Durability and Performance Evaluation of *Elastatrode*™ Textile Electrodes for Functional Electrical Stimulation (FES)

Context
Functional Electrical Stimulation (FES) restores purposeful movement by electrically activating muscles. Disposable hydrogel electrodes are common but limit long-term and home-based use. Ink-based textile electrodes offer reusability and garment integration but require quantitative validation of electrical behaviour, stimulation performance, and mechanical durability.

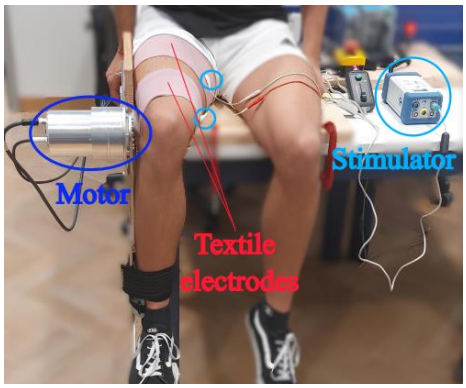

Figure 1: Experimental setup for the FES tests, highlighting the textile electrodes, the motor of the test bench

Objective
Develop an experimental and data-centric evaluation pipeline to quantify durability (mechanical + cleaning) and stimulation performance (thresholds, kinematics, comfort) of Elastatrode™ textile electrodes and identify failure modes that affect reproducibility and clinical adoption.

Methods

- **Data collection:** impedance and resistance measurements recorded as digital logs (CSV) across repeated cycles; stimulation sessions synchronized with kinematic encoder data.
- **Durability tests:** controlled stretching, folding, repeated soaking and machine-washing cycles; per-cycle resistance and impedance monitoring.
- **FES protocol:** randomized comparison of new vs washed electrodes on healthy subjects; automated threshold detection and repeated dynamic trials with encoder sync.
- **Analysis:** scripted preprocessing, threshold extraction, normalization of kinematics, statistical analysis, and summary statistics/figures produced for reproducibility.

Key results

- Use of an external electrolyte materially reduced skin–electrode impedance and produced repeatable stimulation thresholds comparable to hydrogel electrodes.
- Electrodes tolerated typical mechanical deformation (stretch/fold) with reversible resistance changes; repeated washing produced progressive, often irreversible increases in conductive-track resistance — primary failure mode.
- Short-term FES performance (thresholds, normalized displacement, subjective comfort) was similar for new and washed electrodes in most trials, but washed electrodes showed higher variability and occasional mechanical failure at the cable/track interface.

Conclusions & practical takeaways
Ink-based textile electrodes are promising for FES if electrolyte use is standardized and hardware durability (conductive tracks, cable/button interfaces) is improved. Consistent data logging and scripted analysis pipeline allow reproducible assessment and facilitate translation to product verification and regulatory review.