ORIGINALARTICLE

Correlation between Tapping and Inserting of Pegs in Parkinson's Disease

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ABSTRACT: ***Background:*** Various investigators have developed complex quantitative instrumental procedures for objective assessment of parkinsonian motor impairment, since drawbacks of rating scales are interrater variability, subjective impression, and insensitivity to subtle modifications. ***Objectives:*** To determine whether performance of inserting of pegs and tapping (i) correlates with each other (ii) differentiates between parkinsonian subjects and healthy controls and (iii) reflects severity of Parkinson's disease (PD). ***Subjects and methods:*** In 157 previously untreated idiopathic parkinsonian patients and healthy controls, we measured (i) the total time taken to insert 25 pegs from a rack into a series of appropriate holes in a Purdue pegboard-like apparatus and (ii) the number of taps on a contact board with a contact pencil for a period of 32 seconds for assessment of fine motor skills. ***Results:*** Results of both tests correlated with each other, differed between parkinsonian subjects and controls and reflected scored severity of PD. Better correlation with intensity of PD was noted with the Purdue pegboard-like task. ***Conclusion:*** Both tapping and inserting of pegs represent useful tools for objective evaluation of severity of PD. Peg insertion correlated better with disease severity. Both approaches may be useful in future clinical studies.

RÉSUMÉ: Corrélation entre le tapping et la planche à chevilles dans la maladie de Parkinson. ***Introduction:*** Différents investigateurs ont développé des méthodes instrumentales quantitatives complexes pour l'évaluation objective du déficit moteur parkinsonien à cause des inconvénients inhérents aux échelles d'évaluation, soit la variabilité entre les observateurs, la subjectivité et le peu de sensibilité à des modifications subtiles. ***Objectifs:*** Déterminer si la performance au tapping et à la planche à chevilles (i) sont en corrélées (ii) identifie les parkinsoniens et les contrôles et (iii) reflète la sévérité de la maladie de Parkinson (MP). ***Sujets et Méthodes:*** Nous avons mesuré (i) le temps total pour transférer 25 chevilles d'un support à une série de trous appropriés dans une planche à chevilles de type Purdue et (ii) le nombre de percussions avec un stylet sur une surface de contact pendant une période de 32 secondes pour évaluer la motricité fine chez 157 patients atteints de MP idiopathique jamais traités. ***Résultats:*** Les résultats de ces deux tests étaient corrélés entre eux, différaient entre les parkinsoniens et les contrôles et reflétaient la sévérité de la MP. Une meilleure corrélation a été observée entre la sévérité de la MP et la performance à la planche à chevilles de type Purdue. ***Conclusion:*** Le tapping et la planche à chevilles sont des outils utiles pour évaluer objectivement la sévérité de la MP. La performance à la planche à chevilles a une meilleure corrélation avec la sévérité de la maladie. Les deux approches pourraient s'avérer utiles lors d'études cliniques ultérieures.

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Neurological examination of parkinsonian symptomatology encompasses a range of procedures that gauge the status of the extrapyramidal motor system.[1] These procedures typically consist of clinical rating scales, that estimate motor function but are variable from one examiner to the other and are relatively insensitive to subtle disease.[1-4] The subjective impression of the parkinsonian patient by the examiner may also influence the scores.[1] As a result, investigators have developed complex quantitative instruments for objective assessment of parkinsonian motor impairment.[4,5] These instruments objectively assess tremor and motor slowness, characterized by two components: failure to initiate a willed movement (akinesia) and slowness of the ongoing movement (bradykinesia).[4,5] However, such techniques are difficult to handle for assessment and evaluation of therapy and may not reflect all motor symptoms in Parkinson's disease (PD).[4,5] In contrast, the Purdue pegboard is a simple apparatus, that shows a good test-retest reliability and

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correlates with the dopaminergic nigrostriatal deficit in PD.[6-10] Our Purdue pegboard-like apparatus measures the total time taken to insert 25 pegs from a rack into a series of holes in contrast to the standard test, that counts the number of pegs inserted during 30 seconds for each hand.[7-10] Tapping represents an additional simple instrument to quantitate a motor deficit. Various finger tapping procedures have been used to evaluate antiparkinsonian drug response in treated parkinsonian subjects in previous studies.[11-14] To date, no study has investigated the relationship between both tools in previously untreated parkinsonian subjects and healthy controls and analyzed their association to intensity of PD.

On the one hand, study of motor function in parkinsonian patients in the medicated state provides useful information about how they perform tasks in everyday life. On the other hand, testing patients while off medication is essential to get further information on the pathophysiology of the disease, the mechanisms underlying PD and basal ganglia function.[15] Since previously untreated parkinsonian individuals are identified less often, patients off medication for at least 12 hours, are generally studied.[16] Nevertheless, investigation of motor function of previously untreated parkinsonian patients may be more informative, because dopaminergic substitution therapy may include drugs with a half life much longer than 12 hours.

The objectives of the present study were to determine whether standardized performance of inserting of pegs and tapping correlates with each other, differentiates between parkinsonian subjects and healthy controls and reflects severity of PD.

Subjects and Methods

Subjects

We enrolled 157 right-handed, previously untreated, idiopathic parkinsonian subjects (mean age: 59.1 ± 8.7 standard deviation (SD) years, range: 30-75 years, female n = 51, male n = 106; Hoehn and Yahr scale (HYS) (mean: 2.2 ± 0.7 (SD), range I: n = 26, range II: n = 78, range III: n = 53; Unified Parkinson's Disease Rating Scale (UPDRS) I–III: 32.1 ± 15.2 (SD), range: 5-75) into the study.[17,18] They fulfilled clinical diagnostic criteria for PD and were not treated prior to or during the study.[19,20] Subsequent therapy was not delayed by participation in the study.

Ethics

Informed consent was obtained from each subject. This study was approved by the local ethical committee.

UPDRS

We subdivided suitable items of UPDRS part III into the right and left side to score motor symptoms (UPDRS III right/left [item: 20b, 20c, 21, 22b, 22c, 23-26]), respectively on each arm (UPDRS III right/left arm [item: 20b, 21, 22b, 23-25]).[21] Scoring with part III (motor score) of the UPDRS revealed pronounced motor symptoms on the right side in 67 and on the left side in 83 subjects. Seven patients showed no side-to-side differences. UPDRS part III did not significantly differ between participants with an accentuated parkinsonian symptomatology on the right – compared to the left side (p = 0.85). Comparisons between

Table 1: Data of inserting of pegs (ms) and tapping of parkinsonian subjects, subdivided according to their Hoehn and Yahr stage, and healthy controls and corresponding comparisons.

		inserting of pegs					tapping				
		mean	SD	range	median	comparison	mean	SD	range	median	comparison
total	0	817.2	97.7	645-1072	800	**ANOVA: H = 75.2 p < 0.0001**	364.8	38.3	250-454	366.5	**ANOVA: H = 50.9 p < 0.0001**
	I	925.9	154.5	709-1363	909	**0 vs I: p = 0.0009**	338.9	41.8	250-406	340.5	0 vs I: p = 0.013
	II	981.0	186.7	634-1677	956	**0 vs II: p = 5.6 E-08**	309.0	44.0	139-398	310.0	**0 vs II: p = 7.4 E-11**
	III	1158.8	213.9	780-1796	1107	**0 vs III: p = 1.9 E-14**	299.9	57.4	169-415	303	**0 vs III: p = 3.4 E-8**
right	0	398.0	54.9	300-555	387	**ANOVA: H = 68.6 p < 0.0001**	190.0	20.0	131-227	189.5	**ANOVA: H = 41.8 p < 0.0001**
	I	454.3	65.1	351-571	438	**0 vs I: p = 0.0004**	173.9	21.5	131-207	181	**0 vs I: p = 0.006**
	II	469.	98.3	315-1020	443	**0 vs II: p = 7.5 E-07**	162.9	25.2	61-203	168	**0 vs II: p = 3.4 E-9**
	III	568.4	119.0	379-824	538	**0 vs III: p = 2.5 E-13**	159.0	31.6	68-216	162	**0 vs III: p = 2.3 E-7**
left	0	419.2	49.0	327-530	419	**ANOVA: H = 69.4 p < 0.0001**	174.9	21.5	119-231	178	**ANOVA: H = 45.6 p < 0.0001**
	I	471.5	109.2	346-800	441	0 vs I: p = 0.064	164.9	26.9	119-217	159.5	0 vs I: p = 0.11
	II	512.0	110.1	319-1005	505	**0 vs II: p = 7.9 E-08**	146.1	22.6	78-198	147	**0 vs II: p = 7.8 E-10**
	III	590.4	111.0	381-972	576	**0 vs III: p = 2.2 E-14**	140.8	31.5	83-201	142	**0 vs III: p = 2.7 E-07**

Abbreviations:
- total = sum of results of the right and left hand peg insertion score respectively tapping score, right = right hand, left = left hand,
- 0 = controls, I = Hoehn and Yahr Stage I, II = Hoehn and Yahr Stage II, III = Hoehn and Yahr Stage III,
- ANOVA: results of the Kruskal Wallis ANOVA test.
- 0 vs I, 0 vs II, etc. p-values of post hoc analysis
- significant results are in bold fonts

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Table 2: Correlation analysis of parkinsonian subjects'data and their UPDRS scores

Correlation		Inserting of pegs			Tapping		
variable 1	**variable 2**	**R**	**t(N-2)**	**p**	**R**	**t(N-2)**	**p**
UPDRS I	both hands	0.19	2.37	0.019	-0.26	-3.33	0.0011
UPDRS II	both hands	0.57	8.57	9.54E-15	-0.31	-3.99	0.0001
UPDRS III	both hands	0.63	10.07	1.14E-18	-0.29	-3.78	0.0002
UPDRS III right + left arm	both hands	0.54	8.04	2.14 E-13	-0.27	-3.45	0.0007
UPDRS I-III	both hands	0.66	10.94	5.20E-21	-0.32	-4.18	0.00005
UPDRS III right	right hand	0.37	5.03	1.31E-06	-0.21	-2.64	0.009
UPDRS III right arm	right hand	0.38	5.17	7.08E-07	-0.22	-2.75	0.0066
UPDRS III left	left hand	0.59	9.12	3.82E-16	-0.27	-3.48	0.0007
UPDRS III left arm	left hand	0.60	9.45	5.00E-17	-0.23	-3.00	0.0031

R = Spearman rank correlation coefficient, p = p-value

UPDRS part III right and UPDRS part III left (p = 0.28) and UPDRS part III right arm vs UPDRS part III left arm (p = 0.26) were not significant. Nine parkinsonian individuals of HYS I had their symptoms on the left side, the other 17 individuals showed motor impairment on the right side.

Controls

We also performed both tests in 46 right-handed healthy controls (mean age: 56.95 ± 9.31 SD years, range: 29-74 years, female n = 25, male n = 21).

Exclusion criteria

We excluded individuals with a cerebral parenchymal lesion or atrophy, previous exposure to drugs affecting the dopaminergic system, dementia or depression.

Clinical assessment

We immediately scored parkinsonian patients with UPDRS and HYS before or after the subjects' test performance. Raters were blinded to the peg insertion and the tapping results.

Inserting of pegs

We asked subjects to individually transfer 25 pegs (diameter 2.5 mm, length 5 cm) from a rack into a series of appropriate holes (diameter 2.8 mm) in a computer-based contact board, as quickly as possible. The distance between rack and appropriate holes was exactly 32 cm. The board was in a centralized position. When transferring each peg from rack to hole, elbows were allowed to be in contact with the Table. We measured the time interval between inserting of the first and the last pin, initially with the right, and then with the left hand. We used a computer to assess the time period for this task to 100 ms accuracy. The peg insertion score represents the sum of results of the right hand (inserting of pegs right) and left hand (inserting of pegs left) (Table 1).

Table 3: Correlation analysis of both apparative tasks in parkinsonian subjects and controls.

Correlation of tapping and inserting of pegs			
Parkinsonian patients	**R**	**t(N-2)**	**p**
both hands	-0.32	-4.14	0.000056
right hand	-0.29	-3.84	0.0002
left hand	-0.34	-4.49	0.000014
Controls			
both hands	-0.39	-2.79	0.0079
right hand	-0.28	-1.94	0.058
left hand	-0.53	-4.10	0.0002

R = Spearman rank correlation coefficient, p = p-value.

Tapping

Individuals tapped, as quickly as possible, on a contact board (3 cm x 3 cm) with a contact pencil for a period of 32 seconds after the initial flash of a yellow stimulus light. We did not control for peak height reached by the pencil. The board was in a centralized position, when the task was carried out on each side. When performing the task, elbows were allowed to be in contact with the Table. We obtained the number of contacts by a computer. First, we measured the frequency of tapping with the right hand (tapping right) and then with the left hand (tapping left). The tapping score represents the sum of tapping results of the right hand (tapping right) and left hand (tapping left) (Table 1).

We allowed all participants to get familiar with both tasks for a time period of 60 seconds before evaluation, to avoid learning and training effects.[22]

Statistics

Data from both tasks did not have a normal distribution according to the Kolmogorow-Smirnow test. As a result, non-parametric tests were used for statistical analysis. We used the Kruskal Wallis ANOVA test and for *post hoc* analysis the Mann Whitney U test. We required significance at the 0.0125 level for *post hoc* tests to be significant, when performing the *post hoc* comparisons between controls and parkinsonian subjects in HYS stage I, II and III for each task. We employed the Wilcoxon matched pairs test with an α-adjustment to 0.01 for comparisons within individuals. We used Spearman Rank Order Correlation with an α-adjustment of the p-value to 0.005 for each test. We discussed p-values below 0.05 as significant trend.

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Results

Comparison between parkinsonian subjects and controls

Calculated results of both hands differed between parkinsonian subjects, subdivided according to their HYS range, and controls. We found significant differences between obtained data of the right hand for both tests within all four groups. Data of both tools, performed with the left hand, significantly varied except for the comparison between controls and parkinsonian subjects of HYS I (Table 1).

Comparisons between the right and the left hand

Significant differences of both tasks appeared between the right- and the left hand in the parkinsonian - (inserting of pegs: p = 0.000003; tapping: p = 1.2 E-14) and control group (inserting of pegs: p = 0.0009; tapping: p = 0.000002).

Correlation analysis between data of both tests and severity of PD

Tapping showed a significant association to part I (mental behaviour) of the UPDRS. In contrast, we found only a significant trend in the case of inserting of pegs. UPDRS part II (activities of daily living) and UPDRS part III (motor symptoms) correlated to both tests, but correlation coefficients were higher and p-values lower in the Purdue pegboard-like task (Table 2).

Correlation analysis between tapping and inserting of pegs

Tapping significantly correlated to inserting of pegs in parkinsonian subjects, the association was stronger on the left than on the right side. A same pattern appeared in the controls, but the correlation between tapping and inserting of pegs on the right side was not significant (Table 3).

Influence of sex and age

We found no significant influence of sex (comparison [both hands]: PD: inserting of pegs: female vs male: p = 0.34; tapping: p = 0.31; controls: inserting of pegs: female vs male: p = 0.06; tapping: p = 0.36).

Age significantly influenced (inserting of pegs: correlation [both hands]: PD: R = 0.26, t(N-2) = 3.45, p = 0.0007; controls: R = 0.59, t(N-2) = 4.97, p = 1.05 E-05) our data in the case of inserting of pegs. Age did not correlate to tapping in the parkinsonian subjects (R = 0.08, t(N-2) = 0.94, p = 0.34) but did in the controls (R = -0.35, t(N-2) = -2.48, p = 0.017).

Age of controls and parkinsonian subjects did not significantly differ (p = 0.18), even when comparing age of controls with the one of parkinsonian subjects in HYS I (p = 0.51), II (p = 0.06) and III (p = 0.26).

Discussion

Both applied tasks differed between parkinsonian participants and controls, but a certain overlap of data occurred with both methods (Table 1). Comparison between controls and parkinsonian individuals of HYS I was not significant on the left side, when examined alone (Table 1). We assume this results from the majority (17 vs 9) of parkinsonian subjects of HYS I presenting their motor symptoms on the right side.

Significant associations to intensity of PD, evaluated by part II (activities of daily living) and part III (motor symptoms) of the UPDRS, confirm the literature which suggests that both instruments reflect severity of PD.[6-14] Higher correlation coefficients appeared in the case of tapping compared to inserting of pegs (Table 2). This may indicate a superiority of the Purdue pegboard-like task in comparison to the tapping test in reflecting severity of PD, evaluated with the UPDRS.

The relationship between UPDRS motor score and data of both applied tasks of the right dominant side showed a lower correlation coefficient compared to the left hand. Thus our study confirms previous trials demonstrating a better expression of motor symptoms on the non-dominant side in parkinsonian subjects.[5,23] The higher correlation coefficient between tapping and inserting of pegs results on the left compared to the right side and the absence of a significant correlation on the right hand in the controls supports this view. The main findings of this study are the significant associations between results of both tools (Table 3). Future comparative studies between both tests will evaluate whether both are able to reflect improvement of motor symptoms as a response to antiparkinsonian drugs in serial testing within controlled trials as adjunct to disability scoring of patients and reach the same sensitivity.

The significant impact of age on test results of our healthy study participants confirms previous trials.[24] In the case of inserting of pegs we also found an age dependence in the parkinsonian patients, but the parkinsonian tapping results did not correlate with age. The severity of PD as bias may represent one reason for this absent correlation between age and tapping data in our parkinsonian group. A drawback of our study is that we did not exactly match for age with healthy controls for each group in the various Hoehn and Yahr stages due to the limited availability of data of healthy controls. But age of our controls did not significantly differ from the various groups of parkinsonian subjects, subdivided according to their Hoehn and Yahr stage. The impact of sex on fine motor skills with women performing significantly better than men represents a further important, but controversially discussed issue in the literature.[25] All significant sex differences in performance of fine motor tasks disappeared when measures of index finger and thumb thickness were used as covariates.[25] Nevertheless, the validity of our study may have improved had there been exact matching for sex and additional estimation of finger size. Another crucial issue may be the significant trend of tapping, respectively significant association in the case of inserting of pegs, for the correlation between part I (mental behaviour) of the UPDRS and the results of task performance with both hands. On the one hand these associations may support the validity of both tests. On the other hand, a more detailed evaluation and analysis of study participants' cognition would have improved the quality of our trial since depression, for example, may affect motor performance in PD.[26-28] Both instruments are not specific for PD, because other diseases and/or fatigue may also influence fine motor skills.[9,29]

In conclusion, our results promote the clinical validity of both tasks for objective assessment of parkinsonian motor impairment, but inserting of pegs appeared to be superior to tapping. Future comparative studies will evaluate the ability and sensitivity of both procedures to follow intra patient responses to therapeutic interventions or disease progression.

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