EREDETI KÖZLEMÉNY

ORIGINAL ARTICLE

Role of the video head impulse test in the evaluation of vestibulo-ocular reflex in individuals with Parkinson's disease

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Background and purpose – Parkinson's disease (PD) is the most common movement disorder and the second most common neurodegenerative disease of the central nervous system. Dizziness is frequently reported by PD patients, yet there is a paucity of research focusing on the vestibulo-ocular reflex (VOR) in this population using high-frequency vestibular testing. This study aims to investigate the VOR in individuals with PD using the video head thrust test with and without suppression.
Methods – Forty individuals with PD and 40 healthy individuals were included in the study. According to the Hoehn-Yahr Scale, individuals with PD were defined as early stage with a score of 1–2.5 and middle to late stage with a score of 3 to 5. The Head Impulse Testing Paradigm (HIMP) and Suppression Head Impulse Testing Paradigm (SHIMP) were applied to all individuals.
Results – No statistically significant difference was observed between the PD group and the control group in terms of semicircular canal (SCC) gains in both HIMP and SHIMP tests. No catch-up saccades were observed in the right anterior, right posterior, left anterior, and left posterior SCC planes in the PD and control groups. However, in the right lateral SCC plane 32 patients in the PD group had saccades, while 8 patients in the control group had saccades. In the left lateral SCC plane, 32 patients in the PD group and 9 patients in the control group had catch-up saccades. A statistically significant difference was observed in the number and ampli-

A videós fejimpulzusteszt szerepe a vestibuloocularis reflex értékelésében Parkinson-kóros egyéneknél

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Háttér és cél – A Parkinson-kór (Parkinson's disease, PD) a leggyakoribb mozgászavar és a második leggyakoribb központi idegrendszeri neurodegeneratív betegség. A PD-betegek gyakran számolnak be szédülésről, mégis kevés kutatás összpontosít a vestibuloocularis reflexre (VOR) ebben a populációban nagyfrekvenciás vestibularis teszteléssel. E tanulmány célja a VOR vizsgálata PD-betegeknél videós fejlökésteszt (head thrust test) segítségével, szuppresszióval és a nélkül.
Módszerek – A vizsgálatba 40 Parkinson-kóros és 40 egészséges személyt vontunk be. A PD-betegeket a Hoehn–Yahr-skála szerint korai stádiumúnak (1–2,5 pont), illetve középső és késői stádiumúnak (3–5 pont) definiáltuk. A fejimpulzus-tesztelési paradigmát (Head Impulse Testing Paradigm, HIMP) és a szuppressziós fejimpulzus-tesztelési paradigmát (Suppression Head Impulse Testing Paradigm, SHIMP) alkalmaztuk minden egyénnél.
Eredmények – A PD-csoport és a kontrollcsoport között nem volt statisztikailag szignifikáns különbség a félkörös ívjárat- (semicircular canal, SCC) nyereséget illetően a HIMP- és SHIMP-tesztekben. Sem a PD-, sem a kontrollcsoportban nem figyeltek meg felzárkózó (catch-up) szakkádokat a jobb elülső, a jobb hátsó, a bal elülső és a bal hátsó SCC-síkokban. A jobb lateralis SCC-síkban azonban a PD-csoportban 32 betegnél, míg a kontrollcsoportban nyolc betegnél volt szakkád. A bal lateralis SCC-síkban a PD-csoportban 32 betegnek, a kontrollcsoportban pedig kilenc főnek voltak catch-up szakkádjai.

tude of saccades in the right and left lateral SCC planes compared to the control group ($p<0.05$). In addition, in the PD group, the amplitude, peak velocity, and latency of the anticompensatory saccades seen in SHIMP showed a statistically significant difference compared to the control group ($p<0.05$).
Conclusion – VOR in the vertical SCC plane was not affected in individuals with PD. However, VOR in the lateral SCC plane was affected. It was concluded that when evaluating VOR with both HIMP and SHIMP in individuals with PD, the presence of catch-up saccades should be focused on and evaluated for possible vestibular dysfunction, even though SCC gains are normal. This study will contribute to a deeper understanding of vestibular function in PD, potentially informing better management strategies for dizziness in this population.

Keywords: head impulse test; Parkinson's disease; suppression head impulse test; vestibulo-ocular reflex

A jobb és bal lateralis SCC-síkban a kontrollcsoporthoz képest statisztikailag szignifikáns különbség volt megfigyelhető a szakkádok számában és amplitúdójában ($p < 0,05$). Ezenkívül a PD-csoportban a SHIMP-ben észlelt antikompenzátoros szakkádok amplitúdója, csúcssebessége és latenciája statisztikailag szignifikáns különbséget mutatott a kontrollcsoporthoz képest ($p < 0,05$).
Következtetés – PD-betegeknél a vertikális SCC-síkban nem érintett a VOR, azonban a lateralis SCC-síkban érintett. Arra a következtetésre jutottunk, hogy a VOR HIMP és SHIMP segítségével történő értékelése során a PD-ben szenvedő egyéneknél a catch-up szakkádok jelenlétére kell összpontosítani, és ki kell értékelni azokat az esetleges vestibularis diszfunkció felfedezése érdekében, még akkor is, ha az SCC-nyereség normális. Ez a tanulmány hozzájárulhat a vestibularis funkció mélyebb megértéséhez Parkinson-kórban, ami jobb kezelési stratégiákat eredményezhet a szédülés ellen ebben a populációban.

Kulcsszavak: fejimpulzusteszt, Parkinson-kór, szuppressziós fejimpulzusteszt, vestibuloocularis reflex

Parkinson's disease (PD) is the second most common neurodegenerative disease, characterized by motor and non-motor symptoms including tremor, rigidity, bradykinesia, and postural instability[1]. The prevalence of PD increases with age and reaches a peak at the age of 85. Furthermore, it has been reported that the incidence rate is 1.4 at the age of 60 years and 2.0 in patients older than 90 years[2]. Dizziness is a common symptom in PD patients, and its prevalence varies between 48 and 68%[3]. It has also been reported that vestibular dysfunction is observed in individuals with PD[4].

The Head Impulse Test Paradigm (HIMP) is a testing method used to evaluate the vestibulo-ocular reflex (VOR) gain of each semicircular canal (SCC) individually. It is utilized to identify any catch-up saccades that may occur during or after head movement[5,6]. The Suppression Head Impulse Test (SHIMP) is a new test method that evaluates the VOR gain of only the lateral SCC[7]. The VOR gain value obtained from SHIMP is considered more reliable as it is not influenced by covert saccades. It has been reported that saccades seen in SHIMP provide important information as they are a sign of vestibular function[8].

Two studies evaluating VOR with HIMP in individuals with PD[9, 10] and one study applying both HIMP and SHIMP tests were identified[11]. Since one of the main symptoms of PD is postural instability, it is estimated to be related to dysfunction in the vestibular system[4]. Upon reviewing the literature, it becomes evident that there remains a paucity of studies examining VOR in Parkinson's disease utilizing high-frequency vestibular tests. Therefore, we aimed to evaluate the VOR function in individuals with PD using HIMP with and without suppression.

Materials and methods

Individuals with PD and control groups participated in the study after providing informed consent. Our study was conducted according to the Declaration of Helsinki. After approval by the Clinical Research Ethics Committee of our university (Protocol Number: 2022/30; December 13, 2022), data were collected between January 2023 and November 2023. All patients with PD were examined by a neurologist who was one of the authors. Additionally, the modified Hoehn & Yahr scale was employed to assess disease severity[12]. According to this scale, individuals with PD were defined as having an early stage with 1 to 2.5 score and a mid-late stage with 3 to 5. Individuals with PD continued to use their medications. Bedside

assessment (spontaneous nystagmus, positional nystagmus) was performed, and other diseases were excluded. Individuals with spontaneous nystagmus due to an acute or chronic peripheral disease, individuals with positional nystagmus in Dix Hallpike and Head Roll tests were excluded from the study. HIMP and SHIMP tests were applied to all individuals, respectively. Inclusion criteria for the PD group: individuals diagnosed with idiopathic PD according to the UK Parkinson's Disease Society Brain Bank diagnostic criteria. For the control group, healthy individuals without any vestibular complaints were included. Individuals with more than 30 dB hearing loss, other neurologic disorders, and ear surgery were excluded from the study. All measurements were performed in the 'on' period of patients with PD. Individuals with PD who continued to use medication (Clinic on Period) were included in the study. Moreover, while applying the vHIT and SHIMP tests, head impulse movements were made with small amplitudes of 10-20 degrees/second. Therefore, the influence of stiffness seen in individuals with PD was minimized.

Table 1. *Demographic characteristics*

Characteristic	Parkinson's Disease Group (n=40)		Control Group (n=40)		t, Z	p
Age (year, χ ± SS)	61.13 ± 9.48		59.63 ± 8.06		t: 0.762	0.448
Disease duration [year, χ (min/max)]	5 (1/18)		–			
Gender	n	%	n	%	X^2	p
Female	17	42.5	20	50	0.201[a]	0.654
Male	23	57.5	20	50		
Tremor status			–			
Right tremor	18	45				
Right non-tremor	4	10				
Left tremor	10	25				
Left non-tremor	8	20				
Disease stage			–			
Early stage	26	65				
Middle-late stage	14	35				

χ ±SS: Mean ± Standard deviation; X̄ (min/max): Median (minimum-maximum); Z: Mann Whitney U Test; t: Independent Samples t-test; X^2: Chi Square; a: Continuity Correction; n: number of individuals; %: percent

Head Impulse Test Paradigm (Video Head Impulse Test, HIMP)

HIMP (Interacoustics, Denmark) was applied to all individuals in the PD and control groups by the same clinician. The data obtained from the goggles with a monocular camera weighing 32 g was transferred to the monitor with the OtoAccessTM computer software program. All subjects were seated on a fixed chair with a distance of 1 meter from a round, 1 cm target on the wall. The goggles were worn tightly on the head to prevent the goggles from slipping during head thrusts. All individuals were given a detailed explanation of HIMP. After head and eye calibration, lateral, right anterior left posterior (RALP), and left anterior right posterior (LARP) head thrusts were performed in the SCC planes. For each channel, 10 head thrusts were applied[5].

Supression Head Impulse Test (SHIMP)

After the HIMP test, the SHIMP test was performed without changing the position of the subjects. In this test, they were asked to look at the laser light on the goggles instead of the target on the wall. All subjects were examined by the same clinician performing 10 head thrusts in the lateral SCC plane. Head thrust movements were performed randomly so that the patient could not predict the direction of the impulse. Meanwhile, they were instructed to follow the laser light projected on the wall in the center of the goggles during head thrusts[7].

Statistical analysis

Data obtained in study were analyzed statistically using SPSS v.24.0 software (Chicago, IL, USA). Conformity of variables to normal distribution was assessed using analytical (Shapiro-Wilk test) and visual (histograms, probability graphs) techniques. Differences in demographic information and measurement results were compared using the Independent Samples t-test and the Mann-Whitney U-test. The Chi-square test was employed to evaluate gender differences. The alpha level of statistical significance was set as $p<0.05$.

Results

In our study, 42.5% of the Parkinson's patients were female and 57.5% were male, and their mean age was 61.13 ± 9.48 years. In the control group, the gender ratio was equal (50%) and the mean age was 59.63 ± 8.06 years. There were no statistically significant differences between the two groups in terms of gender and age ($p>0.05$) **(Table 1)**.

On average, Parkinson's disease started five years before, with 65% of patients in the early stage and 35% in the middle to late stage. Additionally, when classified by

Table 2. *Pairwise group comparisons*

	n (P-C)	Parkinson's Disease Group	Control Group	p	t, Z
Right lateral gain (χ ± SS)	40-40	0.92 ± 0.15	0.95 ± 0.10	0.279	t: –1.091
Right lateral saccade count [χ (min/max)]	40-40	6 (0/10)	0 (0/10)	*≤0.00**	Z: –5.258
Right lateral saccade amplitude [χ (min/max)]	32-8	1.65 (0.68/4.55)	1.25 (0.64/1.35)	*0.08**	Z: –2.672
Right lateral saccade peak velocity [χ (min/max)]	32-8	116.24 (51.63/241.26)	90.02 (52.59/109.43)	*0.023**	Z: –2.265
Right lateral saccade duration [χ (min/max)]	32-8	34.73 (26.50/76)	32.99 (28.25/34.50)	0.164	Z: –1.420
Right lateral saccade latency (χ ± SS)	32-8	299.91 (128.90/491.67)	247.15 (155.30/360)	0.222	t: 1.241
Left lateral gain (χ ± SS)	40-40	0.93 ± 0.16	0.99 ± 0.12	0.057	t: –1.936
Left lateral saccade count (χ ± SS)	40-40	5.15 ± 3.46	1.47 ± 2.90	*≤0.00**	t: 5.141
Left lateral saccade amplitude [χ (min/max)]	32-9	1.59 (0.90/4.43)	1.17 (0.74/1.95)	*0.029**	Z: –2.174
Left lateral saccade peak velocity [χ (min/max)]	32-9	105.63 (60.87/240.85)	86.62 (60.05/123.60)	0.060	Z: –1.890
Left lateral saccade duration [χ (min/max)]	32-9	34.69 (29.33/77.29)	35.11 (30.22/41.72)	0.793	Z: –0.284
Left lateral saccade latency [χ (min/max)]	32-9	261.50 (119.78/2228.50)	267.44 (179.89/372.80)	0.609	Z: –0.535
Right posterior gain [χ (min/max)]	40-40	0.88 (0.43/1.23)	1.01 (0.76/1.20)	0.121	Z: –1.550
Right anterior gain [χ (min/max)]	40-40	1.03 (0.40/1.22)	0.98 (0.82/1.18)	0.185	Z: –1.234
Left anterior gain [χ̄ (min/max)]	40-40	1.04 (0.32/1.22)	1.02 (0.77/1.20)	0.627	Z: –0.486
Left posterior gain (χ ± SS)	40-40	0.88 ± 0.28	0.96 ± 0.13	0.112	t: –1.617

χ ±SS: Mean ± Standard deviation; χ (min/max): Median (minimum-maximum); Z: Mann Whitney U Test; t: Independent Samples t-test; n: number of individuals; * p<0,05; P-C: Parkinson-Control

tremor findings, 45% of patients exhibited a right tremor, 25% a left tremor, 20% a left non-tremor, and 10% a right non-tremor **(Table 1)**.

The counts of right lateral saccades ($p \leq 0.00$), left lateral saccades ($p \leq 0.00$), and the amplitudes of left lateral saccades (p: 0.029) were found to be significantly increased in patients compared to controls. While the amplitude of right lateral saccades (p: 0.08) did not show a significant difference, the peak velocity of right lateral saccades (p: 0.023) was also significantly increased in patients **(Table 2)**.

The analysis of SHIMP data revealed significant decreases in the count of right lateral anticompensatory saccades ($p \leq 0.001$), the amplitude of right lateral saccades ($p = 0.002$), the peak velocity of both right lateral ($p = 0.002$) and left lateral ($p \leq 0.001$) saccades, as well as the count of left lateral anticompensatory saccades ($p = 0.001$) among patients compared to controls. Moreover, the latency of both right lateral ($p = 0.001$) and left lateral saccades ($p \leq 0.001$) exhibited significant increases in patients compared to controls **(Table 3)**.

Pairwise group comparisons were made according to tremor findings in the Parkinson's disease group, and according to this analysis, no statistical difference ($p > 0.05$) was found in the SHIMP right lateral gain, HIMP right lateral gain, HIMP right lateral saccade count, HIMP right anterior gain, HIMP right anterior saccade count, HIMP right posterior gain, and right posterior saccade count results of right tremor and right non-tremor Parkinson's patients. However, a statistically significant dif-

Table 3. *Paired group comparisons of SHIMP values*

	n (P-C)	Parkinson's Disease Group	Control Group	p	t, Z
SHIMP right lateral gain (χ ± SS)	40-40	0.88 ± 0.15	0.90 ± 0.09	0.618	t: –0.501
SHIMP left lateral gain (χ ± SS)	40-40	0.90 ± 0.15	0.95 ± 0.10	0.070	t: –1.839
SHIMP right lateral anticompensatory saccade count [χ̃ (min/max)]	40-40	7.5 (0/10)	9.5 (3/10)	*≤0.00**	Z: –4.128
SHIMP right lateral saccade amplitude (χ ± SS)	34-40	4.7 ± 1.6	6.2 ± 2.09	*0.002**	t: –3.286
SHIMP right lateral saccade peak velocity [χ (min/max)]	34-40	228.18 (120.75/330.74)	289.21 (144.31/432.52)	*0.002**	Z: –3.070
SHIMP right lateral saccade duration [χ (min/max)]	34-40	48.35 (34/62.12)	46.65 (30.33/64.20)	0.558	Z: –0.586
SHIMP right lateral saccade latency [χ (min/max)]	34-40	330.03 (161.10/455.75)	209.95 (82/454.41)	*0.001**	Z: –3.319
SHIMP left lateral anticompensatory saccade count [χ (min/max)]	40-40	8 (0/10)	10 (2/10)	*0.001**	Z: –3.293
SHIMP left lateral saccade amplitude (χ ± SS)	33-40	4.97 ± 1.91	6.87 ± 2.07	*≤0.00**	t: –4.033
SHIMP left lateral saccade peak velocity [χ (min/max)]	33-40	238.87 (123.28/367.09)	348.22 (154.86/434.68)	*≤0.00**	Z: –3.791
SHIMP left lateral saccade duration (χ ± SS)	33-40	47.73 ± 5.68	48.99 ± 4.15	0.293	t: –1.093
SHIMP left lateral saccade latency [χ (min/max)]	33-40	298.12 (119.22/542.25)	190.63 (120.90/553)	*≤0.00**	Z: –4.090

χ ±SS: Mean ± Standard deviation; χ (min/max): Median (minimum-maximum); Z: Mann Whitney U Test; t: Independent Samples t-test; n: number of individuals; * p<0,05; P-C: Parkinson-Control; SHIMP: Suppression Head Impulse Paradigm

ference was observed between the two groups in the left lateral saccade count (p: 0.043) and left posterior gain (p: 0.044) results of left tremor and left non-tremor Parkinson's patients. HIMP left lateral saccade count was found to be higher in left tremor Parkinson's patients, but HIMP left posterior gain results were higher in left non-tremor Parkinson's patients **(Table 4)**.

Discussion

According to our results, VOR gains between the PD and the control groups were observed within normal limits in all SCC planes. However, within the PD group, a higher number of saccades were observed in the lateral SCC plane compared to the control group, and the amplitudes of saccades detected in HIMP were larger. In SHIMP, anticompensatory saccades with smaller amplitudes were observed.

In our previous study[13], where we evaluated VOR using the functional head impulse test (fHIT) in individuals with PD, we observed impaired functional VOR in the right lateral, left lateral, and left posterior SCC planes. In the present study, while the VOR gains in the right and left lateral SCC planes were within normal limits, we observed VOR impairment due to the presence of saccades. In contrast to our previous study, we did not detect any effects in the vertical SCC plane. We speculate that this discrepancy may be attributed to the greater sensitivity of the fHIT to detect minor eye movements compared to the HIMP test. Despite the VOR gains appearing normal in HIMP, the occurrence of catch-up saccades may suggest an underlying VOR defect.

Hawkins et al. found that HIMP and SHIMP VOR gains applied to individuals with PD were similar to those in the control group. However, they found that the anticompensatory saccade peak velocity in SHIMP decreased and its latency prolonged[11]. In another study by Hawkins et al., where only HIMP test was applied to individuals with PD, they reported that VOR gains in all SCC planes were not affected[10]. Both studies showed similar results to ours. The anticompensatory saccades seen in the SHIMP test are an indicator of vestibular function. In our study, the amplitude of anticompensatory saccades in the PD group was significantly lower than in the control

Table 4. *Pairwise group comparisons according to tremor findings in Parkinson's disease group*

	Right tremor n: 18	Right non-tremor n: 4	p	t, Z
SHIMP right lateral gain (χ ± SS)	0.86 ± 0.12	0.93 ± 0.11	0.324	t: –1.011
HIMP Right lateral gain (χ ± SS)	0.89 ± 0.15	0.98 ± 0.12	0.267	t: –1.141
HIMP Right lateral saccade count [χ̄ (min/max)]	6 (0/10)	4.50 (4/9)	0.774	Z: –0.301
HIMP Right anterior gain [χ (min/max)]	0.99 (0.40/1.22)	1.12 (1/1.22)	0.118	Z: –1.577
HIMP Right anterior saccade count [χ̄ (min/max)]	0 (0/9)	0 (0/0)	0.538	Z: –1.012
HIMP Right posterior gain (χ ± SS)	0.90 ± 0.21	1.06 ± 0.16	0.195	t: –1.339
HIMP Right posterior saccade count [χ (min/max)]	0 (0/9)	1 (0/9)	0.652	Z: –0.544
	Left tremor n: 10	Left non-tremor n: 8	p	t, Z
SHIMP left lateral gain (χ ± SS)	0.94 ± 0.17	0.88 ± 0.16	0.494	t: 0.701
HIMP Left lateral gain (χ ± SS)	0.98 ± 0.20	0.92 ± 0.19	0.540	t: 0.627
HIMP Left lateral saccade count [χ (min/max)]	8 (0/10)	5 (0/7)	*0.043**	Z: –2.061
HIMP Left anterior gain [χ (min/max)]	0.96 (0.43/1.22)	1.13 (0.32/1.20)	0.146	Z: –1.514
HIMP Left anterior saccade count [χ (min/max)]	0 (0/5)	0 (0/0)	0.762	Z: –0.894
HIMP Left posterior gain (χ ± SS)	0.84 ± 0.22	1.04 ± 0.16	*0.044**	t: –2.190
HIMP Left posterior saccade count [χ (min/max)]	0 (0/10)	1 (0/8)	0.696	Z: –0.455

χ ±SS: Mean ± Standard deviation; χ (min/max): Median (minimum-maximum); Z: Mann Whitney U Test; t: Independent Samples t-test; n: number of individuals; * p<0,05; P-C: Parkinson-Control; SHIMP: Suppression Head Impulse Paradigm; HIMP: Head Impulse Paradigm

group. Individuals with PD did not show anticompensatory saccades as much as the control group. In addition, the fact that the amplitude of the catch-up saccades in the HIMP was larger than in the control group also supports the involvement of the VOR. This may be explained by the involvement of the VOR function.

No significant difference was observed between SHIMP VOR gains in individuals with PD with and without left and right tremors. In HIMP, significant difference was observed only between the left posterior SCC gains of individuals with left tremor and individuals with left non-tremor. VOR gains in all other SCC planes showed similar results.

In our study, lateral SCC VOR gains in SHIMP were lower than HIMP in both groups. However, it was not statistically significant. In a study conducted on patients diagnosed with bilateral vestibulopathy, VOR gains in SHIMP were lower than those in HIMP[14]. Although the mechanism of this situation is not yet fully known, it has been suggested that the underlying cause of VOR gain differences in both tests may be VOR phasic response inhibition[15]. The amplitude in SHIMP was lower in the PD group compared to the control group. In a study, it was reported that there may be a decrease in amplitude with age[16]. In our study, we think that there is a decrease in amplitude due to PD, since the ages of both the PD and control groups are similar.

In conclusion, although VOR gains in the HIMP test were within normal limits, the catch-up saccades seen in the lateral SCC plane indicate impairment in the VOR.

The small number of saccades seen in the SHIMP test, and their lower amplitude compared to the control group support and explain the saccades seen in the HIMP test. We propose that developing a rehabilitation program targeting not only the proprioceptive system but also the VOR in the lateral SCC plane may prove effective in addressing the imbalance observed in individuals with PD.

We do not know whether the medication (L-dopa) used by the individuals with PD who participated in our study has an effect on VOR and it is a limitation of our study. We recommend that future studies explore VOR functions in more comprehensive groups encompassing various forms of parkinsonism.

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