A Pilot Study Comparing Speech Processing in People with Parkinson's Disease and Controls Who Dance over 5-years

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INTRODUCTION

Parkinson's Disease (PD) is a progressive neurodegenerative disorder that affects approximately 2-3% of individuals over the age of 65 (1). Characterized by both motor and non-motor symptoms (2), PD is notably associated with significant impairments in speech, which can impact up to 90% of patients (3). These speech impairments often manifest as dysarthria, marked by a reduced range of pitch and intensity, and can severely hinder communication, thereby diminishing the quality of life (QoL) for those affected.

Recent studies have suggested that physical and cognitive activities, such as dance, may offer neuroprotective benefits for people with PD (4, 5, 6, 7). Dance in particular has been shown to promote neuroplasticity in brain regions associated with motor control, thereby potentially mitigating the decline in motor and non-motor functions (4, 5, 6).

Current Aims:

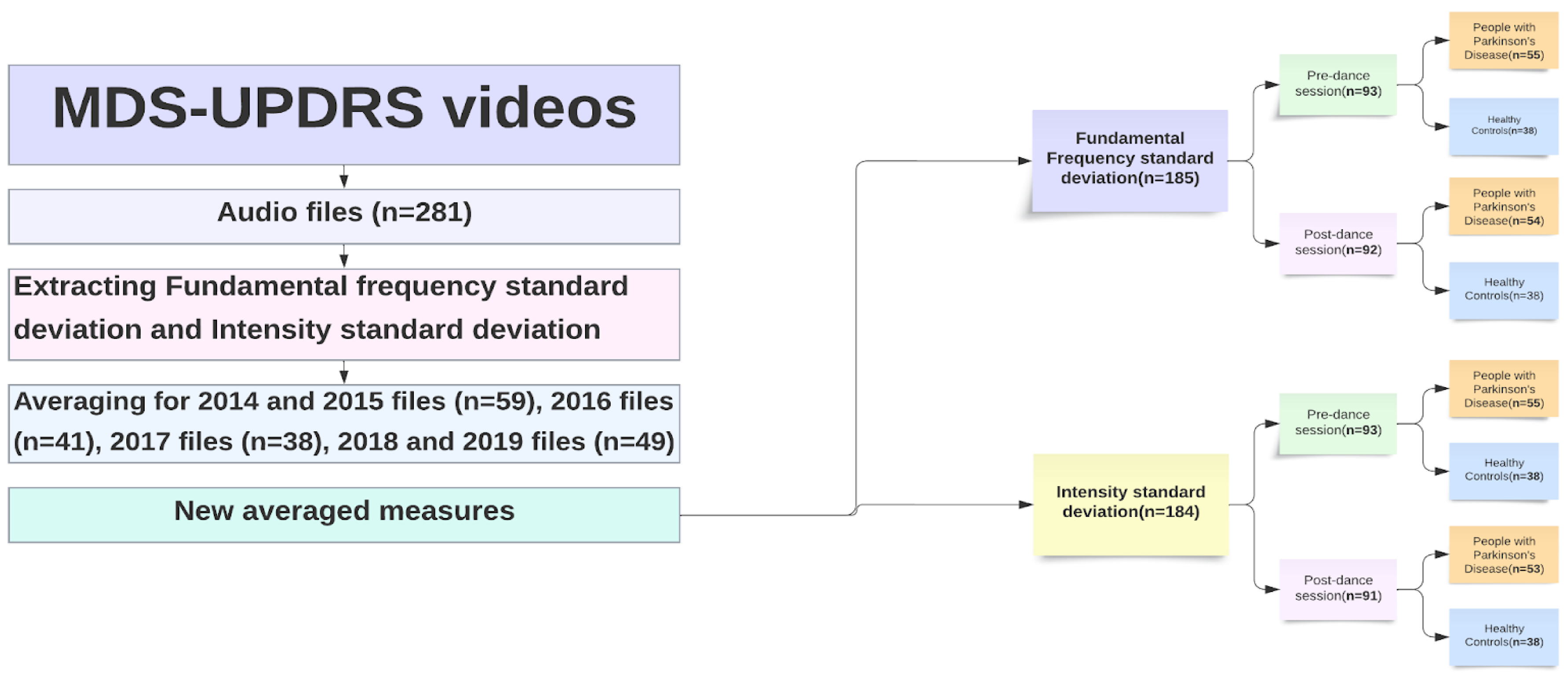
1. This study aims to investigate the differences in voice parameters, specifically the standard deviation of fundamental frequency (F0SD) and intensity (IntSD), between individuals with PD and healthy controls.
2. Additionally, the study explores whether regular dance practice can attenuate the progression of these vocal impairments over a five-year period.

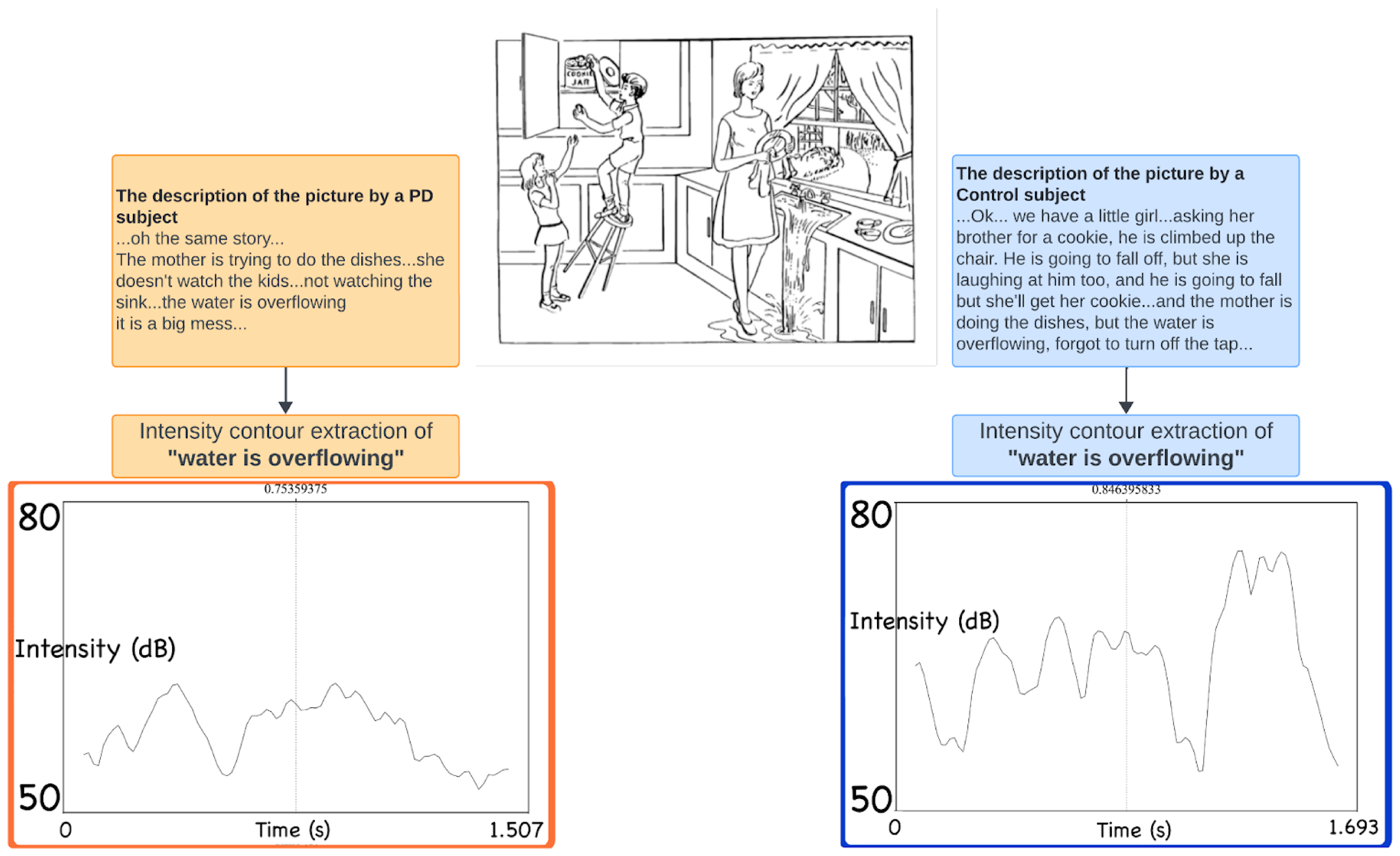
METHODS

This study involved a secondary analysis of voice recordings collected from individuals with Parkinson's Disease (PD) and healthy controls who participated in a longitudinal dance program at Canada's National Ballet School Trinity St. Paul's church in Toronto, Ontario, from 2014 to 2019. The participants, consisting of 29 individuals with PD and 29 healthy controls, were evaluated over a five-year period. Voice recordings were taken before and after dance sessions as part of a broader study investigating the effects of dance on PD.

Participants were video recorded during the evaluation of the Movement Disorder Society's Unified Parkinson's Disease Rating Scale (MDS-UPDRS). Voice features were measured across 11 time points from 2014 to 2019. The 11 time points were consolidated into four to reduce variability, optimize statistical power, and address participant attrition.

Voice features were extracted using a machine learning model implemented in Python. The primary features of interest were the standard deviation of fundamental frequency (F0SD) and intensity (IntSD), which were chosen based on their relevance to speech impairments in PD (8, 9).





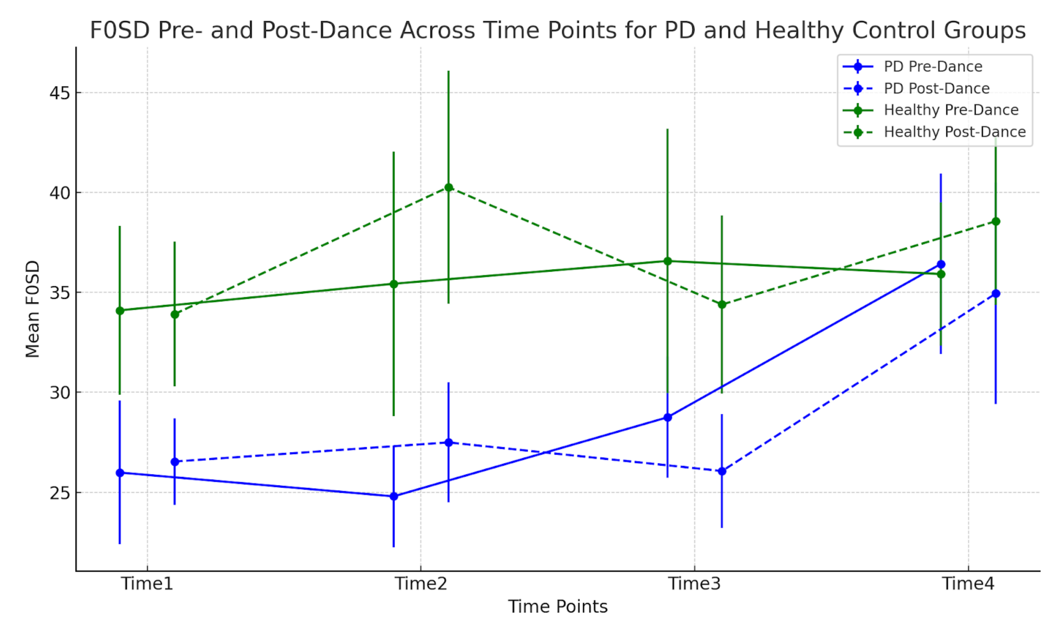
RESULTS

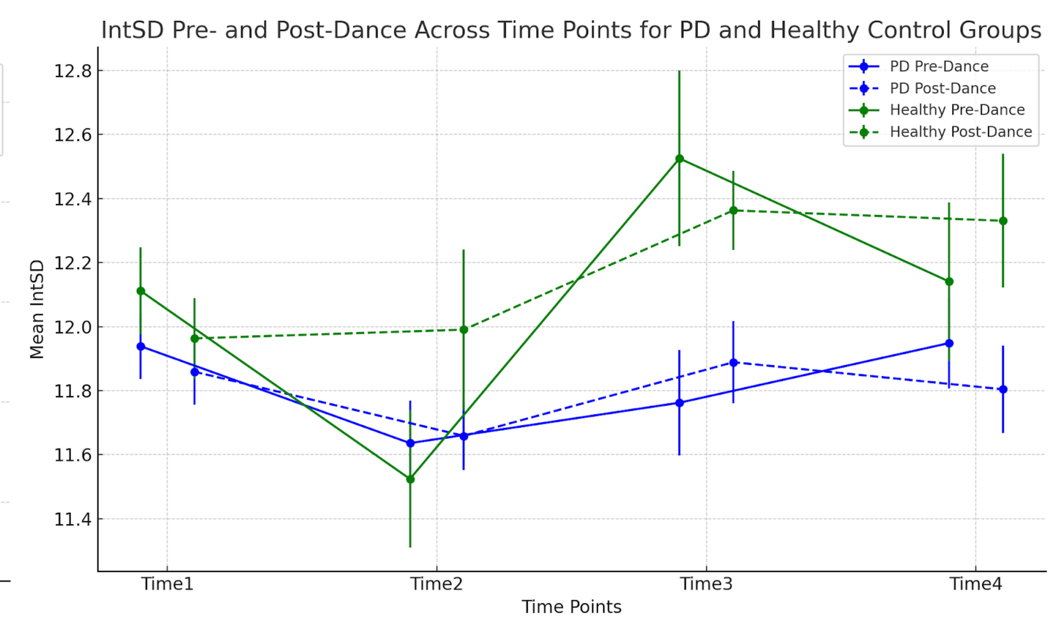
Differences in Voice Features:

The PD group exhibited significantly higher variability in both F0SD and IntSD compared to healthy controls in initial (2014) and final (2019) measurements. Specifically, ANOVA results showed a significant interaction effect for F0SD ($F = 3.906$, $p = 0.0346$, Cohen's $d = 0.54$) and a significant main effect for IntSD over time ($F = 5.904$, $p = 0.0242$, Cohen's $d = 0.57$). This confirms that individuals with PD experience greater variability in their speech features, aligning with known PD-related vocal motor control impairments. Although significant interaction effects were found for F0SD among group and time in the initial analysis, post hoc comparisons adjusted with Bonferroni corrections did not reveal specific statistically significant differences.

Effect of Dance on Voice Features:

A mixed-effect ANOVA evaluated the impact of dance sessions. While both PD and healthy control groups participated in pre- and post-dance evaluations, a significant main effect of time was found only for F0SD ($F = 7.1065$, $p = 0.0084$), indicating improved F0SD stability after dance. However, the interaction between time and group was not significant ($p = 0.4501$), implying similar improvements across both groups. For IntSD, neither main effects nor interactions were statistically significant, suggesting that IntSD variability remained unaffected by dance ($p > 0.05$).





DISCUSSION

This study explored differences in voice parameters between individuals with Parkinson's Disease (PD) and healthy controls, focusing on the standard deviation of fundamental frequency (F0SD) and intensity (IntSD). While no significant difference in F0SD was found between the two groups, the interaction of group and time was significant, suggesting that PD affects pitch variability over time. However, individual time-point comparisons showed no significant differences due to intra-group variability. For IntSD, a significant effect of time was observed in both groups, indicating that changes in vocal intensity were likely age-related rather than PD-specific. Moderate effect sizes (Cohen's $d \approx 0.54$–0.57) suggest measurable but variable impacts.

The mixed-effect ANOVA for F0SD showed a significant effect of time ($F = 7.1065$, $p = 0.0084$), indicating that dance positively influenced pitch variability in both PD and healthy participants. However, there was no significant interaction between time and group, suggesting similar effects of dance across both groups. In contrast, IntSD did not show significant changes, indicating that intensity variability may not respond to short-term interventions like dance.

CONCLUSION

This study underscores the complexity of speech changes in PD. While dance may provide immediate benefits for pitch variability (F0SD), more intensive or longer interventions may be needed to impact both F0SD and IntSD. The findings suggest that speech parameters could serve as biomarkers for tracking PD progression, and integrating early interventions, such as dance, with conventional therapies may enhance communication and quality of life for individuals with PD.

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