Assessment of manual motor performance in Parkinson's disease

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ABSTRACT: The purpose of our study was to assess manual motor performance in patients with Parkinson's disease (PD) by means of simple instrumental timed tests and compare these findings with normative data. Ninety seven right-handed PD patients and 80 matched controls participated in the study. Motor dexterity was assessed by means of the following instruments: 1) Tapping board, 2) Dual Tally, and 3) Purdue Pegboard. PD patients performed worse than normal controls in all instrumental timed tests ($p = 0.0001$). However this difference was not always maintained in the group of PD patients who were older than 71 years.

Finally we explored the relationship between motor disability and instrumental test scores in a subgroup of PD patients who were younger than 70 years. A negative correlation between UPDRS score and instrumental test scores was significant for all tests. ANOVA exploration of the differences in instrumental test scores between different stages of the disease showed significant differences for Tapping Board, Dual Tally left, Purdue Pegboard at 15 sec bilateral and Purdue Pegboard at 30 sec right. Performance in these tests deteriorated as stage progressed.

Our findings indicate that the instrumental timed tests studied can be used reliably for manual motor performance assessment in PD patients under the age of 70 years.

Key Words: Parkinson's disease, Motor assessment, Motor dexterity.

INTRODUCTION

Parkinson's disease (PD) is a common neurodegenerative disorder with a prevalence of 100-200 per 100.000 people[1]. Clinically PD is characterized by motor symptomatology such as tremor at rest, rigidity, bradykinesia/akinesia, postural reflex impairment, stooped posture and freezing episodes. Bradykinesia/akinesia is the core and most disabling symptom experienced by the patients. It is expressed as delayed initiation of movement, slowness in the execution and diminution of voluntary movements, decreased dexterity, impaired sequential movements and inability to perform simultaneous actions[2]. The motor symptoms compromise manual dexterity from the beginning of the illness. Since the disease slowly progresses 67% of the patients develop severe disability and impairment in daily activities within 15 years of onset[3].

Currently the diagnosis of PD relies on clinical basis. There is no biomarker of the disease and neuroimaging testing has a lot of limitations. Clinicopathological studies have found a 76% accuracy of clinical diagnosis of PD[4,5]. Using standard clinical criteria (UK Parkinson's Disease Brain Bank criteria for idiopathic Parkinson's disease)[6] the diagnostic accuracy increased to 90%[7]. The Unified Parkinson's Disease Rating Scale (UPDRS)[8] is the gold standard for the clinical evaluation of PD patients. However this scale is a subjective method of assessment, while for objective evaluation instrument based quantification of performance is required.

The purpose of our study was to assess manual motor performance in PD patients by means of simple instrumental timed tests and compare these findings with normative data.

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Table 1. Differences in performance in instrumental timed tests between PD patients [n = 97] and normal controls (NC) [n = 80].

Test	Subjects	Mean	SD	Significance
tapping right	PD	67.03	15.74	p = 0.0001
	NC	93.55	24.69	
tapping left	PD	59.04	13.70	p = 0.0001
	NC	86.86	20.37	
dual tally right	PD	77.00	20.66	p = 0.0001
	NC	102.60	24.45	
dual tally left	PD	71.61	20.14	p = 0.0001
	NC	99.33	23.56	
pegboard 15 sec right	PD	5.45	1.50	p = 0.0001
	NC	6.42	1.47	
pegboard 15 sec left	PD	4.98	1.33	p = 0.0001
	NC	6.58	1.35	
pegboard 15 sec bilateral	PD	3.62	1.35	p = 0.0001
	NC	5.38	1.35	
pegboard 30 sec right	PD	10.37	2.57	p = 0.0001
	NC	12.61	2.80	
pegboard 30 sec left	PD	9.49	2.35	p = 0.0001
	NC	12.57	2.68	
pegboard 30 sec bilateral	PD	7.00	2.46	p = 0.0001
	NC	10.50	2.62	

SD = Standard Deviation.

SUBJECTS AND METHOD

We measured manual dexterity of 97 PD patients (mean age = 62.4 ± 8.2, disease duration = 6.8 ± 5.1 years) and 80 normal matched for age normal subjects (normal controls). All patients and controls were right-handed. PD patients were clinically evaluated by means of the UPDRS and were classified in stages by means of the Hoehn and Yahr classification scale. Their mean UPDRS motor score was 19.3 ± 8.4 and their mean stage was 2.1 ± 0.57. All patients were under treatment. Fifty five were treated with levodopa plus a dopaminergic agonist and 42 with a dopaminergic agonist only. They were examined during their optimal response to medication.

Manual motor performance was assessed by means of the following instrumental tests:

1. Tapping Board Test (Lafayette Instruments): It measures speed of successive arm movements. While using a metal-tipped stylus, the subject's task is to tap, as rapidly as possible, the two fixed 8 cm square plates at each end of a 45 cm board. The number of taps per 30 seconds is recorded by means of an electronic counter.

2. Dual Tally Test (Lafayette Instruments): It is a measure of bilateral finger tapping speed, which can be particularly compromised in PD. The subject is asked to push down on the circular paddle attached to a counter by both thumbs simultaneously as rapidly as possible for 30 seconds.

3. The Purdue Pegboard Test (Lafayette Instru-

Table 2. Differences in performance between PD patients [n = 8] and controls (NC) [n = 20]. Age Group: 40-50 years.

Test	Subject	Mean	SD	Significance
tapping right	PD	78,62	18.79	p = 0.001
	NC	114.00	23.67	
tapping left	PD	62.25	12.69	p = 0.0001
	NC	104.85	18.09	
dual tally right	PD	80.50	12.44	p = 0.0001
	NC	125.20	16.14	
dual tally left	PD	77.50	18.18	p = 0.0001
	NC	120.50	16.61	
pegboard 15 sec right	PD	6.50	1.4	p = 0.018
	NC	7.90	1.29	
pegboard 15 sec left	PD	6.12	1.12	p = 0.0001
	NC	7.85	0.93	
pegboard 15 sec bilateral	PD	4.00	0.53	p = 0.0001
	NC	6.75	1.019	
pegboard 30 sec right	PD	12.87	2.587	p = 0.67*
	NC	15.05	2.76	
pegboard 30 sec left	PD	11.25	2.12	p = 0.0001
	NC	15.10	1.83	
pegboard 30 sec bilateral	PD	7.62	0.74	p = 0.0001
	NC	13.00	1.80	

SD = Standard deviation; *= Not significant.

ments): It requires a combination of speed motor coordination and dexterity to pick up long pins and place them in round holes over 15 and 30 seconds time periods. Testing is done for each hand individually and then both hands simultaneously.

Statistical analysis was performed by means of the t test for independent samples for comparisons between all PD patients and controls. Comparison between groups was performed after age stratification.

Furthermore in the Group of PD patients correlation between instrumental tests scores and UPDRS was explored by means of Pearson's r correlation coefficient. One way analysis of variance (ANOVA) was employed for estimation of differences in instrumental test performance between different disease stages. Significance was accepted at p = 0.05 level. Calculations were performed with the SPSS for Windows, Version 12, statistical software.

RESULTS

Mean values of all tests performed are shown in Table 1. PD patients performed worse than normal controls in all instrumental timed tests:

1. Tapping Board Test. PD patients performed significanty less taps with both their dominant and subordinate hands compared with the controls. However this difference applied to patients younger than 71 years, since performance of normal controls aged 71-80 years was rather slow, (Tables 2-5).

2. Dual Tally Test. Bimanual tapping was sig-

Table 3. Differences in performance between PD patients [n = 25] and controls (NC), [n = 20]. Age Group: 51-60 years.

Test	Subjects	Mean	SD	Significance
tapping right	PD	67.48	17.84	p = 0.0001
	NC	95.85	20.21	
tapping left	PD	61.04	15.08	p = 0.0001
	NC	89.70	16.46	
dual tally right	PD	79.16	23.55	p = 0.0001
	NC	106.50	21.46	
dual tally left	PD	73.68	24.89	p = 0.0001
	NC	102.10	18.44	
pegboard 15 sec right	PD	6.24	1.39	p = 0.473*
	NC	6.50	0.88	
pegboard 15 sec left	PD	5.48	1.22	p = 0.0001
	NC	6.90	0.78	
pegboard 15 sec bilateral	PD	4.32	1.31	p = 0.0001
	NC	5.60	0.75	
pegboard 30 sec right	PD	11.16	2.37	p = 0.002
	NC	13.25	1.71	
pegboard 30 sec left	PD	10.12	1.94	p = 0.0001
	NC	13.60	1.53	
pegboard 30 sec bilateral	PD	7.920	2.21	p = 0.0001
	NC	11.25	2.02	

SD = Standard deviation ;* = Not significant.

nificantly slower in PD patients. This difference was abolished in the older age group, (Tables 2-5).

3. The Purdue Pegboard Test. In PD patients there was a significant reduction in the number of pins placed by the dominant hand, the subordinate hand and both hands, compared with normal subjects. However in age stratified groups this difference was not always present, with the exception of the 61-70 years group (Tables 2-5).

Figures 1-6 show the most pertinent differences between PD patients and normal controls in the instrumental timed tests.

Finally we explored the relationship between motor disability and instrumental test scores in a subgroup of PD patients who were younger than 70 years. A negative correlation between UPDRS score and instrumental test scores was significant for all tests. Coefficient r ranged from -0.325 to -0.527 (p = 0 .004 - p = 0.0001). ANOVA exploration of the differences in instrumental test scores between different stages of the disease showed significant differences for Tapping Board right ($F_{2,78}$ = 3.55, p = 0.034); Tapping Board left ($F_{2,78}$ = 7.42, p = 0.001); Dual Tally left ($F_{2,78}$ = 4.09, p = 0.021); Purdue Pegboard at 15 sec bilateral ($F_{2,78}$ = 5.23, p = 0.007) and Purdue Pegboard at 30 sec right ($F_{2,78}$. = 5.27, p = 0.007). Performance in these tests deteriorated as stage progressed . A tendency toward significance was observed in the rest of the instrumental tests with p ranging from 0.057 to 0.066 ,but it did not reach the accepted 0.05 level. Examples are presented in figures 7-8.

Table 4. Differences in performance between PD patients [n = 47] and controls (NC), [n = 20]. Age Group: 61-70 years.

Test	Subjects	Mean	SD	Significance
tapping right	PD	64.76	14.05	p = 0.0001
	NC	92.25	21.50	
tapping left	PD	56.87	13.53	p = 0.0001
	NC	84.95	16.37	
dual tally right	PD	76.17	21.45	p = 0.0001
	NC	99.05	19.68	
dual tally left	PD	69.59	18.07	
	NC	97.20	20.45	p = 0.0001
pegboard 15 sec right	PD	5.19	1.39	p = 0.0001
	NC	6.45	0.94	
pegboard 15 sec left	PD	4.91	1.24	p = 0.0001
	NC	6.45	1.05	
pegboard 15 sec bilateral	PD	3.42	1.41	p = 0.0001
	NC	5.20	1.01	
pegboard 30 sec right	PD	10.02	2.32	p = 0.0001
	NC	12.40	1.90	
pegboard 30 sec left	PD	9.36	2.48	p = 0.0001
	NC	12.00	1.86	
pegboard 30 sec bilateral	PD	6.65	2.85	p = 0.0001
	NC	9.95	1.79	

SD = Standard Deviation.

DISCUSSION

The exact etiology of sporadic Parkinson's disease is still unknown despite our increased knowledge about the biochemical and molecular biological abnormalities of the disease process. No definite diagnostic test for symptomatic and presymptomatic disease is currently available. Furthermore optimization of treatment requires accurate information about the ongoing disease process. As new therapies (neuroprotective agents, surgery) are increasingly being recognized there is a need for specific diagnostic markers and objective evaluation of parkinsonian patients. Quantitative assessment of motor performance has been proposed to be useful not only for early detection of the disease but also for monitoring disease progression and judging the effectiveness of therapy. A number of instrumental based techniques have been developed for objective evaluation of motor function in PD. However most of them require expensive equipments and are not of practical use. Furthermore only few have been standardized and validated for clinical practice.

In our study we selected three simple instrumental timed tests (Dual Tally, Tapping Board and Perdue Pegboard) for the assessment of manual performance in parkinsonian patients. These tests evaluate tapping speed, hand and arm movements, finger and hand dexterity and ability to perform sequential and simultaneous motor tasks. Our patients performance was significantly inferior to controls .Nevertheless the older age group could not be accurately differentiated from controls in most tests. The Purdue pegboard

Table 5. Differences in performance between PD patients [n = 17] and controls (NC), [n = 20]. Age Group: 71-80 years.

Test	Subjects	Mean	SD	Significance
tapping right	PD	67.17	14.28	p = 0.282*
	NC	72.10	13.13	
tapping left	PD	60.58	12.64	p = 0.071*
	NC	67.95	11.43	
dual tally right	PD	74.47	17.75	p = 0.334*
	NC	80.00	16.54	
dual tally left	PD	71.41	19.63	p = 0.317*
	NC	77.50	16.87	
pegboard 15 sec right	PD	4.52	1.28	p = 0.374*
	NC	4.85	0.87	
pegboard 15 sec left	PD	3.94	1.08	p = 0.001
	NC	5.15	1.03	
pegboard 15 sec bilateral	PD	3.00	1.11	p = 0.008
	NC	4.00	0.97	
pegboard 30 sec right	PD	9.00	2.52	p = 0.297*
	NC	9.75	1.77	
pegboard 30 sec left	PD	8.11	1.93	p = 0.021
	NC	9.60	1.78	
pegboard 30 sec bilateral	PD	6.29	1.75	p = 0.012
	NC	7.80	1.70	

Standard deviation ;* = Not significant.

test also was not particularly useful for PD differentiation in most age groups.

Timed tests such as pronation-supination test, hand/arm movement between two points and finger dexterity have been included in the evaluation of PD patients selected for surgical intervention (CAPIT)[9]. Lang et al recommended the Purdue Pegboard to be added in the evaluation of these patients[10]. The new CAPIT-PD program contains only the hand/arm movement between two points timed test[11]. However there are controversies about the use of multiple tests in the evaluation of patients with advanced PD who were candidates for surgical intervention. Menman et al[12] argued against multiple baseline assessments while Ruiz et al[13] proposed that the timed test movement between two points, given the excellent correlation with clinical scores before and after subthalamic stimulation, should be used for objective and fast evaluation of PD patients.

Kraus et al developed and standardized a multidimentional test battery (line tracing, steadiness, tapping, plugging) for evaluation of motor skills and motor performance of the upper extremities[14]. According to Nutt et al[15] tapping speed is influenced by PD and practice but parkinsonian patients do not benefit as much from continued practice as do normal subjects. In the study of Adler et al[16] timed tapping test and Purdue pegboard test showed a graded reduction in those patients clinically found to have possible and probable PD. However test scores did

not reveal a definite longitudinal worsening in motor performance despite evidence of clinical worsening on examination.

Motor performance testing is influenced by a number of factors of which age is the most important one. Slower motor performance is part of the normal aging. Motor examination reveals increase tone, decreased arm swing and declining motor speed in elderly population[17,18]. Furthermore there is a decline in performance in various coordination tests and in activities of daily living that need manual dexterity[17,18]. Tapping speed is inversely related to age. Adler et al[16] reported a negative correlation between tapping speed in both hands and age, that is as age increased, the speed of tapping decreased. This can explain the failure of timed instrumental tests to differentiate PD patients older than 71 years from controls in our study.

Exploring the relationship of motor disability to instrumental timed test scores in a subgroup of PD patients younger than 70 yrs, we observed that all test scores correlated negatively to UPDRS motor score. On the other hand PD patients' performance was significantly worse as stage of the disease advanced in some of these tests only. This last finding must be interpreted with caution. Stratification of patients according to stage yielded small subgroups that might have affected statistical significance. UPDRS correlated better with timed instrumental test scores since it is a motor scale heavily loaded by akinesia and rigidity severity. It is obvious that these two PD signs were directly related to inferior performance in timed motor testing.

In conclusion simple instrumental timed tests are useful in the objective evaluation of PD patients. These tests can be used complementary to clinical evaluation taking into consideration that their reliability is compromised in old age.

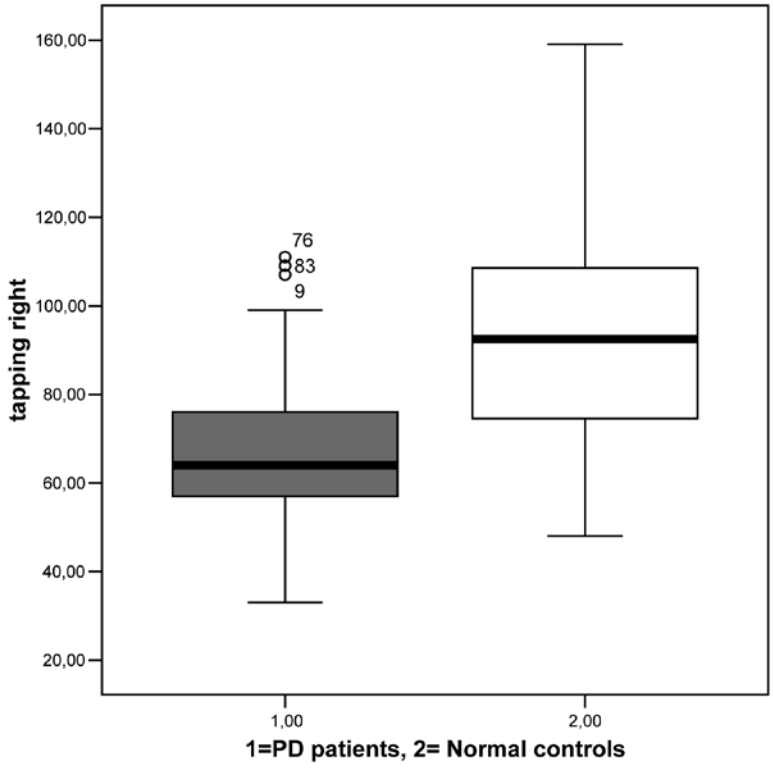

Figure 1. Boxplots depicting differences in Tapping test performance with the dominant hand between PD patients and controls (p = 0.0001).

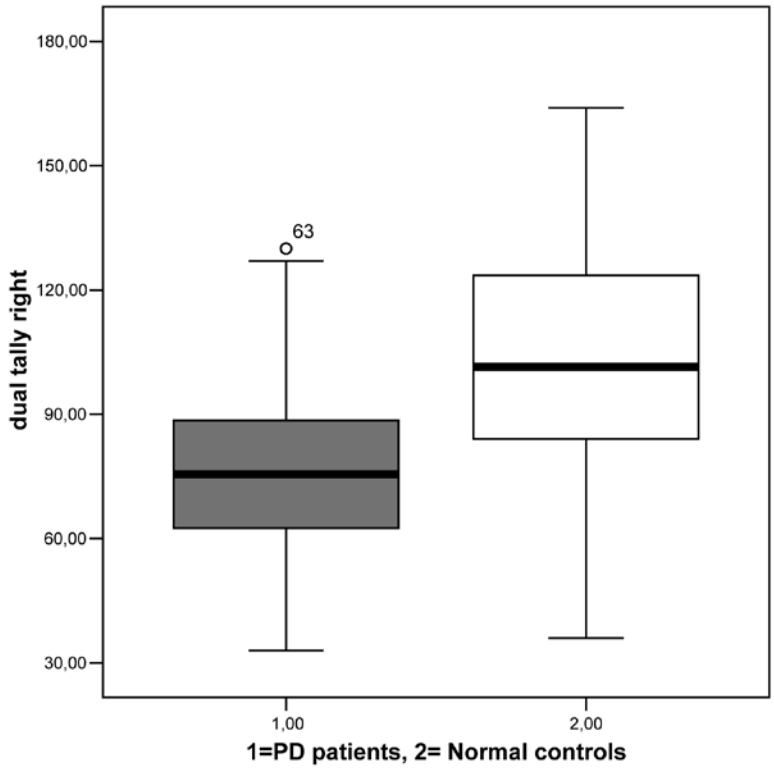

Figure 2. Boxplots depicting differences in Dual tally test performance with the dominant hand between PD patients and controls (p = 0,0001).

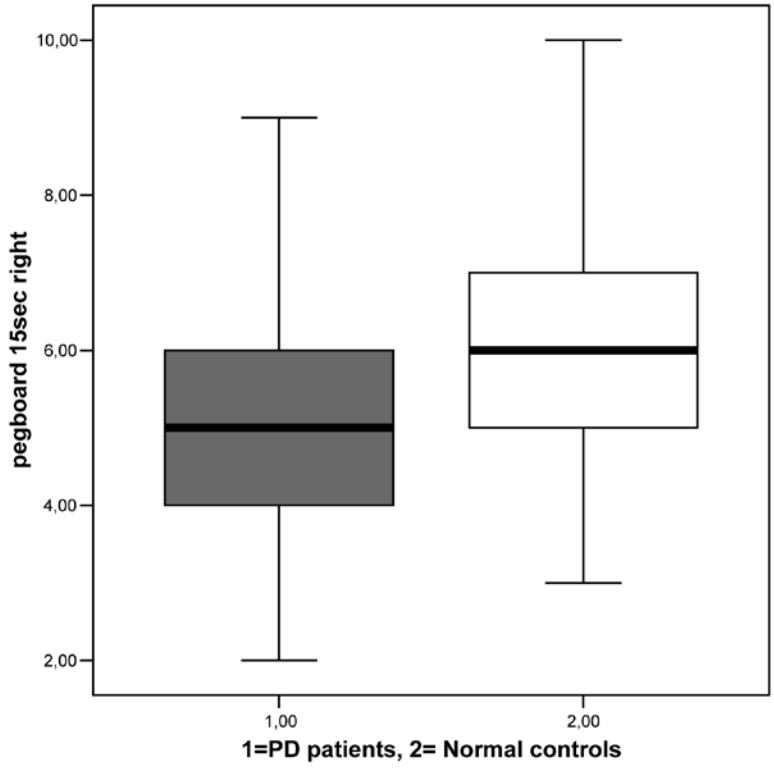

Figure 3. Figure 3. Boxplots depicting differences in Purdue pegboard test performance (with the dominant hand at 15 seconds), between PD patients and controls (p = 0.0001).

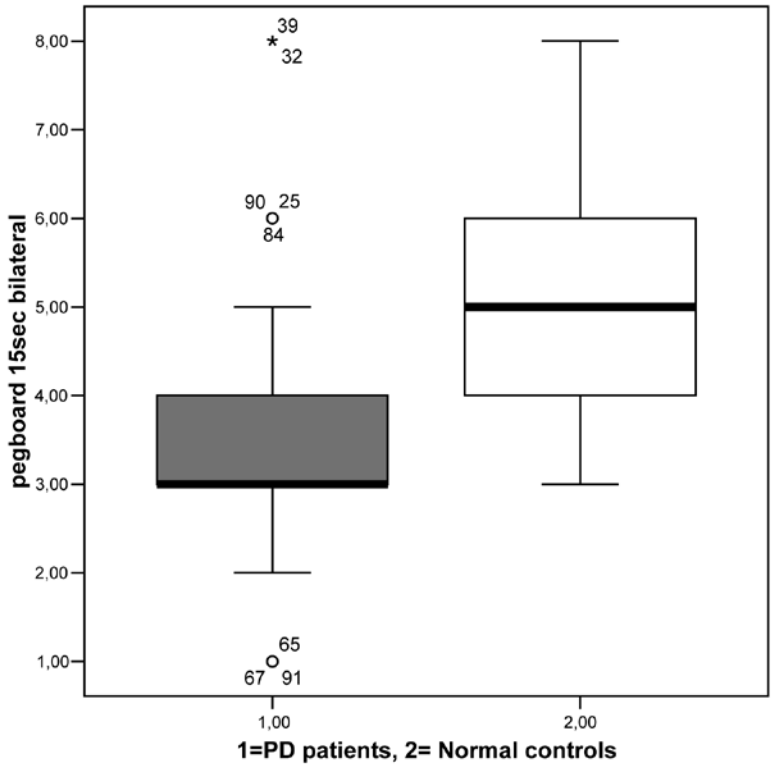

Figure 4. Boxplots depicting differences in Purdue pegboard test performance (with both hands at 15 seconds), between PD patients and controls (p = 0.0001).

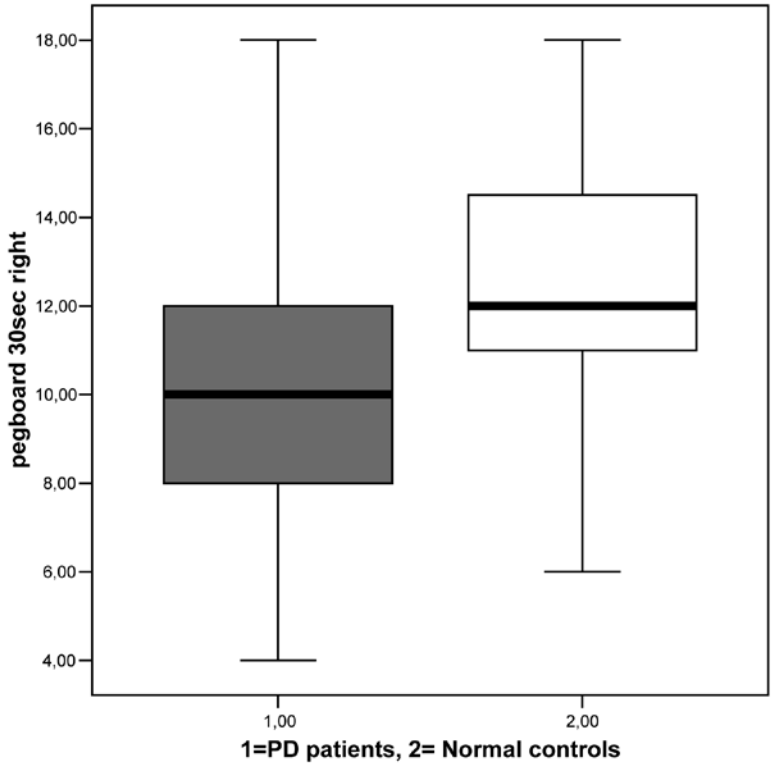

Figure 5. Boxplots depicting differences in Purdue pegboard test performance (with the dominant hand at 30 seconds), between PD patients and controls (p = 0.0001).

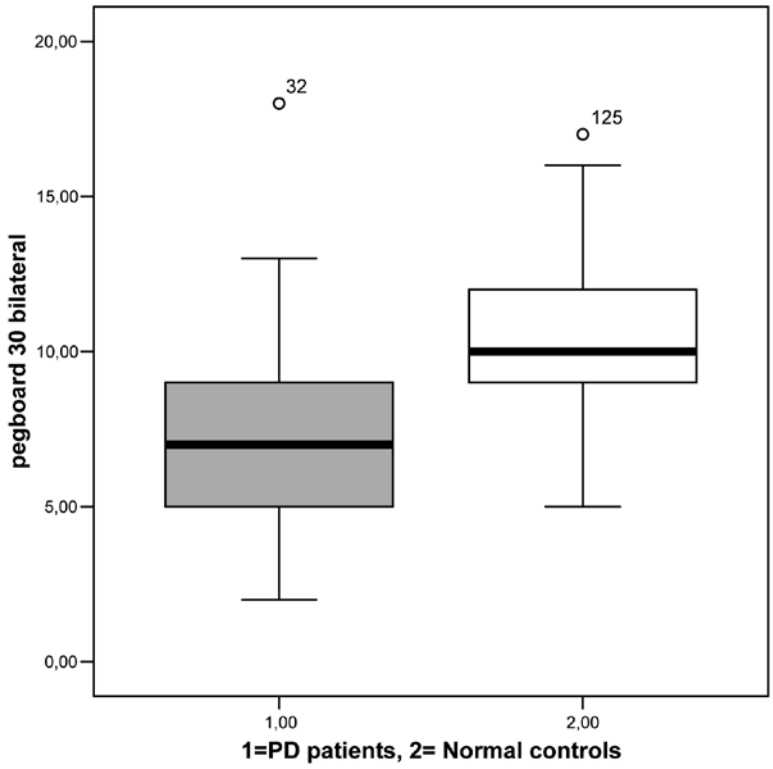

Figure 6. Boxplots depicting differences in Purdue pegboard test performance (with both hands at 30 seconds), between PD patients and controls (p = 0.0001).

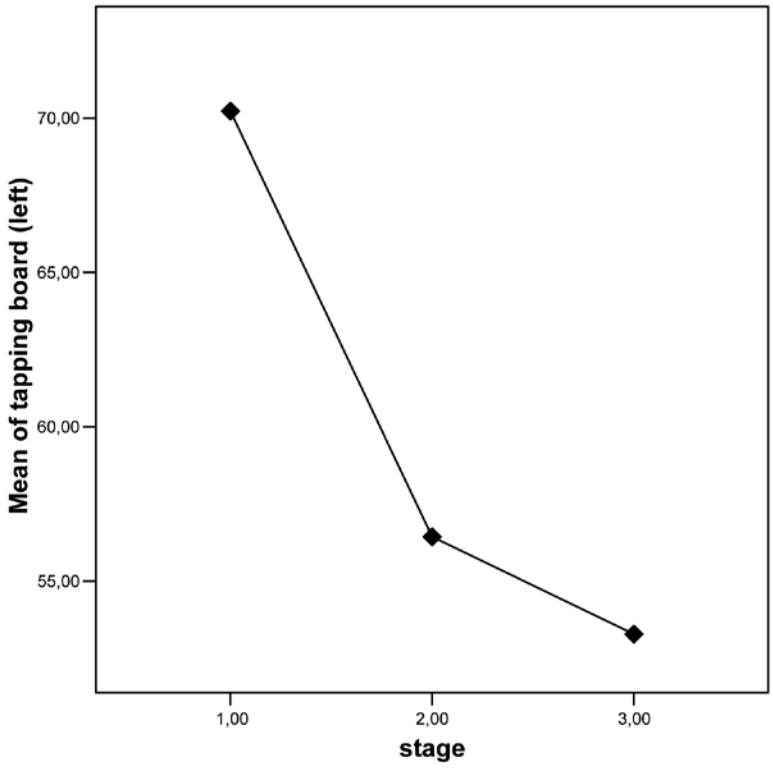

Figure 7. Mean Tapping board score (left upper extremity) in relation to stage of Parkinson's disease (p = 0.001).

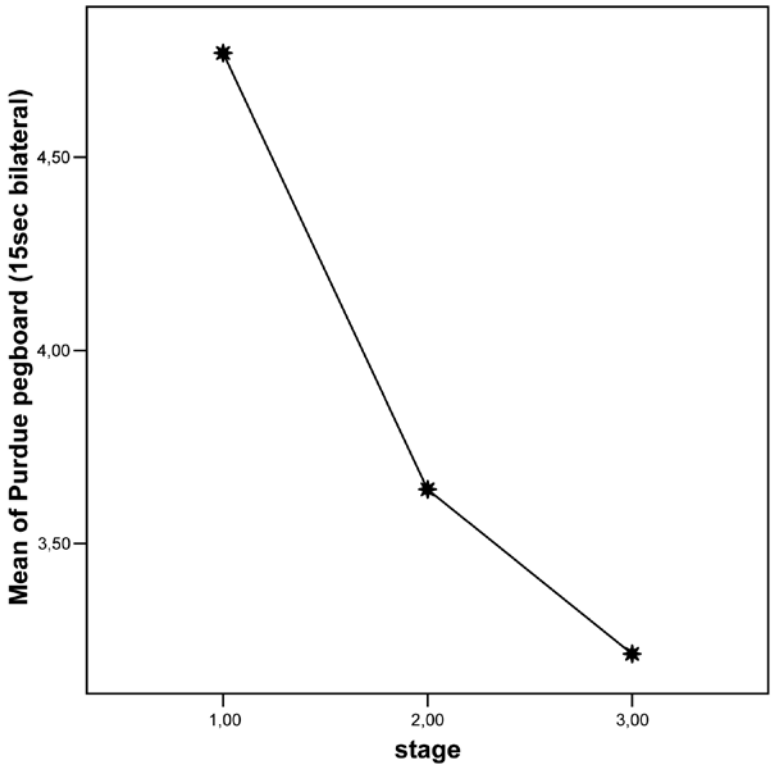

Figure 8. Mean Purdue pegboard score (bilateral performance at 15 seconds) in relation to stage of Parkinson's disease ($p = 0.007$).

Αξιολόγηση της κινητικότητας των άνω άκρων στη νόσο του Parkinson

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Γ΄ Νευρολογική Κλινική Α.Π.Θ.

ΠΕΡΙΛΗΨΗ: Ο σκοπός της μελέτης μας ήταν η αντικειμενική αξιολόγηση της επιδεξιότητας των χεριών των παρκινσονικών ασθενών με τη βοήθεια απλών χρονομετρούμενων οργάνων και η σύγκριση τους με φυσιολογικά άτομα. Μελετήθηκαν 97 δεξιόχειρες παρκινσονικοί και 80 φυσιολογικά άτομα ίδιας ηλικίας. Ο έλεγχος της επιδεξιότητας των άνω άκρων έγινε με τη βοήθεια τριών ειδικών οργάνων: 1) Σανίδα πλήξης, 2) Αμφίχειρο πλήκτρο αντίχειρα και 3) Purdue pegboard. Οι παρκινσονικοί ασθενείς είχαν σημαντικά χαμηλότερες επιδόσεις σε σύγκριση με τα φυσιολογικά άτομα σε όλες τις δοκιμασίες. Οι επιμέρους αναλύσεις κατά ομάδες ,ανάλογα με την ηλικία, έδειξαν ότι οι ασθενείς άνω των 71 ετών δεν είχαν διαφορές από τα φυσιολογικά άτομα της ίδιας ηλικίας.

Περαιτέρω έγινε διερεύνηση της σχέσης των επιδόσεων των παρκινσονικών ασθενών οι οποίοι είχαν ηλικία κάτω των 70 ετών με την κινητική τους αναπηρία. Η κλίμακα κινητικής αναπηρίας UPDRS παρουσίασε σημαντική αρνητική συσχέτιση με την επίδοση σε όλα τα όργανα. Η σύγκριση των επιδόσεων στα ειδικά όργανα μεταξύ των διαφόρων σταδίων της νόσου έδειξε σημαντική διαφορά στη Σανίδα πλήξης, στο Αμφίχειρο πλήκτρο αντίχειρα με το αριστερό χέρι , στο Purdue pegboard με αμφίχειρη εκτέλεση στα 15 sec και στα 30 sec με το δεξί χέρι.

Από τη μελέτη μας συμπεραίνουμε ότι η αξιολόγηση της επιδεξιότητας των χεριών των παρκινσονικών ασθενών με τη βοήθεια των τριών παραπάνω οργάνων είναι αξιόπιστη, με την προϋπόθεση ότι γίνεται σε άτομα ηλικίας μικρότερης των 70 ετών.

Λέξεις Κλειδιά: Νόσος του Parkinson, Κινητική αξιολόγηση, Κινητική επιδεξιότητα.

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