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Education effects on cognitive function in a healthy aged Arab population

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ABSTRACT

Background: The Mini-mental State Examination (MMSE) has not been validated in Arabic speaking populations. The Brookdale Cognitive Screening Test (BCST) has been developed for use in low schooling populations. We investigated the influence of gender, education and occupation in a cognitively normal community sample which was assessed using an Arabic translation of the MMSE and the BCST.

Methods: Cognitively normal subjects (n = 266, 59.4% males, mean age (SD): 72.4 (5.5) years) from an Arab community in northern Israel (Wadi Ara) were evaluated. Education was categorized into levels: 1 = 0–4 years, 2 = 5–8 years, 3 = 9–12 years. Effects of gender, education and occupation on MMSE and BCST were analyzed by ANOVA, taking age as a covariate.

Results: The mean MMSE score of males [26.3 (4.1)] was higher than that of females [23.6 (4.2) points]. Two-way ANOVA showed a significant interaction between gender and education on MMSE ($p = 0.0017$) and BCST scores ($p = 0.0002$). The effect of gender on MMSE and BCST was significant in education level 1 ($p < 0.0001$, both tests) and level 2 ($p < 0.05$, both tests). For education level 1, MMSE and BCST scores were higher for males, while both scores were higher for females in education level 2. The effect of occupation was not significant for both genders.

Conclusion: Education and gender influence performance when using the Arabic translation of the MMSE and BCST in cognitively normal elderly. Cognitively

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normal females with 0–4 years of education scored lower than males. These results should be taken into consideration in the daily use of these instruments in Arabic.

Key words: Mini-mental State Examination, MMSE, cognitive, Arabic, elderly, gender, education

Introduction

Dementia is a major health problem worldwide because of the fast-growing elderly population. The validation of appropriate assessment instruments is an important starting point for ensuring adequate delivery of health care to older people (Rait *et al.*, 1996). These instruments should be reliable, valid, sensitive and specific for dementia, culturally and linguistically appropriate to the population, usable with illiterate subjects, and comparable in reference to western populations. Besides age, demographic variables, including educational levels, are influential (Li *et al.*, 1991; Chandra *et al.*, 2001; Hendrie *et al.*, 2001). Despite the known flaws of the Mini-mental State Examination (MMSE) (Folstein *et al.*, 1975; Teng and Chui, 1987; Tombaugh and McIntyre, 1992), it remains the most widely used brief cognitive test in clinical practice, clinical research, and epidemiological studies (Bleecker *et al.*, 1988; Bravo and Hebert, 1997).

To our knowledge, a validated Arabic translation of the MMSE has not yet been published. A major challenge to studying cognitive function in Arabic populations is the need for dementia screening instruments that are in Arabic, are culturally appropriate, are suitable for testing individuals with different levels of schooling, and are comparable to the tests being used in the reference Western population.

The aim of this study is to describe the distribution of MMSE scores obtained using the Arabic translation in cognitively normal elderly subjects for different education levels in both genders, and to compare MMSE performance with data from the Brookdale Cognitive Screening Test (BCST), developed in Israel for use in populations with high illiteracy rates (Davies, 1987). This test includes items on orientation, language, memory, attention, naming, abstraction, concept formation, attention, praxis, calculation, right left orientation, and visuospatial orientation.

Methods

Study population

Wadi Ara (the Ara Valley located in northern Israel) has a population of 81,400 Arab inhabitants of whom 51% are men. The elderly cohort (≥65 years) included 2067 residents (2.5%) on prevalence day (1 January 2003), according to the

Israel Central Statistics Bureau. Between January 2003 and June 2005, we systematically approached a subset of 442 elderly subjects living in consecutive houses. The present study reports the results of cognitively normal elderly subjects.

The study was performed under the approval of the Helsinki Committee of the Hillel Yaffe Medical Center, the Israel Ministry of Health and was reviewed by the Institutional Review Boards of University Hospitals of Cleveland, Case Western Reserve University and Boston University. All participants signed a written consent form in Arabic. Where a subject was illiterate, the interviewer read aloud the consent form to the subject, who then signed by fingerprint of the first digit of the right hand.

Subject evaluation

This work is part of an epidemiological study of brain aging-related disorders in Wadi Ara. All subjects are evaluated for cardiovascular risk factors by using questionnaires concerning activities of daily living, life-style and cognitive function. All participants were examined in their homes by a team including a neurologist, a social worker and an academic nurse, all of whom were native Arabic speakers. Elderly subjects in Wadi Ara never reside alone; they live either with their spouse or in the home of one of their children. None was institutionalized. All subjects were first approached by the nurse. An interview with a relative who knew the subject well (usually the spouse or a child) captured information about the person's medical and family history, medication use and activities of daily living. The informant interview also ascertained the history of changes in behavior, cognitive abilities, and performance of daily living, occupational and recreational activities. In a second visit, the neurologist performed a complete neurological examination and the motor part of the Unified Parkinson's Disease Scale (UPDRS) for all subjects. Subjects who demonstrated impairment were further evaluated by the Hamilton Depression Score and the Geriatric Daily Activities Score. Four neurologists reviewed the results in a bi-monthly consensus conference, and in the case of those subjects who were impaired, they generated a consensus diagnosis.

A subject was defined as cognitively normal if there were no complaints about memory impairment or any other cognitive domain and no evidence of such disturbance according to surrogates or neurological examination, and no evidence of impairment in the activities of daily living stemming from cognitive disturbances.

Cognitive evaluation instruments

Arabic translations of the MMSE (maximum score = 30) and BCST (maximum score = 24) were used. The BCST was developed at the Brookdale Institute of Gerontology, Jerusalem for use in populations with high illiteracy rates (Davies, 1987). Questionnaires about occupation focused on both present and past working activities. Occupation type was categorized for statistical analysis purposes as follows: 1 = never worked outside the house, or housewife; 2 = handy work (trader in shop, cook, carpenter, builder, etc); 3 = agriculture; 4 = office (secretary, accountant, post office worker, teacher). Since MMSE involves a task that uses a word, a task for writing a sentence and reading, these items scored 0 in subjects with 0 years of schooling.

Statistical analysis

Statistical analyses were performed using SAS (Statistical Analysis Software). Education level was treated as an ordinal variable by grouping the subjects by years of formal schooling, in accordance with previous studies on MMSE (Crum *et al.*, 1993) as follows: 1 = 0–4 years, 2 = 5–8 years, 3 = > 8 years. Since only four subjects had >12 years of education, we defined education level 3 as 9–12 years and calculated the means of MMSE and BSCT at education level 3 accordingly. Proportions of subjects within different education levels by gender were compared using the χ^2 test for independence.

The means of MMSE and BCST scores for each gender and level of education were compared by Analysis of Covariance, treating age as a covariate. When a significant interaction between education and gender was found, the difference between scores of males and females within a given education level were compared using the Student's t-test. Correlation between MMSE and BCST scores was analyzed by Spearman correlation.

Differences between MMSE and BCST scores for different occupations and genders were analyzed using ANOVA. Means of MMSE and BCST scores of different occupation types and education levels were compared separately for males and females by Student's t-test. We corrected alpha for multiple comparisons (Bonferroni) to 0.05/4 = 0.0125.

Results

Of the 442 subjects that were approached, 438 agreed to participate in the study (refusal rate 0.9%). Four were excluded due to severe systemic non-neurological disease. Of the remainder, 266 subjects were cognitively normal and these subjects constituted the study group. There were 158 males (59.4%) and 108 females (40.6%).

Effect of age

The mean age of the cohort was 72.4 (5.5). The mean age (SD) of males was 72.8 (5.6) years and of females 71.6 (5.4) years (not significantly different,

$p > 0.1$). Regression analysis showed that age significantly affected MMSE scores ($R^2 = 0.03$, $p = 0.003$) and BCST ($R^2 = 0.03$, $p = 0.004$). We found a significant effect of age on MMSE for males [$F = 12.98$, d.f. (1, 152), $p = 0.0004$) but not for females [$F = 0.96$, d.f. (1, 104), $p > 0.1$). A similar finding was observed for the BCST for males [$F = 12.73$, (d.f. (1, 152), $p = 0.0005$), but not for females [$F = 0.52$, d.f. (1, 104), $p > 0.1$).

Effect of gender and education

The mean MMSE score of the population was 25.2 (4.4); 26.3 (4.1) for males; 23.6 (4.2) for females, $p < 0.0001$ (compared to males). The mean BCST score of the population was 19.1 (4.2), 20.3 (3.8) for males, 17.3 (4.0) for females ($p < 0.0001$).

The mean number of school years was 4.0 (3.6) years (range 0–20 years). The distribution of education levels for each gender was as follows: education level 1 = 46% of males (n = 72), 84% of females (n = 90); level 2 = 40% of males (n = 62), 15% of females (n = 17), level 3 = 12% of males (n = 18), 0.1% of females (n = 1). The proportions of males and females for each education level significantly differed ($\chi^2 = 39.95$, d.f 2, $p < 0.0001$).

Since MMSE and BCST were significantly influenced by age, we used age as covariate. Two-way ANCOVA taking age as covariate showed a significant interaction between gender and education for MMSE ($F = 6.51$, d.f. (2, 258), $p = 0.0017$ and Brookdale scores ($F = 8.75$, d.f. (2, 258), $p = 0.0002$). The difference between mean MMSE for males and females (Table 1, Figure 1) was significant in education level 1 [males 25.0 (4.8), females 22.5 (3.8); $F = 16.83$, d.f. (1, 159), $p < 0.0001$] and education level 2 [males 27.2 (3.0), females 28.9 (1.4); $F = 4.77$, d.f. (1, 159), $p = 0.032$]. A similar result was observed (Table 1, Figure 1) for BCST scores at education level 1 [males 19.2 (4.5), females 16.2 (3.5; $F = 26.15$, d.f. 1, $p < 0.0001$] and level 2 [males 20.9 (3.1), females 22.5 (1.7); $F = 4.55$, d.f. 1, $p = 0.036$).

Both MMSE and BCST scores of females were lower than those of males in education level 1, but were significantly higher than those of males in education level 2, hence the significant interaction. The significant interaction between education and gender is a reflection of the lower mean MMSE and BCST scores of one gender than those of the other gender in education level 1, but the order is reversed in education level 2 (Figure 1). There were not enough females at education level 3.

Effect of gender and occupation

The distribution of occupational categories within each educational level for each gender is shown in Table 2. Data on occupation were missing for 19 subjects. ANOVA revealed a significant interaction between occupation and gender for

Table 1. MMSE and BCST scores by education level and gender

GENDER	MEAN (SD) MMSE	95% CI#	MEAN (SD) BCST	95% CI#
Education level 1 (0–4 years)				
Male	25.0 (4.8)	15–30	19.2 (4.5)	10–24
Female	22.5(3.8)*	15–30	16.2 (3.5)*	10–23
##English norms per age groups: 65–74 = 22(2), 75–79 = 21(2), 80–84 = 20(2), > 85 = 19(3)				
Education level 2 (5–8 years)				
Male	27.2 (3.0)	21–30	20.9 (2.8)	15–24
Female	28.9 (1.7)**	26–30	22.5 (1.7)**	19–24
##English norms per age groups: 65–74 = 26(2), 75–79 = 25(2), 80–84 = 25(2), >85 = 23(3)				
Education level 3 (9–12 years)				
Male	27.8 (3.8)	26–30	22.3 (2.9)	18–24
Female	30.0	–	24.0	–
##English norms per age groups: 65–70 = 28(1), 70–80 = 27(2), 80–84 = 25(2), > 85 = 26(2)				

*Significantly lower than males ($p < 0.05$).
**Significantly higher than males ($p < 0.05$).
#The upper confidence limit exceeded the maximum possible score. Therefore, it was truncated at 30 for MMSE and 24 for BCST.
##Mean (SD) scores of norms of MMSE in the U.S.A. per age group (Crum *et al.*, 1993).

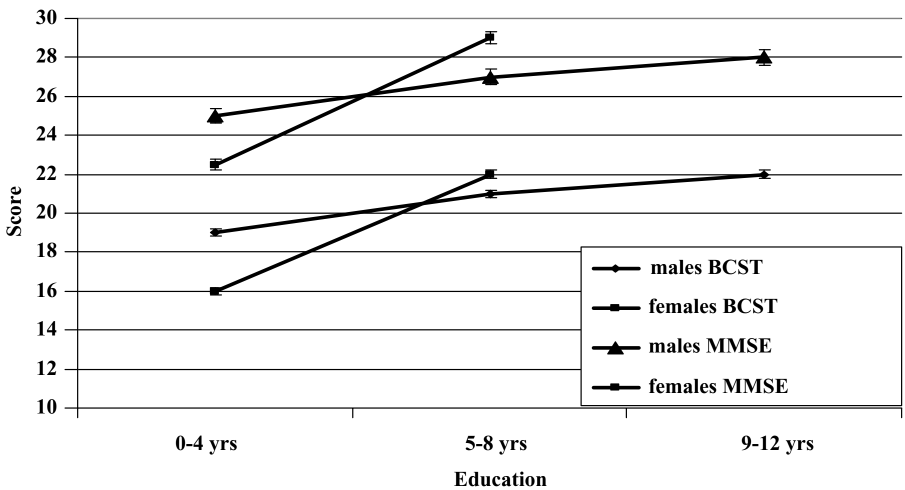

Figure 1. The mean values of MMSE and BSCT scores are shown for each education level for each gender separately. The vertical bars indicate the standard error values. The scores are significantly lower for females in education level 1 and significantly higher for education level 2. Education level 3 is not shown for females ($n = 1$).

Table 2. Occupational categories by education level and gender (n (%))

GENDER	NO WORK/ HOUSEWIFE	HANDY	AGRICULTURE	OFFICE
Education level 1 (0–4 years)				
Male	2 (3)	25 (35)	37 (52)	7 (10)
Female	22 (27)	7 (9)	53 (67)	0
Education level 2 (5–8 years)				
Male	1 (2)	25 (45)	26 (46)	4 (7)
Female	2 (13)	6 (38)	7 (44)	1 (6)
Education level 3 (9–12 years)				
Male	0	7 (40)	5 (29)	5 (29)
Female	0	1 (100)	0	0
Total				
Male	3 (2)	57 (40)	68(47)	16 (11)
Female	24 (24)	14 (14)	60 (60)	1 (1)

MMSE scores ($F = 3.84$, d.f. $(3, 238)$, $p = 0.013$) and BCST scores ($F = 3.57$, d.f. $(3, 238)$, $p = 0.015$). We therefore compared the mean MMSE and BCST scores between occupations separately for males and females. Since occupation types and education levels are interrelated, we added education level to our model; hence we used a two-way ANOVA to compare the means of MMSE and BCST scores of different occupations within each education level, separately for males and females. There were only two males who did not work and only one female in office work. We therefore excluded these subjects from the analysis.

Two-way ANOVA with the two factors of education and occupation types showed that for males, MMSE scores were significantly different for different education levels ($F = 4.12$, d.f. $(1, 118)$, $p = 0.048$). The effect of occupation was not significant. BCST scores were not significantly different for education and occupation groups (Table 3). For females, mean MMSE scores [$F = 18.65$, d.f. $(1, 89)$, $p < 0.0001$] and BCST scores [$F = 21.51$, d.f. $(1, 89)$, $p < 0.0001$] were significantly different for education levels, but not for occupation.

Correlation between MMSE and BCST

There was a highly significant correlation between MMSE and Brookdale scores in the entire group ($r = 0.852$, $p < 0.0001$). This correlation was of the same magnitude for both genders (men: $r = 0.8223$; women: $r = 0.854$, $p < 0.0001$, both). The mean MMSE score of males was 26.3 (4.2) and of females 23.6 (4.2) points (see Table 1). The mean BCST scores of males was 20.3 (3.8) and of females 17.3 (4.0) (see Table 1).

Table 3. MMSE and BCST scores by education level, gender and occupation category (mean (SD))

GENDER	NO WORK/ HOUSEWIFE	HANDY	AGRICULTURE	OFFICE
(1) MMSE scores				
Education level 1 (0–4 years)				
Male	21.5 (2.1)	25.2 (4.7)	24.9 (5.3)	26.8 (3.3)
Female	23.7 (3.8)	26.1 (2.0)	22.0 (3.7)	–
Education level 2 (5–8 years)				
Male	19.0 (–)	27.3 (2.6)	27.1 (3.1)	28.8 (1.5)
Female	29.0 (1.4)	28.5 (2.0)	29.3 (1.1)	29.0 (–)
Education level 3 (9–12 years)				
Male	28.9 (1.2)	28.9 (1.2)	25.2 (6.0)	28.6 (2.6)
Female	–	30.0 (–)	–	–
(2) BCST Scores				
Education level 1 (0–4 years)				
Male	14.5 (0.7)	19.7 (3.4)	18.4 (5.0)	21.2 (2.9)
Female	17.9 (3.6)	18.4 (4.0)	15.5 (3.1)	–
Education level 2 (5–8 years)				
Male	16.0 (–)	21.6 (2.5)	20.6 (2.7)	22.0 (2.5)
Female	21.5 (0.7)	22.5 (2.0)	22.6 (1.8)	24.0
Education level 3 (9–12 years)				
Male	23.6 (0.8)	23.8 (0.8)	19.8 (4.3)	23.0 (1.7)
Female	–	24.0	–	–

Discussion

We describe normative data for of the Arabic translations of the MMSE and of the BCST. Mean values of the MMSE scores were comparable to population-based norms described for MMSE in English in the U.S.A. at all correspondent education levels (see Table 1) (Crum *et al.*, 1993).

We observed a divergent effect of gender at different education levels. Our results showed that at low schooling (≤ 4 years) females perform significantly worse than males. However, with education of more than 4 years, females perform significantly better than males. A possible explanation could be that in the studied generation, girls who were intellectually privileged were given the possibility of spending more years in education, while boys had the opportunity to study routinely. This might have generated selection bias for women in the higher education level group.

To our knowledge, a validated Arabic translation of the MMSE has not yet been published. Al-Rajeh *et al.*, (1999) used a modified version of the MMSE in Arabic in a group of 37 subjects (cognitively preserved and demented) and found that females had significantly lower scores than males, suggesting a possible effect of limited education in females. Reading levels show highest correlation with MMSE scores, even more prominently than education (Weiss *et al.*, 1995). In that study, only a small proportion of the subjects had a zero reading level, while in our population the majority of females were illiterate.

In our study within the same education level, females had lower scores, suggesting additional factors beyond education. One of them could be the different social exposure and life-style of males versus females in this cultural group. Until recently, Arab women were underprivileged in terms of education and employment (Okun and Friedlander, 2005). We verified whether working in the community might contribute to the performance. We found that MMSE scores are influenced by education and not by occupation within genders. Frisoni *et al.* (1993) found a correlation between principal lifetime occupations with MMSE scores, independently of the effect of age and education. Independent influences of age, gender, education and occupation on cognitive test scores were reported in a study on African–Caribbean elders (Stewart *et al.*, 2001).

In a dementia-incidence study in India, the illiteracy of three-quarters of the cohort raised concern about the possibility of false positive cognitive screens. In their study, as in ours, the fact that all older adults in this community lived with their families allowed us always to question a relative, which was particularly useful when subjects were cognitively impaired. The effect of education beyond that of age was also observed in neuropsychological performance in Spanish (Ostrosky-Solis *et al.*, 1998; 2000).

The BCST (Davies, 1987) includes no items related to reading and writing. We found a highly significant correlation between MMSE and BCST scores in both genders. Despite the fact that the BCST does not include items requiring literacy (i.e. reading or writing), it was still influenced by education as much as the MMSE.

A limitation of our study is the possibility that very mild dementias might have been unrecognized and misclassified as cognitively normal. Older adults in these villages do not live alone and are being cared for by their families. They live in a protected environment and certain functional limitations may be underestimated owing to low expectations from the elderly.

Our results show that the Arabic translation of the MMSE is comparable to the original English MMSE for the appropriate education levels. Because of the effect of education on performance, different cut-off scores should be used for different educational strata. Scores of females at low levels of education should be treated with caution to prevent false positive interpretation. All these render the use of Arabic MMSE difficult for the screening of large populations, where information on education might not be readily available. Still, in such cases, MMSE is useful for measuring change over time. This is particularly relevant for Wadi Ara because previous studies have shown that AD is highly prevalent in this area (Farrer *et al.*, 2003; Bowiratt *et al.*, 2000).

At present, females within the younger generations in Wadi Ara are educated in the same way as males; they also enjoy higher health literacy and find employment outside the home (Elnekave and Gross, 2004; Okun and Friedlander, 2005. Given this, gender differences in MMSE may disappear in a few decades. Our findings may be helpful in daily clinical situations and also in research within Arab communities.

Conflict of interest

None.

Description of the authors' roles

Rivka Inzelberg supervised data collection, participated in consensus meetings and wrote the manuscript. Edna Schechtman performed the statistical analysis and participated in writing the manuscript. Amin Abuful interviewed the subjects and performed cognitive evaluations. Magda Masarwa interviewed the subjects, performed neurological examinations and participated in consensus meetings. Aziz Mazarib interviewed the subjects, performed neurological examinations and participated in consensus meetings. Rosa Strugatsky read the medical records of the subjects and participated in consensus meetings. Lindsay A. Farrer participated in building the study methodology, supervised data collection and participated in writing the manuscript. Robert C. Green participated in building the study methodology and in writing the manuscript. Robert P. Friedland participated in building the study methodology, supervised data collection and participated in writing the manuscript.

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Note: The Arabic translations of the MMSE and BCST are available from the authors upon request.

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