Wearable Sensors: Measuring Spinal Flexion with Textile Strain Sensors

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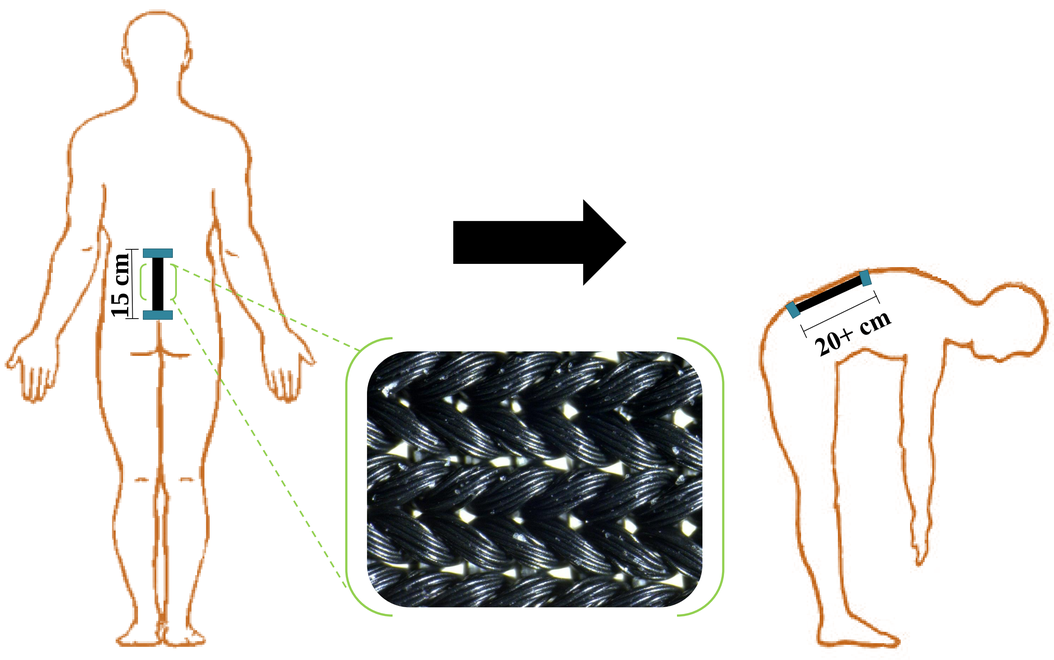
Introduction

Wearable sensors have the potential to enable continuous real-time health monitoring of people during normal daily activities. In contrast, the current paradigm requires patients to devote a period of time to attend for tests in specialist facilities and under conditions that, at best, are not representative of their normal life patterns, and at worst, may induce considerable stress, leading to significantly biased data. Physical therapy, training technique, rehabilitation, respiration monitoring and diagnostics could all be improved by implementing wearable sensors and data acquisition software. This will not only improve the accuracy of the measurements, but the ability to analyze the data over time.

Background



We present an alternative to the current clinician measurement of spinal flexion: the modified Schober's test. By implementing a strain sensor in place of the measuring tape currently used, it is proposed that inter-observer error would be reduced and more consistent measurements would be provided over time.

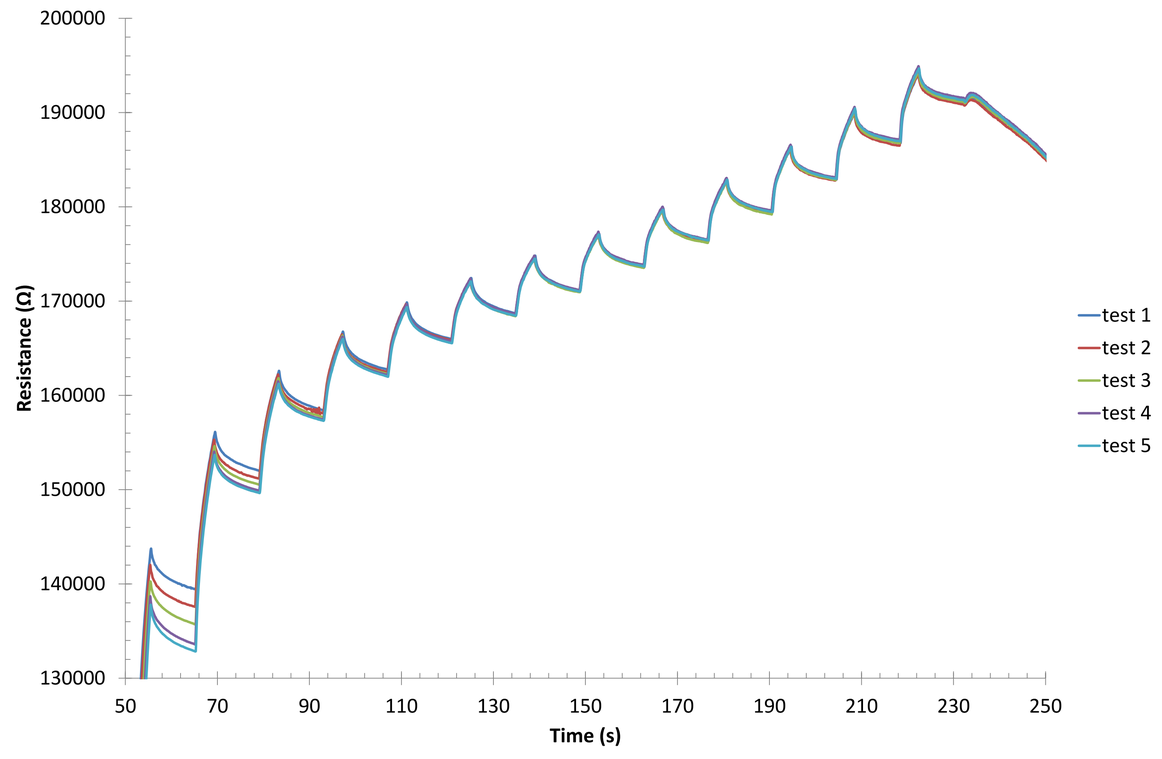
Textile Sensors

Relaxed Sensor

Stretched Sensor

A wide variety of flat, knitted piezoresistive fabric (KPF) sensors are being tested to determine the optimum size, knit direction, and thread tension needed for this application.

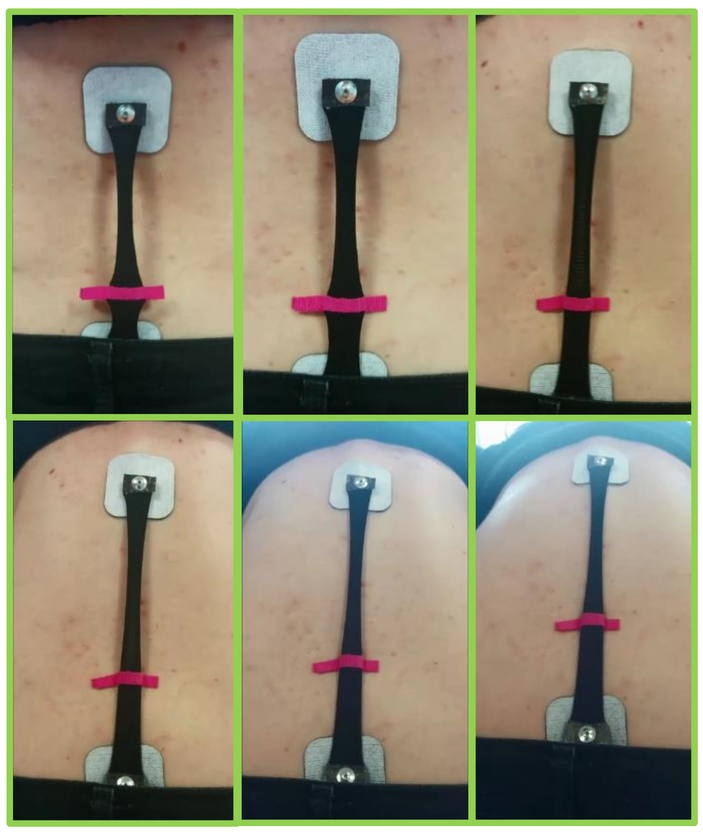
Strain Testing



All sensors were tested on a Zwick 5kN tensile machine with a 0.5N pre-load and 5% increases in displacement from 0-70% strain. Sensors were held for 10 sec between strain increases to allow for settling of the fabric. The above graph shows a single sensor over a series of 5 consecutive tests. The sensors show a high degree of sensitivity and repeatability even at extremely high percentage strains.

On-body Testing

In addition to testing the electrical properties of the sensors, it was also necessary to test methods of attaching the sensor to the subject. This requires a material strong enough to resist the force of the sensor pulling against it, while remaining safe and comfortable on the skin. Several different materials were tested before determining that electrostimulation electrodes provide the strength needed without being difficult or uncomfortable to remove from the skin.



Conclusions

The results of this work will be implemented in a real-time, wearable device for measuring the flexion of the spine. Such a device is believed to increase the accuracy of measurements and monitoring of diseases over time.

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