

Examining Sensory Systems that Contribute to Falls in Parkinson's disease using Computerized Dynamic Posturography: A Secondary Analysis

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Examining Sensory Systems that Contribute to Falls in Parkinson's disease using Computerized Dynamic Posturography: A Secondary Analysis

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Abstract

Background: Falls in PD are a complex, multifactorial entity that involves motor, non-motor, environmental, and cognitive factors. While the environmental, cognitive, and motor factors that contribute to falls in PD are well-documented, there are limited investigations into the sensory systems that also contribute to falls.

Objective: The study's purpose is to determine whether any of the Sensory Organization Test (SOT) conditions or composite scores are associated with falls in people with PD.

Methods: The study was a secondary analysis of interventions studies in people with Parkinson's disease aimed at reducing falls and improving mobility. This analysis was to examine correlations between the SOT variables (Conditions 1-6 and composite scores) and the number of falls. Further analysis was performed using the Kruskal-Wallis test to determine if there were differences amongst fall groups and SOT variables).

Results: Data from 40 participants were included in the study, 24 males and 16 females with a mean age of 68.9 (SD 8.1). Spearman rank correlations found significant negative correlations between the number of falls and SOT Condition (P < .05). Condition 1 (? = -.331), Condition 2 (? = -.512), and Condition 3 (? = -.462). A Kruskal-Wallis test documented a significant group effect between the fall group and Condition 2, (?² = 8.434, P = .015) and Condition 3, (?² = 8.708, P = .013).

Conclusions: SOT Condition 2 and 3 were the variables that showed an association with falls in this cohort. The literature indicates that the vestibular system contributes to postural instability; however, it may be that the early decline of the vestibular system, combined with the later decline of the visual system, leads to falls in PD. Readers should exercise caution regarding the results because of the small sample size and the inclusion of only sensory variables. Further investigations should continue on the sensory contributions to falls in PD and in particular, SOT Condition 2. Clinical Trial: n/a

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Original Manuscript

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Abstract

Background: Falls in Parkinson's disease (PD) are a complex, multifactorial entity that involves motor, non-motor, environmental, and cognitive factors. While the environmental, cognitive, and motor factors that contribute to falls in PD are well-documented, there are limited investigations into the sensory systems that contribute to falls. The study's purpose is to determine whether any of the Sensory Organization Test (SOT) conditions or sensory ratios are associated with falls in people with PD.

Methods: The study was a secondary analysis of interventions studies in people with Parkinson's disease aimed at reducing falls and improving mobility. This analysis was to examine correlations between the SOT variables (Conditions 1-6 and composite scores) and the number of falls. Further

analysis was performed using the Kruskal–Wallis test to determine if there were differences amongst fall groups and SOT variables.

Results: Data from 40 participants were included in the study, 24 males and 16 females with a mean age of 68.9 (SD 8.1). Spearman rank correlations found significant negative correlations between the number of falls and SOT Condition ($P < .05$). Condition 1 ($\rho = -.331$), Condition 2 ($\rho = -.512$), and Condition 3 ($\rho = -.462$). A Kruskal-Wallis test documented a significant group effect between the fall group and Condition 2, ($\chi^2_2 = 8.434$, $P = .015$) and Condition 3, ($\chi^2_2 = 8.708$, $P = .013$).

Discussion: SOT Condition 2 and 3 were the variables that showed an association with falls in this cohort. The literature indicates that the vestibular system contributes to postural instability; however, it may be that the early decline of the vestibular system, combined with the later decline of the visual system, leads to falls in PD. Readers should exercise caution regarding the results because of the small sample size and the inclusion of only sensory variables. Further investigations should continue into the sensory contributions to falls in PD and in particular, SOT Condition 2.

Key words: Falls, Sensory Organization Test, Parkinson's disease, Postural Control

Introduction

Parkinson's disease (PD) is a progressive neurologic disease involving motor and non-motor systems.¹ Falls occur more frequently in people with PD with rate of 60.5% compared to 28-30% in the general population.² Motor, non-motor, disease severity, and cognition are contributors to falls.³ However, there are limited investigations in the sensory systems and their contribution to falls. The purpose of this paper is to examine whether the Sensory Organization Test (SOT) variables (Conditions 1-6 and composite score) are associated with falls in a cohort of people with PD.

Methods

Study Design and Recruitment: The study is a secondary analysis of fall and mobility investigations in people with PD. Recruitment was performed through the local Parkinson's Support

Group via flyer.

Ethical Considerations: The investigations were approved by the Department of Physical Therapy Research Committee and the University Human Subjects Review Board. All participants reviewed and signed a consent form to participate.

The primary investigator extracted the following data: SOT results, demographics, (age, sex, and Hoehn and Yahr stage), and participant reported falls. The data did not include any personal information and maintained participants' confidentiality. The study divided falls into three groups: Group 1: no falls; Group 2: 1-3 falls; and Group 3: 4 or more falls. A computerized dynamic posturography device, Bertec®, collected and analyzed the SOT test results. The SOT is a subtest in a computerized posturography device that consists of 6 postural conditions that measure visual, somatosensory, and vestibular systems to identify postural disturbances. The device is renowned for its ability to accurately measure postural sway under various sensory conditions in the absence of or disruption of sensory input. Table 1 SOT description.

Table 1. Sensory Organization Conditions 1-6 and Composite

SOT Conditions	Description	Rely on
1. Eyes open, stable surface, and visual surround	All three sensory systems are available	All systems
2. Eyes closed, stable surface, and visual surround	Visual input removed	Rely on somatosensory and vestibular
3. Eyes open, stable surface, and sway-reference visual surround	Visual surround moving in proportion to sway	Rely on vestibular and accurate somatosensory
4. Eyes open, platform sway, and visual surround	Platform surface moving in proportion of sway	Rely on visual and vestibular input
5. Eyes closed, platform sway, and visual surround	Visual input removed and somatosensory is in conflict	Rely on vestibular
6. Eyes open, platform sway, and sway reference visual surround	All three systems are in conflict	Rely on vestibular
Composite Score	Description	Calculation
Single weighted score from all 6 Conditions	The degree to which an individual relies on somatosensory cues for balance.	A weighted average of the six conditions, with greater weight given to the more difficult conditions.

A non-parametric analysis determined if there was a significant correlation between the number of reported falls and the SOT variables. A Kruskal-Wallis test determined if there were differences in the SOT variables across the three fall groups.

Results

Data from 40 participants were included in the study, 24 males and 16 females with a mean age of 68.9 (SD 8.1). Eighteen participants reported no falls, 12 reported 1 to 3 falls, and 10 participants had four or more falls.

Spearman rho correlations between the number of falls and the SOT variables showed a significant negative correlation in Condition 1, ($\rho = 0.331$, $P = .037$), Condition 2, ($\rho = -0.512$, $P < .001$), and Condition 3, ($\rho = -0.462$, $P = .003$). Results of the Kruskal-Wallis test revealed significant group differences: SOT Condition 2, $\chi^2_2 = 8.434$, $P = .015$, and SOT Condition 3, $\chi^2 (2) = 8.708$, $P = .013$. Post hoc Dunn-Bonferroni showed significant differences in between Fall group 1 and Fall

group 3 in SOT Conditions 2 and 3; $P < .05$. See Table 2.1

**Table 2. Independent Samples Kruskal-Wallis test
Group 1- 3 and Sensory Organization Conditions and Composite Score**

SOT	Fall Group	n	Mean ES	SD	Median	Omnibus Statistic	D p value p	Dunn- Bonferroni $P > .05$
C 1	1	18	90.77	4.03	92.0	2.995	.228	
	2	12	87.82	5.64	89.96			
	3	10	87.55	4.32	87.98			
C 2	1	18	90.12	2.98	89.15	8.434	.015	1-3
	2	12	847.72	3.09	87.31			
	3	10	85.61	4.54	85.61			
C 3	1	18	89.52	3.75	89.48	8.708	.013	1-3
	2	12	84.32	8.77	86.8			
	3	10	80.38	9.88	84.33			
C 4	1	18	65.97	13.83	63.27	3.366	.186	
	2	12	63.27	12.53	66.00			
	3	10	57.37	8.77	58.1			
C 5	1	18	56.92	19.21	58.5	.916	.633	
	2	12	53.09	24.29	59.49			
	3	10	48.08	16.46	56.46			
C 6	1	18	51.74	23.01	54.98	2.819	.244	
	2	12	47.24	22.87	50.63			
	3	10	37.80	21.47	40.8			
COM P	1	18	66.92	16.67	68.7	.189	.138	
	2	12	65.92	12.71	69.5			
	3	10	60.71	7.85	65.07			

Abbreviation: SOT: Sensory Organization Test, n: number, ES: equilibrium score, SD: standard deviation, C:condition, COMP: composite score, Fall group 1: no falls, Fall group 2: 1-3 falls, Fall group 3: 4 or more falls.

Discussion

Principal Results: The purpose of this study was to determine whether SOT variables are related to falls in people with PD. Three SOT Conditions revealed moderate negative correlations with falls in Condition 2 showing the most significant correlation. In determining significance in SOT condition among the fall groups, two variables showed significance, conditions 2 and 3.

SOT Conditions 2 and 3 remove visual input by closing eyes and distort visual surround. Supporting evidence from a community dwelling fall study indicated that condition 2 showed a higher association with falls.⁴ However, these findings were in direct contrast to postural studies proposing that the vestibular system is a primary contributor of postural disturbances in PD.^{5,6}

Investigating the onset of vestibular and visual system deficits may provide insight into sensory systems contributions to falls. Early in the disease process, the vestibular system is less dependable and people with PD rely on vision to navigate in the environment.^{7,8} In the later disease stages, visual disturbances become prominent, and the sensory system is unable to adjust vestibular and visual input to maintain postural stability.⁹ As a result, is unable to produce an appropriate postural strategy to maintain stability.¹⁰

Limitations: The limitations are small sample size and sample of convenience. Readers must take caution with the results because of unequal group sizes and the data is in a preliminary stage.

Conclusion

Falls in PD is a complex challenge to clinicians and researchers as the interactions between the environment, motor signs, sensory, and cognitive factors have not been fully elucidated. While the vestibular system has been identified as a probable source of postural instability, this paper provides evidence that SOT condition 2 may be an added contributor to falls in PD. Continued investigation on the interaction of the vestibular and visual systems are needed to understand the sensory contribution to falls.

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Conflict of Interest

None declared.

Data Availability

The datasets generated or analyzed during this study are available from the corresponding author on reasonable request.

Abbreviations

PD: Parkinson's disease

SOT: Sensory Organization Test

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