Wearable Sensor Assessment of Neuropathic Physiological Impairments and Sensory Reweighting Caused by Lumbar Spinal Stenosis and Diabetic Peripheral Neuropathy: An Observational Pilot Study

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Introduction

- Peripheral neuropathy arises from multiple different underlying medical conditions and can lead to serious functional limitations and significant long-term healthcare costs.
- Lumbar spinal stenosis (LSS) and diabetic peripheral neuropathy (DPN) are often misdiagnosed
  - due to the similarities in symptoms and pathologies
    - The ability to classify these impairments non-invasively and with high specificity at a low cost would be beneficial.
- A Head-mounted, triaxial inertial measurement unit (IMU) sensor may offer a unique and non-invasive method to identify various features in physiological vibration acceleration signals following sensory re-weighting.

Purpose

- To investigate the application of IMU sensors to differentially classify LSS from DPN compared to a control participant.

Methods

Classification	Gender	Age (Years)	Height (cm)	Weight (kg)
DPN (n=1)	Male	67	170	75
LSS (n=1)	Female	33	165	75
CON (n=1)	Male	42	176	74

Table 1. Participant Characteristics

- The IMU sensor was attached to participant's right mastoid using a disposable medical adhesive.
- Participants were instructed to:
  - Stand upright in a relaxed position with feet together and arms by their sides
  - Participants maintained this position twice for 20 s each test:
    - once with eyes open (Eo)
    - once with their eyes closed (Ec)

Methods

Figure 1. IMU sensor placement on exemplar participant

- Eo was always performed first. Participants maintained their gaze on a marker placed at eye-level, 1.5 m in front of them.
- The filtered IMU data were collected at 100 Hz.
- Eo and Ec powers, Eo/Ec power ratio, left-right asymmetry, time-resolved power spectral density (PSD) distributions (0-50 Hz), and sensory reweighting profiles were compared.
- Spectral shifts during each test were quantified using the mean frequency of a rolling 500 ms (250 ms overlap) analysis window.

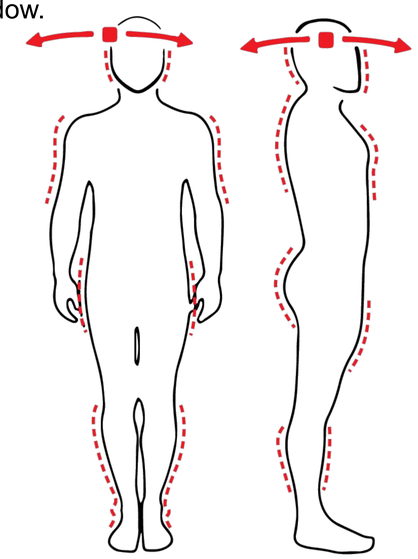

Figure 2. Measurement of inertial measurement unit accelerations in the frontal (left) and sagittal planes (right) to classify normal and pathological accelerations patterns.

Results

- EO and EC cumulative powers were similar for LSS and CON but were both meaningfully elevated for DPN (See Figure 3).
- The EO:EC ratio was higher in LSS compared to either DPN or CON. (See Figure 4).
- Left-right asymmetry was highest in the control during EO but was highest in DPN during EC (See FIgure 5.)
- PSD distributions showed greater power at higher frequencies (12 to 15 Hz) for LSS, compared to either DPN or control (See Figure 6).

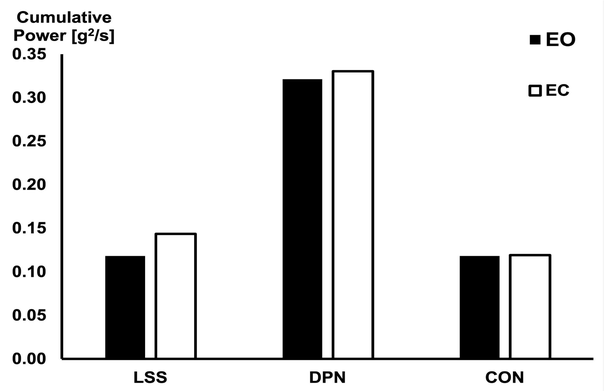

Figure 3. EO and EC powers for LSS, DPN, and CON

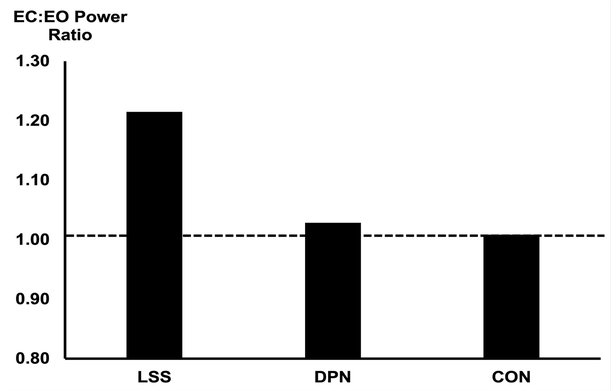

Figure 4. EO:EC ratio for LSS, DPN, and CON

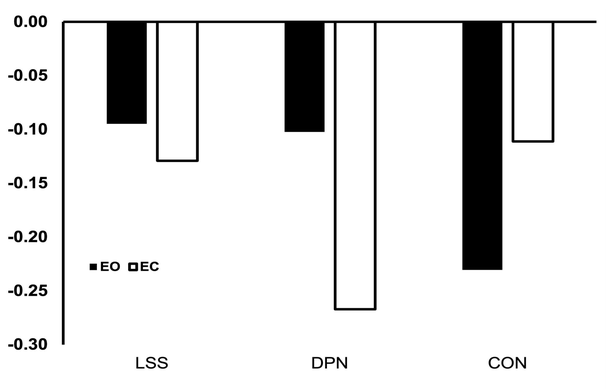

Figure 5. Left-right asymmetry for LSS, DPN, and CON

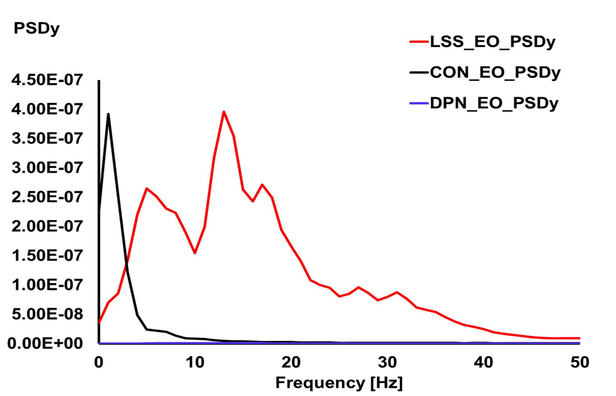

Figure 6. Left-right Power spectral density for LSS, DPN and CON.

Conclusion

- These preliminary data suggest that the unique digital signatures for DPN and LSS may enable classification of the different pathologies.
- These signals may also be used as a quantitative tool to monitor and assess patient treatment plans based on each patient's unique digital signature.