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ARAŞTIRMA / RESEARCH

Postural stability in early Parkinson's disease: effect of cognitive dual-tasking

Erken evre Parkinson hastalığında postural stabilite: kognitif ikili görevin etkisi

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Abstract

Purpose: The primary aim of this study is to evaluate postural stability by using a static posturography in patients with early Parkinson's disease (PD). Secondly, this paper addresses the need for illustrating the effect of dual-tasking on postural stability in early PD patients.
Materials and Methods: Twenty-nine early PD patients with maximum 5 years of disease duration were included in this study. The selected group had no clinical PI while their age- and sex-matched healthy controls were carried out. Neurological examination and mini-mental state examination (MMSE) were performed in all subjects. Unified Parkinson Disease Rating Scale (UPDRS) and modified Hoehn and Yahr (H&Y) scores were recorded in PD patients. Postural stability was assessed in all subjects on a static posturography platform under three different conditions: eyes open, eyes closed and a cognitive task of producing words with given letters.
Results: The mean age of the PD was 59.2±10.5 whereas the control groups mean age was 56.3±7.6 ($p>0.05$). The female-male ratio was 9/20 in the PD and 12/17 in the control group. There was no important difference between the two groups in terms of demographic characteristics. In the PD group, the mean UPDRS was 12.8±4.9. The patients were mostly receiving polytherapy.
Eye closure and cognitive task caused an increase in most sway parameters in both groups.
Conclusion: Early PD patients on medication, postural stability is preserved and cognitive dual-tasking does not affect postural stability in these patients in the early stage.

Keywords: Dual-task interference, cognitive task, Parkinson's disease, postural instability, static posturography

Öz

Amaç: Bu çalışmanın temel amacı, erken evre Parkinson hastalığında (PH)'da statik posturografi cihazı kullanarak postural stabiliteyi değerlendirmektir. İkincil amaç ise erken evre PH'da ikili görevin postural stabilite üzerindeki etkisini incelemektir.
Gereç ve Yöntem: Bu prospektif çalışmaya hastalık süresi en fazla beş yıl olan, klinik PI'sı olmayan, yirmi dokuz erken evre PH ile yaş ve cinsiyet uyumlu yirmi dokuz sağlıklı kontrol grubu alındı. Tüm olgulara hareket bozukluğu uzmanı eşliğinde nörolojik muayene ve mini-mental durum muayenesi (MMSE) yapıldı. Parkinson hastalarında Birleşik Parkinson Hastalığı Değerlendirme Ölçeği (BPHDÖ) ve modifiye Hoehn ve Yahr (H&Y) skorları kaydedildi. Postural stabilite, tüm deneklerde statik posturografi cihazında gözler açık, gözler kapalı ve verilen harflerle kelimeler türetmesi istenerek kognitif görev esnasında olmak üzere üç farklı koşul altında değerlendirildi.
Bulgular: PH yaş ortalaması 59,2±10,5 ve kontrol grubunun yaş ortalaması 56,3±7,6 ($p>0,05$), kadın-erkek oranı PH'da 9/20 ve kontrol grubunda 12/17 olup, demografik özellikler açısından her iki grup arasında anlamlı fark saptanmadı. PH grubunda BPHDÖ ortalama skoru 12,8±4,9 idi. Olgular çoğunlukla politerapi almakta idi. Her iki grupta da göz kapalı tüm ölçümlerde salınım değerlerinin, göz açık ölçümlere göre belirgin olarak arttığı gözlendi.
Sonuç: İlaç kullanan erken evre PH'da postural stabilitenin korunduğunu ve kognitif görevin bu hastalarda erken evrede postural stabiliteyi etkilemediğini göstermektedir.

Anahtar kelimeler: Çift görev çatışması, kognitif görev, Parkinson hastalığı, postural instabilite, statik posturografi

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INTRODUCTION

Postural stability (PS) is ensured by the integration of the visual, vestibular and proprioceptive systems, and normal balance control is ascertained only if two of these three systems are intact. PI is a common feature of Parkinson's disease (PD). This complex mechanism between the two needs to be further clarified, in particular the integration of different neural structures both in the central and peripheral nervous system[1,2]. PI is one of the most disabling symptoms in the advanced stages of PD, causing falls and leading to physical dependence. On the other hand, in early PD, it is an unexpected clinical finding. However, a few studies demonstrated subclinical PI in early PD, some associated with visual deprivation, one with autonomic dysfunction[3-6].

Dual-tasking is a common every-day life situation. It is the ability to perform two tasks, either motor and/or cognitive, simultaneously[7]. Daily activities, such as talking while walking, calculating while dressing, writing while listening to music are examples of dual-tasking and healthy people can perform multiple tasks with ease. There are a few studies on the effect of secondary cognitive or motor tasks increasing postural instability and fall risk in PD[8-12]. All of these studies are with patients with advanced disease. To our knowledge, there is only one study regarding the effect of cognitive tasks on postural stability in early PD[13].

Considering the current literature, we hypothesized that early PD patients may have subtle PI which could be assessed by static posturography (SPG), and dual-tasking may affect postural stability in these patients. Therefore, the primary aim of our study was to assess postural stability in patients with early PD using SPG. Another purpose of this research was to evaluate the effect of cognitive task on postural stability in early PD.

MATERIALS AND METHODS

Our study is a prospective cross sectional study and written informed consent was obtained from all participants before enrollment. This study was approved by the Ethics Committee of Çukurova University, Faculty of Medicine.

Sample

Twenty-nine healthy individuals (17 males, 12 females) and 29 PD patients in early stage of (20 males, 9 females) from the Department of Neurology at the Cukurova University Faculty of Medicine were involved in this study. Inclusion criteria consisted of patients diagnosed with PD according to the UK's Brain Bank Criteria, with a maximum disease duration of 5 years, and with Hoehn & Yahr (H&Y) stage of maximum 2.0. Patients with clinically evident PI, which was assessed by Unified Parkinson's Disease Rating Scale (UPDRS) PI score >0, were excluded.

Procedure

Disease duration was recorded according to the onset of the first symptom. Subjects with a mini-mental state examination (MMSE) score of less than 26, and with an education level less than 5 years were not included[14]. Patients with comorbid neurological disorders which can impair posture and postural stability such as diabetes mellitus, polyneuropathy, ataxia, cerebrovascular disease, rheumatologic or orthopedic problems, orthostatic hypotension, vestibulopathy or otological disease, or severely blurred vision, as well as those on sedative drugs or substances were excluded. Healthy controls with completely normal neurological examination were age, gender, and weight-matched.

Neurological examinations, MMSE and SPG were performed in each subject. Modified H&Y stages were determined. UPDRS motor scores were recorded in the morning one hour after the first medication intake (monooamine oxidase inhibitor, dopamine agonist or levodopa). SPG was performed right after this examination during "on" state.

Static posturography

SPG was performed with a force platform (Lucerne II, Otopront®, Germany) in a quiet room for both PD patients and healthy controls. The subjects were told to stand on the platform in an upright position as stable as possible. They stood barefoot, with their feet 4 cm apart and the arms held alongside the body. The baseline recording was initially done with the eyes open (EO); and then with the eyes closed (EC). Each recording lasted 30 seconds and was performed thrice and then averaged. The third test was a cognitive task performed with EO producing words starting with a given letter. In this cognitive task, the process was repeated thrice with different letters (S, N, and K) each time. The cognitive performance of the participants was not evaluated during the

cognitive task. Total sway path, lateral sway, anterior-posterior (A-P) sway, sway area, and the velocity of all sway values (sway path/time, lateral sway/ time, A-P sway/time, sway area/time) were recorded. Definitions of SPG parameters are described in detail in a previous study[15].

Measures

MMSE

MMSE is a 30-point questionnaire that is used extensively in clinical and research settings to measure cognitive impairment. The MMSE test includes simple questions and problems in a number of areas: the time and place of the test, repeating lists of words, arithmetic such as the serial sevens, language use and comprehension, and basic motor skills[14].

UPDRS

The UPDRS was developed in 1987 as a gold standard by neurologists for monitoring the response to medications used to decrease the signs and symptoms of PD. Clinicians and researchers alike use the UPDRS and the motor section in particular to follow the progression of a person's Parkinson's disease. We also benefited from the UPDRS motor section in our study.

Statistical analysis

Statistical analysis was performed by using the statistical package *SPSS software* (Version 22.0, SPSS Inc., Chicago, IL, USA). If continuous variables were normal, they were described as the mean±standard deviation ($p>0.05$ in Kolmogorov-Smirnov test or Shapira-Wilk ($n<30$)). In case of abnormal continuous variables, they were described as the median. Comparisons between groups were applied true Mann Whitney U test for the unevenly distributed data. The categorical variables between the groups were analyzed by using the Chi square test or Fisher Exc. test. EO versus EC; EO and cognitive task measures data were analyzed with the help of Wilcoxon test. Correlations were tested by Spearman's correlation test. Values of $p < 0.05$ were considered statistically.

Table 1. Demographic characteristics of the subjects

	PD (Mean±SD) n:29	Median (Min-Max)	Control (Mean±SD) n:29	Median (Min-Max)	p
Age (years)	59.2±10.5	58(37-81)	56.3±7.6	56 (43-72)	0.234
Sex (F/M)	9/20	-	12/17	-	0.283
Weight	82.7±13.7	79(57-109)	77.6±10.2	75 (54-94)	0.112
Disease duration (years)	2.0±1.34	2.0(0-7)	-	-	-
MMSE	28.7±1.3	29(26-30)	28.7±1,4	29(24-30)	1.000
UPDRS	12.8±4.9	12(5-22)	-	-	-

UPDRS: Unified Parkinson's Disease Rating Scale; MMSE: mini-mental state examination; min: minimum, max: maximum; SD: standard deviation

Table 2. Pharmacological treatments

	N	%
Monotherapy	5	17.2
Polytherapy	24	82.7
MAO B Inhibitor	24	82.7
Dopamine Agonist	23	79.3
Levodopa	13	44.8

Table 3. Comparison of eyes open, eyes closed and cognitive task values in PD and control groups

	Patient (n=29)	**Control (n=29)**	**p**
	Median (Min-Max)	Median (Min-Max)	
EO total sway	29.3(20.7-51.4)	31.2(20.9-56.2)	0.595
EC total sway	42.0(29.0-137.8)	40.5(24.5-122.8)	0.528
Cognitive Task total sway	33.3(22.0-247.6)	34.2(25.4-500.1)	0.913
P EO vs EC *P EO vs Cognitive*	*0.0001* *0.052*	*0.0001* *0.031*	
EO Lateral sway	15.5(10.4-26.3)	16.6(10.1-31.1)	0.118
EC Lateral sway	18.4(11.2-55.6)	20.1(10.2-45.5)	0.778
Cognitive Task Lateral sway	17.5(9.0-131.6)	18.6(11.8-34.5)	0.511
P EO vs EC *P EO vs Cognitive*	*0.697* *0.459*	*0.052* *0.210*	
EO ant-post	19.7(13.9-41.0)	20.9(14.8-40.9)	0.994
EC ant-post	32.8(23.0-121.8)	29.6(17.5-103.8)	0.359
Cognitive Task ant-post	22.5(15.3-232.2)	22.1(18.5-51.3)	0.146
P EO vs EC *P EO vs Cognitive*	*0.0001* *0.006*	*0.001* *0.024*	
EO sway area(cm2)	3.3(1.3-9.0)	3.6(1.9-9.2)	0.285
EC sway area	5.8(1.6-30.9)	6.3(1.5-38.7)	0.978
Cognitive Task sway area	4.3(1.0-486.4)	4.2(2.0-18.6)	0.265
P EO vs EC *P EO vs Cognitive*	*0.0001* *0.036*	*0.002* *0.187*	
EO total sway path velocity(cm/s)	1.0(0.7-1.7)	1.1(0.7-1.9)	0.344
EC total sway path velocity	1.4(1.0-4.6)	1.4(0.8-4.1)	0.626
Cognitive Task total sway path velocity	1.1(0.7-8.3)	1.2(0.8-2.2)	0.287
P EO vs EC *P EO vs Cognitive*	*0.0001* *0.023*	*0.0001* *0.026*	
EO lateral velocity	0.5(0.3-0.9)	0.6(0.3-1.0)	0.169
EC Lateral velocity	0.6(0.4-1.9)	0.8(0.4-1.5)	0.539
Cognitive Task lateral velocity	0.6(0.3-4.4)	0.5(0.4-1.2)	0.431
P EO vs EC *P EO vs Cognitive*	*0.002* *0.226*	*0.002* *0.480*	
EO ant-post velocity	0.7(0.5-1.4)	0.7(0.5-1.4)	0.531
EC ant-post velocity	1.1(0.8-4.1)	1.0(0.6-3.5)	0.539
Cognitive Task ant-post velocity	1.9(0.8-13.7)	0.9(0.6-1.7)	0.252
P EO vs EC *P EO vs Cognitive*	*0.0001* *0.0001*	*0.0001* *0.0001*	
EO sway area velocity	0.1(0.0-0.3)	0.1(0.1-0.3)	0.355
EC sway area velocity	0.2(0.1-1.0)	0.3(0.1.-1.3)	0.530
Cognitive Task sway area velocity	0.1(0.0-16.2)	0.1(0.1-0.6)	0.272
P EO vs EC *P EO vs Cognitive*	*0.001* *0.014*	*0.001* *0.205*	

EO: Eyes open; EC: Eyes closed; P: patient vs control.
P EO vs EC: EO vs EC p value within each group (patient EO vs patient EC and control EO vs control EC) itself;
PEO vs Cognitive; EO vs Cognitive task p value within each group (patient EO vs patient Cognitive and control EO vs control Cognitive) itself

RESULTS

The mean age of the PD was 59.2±10.5 and that of the control group was 56.3±7.6 (p>0.05). The female-male ratio was 9/20 in the PD and 12/17 in the other group. There was no significant difference between PD and control groups in terms of demographic characteristics (p>0.05). Disease duration was two years on average Mean UPDRS motor score was 12.8±4.9 (5-22) (Table 1). All patients had a normal pull test. Most patients were on polytherapy. MAOI was the most common agent, which was followed by dopamine agonists (Table 2).

There was statistically no significant difference in any of the posturographic variables in EO, EC, and cognitive task conditions between PD and the control group. Compared to the baseline EO condition, both EC and cognitive task caused an increase in most sway values in both PD and control groups (Table 3). For instance, eyes open total sway area was 29.3(20.7-51.4) in the patient group, and 31.2(20.9-56.2) in the control group (p 0.595). Eyes closed measurements were 42.0(29.0-137.8) in the former group and 40.5(24.5-122.8) in the latter one (p 0.528). In addition, cognitive task's sway area was 33.3(22.0-247.6) and 34.2(25.4-500.1) respectively (p 0.913)

DISCUSSION

This study, in compliance with few studies in literature, demonstrates that compared to control groups, postural stability is preserved in patients with early PD and cognitive dual-tasking does not effect their postural stability at this stage [4,16,17,18,19]. It also suggests that visual deprivation and to some extent cognitive-dual tasking affect postural sway in early PD patients in a similar way with healthy controls, which could be an age-related condition.

PI is not expected in patients with early PD. Although some researchers examined its subclinical existence, the number of such studies is limited and they present contradictory results. There are several reasons for this contradiction such as insufficient number of subjects, differences in the methodology as well as in the posturographic devices. Furthermore, some studies were based on H&Y stage 1 predominant subjects while the others utilized from H&Y stage 2-3 subjects. In addition, some investigations were performed in "off" state, whereas the others were carried out "on" state. For this reason, it is not possible to compare previous studies on this subject one to one. Nonetheless, we discussed the results of this study by taking these differences into account.

To our knowledge, there is little research on the effects of cognitive tasks on PI in patients with early PD[13]. Chen et al, in their study consisting of 23 patients with early-stage PD -with the mean H&Y stage 1.17, and duration of disease 1.73 years - evaluated postural sway with an accelerometer at the center of mass at the lower spine. This study showed that early PD patients have mild signs of PI when their attention is divided[13]. However, in addition to different posturographic evaluation, the subjects in this study were older than our patients and they were not on any treatment. The younger age and the treatment effect might have caused our patients to be more stable during the assessment.

There are two other studies on postural stability with dual-tasking in reportedly "early" PD. However, in these studies the mean duration of the disease is around 5 years; H&Y stage is around 2 and the patients are older than our patients. Therefore, the patients in these studies are relatively at early stages but not as "early" as the ones in Chen et al and in our study[16,20]. In one of them, Holmes et al applied two different cognitive tasks with increasing complexity to 12 patients with PD in "on" medication state and 12 healthy controls. They reported that dual-task interference produced increased sway of the centre of pressure, and this effect became more pronounced with increases in task complexity. However, there was a paradoxical effect among participants with Parkinson's disease. On the high complexity tasks, participants with Parkinson's disease demonstrated a significantly reduced excursion, compared to the controls. The authors suggested that participants with Parkinson's disease may be over constraining their postural adjustment. To focus attention on the cognitive tasks without losing their balance, they stabilized their posture beyond normal levels, to prevent threats to their postural stability when attention was directed to the cognitive tasks. They drew attention to the "posture-first principle" which was proposed earlier to account for changes in posture under dual-task conditions, in which the individual copes with complex situations by prioritizing balance over other concurrent tasks[20,21]. Another study performed by Delafontain et al evaluated the center of pressure using a force plate and electromyography signal (EMG) of the ankle/hip

muscles in 15 relatively early PD patients in off-medication state and 15 controls. A cognitive task was applied. Similar to our results, they showed that in PD without clinical PI and in controls, visual deprivation affected postural stability during semitandem stance more than the addition of a secondary cognitive task, putting forward the importance of vision for postural stability[16].

Since there were no other dual-tasking studies in early PD, we reviewed the results of different studies focusing only on PI in patients with early PD. Lee et al employed a dynamic posturography protocol to evaluate 31 early-stage de novo PD patients with no clinical evidence of postural instability. Similar to our study, there were no significant differences in postural instability measured by dynamic posturography between early PD subjects and healthy controls[17].

Chastan et al performed static and dynamic posturographic analyses in early-stage PD subjects; the sway area increased significantly in the patient group compared to the controls with static posturography and anterior-posterior sway increased with EC in PD with dynamic posturography[4]. Most of the other parameters were not different than the controls. This study consisted of nine early-stage PD patients (H&Y stage 1) and 18 control subjects. The number of patients included in the study is highly limited. On the other hand, the duration employed in the posturographic analysis is longer than what we applied in our study. The long duration of posturography may have caused subtle PI to emerge[4]. The authors suggested that early-stage Parkinson's patients can compensate for clinical PI and that even if they are challenged, they can maintain their balance due to neurological mechanisms that are still partially functioning at this stage[4,22].

Various studies, including our study, determined normal postural control by static posturographic analyses in patients with early PD. Valkovic et al performed 30-second static posturographic analyses in 18 early PD patients (H&Y stage 2) and detected no significant difference between the patient and control groups in EO and EC states[18,19]. Frenklach et al carried out static and dynamic posturographic analyses in 102 patients with PD. This study indicated that postural sway was normal in all static and dynamic analyses in 18 patients with early PD who were not on medication. The effect of dual-tasking on postural stability was evaluated in neither of these studies[18,19].

In a study by Falaki et al, multimuscle synergy analysis was used to develop a quantitative biomarker that can identify problems related to postural stability in patients with PD without PI. This study demonstrated that studies on multimuscle synergy during postural tasks can determine subclinical postural stability changes in PD patients; however, the most prominent limitation of the study is the relatively small size of the PD and control groups. Yet, this study provides the first evidence about impaired synergic control during postural tasks, and follow-up studies are needed[23].

Our study demonstrated no significant abnormalities in posturographic analysis compared to controls regarding dual-tasking in early PD patients. There are several theories to explain the difficulties in performing dual tasks[24]. Capacity sharing and bottleneck (task switching) are the most prevalent. According to capacity sharing theory, performing two tasks at the same time decreases the performance of each task due to splitting of the attentional capacity between the tasks· In bottleneck (task-switching) model, when two tasks need the mechanism simultaneously and compete, a bottleneck occurs, and one or both tasks will be affected; mainly processing of the second task is temporarily postponed, directing attention to the first task[24,25]. It is possible that early PD patients, when challenged, could have compensated their PI by prioritizing balance over the concurrent task, as suggested by the bottleneck theory.

The main limitations of our study are the short duration of posturographic analysis and the patients being on medication. These could have prevented the detection of subclinical PI. Even though it has been suggested that the effect of dopaminergic treatment on PI is insufficient, we cannot fully ignore that dopaminergic treatment may have positive effects on PI at an early stage, while there are still available dopaminergic neurons and receptors in the brain.

In conclusion this study showed that postural stability is achieved in early PD patients if and when they receive treatment. Prospective research on dynamic and static posturography, different types of dual-tasking in *de novo* patients or in patients in "off" state can address more questions on postural stability in early PD.

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