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Impact of cognitive functions on the quality of spirometry performance in patients with COPD

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Abstract:

OBJECTIVE: We researched the relationship between the cognitive scores and the error codes which determine pulmonary function test (PFT) compliance accompanied by the phenotypic findings of chronic obstructive pulmonary disease (COPD) patients.

MATERIALS AND METHODS: Patients in a stable condition with COPD, who were diagnosed with the criteria recommended in the international guidelines, were included in the study. PFTs were requested from all the patients during the regular outpatient admission. The following tests were applied to all the patients in a 30-min test session; COPD assessment test, modified British Medical Research Council and neurophysiological tests (Mini-Mental Test, Trail Making Test Part A and B, Clock Drawing Test, Straight and Backward Digit Span, Brown Peterson Task and Verbal Fluency Test). We analyzed the statistical relationship between data collected after cognitive tests and PFT quality data.

RESULTS: The study was concluded with a total of 70 patients. When the PFT evaluations of the patients were examined, the percentage of patients who correctly fulfilled the repeatability criteria was found as 28%, who met the acceptability criteria as 57%, and who correctly fulfilled both criteria as 14%. The relationship between the results of patients, who fulfilled both repeatability and acceptability criteria correctly and incorrectly at the same time, with the backward digit span test results was found to be significant ($P < 0.05$). It was found that the Mini-Mental Test was significantly better in those who performed all of the repeatability and acceptability criteria without errors than the other groups. When the PFT criteria of the patients were evaluated according to the cognitive test results, it was determined that the relationship between the Mini-Mental Test and the results of performing the repeatability and acceptability criteria together was found to be statistically significant ($P < 0.05$).

DISCUSSION AND CONCLUSION: Error codes that identify the compliance in PFTs could be used as predictors of cognitive impairment in COPD.

Keywords:

Chronic obstructive pulmonary disease, cognitive function, pulmonary function test

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Introduction

Pulmonary function test (PFT) should be performed correctly by the patients as it is a criterion for the diagnosis of chronic obstructive pulmonary disease (COPD).[1,2] When COPD is being diagnosed, forced expiratory volume in 1 s (FEV1) and forced vital capacity (FVC) value standardized according to the age and gender of the patients are measured in the PFT, and the treatment considering the disease stage is

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regulated.[3] For this reason, completing PFTs correctly is essential in identifying the potential patients and in reducing stress associated with the repeated failed attempts.

In this study, we investigated the relationship between the cognitive scores and the error codes, which were determined by the ERS/ATS guidelines, showing the respiratory function test compliance of COPD patients. We also aimed to determine the effects of demographic features such as education level, smoking history, and exacerbation counts of the COPD patients with different phenotypic characteristics on PFT compliance and cognitive functions.

Materials and Methods

Participants

Spirometric measurement is essential for the diagnosis of COPD. FEV1/FVC ratio <70% is the diagnostic criteria for COPD. In this study, PFT was performed after short-acting bronchodilator application to the patients. Seventy consecutive newly diagnosed COPD patients were included the study. The study was approved by the Institutional Ethics Committee and all patients signed informed consent documents. The patients who had clinical history, symptoms performed PFT. As recommended by international guidelines postbronchodilator ratio of the FEV1/FVC of <70% of patients included the study.[3]

Any patients with COPD exacerbations, low literacy skills, visual or auditory problems, focal neurological loss, and manual dexterity problems were excluded.

Neuropsychological tests

We used standardized neuropsychological tests, including Mini-Mental State Examination (MMSE), Trail Making Test A and B, Clock Drawing, Forward and Backward Digit Span Tests, Brown–Peterson Test, Verbal Fluency Test, and Geriatric Depression Scale. All of these tests have been already adapted to the Turkish language with high psychometric validity and reliability.

Mini-Mental State Examination

This questionnaire measures general cognitive impairment and it is extensively used in clinical research. The total score of MMSE is 30. Orientation questions 10 points, record memory and recall 6 points, attention, and account 5 points, naming 2 points, repetition 1 point, commands 3 points, reading 1 point, writing 1 point, and the ability to configure 1 point. Total application time is 5–10 min.

Trail Making Test A and B

Trail Making Test measures impairment in executive cognitive functions, specifically disruption in attention, and working memory. There are two parts in this test. In both of the tests, letters and numbers are located randomly on a piece of paper. In Part A, participants connect numbers in ascending order (1, 2, 3 …). In Part B, participants alternately connect numbers and letters in ascending order (1, A, 2, B …). Time to complete Part A and Part B (recorded separately) is used as a score.

Clock drawing

This test is commonly used to assess disruption in concentration and motor planning. Participants are asked to draw an analog clock. The analog clock must show ten past eleven. They are scored with completeness and correctness of drawing. The total score is 4 points. They get a point for a circle (1 pt.), if all numbers are included (1 pt.), if they placed the numbers in the correct position (1 pt.), and place the hands correctly (1 pt.).

Forward and backward digit span tests

These tests measure short term and working memory capacity. In the forward span task, participants are asked to repeat a sequence of digits in the correct order. In the backward span task, they are asked to repeat the sequence in the reverse order. The number of trials remembered correctly used as the score of the test. Maximum score is 16 and 14 in the forward and backward digit span tests, respectively.

Brown–Peterson test

This test is designed to measure working memory capacity. Working memory capacity is related to our ability to hold information in the face of distractors. A consonant trigram and a three-digit number are given to participants. Participants count backward from the number aloud for 0, 9, 18, or 36 s. Then, they must recall the trigram. The total number of correct answers is the score.

Verbal fluency test

This test measures the disruption in language functions. Participants are asked to generate as many words as possible. In the first three sessions, the words must start with K, A, and S, respectively. In the last two sessions, they are asked to generate words belonging to the categories of animals and fruits. The total score is all the words spoken in all letters.

Geriatric depression scale

A self-reported yes/no questionnaire for the assessment of depressive symptoms is used. In the scoring of the scale, each question is given 1 point for the answer given in favor of depression and 0 points for the other answer. As a result of the test, if there is a score between 0 and 11, there is no depression, possible depression for 11–14, and definite depression for 14 and above are considered.

Statistical analyses

The Statistical Package for the Social Science for Windows 15.0 package program was used for the

statistical analysis in ourstudy. The present study included 100 patients seen at the outpatient clinics of the Chest Diseases Department of Selcuk University, Konya, Turkey. In the evaluation of data, demographic characteristics such as age, gender, comorbid disease, the number of annual exacerbations, education level were determined with descriptive statistical methods. PFT values, C-reactive protein (CRP) values, modified British Medical Research Council (mMRC) and COPD assessment test (CAT) scores, and the amount of smoking were quantitatively (mean, standard deviation) revealed. Unfortunately, CR*P* values of 21 patients were missing. The Mann–Whitney U-test performed comparisons of respiratory function test compliance and cognitive parameters, and the statistical significance level was accepted as $P < 0.05$.

Results

The study was begun with 100 patients. Due to 30 patients were excluded from the reasons such as COPD exacerbation, and lack of literacy, the study was completed with 70 patients. Four percent of the patients were female, 96% were male; the mean age was found as 61. The annual exacerbation rate of the all patients was found as 0.57 (±1.001), the mean FEV1 outcome as 62.5% (±19.6), mean FVC outcome as 84.3% (±20.2) and mean FEV1/FVC outcome as 58% (±10.5). The mean values of mMRC and CAT dyspnea questionnaires were found to be 1.5 (±0.7) and 9.6 (±5.4), respectively. The average smoking rate was determined as 32.9 (±14.7) packs-year [Table 1].

When the PFT quality evaluations of the patients were examined, the percentage of patients who correctly fulfilled all the repeatability criteria was found as 28%, who fulfilled all the acceptability criteria as 57%, and who correctly fulfilled both criteria as 14% [Table 1].

Table 1: Demographic and clinical characteristics of patients with COPD

	n	Minimum	Maximum	Mean±SD
Age (years)	70	36	80	61.17±9.51
Exacerbation (years)	70	0	5	0.57±1.001
Height (cm)	70	151	197	169.54±8.13
Weight (kg)	70	46	120	78.8±15.94
FEV_1 (L)	70	25	109	62.53±19.61
FVC (L)	70	35	130	84.33±20.22
FEV_1/FVC (%)	70	23	82	58.06±10.56
FEF25/75 (%)	70	6	77	30.39±13.78
mMRC	70	0	3	1.57±0.77
CAT	70	2	27	9.67±5.47
CRP (mg/L)	49	2.9	121	16.91±20.43
Education (years)	70	5	15	6.89±3.29
Smoking, packs/years	70	18	80	32.96±14/07/19

SD: Standard deviation, FEV: Forced expiratory volume, FVC: Forced vital capacity, FEF: Forced expiratory flow, mMRC: modified British Medical Research Council, COPD: Chronic obstructive pulmonary disease, CAT: COPD assessment test, CRP: C-reactive protein

When the cognitive test performances of the patient groups which fulfilled the PFT repeatability and acceptability criteria correctly or incorrectly were compared; the patients who fulfilled repeatability and acceptability criteria both correctly were found to have better MMST results than the patients who made them incorrect. Besides, the Trail Making Test performance of the patients who performed the repeatability criterion correctly was finitely statistically higher than the patients who did not fulfill it correctly. There was no difference in cognitive test performances between the groups which performed all other PFT quality tests correctly or incorrectly [Table 2].

When the predictive power of cognitive test performances of patients for the PFT repeatability and acceptability criteria was examined; it was observed that the predictive power of both the MMST and the Backward Digit Span Test for the repeatability and acceptability criteria was statistically significant ($P < 0.05$). The predictive power of all other cognitive tests for the PFT repeatability or acceptability criteria was not statistically significant [Table 3].

Discussion

In this study, the ratio of spirometry quality indicators to acceptability and repeatability criteria was found to be quite low (14%) in patients with COPD. Patients who met these criteria were found to be significantly higher than those who could not meet MMST. The predictive power of the MMST and backward digit span tests were statistically significant when cognitive tests predicted the spirometry quality ($P < 0.05$).

The PFT plays a central role in the diagnosis and follow-up of COPD and other respiratory diseases, and because it appears in the national guidelines for diagnosing COPD, it should be performed correctly by patients to guide the clinician to the differential diagnoses. When COPD is being diagnosed, FEV1 and FVC value standardized according to the age and gender of the patients are measured in the PFT, and the treatment considering the disease stage is regulated. Although PFTs were so important in patients with COPD, the rate of meeting the quality criteria correctly in our study was quite low (14%). For this reason, completing PFTs correctly is essential in identifying the potential patients and in reducing stress associated with the repeated failed attempts.[3,4]

Comorbid conditions disregard cognitive dysfunctions and commonly seen in COPD patients.[5] In many

Table 2: The relationship between the cognitive test performance data of patient groups fulfilling the pulmonary function tests repeatability and acceptability criteria correctly or incorrectly

	MMSE	P	Trail making A + B	P	Verbal fluency	P	Clock drawing	P	Forward span	P	Backward span	P	Brown-Peterson total	P	Geriatric depression	
Repeatability																
Correct	26.27 (*n*=19)	*NS*	213.72 (*n*=19)	*NS*	54.83 (*n*=19)	*NS*	3.5 (*n*=19)	*NS*	7.11 (*n*=19)	*NS*	4.5 (*n*=19)	*NS*	37.05 (*n*=19)	*NS*	10.16 (*n*=19)	NS
Incorrect	25.68 (*n*=51)		202.9 (*n*=50)		48.72 (*n*=51)		3.82 (*n*=51)		6.62 (*n*=51)		3.96 (*n*=51)		37.68 (*n*=51)		9.63 (*n*=49)	
Acceptability																
Correct	25.8 (*n*=41)	*NS*	199.35 (*n*=40)	*NS*	49.12 (*n*=41)	*NS*	3.8 (*n*=41)	*NS*	6.82 (*n*=41)	*NS*	4.15 (*n*=41)	*NS*	38.3 (*n*=41)	*NS*	9.30 (*n*=40)	NS
Incorrect	25.7 (*n*=29)		214.93 (*n*=29)		52.07 (*n*=29)		3.64 (*n*=29)		6.64 (*n*=29)		4.03 (*n*=29)		36.39 (*n*=29)		10.46 (*n*=28)	
Repeatability and acceptability																
Both correct	26.66 (*n*=9)	>0.05*	201.11 (*n*=9)	*NS*	56.77 (*n*=9)	*NS*	3.66 (*n*=9)	*NS*	7.44 (*n*=9)	*NS*	4.88 (*n*=9)	>0.05*	38.77 (*n*=9)	*NS*	8.33 (*n*=9)	NS
At least one is incorrect	25.73 (*n*=61)		226.33 (*n*=60)		52.88 (*n*=61)		3.33 (*n*=61)		6.77 (*n*=61)		4.11 (*n*=61)		35.33 (*n*=61)		10.00 (*n*=59)	

The equality between groups were tested with one-tailed nonparametric Mann–Whitney U-test. *Significant result. MMSE: Mini Mental State Examination, NS: Not significant

studies conducted until today, co-morbid conditions in COPD patients make the treatment management difficult and cause recurrent exacerbations by leading to problems such as wrong drug use, incompleted treatment in patients.[5,6] This increases the mortality by causing a vicious cycle in the management of patients' treatments. A significant proportion of COPD patients cannot fulfill PFT, a crucial parameter in the diagnosis of COPD, due to the loss of cognitive functions secondary to hypoxia in COPD patients.[7,8] In a study conducted by Dodd *et al*., it was brought forward that the COPD patients with the cognitive function deterioration formed a separate phenotype, and it was argued that the treatment should be planned more carefully for these patients from the very beginning.[9] In our another study in COPD patients, there was a significant relationship between cognitive function test results of patients and the inhaler device use success.[10] Similar to these studies in our study, a correlation was found between PFT error codes and cognitive function tests.

Studies in patients with COPD showed that PFT compliance was gradually reduced in patients over 75 years of age and FEV1-FVC could not be evaluated. In patients with advanced age, pulmonary damage increases, and hypoxia develops.[11] It was thought that the cognitive dysfunction developed regarding the hypoxia might lead to the compliance problem.[12-14] However, the mean age of the COPD patients in our study was significantly lower than these studies (mean: 61,17). In this case, it may be thought that PFT compliance may be bad in all COPD patients, not only in advanced age.

In the study conducted by Allen *et al*. in COPD patients for the assessment of cognitive functions; PFT success was determined to predict the SMMT and its pentagonal duplication component success, and metered dose inhaler use success with high specificity and moderate sensitivity. Due to the functions such as management and decision-making could be evaluated, Mini-Mental Test is an important test to assess global cognitive functions.[15,16] Again, these functions are also crucial in PFT performances.[17] In another study conducted by Allen *et al*., the Clock Drawing Test was applied to all patients as screening, considering that the relationship between the test and the PFT performance may be significant. PFT compliance and metered dose inhaler use were found to be better in patients whose success in the Clock Drawing Test was more.[17] We also observed in our study that the success of the Clock Drawing Test in patients, who did not have PFT failures, was significantly better than the others. The results of our study repeat the ones of Allen *et al*. The results obtained from Mini-Mental Tests showed in our research that they could predict the repeatability

Table 3: Predictive power of cognitive test performances of patients for the pulmonary function tests repeatability and acceptability criteria

	Repeatability		Acceptability		Repeatibility and acceptibility[†]	
	B	*P*	*B*	*P*	*B*	*P*
MMSE	−0.15	NS	−0.08	NS	−0.43	>0.05*
Trail making A + B	−0.006	NS	−0.002	NS	−0.01	NS
Verbal fluency test	−0.013	NS	−0.007	NS	−0.04	NS
Clock drawing	0.135	NS	−0.84	NS	−1.29	NS
Forward digit span	−0.07	NS	−0.08	NS	0.44	NS
Backword digit span	0.42	NS	0.24	NS	1.12	>0.05*
Brown-Peterson total	0.03	NS	−0.05	NS	−0.06	0.39
Geriatric depression	>0.1	NS	1.16	NS	−1.57	NS

The predictive power of the PFT quality on cognitive measures was estimated with one-tailed regression. *B* indicates the effect that one standard deviation unit change in the independent variable has on the dependent variable. [†]There are two groups in this analysis. One group was correct according to both repeatability and acceptability criteria. The other group consisted of the remaining participants, which completed the test with at least one in-correct result, *Significant result. PFT: Pulmonary function tests, MMSE: Mini Mental State Examination, NS: Not significant

and acceptability criteria of the PFT. No significant correlation was found between the PFT and other tests measuring the deterioration in ideomotor practice and executive functions. This result showed that the PFT test is not related to the attention and reasoning skills of the patient; on the contrary, it is interestingly related to the patient's general cognitive skills. Repeating the results observed by Allen *et al*. with more participants with a different culture and educational background confirms the relationship between PFT performances and general cognitive processes. For this reason, fulfilling the repeatability and acceptability criteria of the PFT could give a clue to the physician about the general cognitive deterioration in the patient. When the importance of the general cognitive functions on the management of COPD, and the correlation between the number and severity of the COPD exacerbations with the cognitive deterioration are considered; the assessment of the cognitive activity of the patient becomes crucial in the planning the choice and process of the treatment.

Conclusion

Cognitive functions are usually disregarded comorbidities.[18] According to the results of this study, the deterioration in cognitive functions may affect the PFT compliance, as well as the presence of cognitive deterioration, may also indicate that there may be errors in PFT compliance. For this reason, we think that applying a test which could provide an insight about the severity of the COPD in a short period, such as SMMT, could be an alternative for determining the management of the disease and reducing the mortality rate in patients who cannot adequately perform PFT. We believe that SMMT being a routine component of the COPD evaluation as a cognitive function measurement in COPD patients would be more useful regarding the disease management.

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Conflicts of interest

There are no conflicts of interest.

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