Effect of Deep Brain Stimulation on Balance in Essential Tremor Individuals with and without Head Tremor Using Inertial Measurement Units.

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Summary

Essential tremor (ET) is a neurodegenerative disease denoted by hand tremor, extending to voice and head, and balance deficits. This study investigated the effects of deep brain stimulation (DBS) on balance in ET patients with head tremor (ETwh) and patients without head tremor (ETnh), comparing them to each other and to healthy controls (HC) using linear and non-linear analysis. The results showed a limited DBS effect on balance improvement in ETwh, indicating an ET subtype-specific response to DBS.

Introduction

ET is a common movement disorder marked by upper-limb tremor, often extending to voice and head [1]. Head tremor is suggested to indicate an ET subtype and is closely related to balance impairments [2,3]. DBS of caudal zona incerta (cZi) is an established treatment for patients with disabling and medically resistant tremor [4]. While effective in reducing tremor, the impact of cZi DBS on balance, considering head tremor, remains unexplored. Linear analysis is a valid tool for evidencing pathology-induced changes in balance; however, it may not quantify the underlying temporal dynamics of balance mechanisms arising from interactions of various systems at different time scales [8]. Multiscale entropy (MSE) is an established non-linear metric for detecting disease- and age-related balance temporal dynamics' changes measuring signal regularity across time scales [5]. This study aimed to quantify effects of different DBS intensities on balance in ET subtypes, comparing them to each other and to HC via linear and non-linear analysis.

Methods

Balance was assessed using gyroscope data from a lumbar-mounted inertial measurement unit in 17 ET patients (9 ETwh, 8 ETnh) and 18 HC, while performing a standing balance task on a foam pad with eyes open and narrow feet for 30s or until balance was lost. Head tremor was assessed via the essential tremor rating scale [7]. ET patients performed the task at three stimulation intensity settings: no stimulation (OFF), therapeutic (ON1), and supratherapeutic (ON2). Gyroscope data (mediolateral X, anterior-posterior Y, inferior-superior Z) were low-pass filtered (10 Hz, 2nd-order zero-phase Butterworth) before computing the trajectory length (TL) and complexity index (CI) over the first 28s, representing the minimum standing balance time (BT) achieved across groups. CI represents the sum of entropy levels calculated across 14 coarse-grained scales using MSE [6]. Two linear mixed models analyzed differences in logarithmic TL (log-TL), CI, and BT. The first model compared each ET subtype vs. HC across DBS settings. The second model assessed differences within ET subtypes across DBS settings. A significant main effect for *condition* (OFF, ON1, ON2, HC) in the first model and *DBS setting* × *ET subtype* interaction in the second model underwent post-hoc analysis with false discovery rate correction. Statistical significance threshold was set $p < .05$.

Results and Discussion

The first model indicated a significant main effect for *condition* for log-TL, CI, and BT ($p<.05$). Post-hoc for CI and log-TL indicated that ETwh had significantly higher log-TL and CI in DBS OFF compared to HC, indicating altered balance control in presence of higher irregularity levels [8]. This pattern persisted for log-TL in DBS ON1 and ON2, suggesting a limited effect of DBS on balance in ETwh. In contrast, ETnh only showed higher log-TL than HC in DBS OFF, with no differences in other DBS statuses or for CI and BT, suggesting distinct balance control performance between ET subtypes (**Figure 1**). The second model indicated a significant *DBS setting* × *ET* subtype for log-TL and BT ($p<.05$). In line with prior studies, post-hoc analysis showed poorer balance control in ETwh as indicated by significantly greater log-TL in DBS OFF compared to ETnh [9].

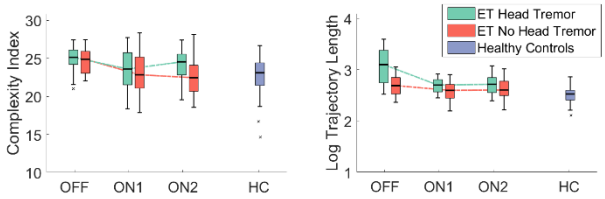

Figure 1: Logarithmic Trajectory Length and Complexity Index in essential tremor patients (with/without head tremor) and healthy controls.

Conclusions

The findings of this study indicate an ET subtype-specific response to DBS, with limited balance improvement in ET patients with head tremor compared to those without.

References

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