Reusable Textile Electrodes: A Scalable Solution For Long-Term Neurostimulation Applications

ID #53

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Introduction

- Neurostimulation technologies are an important group of interventions for pain relief, rehabilitation, and neuromuscular modulation [1–2].
- Traditional hydrogel electrodes are limited by **short use durations**, **potential for skin irritation**, and **disposability**, making them unsuitable for long-term, frequent applications [1].
- **Goal:** Develop and validate textile-based electrodes that are reusable, breathable, washable, and effective for long-term neurostimulation.

Methods

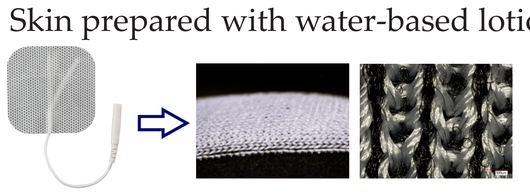
Participants

11 Females, ages 26.3 ± 3.8

10 Males, ages 28.7 ± 4.5 years

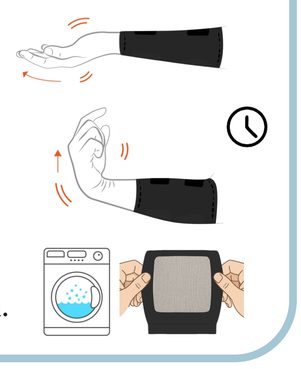
Textile Electrode

- Stainless steel (SS) conductive yarn.
- 3D design for uniform skin contact.
- Skin prepared with water-based lotion.



Performance Tests

- Skin-Electrode Impedance Measurements.
- Sensorimotor Thresholds in Comparison to Hydrogel Electrode [3].
- User Feedback (Comfort, Sensation).
- 6-Hour Continuous Use.
- Durability Tests: 30× Wash Cycles, 1000× Stretch Cycles at 50% Strain.



Results & Discussion

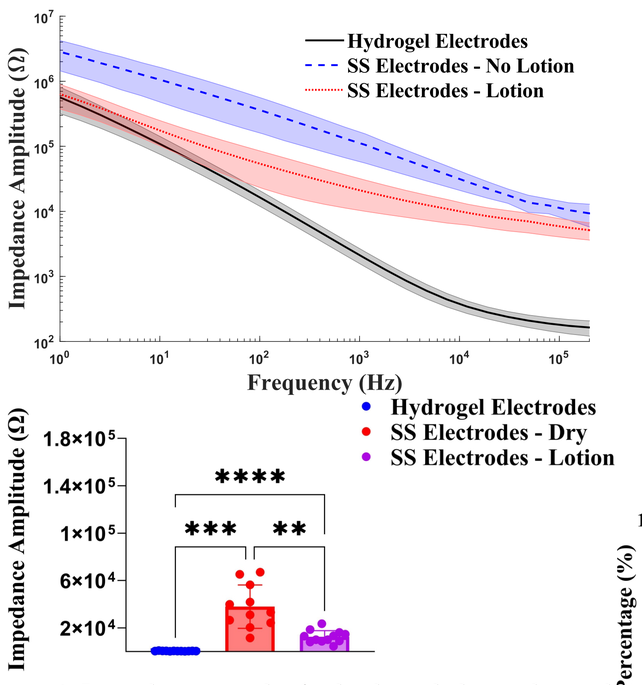


Figure 1: Impedance results for hydrogel electrodes and SS electrodes with and without lotion applied to the skin (n=12 participants) (a) Frequency sweep of average skin-electrode impedance, where lines represent the mean and shaded regions represent the standard deviation, (b) average impedance values at 5000 Hz with error bars of one standard deviation.

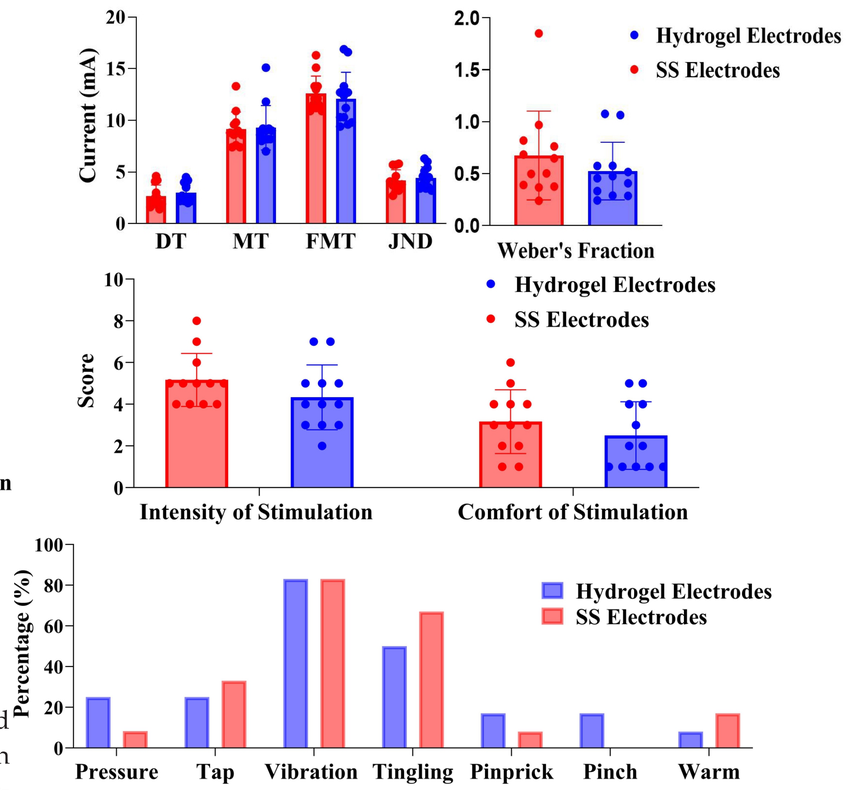


Figure 2: Results of sensorimotor response for hydrogel electrodes and SS electrodes (n=12 participants) (a) Average DT, MT, FMT, JND, Weber's fraction. Error bars represent one standard deviation, (b) Average scores for the intensity of stimulation and comfort level of the stimulation. Error bars represent one standard deviation, (c) Distribution of the survey responses describing the perceived stimulation-evoked sensation.

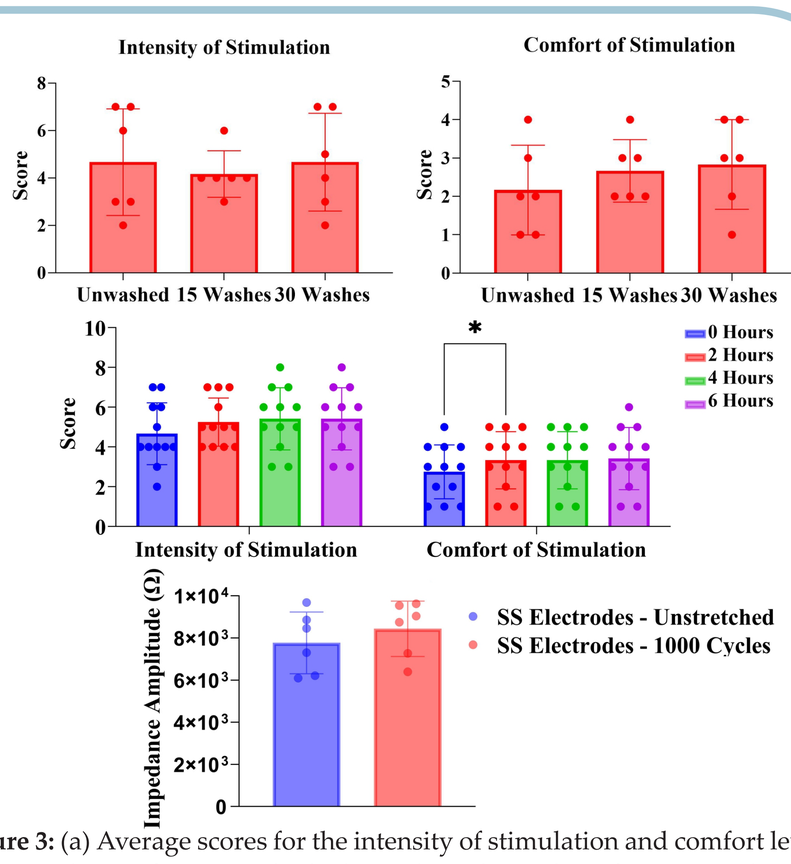


Figure 3: (a) Average scores for the intensity of stimulation and comfort level of the stimulation for unwashed electrodes, electrodes after 15 washes, and electrodes after 30 washes, (b) Average scores for the intensity of stimulation and comfort level of the stimulation immediately after applying lotion, and every 2 hours for up to 6 hours to examine the effect of lotion over time, (c) Skin-electrode impedance (at 5000 Hz) (n=6 participants) of developed electrodes before stretching and after stretching for 1000 cycles at 50% of their breaking strain.

Conclusion



- First demonstration of fully reusable, breathable, and washable textile electrodes performing comparably to hydrogel electrodes.
- Paves the way for scalable integration into smart wearable neurostimulation systems for real-world and long-term applications in both clinical and personal health settings.



Acknowledgment

We thank MyantX Inc. (Canada) for funding and contributions to design and materials. Special thanks to team members for assistance with experiments, coatings, and illustrations.

References

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