control.in 317 patients with type 2 diabetes mellitus[a,b].

Parameter	HbA1c ≥ 7% poor control	HbA1c < 7% good control	Total, *n*
Low adherence, MMAS < 6	92 (69.7)	40 (30.3)	132 (100)
Medium adherence, 6 ≤ MMAS < 8	48 (55.2)	39 (44.8)	87 (100)
High adherence, MMAS = 8	49 (50.0)	49 (50.0)	98 (100)
Total, *n*	189 (59.6)	128 (40.4)	317 (100)

Data presented as *n* (%) of patients.

[a]Relationship between adherence level and HbA_{1c}: $\chi^2 = 10.05$; $P < 0.01$.

[b]Adjusted odds ratio of low adherence group to medium and high adherence groups for poor glycaemic control = 2.00 (95% CI 1.20, 3.34); multiple logistic regression analysis controlling sex, age, education, duration of diabetes, presence of diabetes complications, the number and type of medication and use of fixed combination drugs.

low adherence were poorly controlled, whereas the negative predictive value means that 88 (47.6%) of 185 patients with medium-to-high adherence had good glycaemic control (Table 3). When the cut-off score of low adherence was changed from 6 to 7 (low adherence, MMAS-8 scores < 7), sensitivity, specificity, positive predictive and negative predictive values were 65.1%, 54.7%, 68.0% and 51.5% respectively. Similarly, if the cut-off score was raised to 8 (low adherence, MMAS-8 scores < 8), the sensitivity, specificity, positive predictive and negative predictive values were 74.1%, 38.3%, 63.9%, and 50.0%, respectively.

Construct validity

The CFA for one-factor model of the MMAS-8 showed a poor fit on absolute and comparative fit indices, which were as follows: $\chi^2/df = 9.73$, GFI = 0.82, RMSEA = 0.17 NFI = 0.47, TLI = 0.44, RFI = 0.47 and CFI = 0.49. Exploratory factor analysis showed three factors with eigenvalues >1, which explained 62.4% of the total variance. Factor loadings between the eight items of the MMAS and the three factors are presented in Table 2. Factor 1 is comprised of items 1, 2, 4, and 8, which mostly involved patients forgetting to take medications. Factor 2 consisted of items 3, 5 and 6, which concerned patients stopping medications when they were feeling better or worse. Factor 3 included item 7, in which daily taking of the medication was viewed as a difficulty. Factor 1 had the highest correlation with the MMAS-8 ($r = 0.925$; $P < 0.01$), followed by Factor 2 ($r = 0.72$; $P < 0.01$) and factor 3 ($r = 0.52$; $P < 0.01$).

Discussion

The main objective of the present study was to report the reliability and validity of the translated Korean version of the MMAS-8 in a sample of patients with type 2 diabetes mellitus. To the best of our knowledge, this paper is the first to translate and validate the MMAS-8 into the Korean language, systematically. In addition, only two studies[10,11] previously conducted in patients with type 2 diabetes mellitus have used the MMAS-8.

The MMAS-8 had varied reliability (Cronbach's $\alpha = 0.54 - 0.83$) in previous studies.[9–14] The moderate reliability (Cronbach's $\alpha = 0.66$) in the present study might be due to the low variability of the scale scores, with ~30% of the participants achieving the highest scale score of eight. Internal consistency can be improved with greater variability among scale scores[18] that

would occur in a population with different levels of adherence. In addition, since seven of the eight items on the scale used binary responses (yes/no), which tend to lower Cronbach's α value,[18] internal consistency reliability may be improved by increasing the number of response choices. It was, however, debatable because this procedure was tested on the Morisky, Green and Levine scale,[20] with no difference in internal consistency being observed. Given that the value of Cronbach's α indicating a minimally accepted level could be as low as 0.5,[17,18] internal consistency of the Korean version does not seem to be problematic.

On the other hand, the MMAS-8 displayed excellent test–retest reliability, indicating good stability of the scale over time, which is similar to results observed in other studies.[10–12] Convergent validity was supported by significant correlation with the previous MMAS-4, as shown in other studies.[10–12]

For known-groups validity, a significant association between the adherence levels of the MMAS-8 and glycaemic control indicated that the scale was able to differentiate between patients whose blood glucose was (or was not) controlled, using HbA1c levels. The previous two studies with patients with type 2 diabetes mellitus also showed a significant association between adherence levels and glycaemic control. [10,11] In addition, an adjusted OR of low adherence to poor glycaemic control, which took into consideration confounding variables for those associations, was statistically significant.

Criterion related validity (using glycaemic control as a gold standard) was, however, low or moderate in our study, and was similar to what has been reported elsewhere.[10,11] One explanation for such an unsatisfactory criterion related validity could be the fact that a number of factors other than adherence to diabetes medication regimens (e.g. genetic variation, dietary intake, exercise) can affect glycaemic control. Another explanation could be the overestimation of adherence levels by recall bias and social desirability. Recall bias might occur as adherence increases just before clinic appointments, which may have a large effect on their recall when the questionnaire was being administrated.[24,25] Social desirability might intervene in answering some questions in the present study. Because intentional medication non-adherence (e.g. stopping taking diabetes medications when feeling worse) was much lower than unintentional medication non-adherence (e.g. forgetting to take diabetes medication), patients could answer the questions in a way that resulted in high MMAS scores, even though their glycaemic control was less than satisfactory.[25,26] The increase of the cut-off score of low adherence from 6 to 8 could lead to the improvement of sensitivity at the expense of a drop in specificity. It may be recommended because, in clinical practice, healthcare providers are more interested in identifying patients with both poor glycaemic control and low adherence than well-controlled patients with high adherence.

The CFA also confirmed that a unidimensional structure of the MMAS-8 (which has also been described by others[9,12–14]) showed a poor fit in the present study. The explanatory factor analysis with varimax rotation showed that the MMAS-8 had three factors with eigenvalues >1, such as Factor 1 (items 1, 2, 4, and 8), Factor 2 (items 3, 5, and 6), and Factor 3 (item 7) and was similar to the Thai version in patients with type 2 diabetes mellitus.[10] Theoretically the MMAS-8 is measuring a specific medication-taking behaviour leading to failure of medication adherence, not a determinant of adherence behaviour.[9] It indicates that this measurement could theoretically have more than one factor. In this regard, it seems not to be surprising that the MMAS-8 showed three factors in this study, as well as in the Thai version.[10]

In conclusion, the present study showed acceptable reliability and validity for the Korean language MMAS-8 in measuring adherence to diabetes medication. This score would, therefore, be suitable for use in a busy clinic setting in Korea. Moreover, it could help to identify and develop targeted interventions to improve adherence, using a teachable moment. For instance, for patients classified as having low adherence to medications with poor blood glucose control, a physician could provide tailored counselling to facilitate medication-taking behaviour, such as placement of pill containers near daily hygiene activities. Alternatively, for the patients with high adherence and poor blood glucose control, a change in therapy may be considered, to achieve appropriate blood glucose control. Further studies are needed to investigate the psychometric properties of the scale, in other settings or in other patient populations.

Declaration of conflicting interest

The authors declare that there are no conflicts of interest.

Funding

This research was supported by funding from the research of Korea Centres for Disease Control and Prevention (code 2010E0071700).

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