Objective Assessment and Scoring of Parkinsonian Tremors using Wrist Sensor Technology

Megan E. Sullivan[1], Aditya A. Shanghavi[2], Oliwia Rentley[3], Sarah Elizabeth Zauber[1,4], Anne B. Sereno[1,2,5]

[1]Indiana University, School of Medicine; [2]Purdue University, Weldon School of Biomedical Engineering; [3]Purdue University, College of Health and Human Sciences; [4]Indiana University Health Neuroscience Center, Department of Neurology; [5]Purdue University, Department of Psychological Sciences

Introduction

- Parkinson's disease (PD) is the second most common neurodegenerative disease[1]
- The Movement Disorder Society-Unified Parkinson's Disease Rating Scale (MDS-UPDRS)[2] is the gold standard for assessing task-dependent tremors, responsiveness to Levodopa and dopaminergic medications[3], and disease progression[4]
- The MDS-UPDRS is a visually based scoring system with some concerns raised about subjectivity in ratings[5]

GOAL: Evaluate the use of wrist worn inertial sensors as a more reliable and objective alternative for measuring severity of rest and postural PD tremor and compare to MDS-UPDRS

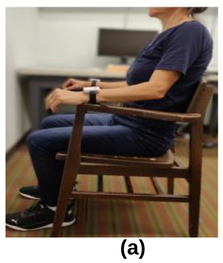
Subjects

Patients:30 PD (age 48-82, 12 female)
PD patients with no history of dementia

Controls: 30 age-matched older adults (age 54-76, 18 female)
Healthy adults with no history of a neurological or muscular disorder

Tasks

Figure 1: Sensors attached to both wrists



(a)

(b)

Figure 2: Rest (a) and Postural (b) tasks. Instructions based on Section 3.17 and 3.15 of MDS-UPDRS III

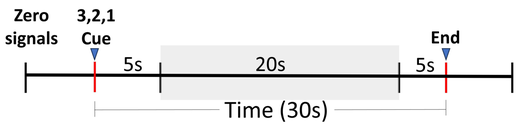


Figure 3:Task Timeline for Rest and Postural tasks

- Sensors recorded in 6 kinematic axes (X, Y, Z, Roll, Pitch, Yaw)
- Task order: (1) Rest (2) Postural

Methods

Clinical Evaluation of Tremor Severity by Neurologist:

- Neurologists rate tremor severity of upper limbs (from 0-4) using MDS-UPDRS for Rest (Section 3.17) and Postural (Section 3.15) tasks

Evaluation of Tremor Severity using Sensors:

Signal Processing

- 12 kinematic variables were converted from time to frequency domains using power spectral density analysis and for each variable
- Power values across 20 different frequency ranges were calculated, resulting in 240 power values for each wrist in each task

Calculation of Sensor-based Tremor Severity Score (TSS)

- Reduced 240 power values to 1-D values (containing ~90% variance) per observation using Multidimensional Scaling (using Manhattan Distance) followed by Principal Component Analysis
- Interpolated 1-D values to 0-4 scale to more appropriately compare to MDS-UPDRS scores

Comparison of Sensor-based Score (TSS) to Clinical Evaluation:

- Compare TSS (yellow highlighted panels) and MDS-UPDRS scores to detect (1) differences between tasks (Rest vs Postural; expect more tremor at Rest) and medication effects (OFF vs ON; expect more tremor in OFF state).

Results

* indicates p<0.05

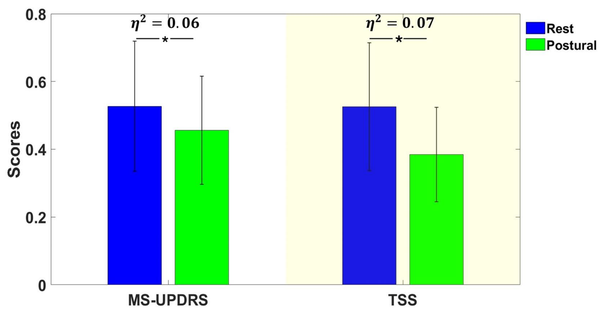
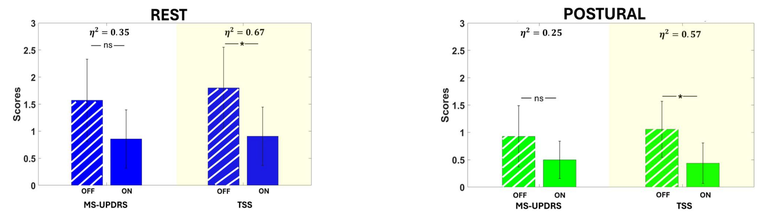


Figure 4: Comparison of MDS-UPDRS and TSS scores (with yellow highlight) for Rest and Postural tasks of 30 PD patients ON medication and 30 controls. Both scores show significant task differences, p<0.05; TSS shows marginally greater sensitivity.



(a) (b)

Figure 5: Comparison of MDS-UPDRS and TSS scores for medication effects for 7 PD patient ON and OFF Medication. Only TSS shows significant medication effects in both tasks, p<0.05; TSS also shows greater sensitivity.

Summary

- TSS scores show significant differences for both task differences and medication states, as well as larger effect size (greater sensitivity[6]) than MDS-UPDRS scores

Implications

- Objective measurements are more sensitive to detect subtle changes in tremor, due to task or treatment
- Improved sensitivity may be helpful for earlier diagnosis
- Sensor based system allows for more frequent monitoring as well as possibility of telehealth-based symptom tracking

Future Directions

- Extend method to analyze tremors in other motor disorders (e.g., essential tremor) or to analyze other PD features (e.g. bradykinesia)
- Examine changes in tremors due to other interventions or non-pharmaceutical factors (e.g. exercise, food intake)
- Capture data offsite in unsupervised settings

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