Wearable Preventive Pressure Ulcers System Using Embroidered Textile Electrodes

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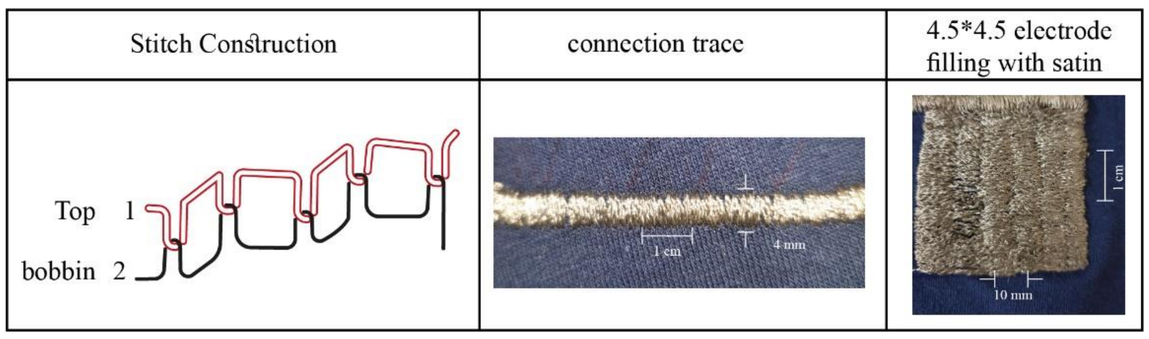
Introduction:

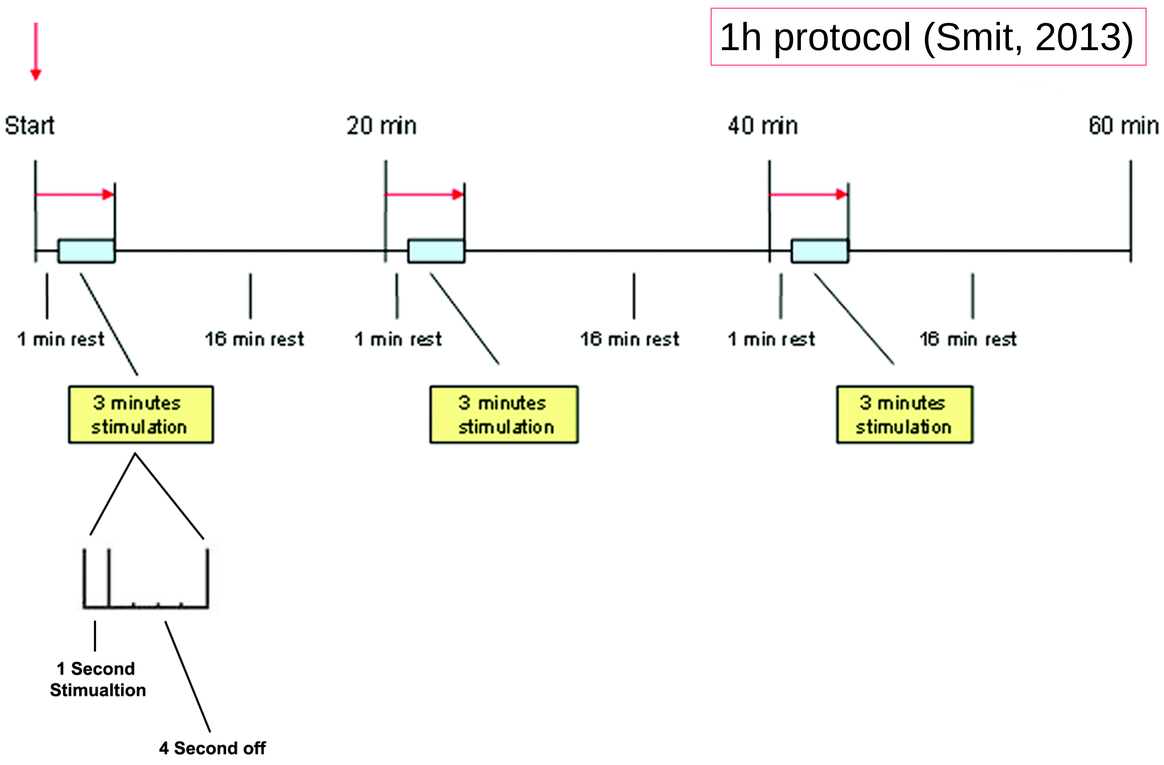
Textile electrodes, also known as textrodes used for biosignal monitoring as well as electrostimulation. Embroidery offers advantageous characteristics of dimensional stability, good reproducibility, and rapid prototyping. In this study, A design of electrical stimulation (ES) short for patients with limited mobility was developed with embroidered electrodes to activate gluteal muscles to prevent pressure ulcer (PU) formation.

Methods:

- 100% cotton knitted stretch fabric, the top stitch and bobbin were both loaded with conductive thread.
- Satin stitch was embroidered to a (4.5*4.5) filling electrode (12 stitches per cm/ 1cm wide) and the connection trace was also with stain stitch (10 stitches per cm/ 4 mm wide).

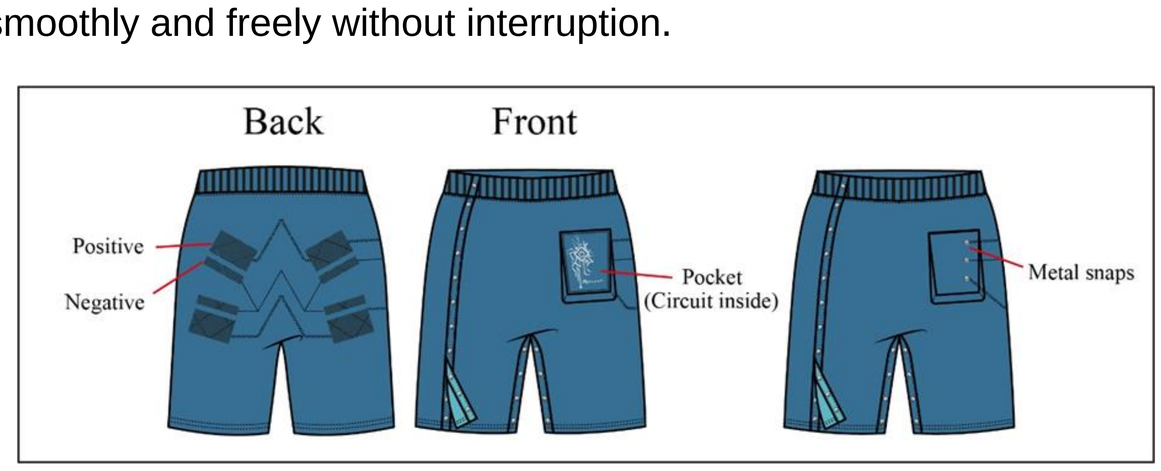


- ES parameters for PU prevention: The frequency >20-50 Hz, the amplitude 20-50 mA, and pulse width 64 to 600 µs. Mechanism underlying PU prevention: (i) Change in blood flow increases tissue oxygenation; helps muscles to survive, (ii) Decrease in tissue pressure caused by gluteal muscle contractions with redistribution of pressure from ischial tuberosities (ITs) to the direction of the knees, and (iii) Improve local circulation of muscle and skin and improve paralyzed muscle strength and mass.
- A custom-made circuit with an electrostimulation protocol of 1:4s on-off protocol as reported by (Smit, 2013); for better pressure relief results and comfort without marked muscle fatigue. this was applied for 3 min, then a 17 min rest period.

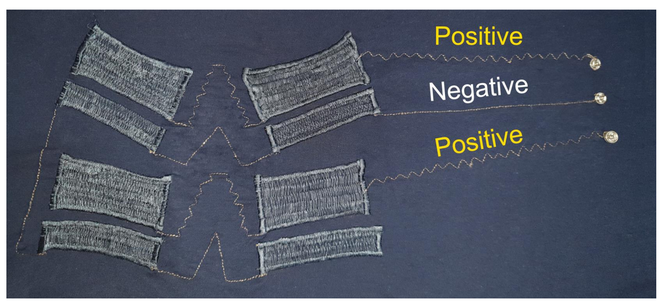


Results and discussion:

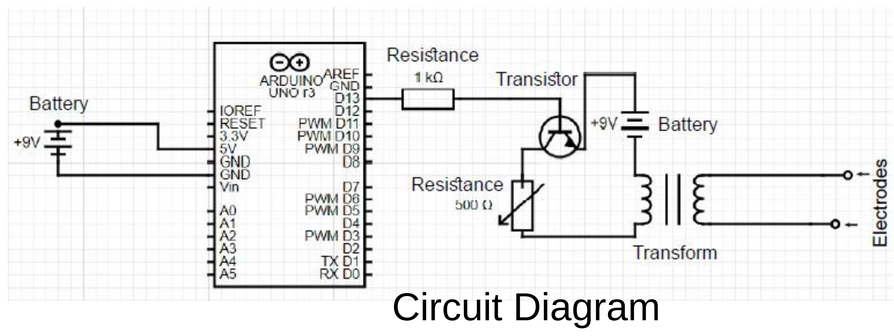
- Embroidery process: Running the machine was not that easy with this specific thread; the thread was cut and jammed several times even after adjusting the tension.
- 8 Electrodes were embroidered of the satin stitch with only a bobbin loaded with conductive thread, Cotton/poly thread was used for the top stitch.
- Traces of electrical paths were sewn on the opposite side of the fabric for better electrode-skin impedance, with a lock stitch by the sewing machine connected to metal snaps to the circuit.
- ES custom short was constructed with a seamless center crotch; to avoid bulky seams and allow the electrode connection traces to run smoothly and freely without interruption.



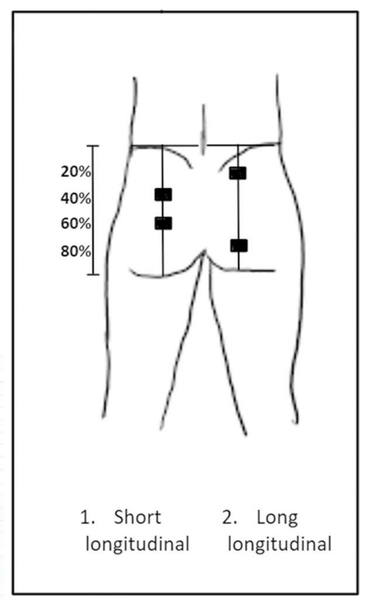
- 4 × 8 cm Electrodes align over gluteal muscles in a long longitudinal placement (LL); regarding comfort and efficiency (Flodin, 2022). ES was induced with a channel to each muscle (4 positive electrodes of 4 channels) and 4 negative electrodes.



Embroidered electrodes



Circuit Diagram



(Flodin, 2022)

Conclusion:

- ES short was applied to a healthy participant, scoring the usability as satisfactory and comfortable. The circuit was optimized with a microcontroller to customize variable ES parameters for each case.
- A cable-free system design that is Cost-effective for mass production and less time-consuming, fit for purpose with ensured contact of the electrodes placed on the skin, easy to use for both caregiver staff and self-dressing patients, eliminates problems of conventional Ag/AgCl electrodes (skin irritation, feeling of discomfort, and unable to be washed).

Acknowledgment:

- Ahmed Othman, for continued support and collaboration, and for creating the custom-made circuit.

Reference:

- Smit, C.A. et al. Prolonged electrical stimulation-induced gluteal and hamstring muscle activation and sitting pressure in spinal cord injury: effect of duty cycle. J Rehabil Res Dev., 2013, vol. 50 (7), pp. 1035-1046.
- Flodin, J et al., 2022, Effects of electrode size and placement on comfort and efficiency during low-intensity neuromuscular electrical stimulation of quadriceps, hamstrings and gluteal muscles, BMC Sports Science, Medicine and Rehabilitation, vol. 14 (11).