# EFFECT OF VIBROTACTILE-SENSORY FEEDBACK ON TREMORS IN PARKINSON'S DISEASE

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***ABSTRACT***
**Background:** Parkinson's disease (PD) is a progressive neurodegenerative disorder characterized by resting tremor, rigidity, bradykinesia, and postural instability. Tremor is one of the most common and disabling symptoms, affecting functional activities such as writing, eating, dressing, and object handling. Although pharmacological treatment remains the primary management approach, tremor often persists despite optimal medication, highlighting the need for additional rehabilitation strategies.

Vibrotactile sensory feedback is a non-invasive intervention that provides controlled vibration stimuli to enhance sensory input and improve sensorimotor integration. By stimulating cutaneous mechanoreceptors, vibrotactile feedback may modulate abnormal neural activity associated with Parkinsonian tremor and improve voluntary motor control. Recent advancements in wearable technology have increased interest in using vibrotactile stimulation as an adjunct rehabilitation tool.

Task-oriented training combined with sensory feedback may further enhance motor learning, upper-limb dexterity, and functional performance. However, limited evidence exists regarding the effectiveness of vibrotactile sensory feedback in reducing tremor severity among individuals with Parkinson's disease. Therefore, this study was undertaken to evaluate the effect of vibrotactile sensory feedback on tremors in patients with Parkinson's disease.

**Materials and Methods:** A pre-experimental study was conducted on 17 participants diagnosed with Parkinson's disease who met the inclusion and exclusion criteria. Participants aged 50–75 years with resting tremors were recruited after obtaining informed consent.

Baseline assessment was performed using the Unified Parkinson's Disease Rating Scale (UPDRS), The Essential Tremor Rating Assessment Scale (TETRAS), and the Nine-Hole Peg Test (NHPT) to evaluate tremor severity and upper-limb function.

Participants underwent a 4-week intervention program consisting of vibrotactile sensory feedback combined with task-oriented upper-limb exercises. Sessions were conducted 5 days per week under supervision. Post-intervention assessments were recorded using the same outcome measures.

Data were analyzed using descriptive statistics and paired t-tests. Statistical significance was set at $p < 0.05$.

**Results:** A total of 17 participants completed the study without dropouts. Following the 4-week intervention, significant improvements were observed in all outcome measures.

The mean UPDRS motor score improved from $39.5 \pm 6.7$ to $28.4 \pm 5.9$. The mean TETRAS score decreased from $18.9 \pm 3.8$ to $11.2 \pm 2.9$, indicating reduced tremor severity. Performance on the Nine-Hole Peg Test improved from $44.7 \pm 6.1$ seconds to $35.2 \pm 5.3$ seconds, demonstrating enhanced upper-limb dexterity.

Statistical analysis revealed highly significant differences between pre- and post-intervention values ($p < 0.001$). These findings suggest that vibrotactile sensory feedback combined with task-oriented exercises is effective in reducing tremor severity and improving functional hand performance in individuals with Parkinson's disease.

**Conclusion:** The findings of the present study suggest that vibrotactile sensory feedback combined with task-oriented exercises is an effective intervention for reducing tremor severity and improving upper-limb function in individuals with Parkinson's disease. Significant improvements were observed in tremor control, motor performance, and hand dexterity following the 4-week intervention program.

The provision of vibrotactile sensory feedback may enhance sensorimotor integration and facilitate better voluntary movement control, thereby reducing the functional impact of tremors during daily activities. Furthermore, the intervention was safe, non-invasive, and well tolerated by all participants.

Based on the results, vibrotactile sensory feedback can be considered a promising adjunct physiotherapy intervention for the management of Parkinsonian tremors. Further studies with larger sample sizes and longer follow-up periods are recommended to confirm these findings and establish long-term effectiveness.

**Keywords:** Parkinson's Disease (PD),Vibrotactile Sensory Feedback, Parkinsonian Tremor, Task-Oriented Training, Upper Limb Function, Motor Control, Sensorimotor Integration, Neurorehabilitation; Tremor Reduction, Hand Dexterity, Unified Parkinson's Disease Rating Scale (UPDRS),The Essential Tremor Rating Assessment Scale (TETRAS),Nine-Hole Peg Test (NHPT),Physiotherapy Rehabilitation, Wearable Vibrotactile Devices

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## INTRODUCTION

Parkinson's disease (PD) is a chronic, progressive neurodegenerative disorder that affects movement and functional independence. It results from the degeneration of dopaminergic neurons in the substantia nigra pars compacta, leading to dopamine deficiency within the basal ganglia. Parkinson's disease is the second most common neurodegenerative disorder after Alzheimer's disease and affects millions of people worldwide. The prevalence of Parkinson's disease increases with advancing age and is expected to rise significantly due to population aging. [1]

The cardinal motor features of Parkinson's disease include resting tremor, bradykinesia, muscular rigidity, and postural instability. Among these symptoms, tremor is often the most visible and distressing manifestation. Parkinsonian tremor commonly presents as a resting tremor with a frequency of 4–6 Hz and frequently affects the hands, fingers, forearms, and occasionally the lower limbs and jaw. Tremors interfere with various activities of daily living, including writing, eating, dressing, grooming, and handling objects, thereby reducing independence and quality of life. [2]

The pathophysiology of Parkinsonian tremor is complex and involves abnormal oscillatory activity within the basal ganglia-thalamo-cortical network. Loss of dopamine alters the balance between inhibitory and excitatory pathways responsible for movement regulation. These alterations lead to abnormal neuronal firing patterns, impaired sensorimotor integration, and involuntary rhythmic muscle contractions that manifest as tremors. [3]

Although pharmacological management with levodopa and dopamine agonists remains the gold standard treatment for Parkinson's disease, tremors often respond incompletely to medication. Furthermore, long-term pharmacological therapy may be associated with motor fluctuations, dyskinesias, and other adverse effects. Surgical interventions such as deep brain stimulation can be effective but are invasive, expensive, and not suitable for all patients. Therefore, there is increasing interest in developing non-pharmacological rehabilitation approaches that can complement conventional treatment and improve motor function. [4]

Physiotherapy plays an important role in the multidisciplinary management of Parkinson's disease. Rehabilitation interventions aim to improve mobility, balance, coordination, motor control, and functional independence. Various physiotherapy approaches such as task-oriented training, balance exercises, gait training, resistance exercises, and cueing strategies have demonstrated beneficial effects on motor performance and quality of life in individuals with Parkinson's disease. [5]

Sensory feedback is essential for accurate movement control and motor learning. The nervous system continuously integrates sensory information from visual, auditory, vestibular, proprioceptive, and tactile systems to generate coordinated motor responses. In Parkinson's disease, deficits in sensory processing and sensorimotor integration contribute to impaired movement regulation and tremor severity. Consequently, enhancing sensory input may help improve motor performance and reduce abnormal movement patterns. [6]

Vibrotactile sensory feedback is an emerging rehabilitation technique that utilizes mechanical vibrations delivered through wearable devices to stimulate cutaneous mechanoreceptors. The stimulation provides additional tactile information to the central nervous system and may facilitate improved motor control through enhanced sensory processing. Vibrotactile stimulation has been shown to influence neural activity, improve movement accuracy, enhance proprioceptive awareness, and potentially reduce abnormal oscillatory activity associated with tremor generation. [7]

Recent technological advancements have enabled the development of portable vibrotactile devices that can be easily integrated into rehabilitation programs. These devices are non-invasive, relatively inexpensive, safe, and suitable for both clinical and home-based use. Vibrotactile stimulation may serve as an external sensory cue that improves timing, coordination, and voluntary movement control. Such feedback can potentially suppress tremor activity and enhance functional performance during upper-limb tasks. [8]

Task-oriented exercises involve repetitive practice of meaningful functional activities and are based on principles of motor learning and neuroplasticity. Combining vibrotactile sensory feedback with task-oriented exercises may provide additional benefits by simultaneously targeting sensory and motor systems. Enhanced sensory input during functional movement practice may facilitate motor relearning, improve upper-limb dexterity, reduce tremor interference, and promote functional independence. [9]

Despite growing interest in sensory feedback-based rehabilitation, evidence regarding the effectiveness of vibrotactile sensory feedback for tremor management in Parkinson's disease remains limited. Therefore, the present study was undertaken to evaluate the effect of vibrotactile sensory feedback on tremors in individuals with Parkinson's disease and to determine its effectiveness in improving motor control and functional performance. [10]

Parkinson's disease (PD) is a progressive neurodegenerative disorder characterized by the loss of dopaminergic neurons in the substantia nigra, leading to motor impairments such as tremor, rigidity, bradykinesia, and postural instability. Tremor is one of the most common symptoms affecting individuals with Parkinson's disease and can significantly interfere with functional activities and quality of life. Despite advances in pharmacological management, tremor often remains challenging to control completely, necessitating the exploration of adjunct rehabilitation strategies. [11]

Sensory feedback has emerged as an important component of neurological rehabilitation due to its role in enhancing motor control and movement regulation. Wearable technologies capable of providing sensory cues have gained increasing attention for their potential to improve motor performance and facilitate objective monitoring of symptoms in individuals with Parkinson's disease. Quantitative wearable sensors have demonstrated utility in assessing motor impairments and supporting rehabilitation interventions. [11,12]

Vibrotactile sensory feedback is a non-invasive technique that utilizes controlled vibration stimuli delivered through wearable devices to stimulate cutaneous mechanoreceptors and enhance sensory input to the central nervous system. Augmented sensory cues have been shown to improve motor performance, coordination, and movement execution in individuals with Parkinson's disease by enhancing sensorimotor integration and facilitating motor learning. [13]

Physiotherapy interventions focusing on task-oriented training and external cueing strategies have shown beneficial effects on mobility, balance, and motor function in Parkinson's disease. European physiotherapy guidelines emphasize the importance of evidence-based rehabilitation approaches that incorporate sensory cueing and functional training to maximize patient outcomes. [14,15]

Recent advances in neurorehabilitation have highlighted the potential role of sensory feedback-based interventions in improving motor performance and reducing symptom severity. Vibrotactile stimulation may serve as an external sensory cue that enhances voluntary movement control and reduces tremor interference during functional activities. However, evidence regarding its effectiveness in tremor management remains limited. Therefore, the present study aims to investigate the effect of vibrotactile sensory feedback on tremors in individuals with Parkinson's disease. [16]

Participants

A total of 17 participants diagnosed with Parkinson's disease were recruited for this study from the outpatient physiotherapy department. Participants were selected based on the inclusion and exclusion criteria. Both male and female participants aged between 50 and 75 years who presented with resting tremors and were medically stable were included in the study. Individuals with severe cognitive impairment, other neurological disorders, musculoskeletal conditions affecting upper-limb function, or those who had undergone recent surgical intervention were excluded.

All participants were informed about the purpose and procedure of the study, and written informed consent was obtained prior to participation. The study was conducted in accordance with ethical principles, and confidentiality of participant information was maintained throughout the study.

Ethical approval and participation conset

The ethical approval for undertaking the suggested studies has been obtained from the Institutional Committee of Ethics of Krishna Vishwa Vidyapeeth (Deemed to be University), Karad, Maharashtra, India, vide their letter no. KVV/IEC/02/2026 dated January 22, 2026. Every participant provided their informed permission in writing after being given the assurances of confidentiality and the freedom to discontinue participation at any moment.

Outcome measures

Pre- and post-intervention assessments were recorded to evaluate the effectiveness of vibrotactile sensory feedback combined with task-oriented exercises on tremor severity, hand dexterity, and motor function in individuals with Parkinson’s disease. The selected outcome measures included the Unified Parkinson’s Disease Rating Scale (UPDRS), The Essential Tremor Rating Assessment Scale (TETRAS), and the Nine-Hole Peg Test (NHPT). These measures were used to assess changes following the 4-week intervention program. The protocol specifically identifies UPDRS, hand dexterity testing, and TETRAS as the primary outcome measures.

Statistical Analysis

Data were analyzed using Statistical Package for the Social Sciences (SPSS) version 26.0. Descriptive statistics were used to summarize demographic and clinical characteristics of the participants. Continuous variables were expressed as mean ± standard deviation (SD), while categorical variables were presented as frequencies and percentages.

The normality of data distribution was assessed using the Shapiro–Wilk test. Pre- and post-intervention scores of the Unified Parkinson's Disease Rating Scale (UPDRS), The Essential Tremor Rating Assessment Scale (TETRAS), and Nine-Hole Peg Test (NHPT) were compared using a paired t-test for normally distributed data. In cases where data were not normally distributed, the Wilcoxon Signed-Rank Test was used.

The level of statistical significance was set at $p < 0.05$. Effect size (Cohen's d) was calculated to determine the magnitude of treatment effects. The results were presented using tables and graphical representations where appropriate.

Exercise Protocol :

| Week | Session frequency | Duration per sessions | Vibrotactile sensory feedback + Task oriented exercises |
|---|---|---|---|
| Week 1 | 5 Sessions/week | 45-60 min | Introduction and familiarization with the vibrotactile device. Baseline tremor and motor assessment.<br>Task-oriented activities including reaching, grasping, cup lifting, and buttoning tasks with real-time vibrotactile cues. |
| Week 2 | 5 Sessions/week | 45-60 min | Progression of task difficulty using smaller objects and dual-task activities.<br>Vibrotactile cues were triggered according to tremor amplitude threshold.<br>Feedback training focused on improving movement control and motor accuracy. |
| Week 3 | 5 Sessions/week | 45-60 min | Complex functional tasks including pouring, writing, and utensil handling.<br>Vibrotactile feedback was provided for tremor suppression and movement correction. Emphasis was placed on smooth, rhythmic, and coordinated movement |

| | | | |
|---|---|---|---|
| Week 4 | 5 Sessions/week | 45-60 min | Integration of vibrotactile feedback into activities of daily living (ADL)-based tasks. Gradual reduction of external cues to promote motor learning and independent task performance. Post-intervention tremor and motor assessment were conducted. |

**RESULTS**

1. Participation Flow - A total of 17 participation met inclusion criteria and were allocated to the experimental group (n=17). All participants completed the 4 week intervation and were included in the final analysis
2. Baseline Characteristics – The baseline demographic and clinical characteristics of the participants are presented in Table 1. A total of 17 participants with Parkinson's disease were included in the study. The mean age, disease duration, and baseline outcome measures were recorded prior to the intervention.

**Baseline Characteristics**

| Variable | Mean ± SD |
|---|---|
| Age (years) | 63.4 ± 4.8 |
| Disease Duration (years) | 5.6 ± 2.3 |
| UPDRS (Pre) | 39.5 ± 6.7 |
| TETRAS (Pre) | 18.9 ± 3.8 |
| NHPT (sec) Pre | 44.7 ± 6.1 |

**Within-Group Comparison**

The effects of Vibrotactile Sensory Feedback on tremors were evaluated by comparing pre- and post-intervention scores of the Unified Parkinson's Disease Rating Scale (UPDRS), The Essential Tremor Rating Assessment Scale (TETRAS), and Nine-Hole Peg Test (NHPT). Significant improvements were observed in tremor severity, motor function, and hand dexterity following the intervention.

| Outcome | Pre (Mean ± SD) | Post (Mean ± SD) | Mean Difference | p value |
|---|---|---|---|---|
| UPDRS | 39.5 ± 6.7 | 28.4 ± 5.9 | 11.1 | <0.001 |
| TETRAS | 18.9 ± 3.8 | 11.2 ± 2.9 | 7.7 | <0.001 |
| NHPT(sec) | 44.7 ± 6.1 | 35.2 ± 5.3 | 9.5 | <0.001 |

**Effect Size Analysis**

Effect size analysis demonstrated a large treatment effect across all outcome measures following Vibrotactile Sensory feedback on tremors

| Outcome | Mean Difference | Cohen d | Interpretation |
|---|---|---|---|
| UPDRS | 11.1 | 1.6 | Large |
| TETRAS | 7.7 | 1.4 | Large |
| NHPT | 9.5 | 1.5 | Large |

Clinical significant of primary outcome

The intervention resulted in clinically meaningful improvements in tremor severity, motor function, and hand dexterity. The reduction in UPDRS and TETRAS scores indicates improved motor control and decreased tremor severity, while the reduction in NHPT completion time reflects enhanced upper-limb dexterity and fine motor coordination.

Discussion

The present study was conducted to evaluate the effect of vibrotactile sensory feedback on tremors in individuals with Parkinson's disease. The results demonstrated significant improvements in tremor severity, motor function, and hand dexterity following a 4-week intervention program. Improvements were observed in the Unified Parkinson's Disease Rating Scale (UPDRS), The Essential Tremor Rating Assessment Scale (TETRAS), and Nine-Hole Peg Test (NHPT), indicating the effectiveness of vibrotactile sensory feedback as an adjunct rehabilitation strategy.

In the present study, UPDRS scores showed a significant reduction following the intervention, suggesting improved motor performance and decreased severity of Parkinsonian symptoms. These findings are consistent with previous studies reporting that sensory cueing and feedback-based interventions enhance motor control and movement execution in individuals with Parkinson's disease by improving sensorimotor integration and facilitating motor learning. [13,15]

A significant decrease in TETRAS scores was also observed, indicating reduced tremor severity after vibrotactile sensory feedback training. Tremor generation in Parkinson's disease is associated with abnormal oscillatory activity within the basal ganglia-thalamo-cortical circuits. Vibrotactile stimulation may provide augmented sensory input that modulates abnormal neural activity and improves voluntary movement control. Similar findings have been reported by studies investigating sensory cueing strategies and wearable feedback technologies in Parkinson's disease rehabilitation. [5,9,13]

The improvement observed in NHPT performance suggests enhanced hand dexterity and fine motor coordination. Hand function is frequently impaired in individuals with Parkinson's disease due to tremor, bradykinesia, and reduced movement accuracy. The provision of vibrotactile sensory feedback during task-oriented activities may enhance proprioceptive awareness and movement precision, thereby improving upper-limb performance. Previous research has highlighted the role of task-oriented rehabilitation and external sensory cues in improving functional outcomes and upper-limb function among neurological populations. [4,14,15]

The beneficial effects observed in this study may be explained by the principles of neuroplasticity and motor learning. Repetitive task practice combined with augmented sensory input promotes adaptive changes within the central nervous system, resulting in improved movement control and coordination. Vibrotactile feedback may act as an external cue that enhances sensory processing and compensates for deficits in sensorimotor integration commonly observed in Parkinson's disease. [6,8,10]

Recent advances in wearable rehabilitation technologies have increased interest in the use of vibrotactile stimulation for neurological disorders. Wearable sensory feedback systems are non-invasive, portable, and relatively inexpensive, making them suitable for both clinical and home-based rehabilitation programs. Studies investigating wearable technologies in Parkinson's disease have demonstrated their usefulness in monitoring motor symptoms and supporting rehabilitation interventions aimed at improving functional performance. [10,11,12]

The findings of the present study are also supported by contemporary rehabilitation approaches that emphasize multimodal interventions combining exercise, sensory feedback, and motor learning principles. Physiotherapy guidelines recommend incorporating evidence-based sensory cueing strategies to optimize motor outcomes and improve quality of life in individuals with Parkinson's disease. [14,16]

Therefore, the results of the present study suggest that vibrotactile sensory feedback combined with task-oriented exercises is effective in reducing tremor severity, improving motor control, and enhancing hand dexterity in individuals with Parkinson's disease. The intervention may serve as a valuable adjunct to conventional physiotherapy management and contribute to improved functional independence and participation in daily activities.

Conclusion

The present study investigated the effect of vibrotactile sensory feedback on tremors in individuals with Parkinson's disease. Significant improvements were observed in tremor severity, motor function, and hand dexterity following the 4-week intervention program.

The improvements in UPDRS, TETRAS, and NHPT scores suggest that vibrotactile sensory feedback may enhance sensorimotor integration, improve voluntary movement control, and facilitate better functional performance. These findings indicate the potential of sensory feedback as a valuable rehabilitation approach for tremor management.

Therefore, vibrotactile sensory feedback can be considered a safe, non-invasive, and clinically useful intervention for individuals with Parkinson's disease. Further studies with larger sample sizes and longer follow-up periods are recommended to establish its long-term effectiveness.

**Strengths of the study**

This study focused on a novel and non-invasive intervention for tremor management in Parkinson's disease. Standardized outcome measures (UPDRS, TETRAS, and NHPT) were used to assess changes in tremor severity and motor function. The intervention was safe, feasible, and well tolerated by all participants. The study demonstrated significant improvements following a structured 4-week treatment program. The findings provide preliminary evidence supporting the clinical use of vibrotactile sensory feedback in neurological rehabilitation.

Limitation of study

The present study had several limitations. The sample size was relatively small (n = 17), which may limit the generalizability of the findings to the broader Parkinson's disease population. The study was conducted over a short intervention period of four weeks; therefore, the long-term effects of vibrotactile sensory feedback could not be determined. As this was a single-group pre–post experimental study without a control group, it was not possible to compare the intervention with other treatment approaches. Additionally, only individuals with mild to moderate Parkinson's disease were included, limiting the applicability of the findings to patients with advanced disease stages. Future studies with larger sample sizes, controlled study designs, and longer follow-up periods are recommended to establish the long-term effectiveness of vibrotactile sensory feedback in Parkinson's disease rehabilitation

Clinical Implication

The present study suggests that vibrotactile sensory feedback is a promising rehabilitation strategy for managing tremors in individuals with Parkinson's disease. The intervention resulted in significant improvements in tremor severity, motor function, and manual dexterity. These findings support the incorporation of vibrotactile sensory feedback into neurological physiotherapy programs as an adjunct to conventional treatment. The technique is non-invasive, safe, and easy to administer in clinical settings. Improved motor performance may facilitate better execution of daily activities and enhance functional independence. Therefore, vibrotactile sensory feedback may contribute to improved rehabilitation outcomes and quality of life in patients with Parkinson's disease.

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