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Screening the cognitive impairment among older outpatient population of a general hospital and comparison of the MoCA and MMSE tests

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Abstract
Objectives: To examin the random non- clinically recognized cognitive impairment of 300 individuals admitted to a general hospital, to determine the sensitivity and specificity of the Montreal Cognitive Assessment scale (MoCA) as a screening tool in Greek elder population. To investigate the predictive value of sociodemographic- health variables on participants' performance.
Methods: MoCA was used as the essential cognitive assessment tool and after, the Mini Mental State Examination scale (MMSE) was administered. IPAQ scale evaluated physical activity and Hamilton Depression rating scale was used to identify patients with depression and exclude them.
Results: Mean age was 65.4 years. Comorbidities were present in 76.7%. Agreement between the results of MMSE and MoCA test was found in 43.3% of the cases. Subjects with moderate or high physical activity levels had 48% lower odds for having cognitive impairment.
Conclusion: Education and physical activity enhance the prevention of cognitive decline. MoCA test demonstrated a superior sensitivity to detect mild cognitive impairment.

Keywords: screening tools, cognitive decline, MoCA scale, physical activity, mental health

Introduction

The World Health Organization (WHO) estimates dementia affects 50 million people and this number will triple by the year 2050 (World Health Organization, 2019) [32]. It is estimated that 44.35 million people suffer from Alzheimer's disease (AD) worldwide, with an increasing rate that may reach 75.65 million by 2030 (Prince *et al*., 2013). Dementia is, thus, a major economic problem in society.

A phase of gradual loss in cognitive function, in general, comes before the emergence of dementia. Petersen and his colleagues (1999) [19] coined the term "Mild Cognitive Impairment" (MCI) to define the boundaries between dementia and normal cognitive aging. MCI has been reported to be the transitional stage between cognitive deficits caused by pathological conditions (e.g., AD) and normal cognitive aging. Symptoms reported by these patients are memory loss, problems in critical ability, language, attention, speech, and writing (Fujiwara *et al*., 2010). Criteria for MCI have recently been proposed by the National Institution on Aging, the Alzheimer's Association and the DSM-V.

Therefore, the early and accurate detection of any cognitive impairment is a necessity. Furthermore, there is a need for assessment tools that will lead to rapid and effective screening.

The Mini Mental State Examination (MMSE) is the most widespread screening tool. However, several diagnostic problems have been reported regarding the detection of mild cognitive deficits. It has shown a difficulty in identifying mild cognitive impairments, especially when the population examined is highly functional (Polito *et al*., 2015) [21]. MoCA was created as an alternative choice to the MMSE and has increasingly demonstrated its high sensitivity and specificity in identifying mild cognitive impairment (Horton *et al*., 2015; Rossetti *et al*., 2011) [7, 25].

As Konstantopoulos *et al*. (2016) [9] pointed out in the introduction of their study, there is a paucity of clinical data to relate the MoCA test to the MMSE. Lyrakos *et al*. (2014) [12] compared the two assessment tools in Greek population and found that MoCA is efficient to detect cognitive impairment in patients who score in normal levels of MMSE.

The duration and the period of exposure to any potential risk or protective factor play a decisive role (Oboudiyat *et al*., 2013). The period before the onset of clinical symptoms may include a gradual decline in physical fitness or mental activity, or an increase in cardiovascular risk factors. It is probable that the disease is already under development and that these factors are precursors rather than independent predictors of the disorder (Reitz *et al*., 2011) [24].

The present study aims to determine the sensitivity and specificity of the MoCA test as a screening tool in a sample of Greek elder population, regarding the accurate detection and identification of patients with MCI. In addition to this, the purpose of the present study is to draw useful clinical conclusions by comparing the MMSE and the MoCA. Furthermore, aims to investigate the predictive value of sociodemographic (age, gender, years of education, marriage) and health variables (BMI, family history of dementia, smoking, alcohol, fruit and vegetable consumption, physical activity, and comorbidities) on participants' performance on MMSE and MoCA respectively.

Method

Participants

A population of 300 general hospital outpatients over the age of 55. The sample was selected based on certain prerequisites that have been defined as inclusion and exclusion criteria. The inclusion criteria were: (a) patients were 55 years of age or older, (b) patients were demonstrating sufficient decision-making ability in order to participate in the research and sign their informed consent form and (c) patients were being monitored by a general hospital practitioner. Exclusion criteria were the following: (a) patients diagnosed with mental retardation according to the DSM-V, (b) patients whose medical condition was considered severe and unstable, (3) illiteracy, (d) patients who were not native speakers, (e) absence of informed consent, (f) patients with diagnosed depression, and (g) patients with impaired hearing.

Measures

Sociodemographic variables. Initial patient evaluation included demographic and social data as shown in table 1.

Montreal Cognitive Assessment (MoCA). MoCA is now known as a short cognitive assessment tool available to all (www.mocatest.org), which has been translated into 37 languages and weighted in Greek (Zhou, 2015) [35]. The scale's sensitivity to detect mild cognitive deficits ranges from 90 to 100%.

Mini Mental State Examination (MMSE). The Greek version of the MMSE was also administered (Foundoulakis *et al*., 2000). The MMSE's score ranges from 0 to 30, with higher scores indicating a better cognitive functioning. It comprises thirty items, providing information about attention, calculation, orientation, delayed recall, learning, and construction.

International Physical Activity Questionnaire (IPAQ). The International Physical Activity Questionnaire (IPAQ) evaluates the physical activity of adults and it is a tool also widely used in clinical trials. It consists of 7 questions that respondents are asked to answer considering their last week before the interview. The scale assesses intense, moderate, and mild physical activity, measured in minutes of exercise per week (Craig *et al*., 2003).

Hamilton Depression Rating Scale (HAM). HAM (Hamilton, 1967) was used to identify patients with depression and then exclude them from the study (Ferentinos *et al*., 2003) [3].

Procedure

An approval of the local Ethics Committee for Clinical Trials was obtained and the researcher was conducted at a general hospital in Athens. The initial approach took place when the eligible patient visited one of the outpatient clinics (cardiological, ophthalmological, oncological, orthopedic, dental, pathological, pulmonary). The researcher informed the patient and his caregiver about the research program, its purposes and usefulness. Then, a first meeting was held to check the inclusion and exclusion criteria, which were also cross-checked by the patients' medical file. A second meeting was scheduled, where the patient who met the inclusion criteria gave their consent for their participation in the present study, and then the researcher proceeded with the interview in order to collect the data.

Statistical analysis

Quantitative variables are expressed as mean values (SD). Qualitative variables are expressed as absolute and relative frequencies. Chi-square test was used for the comparison of proportions. A multiple logistic regression analysis was performed in order to identify independently associated variables for cognitive impairment derived from MMSE (mild, moderate and severe impairment vs. normal) and cognitive impairment derived from MoCA (mild, moderate and severe impairment vs. normal). Adjusted odds ratios with 95% confidence intervals were computed from the results of the logistic regression analyses. All reported p values are two-tailed. Statistical significance was set at $p \leq 0.05$ and analyses were conducted using SPSS statistical software (version 22.0).

Results

Sample consisted of 300 patients (79 men and 221 women) with mean age 65.4 years (SD=8.8). Demographics and clinical characteristics are presented in Table 1. 60% of the sample had moderate or high Physical activity levels and 21.3% were obese. 27% of the sample had a positive family history, while comorbidities were present in 76.7% of the total sample. 54% of the participants were smokers and 15.3% consumed alcohol.

Table 1: Sample characteristics

	N (%)
Age, mean (SD)	65.4 (8.8)
Gender	
Male	79 (26.3)
Female	221 (73.7)
Years of education, mean (SD)	11.8 (3.8)
Married	40 (48.2)
BMI, mean (SD)	27.3 (3.8)
BMI	
Normal	77 (25.7)
Overweight	159 (53.0)
Obese	64 (21.3)
Family history of dementia - Alzheimer's disease	81 (27.0)
Smoking	162 (54.0)
Alcohol	46 (15.3)
Fruit and vegetable consumption	
Every day	48 (16.0)
2-3 times/ week	143 (47.7)
Rarely	109 (36.3)
Never	0 (0.0)
Physical activity	
Low	120 (40.0)
Moderate	161 (53.7)
High	19 (6.3)
Comorbidities	230 (76.7)

27.7% of the patients were categorized as having mild impairment according to MMSE, 2.7% as having moderate impairment and 0.3% as having severe impairment (Figure 1).

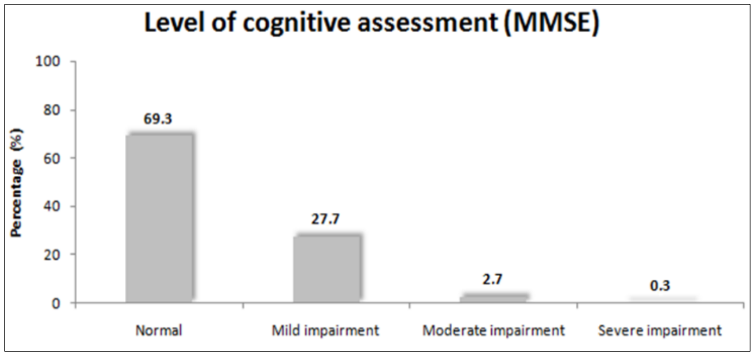

Fig 1: Levels of cognitive assessment derived from MMSE total score

The correspondence proportions for mild, moderate and severe impairment according to MoCA test were 60.7%, 13.3% and 1.7% (Figure 2).

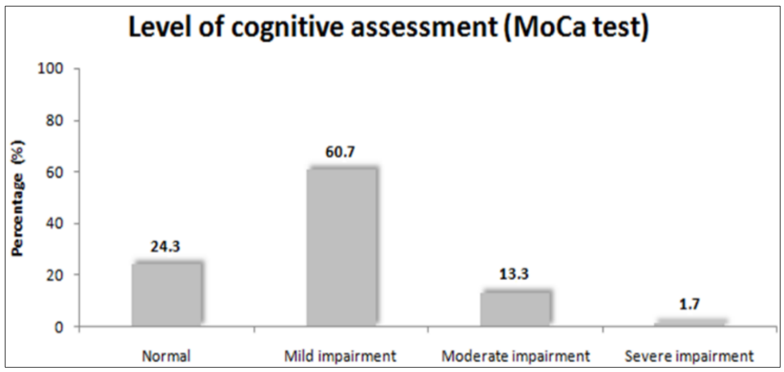

Fig 2: Levels of cognitive assessment derived from MoCa test

Table 2 shows concordance between MMSE and MoCA test. Agreement between the results of MMSE and MoCA test was found in 43.3% of the cases. Also, the number of patients that categorized as having mild impairment was significantly greater with MoCA test rather that MMSE test.

Table 2: Concordance between MMSE and MoCA

Level of cognitive assessment (MoCA test)	Level of cognitive assessment (MMSE total score)			
	Normal	Mild impairment	Moderate impairment	Severe impairment
	N	N	N	N
Normal	73	0	0	0
Mild impairment	131	51	0	0
Moderate impairment	4	31	5	0
Severe impairment	0	1	3	1

Multiple logistic regression results with dependent variable the presence of cognitive impairment derived from MMSE are shown in Table 3. Increased age was found to be associated with increased likelihood for having cognitive impairment according to MMSE. On the contrast, increased educational years were found to be associated with lower likelihood for having cognitive impairment according to MMSE in multiple analysis. Additionally, it was found that subjects with moderate or high physical activity levels had 48% lower odds for having cognitive impairment according to MMSE.

Table 3: Multiple logistic regression analysis results with presence of cognitive impairment derived from MMSE as the dependent variable

	OR (95% CI)$^{+}$	P
Age	1.05 (1.02 – 1.09)	0.003
Gender		
Male (reference)		
Female	0.95 (0.49 – 1.84)	0.873
Years of education	0.87 (0.81 – 0.95)	0.001
Married		
No (reference)		
Yes	0.97 (0.55 – 1.7)	0.916
Smoking		
No (reference)		

Yes	1.06 (0.58 ─ 1.94)	0.842
Alcohol		
No (reference)		
Yes	0.85 (0.34 ─ 2.12)	0.723
BMI	1.05 (0.97 ─ 1.13)	0.215
Fruit and vegetable consumption		
Every day or 2-3 times/ week (reference)		
Rarely	1.01 (0.55 ─ 1.85)	0.980
Family history of dementia - Alzheimer's disease		
No (reference)		
Yes	1 (0.52 ─ 1.92)	0.993
Comorbidities		
No (reference)		
Yes	2.09 (0.97 ─ 4.5)	0.060
Physical activity		
Low (reference)		
Moderate/ High	0.52 (0.29 ─ 0.92)	0.025

$^{+}$Odds Ratio (95% Confidence Interval)

Multiple logistic regression analysis with presence of cognitive impairment derived from MoCA as the dependent variable (Table 4) showed that age and educational years were independently associated. Specifically, increased age was found to be associated with increased likelihood for having cognitive impairment according to MoCA test. Also, these patients tend to score lower in visuospatial skills. Many types of dementia can affect most aspects of visual processing with the impact on both dorsal and ventral stream areas. Visuospatial functioning can be impaired in the beginning of dementia, and it gradually declines with deterioration of cognition over time. In addition to this, increased educational years were found to be associated with lower likelihood for having cognitive impairment according to MoCA test.

Table 4: Multiple logistic regression analysis results with presence of cognitive impairment derived from MoCA as the dependent variable

	OR (95% CI)$^{+}$	**P**
Age	1.12 (1.07 ─ 1.18)	<0.001
Gender		
Male (reference)		
Female	1.26 (0.61 ─ 2.61)	0.531
Years of education	0.84 (0.75 ─ 0.93)	0.001
Married		
No (reference)		
Yes	1.35 (0.72 ─ 2.52)	0.353
Smoking		
No (reference)		
Yes	1.76 (0.92 ─ 3.38)	0.090
Alcohol		
No (reference)		
Yes	2.11 (0.84 ─ 5.32)	0.114
BMI	1.03 (0.94 ─ 1.12)	0.502
Fruit and vegetable consumption		
Every day or 2-3 times/ week (reference)		
Rarely	1.92 (0.95 ─ 3.86)	0.068
Family history of dementia - Alzheimer's disease		
No (reference)		
Yes	1.08 (0.55 ─ 2.12)	0.829
Comorbidities		
No (reference)		
Yes	1.01 (0.49 ─ 2.08)	0.981
Physical activity		
Low (reference)		
Moderate/ High	0.64 (0.32 ─ 1.28)	0.205

$^{+}$Odds Ratio (95% Confidence Interval)

Discussion

According to MMSE test, 27.7% of the patients were categorized as having mild impairment, 2.7% as having moderate impairment and 0.3% as having severe impairment. On the other hand, according to MoCA test, the correspondence proportions for mild, moderate and severe impairment were 60.7%, 13.3% and 1.7%. Agreement between the results of MMSE and MoCA was found in 43.3% of the cases. Furthermore, not surprisingly, the number of patients who manifested mild cognitive impairment was significantly higher with the MoCA rather than the MMSE test.

As suggested in the introduction of the present manuscript, MoCA has demonstrated its high sensitivity and specificity in identifying MCI (Horton *et al*., 2015; Lee *et al*., 2008; Rossetti *et al*., 2011) [7, 25] and it is considered as a very useful and valid tool for identifying and evaluating these mild stages (Delgado *et al*., 2019; Nasreddine *et al*., 2005) [2, 17]. Compared to the MMSE, a superior sensitivity of the MoCA test to detect patients with MCI has been found in a previous Greek study (Lyrakos *et al*., 2014) [12]. Similar results were found in other studies from the UK (Zhou *et al*., 2015) [35].

Although the MMSE is still the most widely used screening instrument, it seems to be insufficient to detect the earlystages of dementias mild cognitive impairment. A large proportion of patients with MCI develop dementia, even though it is not detected in MMSE. On the contrary, MoCA detects these medical conditions, having, of course, a limitation regarding the years of education of the patients evaluated.

According to both MMSE and MoCA scores, there has not been a significant gender difference found, although rates appear to be higher in the female population, possibly due to longer life expectancy and the presence of estrogen and progesterone, which act highly protective of cognitive brain functions (Zhou *et al*., 2014) [34]. The absence of significant gender difference is not consistent with a Greek normative study showing a difference in mean of 0.3 points between sexes, where men performed better than women on MoCa test (Konstantopoulos *et al*., 2016) [9]. Nevertheless, there are studies documented either no gender differences or slight differences in favor of both sexes (Tombaugh *et al*., 1996; Lu *et al*., 2011; Kopecek *et al*., 2017) [29]. Hence, the influence of the sex on cognitive impairment remains controversial.

Practice Guideline for the Treatment of Patients with Alzheimer's Disease and other dementias reports that in a sample of low-educated patients assessed for their cognitive functions by the MoCA, it was found that men performed better than women. In the present study, elderly people of different educational backgrounds participated, which may explain why our findings do not agree with the findings of previous research. Other studies, on the other hand, have shown opposite results. In a prospective study in Sweden, the impact of the disease was 19.6 for women and 12.4 for men at the age of 75-79 years, while at the age group of > 90 years the impact was found to be 86.7 for women and 15.0 for men per year (Povova *et al*., 2012) [22]. In the present study, there was a younger age group examined, as one of the criteria for admission to the sample was to be over 65 years old. This may be a crucial reason why our findings differ from those in the research of Povova *et al*. (2012) [22].

Our findings are in accordance with previous findings showing that both MMSE and MoCA scores are associated with age and education level. Increased age and decreased education have been associated with significantly lower MMSE score (e.g., Solias *et al*., 2014; Tombaugh *et al*., 1996) [27, 29]. Similarly, it has been documented that MoCA score declines with age increase, and participants with more years of education obtain higher MoCA score, according to the findings of large population-based studies conducted in several countries, e.g. Canada (Larouche *et al*., 2016) [10], Greece (Konstantopoulos *et al*., 2016) [9], USA (Malek-Ahmadi *et al*., 2015; Rossetti *et al*., 2011) [13, 25], etc.

According to the "reserve capacity" hypothesis, "education may exert direct effects on brain structure early in life by increasing synapse number or vascularization and creating cognitive reserve" (Beydoun *et al*., 2014, p. 14) [1]. More frequent participation in cognitive activities has been associated with more education of persons aged 65 years and older (Wilson *et al*., 1999) [31]. Education early in life may have effects later in life if persons with a high level of education continue searching for mental stimulation during the post-education years (Beydoun *et al*., 2014) [1], which, in turn, has an independent protective effect with respect to the development of dementia. Additionally, persons with a high educational level are more likely to have a high occupational level. A high occupational level (having been in charge of subordinates) has a protective effect on cognitive decline. Further, through several "behavioral mediators", education may promote health in general, and improve cognitive functioning in particular (Beydoun *et al*., 2014) [1].

We also found that subjects with moderate or high physical activity levels had 48% lower odds for having cognitive impairment according to MMSE, which means that the physical activity may have a protective role toward cognitive impairment. Indeed, systematic physical activity seems to protect cognitive function (Larson *et al*., 2006; Ploughman, 2008; Sofi *et al*., 2011; Beydoun *et al*., 2014) [11, 20, 26, 1]. It seems that age-related cognitive impairment can be avoided, if individuals maintain a satisfactory level of physical activity at middle age. Thus, they are less likely to develop cognitive deficits in old age (Hamer & Chida, 2009; Nascimento *et al*., 2015; Yeh *et al*., 2015) [4, 16, 33].

Executive functioning has been positively correlated to physical activity, according to a research in an elderly population, suggesting that these two variables may be related through a common biological background. In particular, this association may be explained by the fact that the health of the cardiovascular system protects the frontal lobe, which is responsible for the occurrence of cognitive deficits of vascular etiology, originating from ischemic lesions. Indeed, MoCA has been proven completely reliable in identifying this association (Ihara *et al*., 2013) [8].

As a possible underlying mechanism, the positive effects of exercise on various neurobiological processes have been well documented in the literature (Hooghiemstra *et al*., 2012; Suzuki *et al*., 2014) [6, 28]. Specifically, during aerobic exercise, metabolism processes in the brain are enhanced and oxidative stress is reduced (Deslandes *et al*., 2009; Radak *et al*., 2010; Tarumi & Zhang, 2014) [23, 30]. For the elderly, exercise seems to play a role in preventing atrophy of certain parts of the brain responsible for attention, while increasing its neurotrophicity. Physical activity also appears to be involved in the stress management process, which is negatively related to normal hippocampal function. Additionally, it increases the ability of attention and memory, and further benefits individuals with an increased risk to develop dementia (Nation *et al*., 2011) [18]. It remains uncertain whether older people will be able to increase their physical activity, due to the physical pain that will inevitably arise (Suzuki *et al*., 2014) [28].

Conclusion

Physical activity seems to enhance the prevention of dementia, as it plays a key role in maintaining patients' health on a daily basis. Brain function and cognitive skills are maintained at a satisfactory level, when this exercise is performed systematically

(Mameletzi, 2013) [14], while at the same time it is likely to improve the social skills of these individuals, when performed in group activities. However, further research is needed to determine the most appropriate duration and intensity of this intervention, in order to achieve the desired effect, especially in vulnerable groups.

The association of risk factors like unhealthy eating habits, diabetes, hypertension, smoking, alcohol, with the onset of the disease should be the result of many epidemiological studies as there was not found a statistical significance in this study and since the existing literature still reports many conflicting views on the subject and the data have been interpreted in various ways respectively. Consequently, studies should probably focus more on when and for how long the exposure to a certain factor could be adjusted to reach an optimum level.

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