Utilize space technologies for use in a medical or health application on earth

Background

Ohmatex develops physiological and environmental sensors for inclusion in medical devices, sportswear, and protective clothing. We develop, test and validate sensors, working with medical experts, physiologists and the European Space Agency (ESA) to test, trial and validate our products.
Integrating sensors into textile is very valuable for continuous and prolonged monitoring, as sensors can be integrated into socks, t-shirts, trousers or work wear. This makes it discreet, non-obtrusive and easy to mount.
Since 2009, we have been on a contract with ESA for the development and advancement of a pair of muscle monitoring exercise tights that measures astronauts' muscular activity and fluid shifts during longer durations in space.

In near-zero gravity conditions, muscles deteriorate quickly unless they are exercised intensively. This is a serious issue for astronauts who spend at least 2 hours working out every day whilst in space. In order to optimize the astronaut's exercise programme, and ultimately reduce muscle degeneration, Ohmatex is developing a technology which measures the effect of the astronauts' training exercises in space, and monitors the impact of weightlessness on the body.

To gain a deeper insight into muscular activity and fluid shifts three garment integrated sensor technologies is combined: **EMG sensors** which detect muscle activation; **NIRS sensors** which detect changes in oxygenated hemoglobin and deoxygenated hemoglobin content in selected muscle groups and **Strain Gauge Plethysmography sensors** which measure limb circumference as an indication of changes in muscle volume. The combined data will then be used to analyze muscle activity and optimize training and countermeasures.

The study will also generate new knowledge about fluid shifts in the legs, making the technology of interest in cases of heart and kidney failure and preeclampsia.

Not only is this an exciting development for Ohmatex, but it also opens up commercial spin-off opportunities in telemedicine and health monitoring, where smart textiles are gaining ground by leaps and bounds.

The challenge

In which medical or health application can one of the textile integrated sensors or a combination of the sensors be utilized with valuable benefits for patients and/or health practitioners and how?

Details about the sensors

Plethysmography

The plethysmography sensor is a textile sensor. It detects changes in the stretch of the of the sensors and thus, can be used to measure changes in length and circumference. In the astronaut tights, the plethysmography sensors are used to estimate volume changes of the leg by measuring the circumference at two points and then calculating the volume based on different assumptions.

EMG

EMG sensors detects the electric potential generated by muscles cells. When more muscles fibers are recruited to either sustain a constant load or to meet an increase in load, the amplitude of the EMG signal increases. In the top graph of Figure 1 the amplitude of the EMG signal increases with increasing load. The data is collected for an athlete performing an increment exercise with increasing load until failure. The bottom graph of Figure 1B plots the frequency of the EMG signal during the exercise. The frequency is decreasing with increasing load due to muscle fatigue.

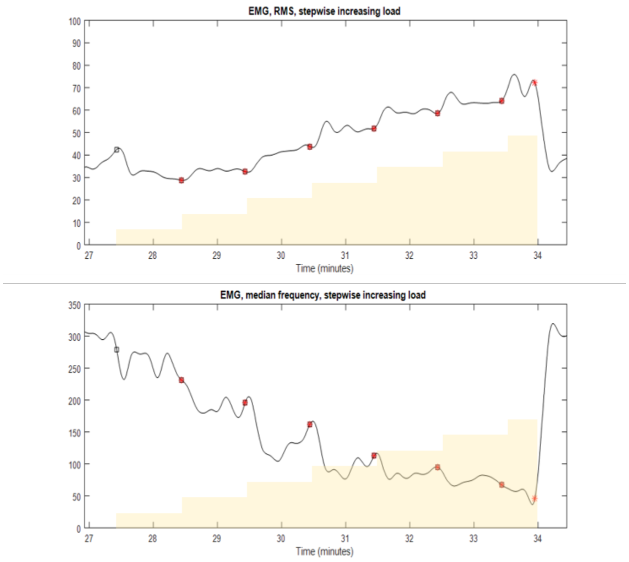

Figure 1. EMG data from an athlete performing an increment exercise with increasing load until failure. In the top graph, the amplitude of the EMG signal increased with increasing load due to increasing muscle fiber recruitment. In the bottom graph, the frequency of the EMG signal is decreasing with increasing load due to increasing fatigue of the muscle.

EMG has been studied in a wide variety of contexts and situations to gain knowledge about e.g. load, strain, gait, and technique.

Criteria

The textile electrodes (left picture, Figure 3) must be tightly connected to the skin above the muscle of interest. A pair of training tights is adequate to obtain a good skin electrode contact, eliminating movement artefacts and to avoid displacement of the electrodes.

NIRS

NIRS is a tool for assessing the oxygenation status and hemodynamics in the muscles as well as other organs by calculating the changes in oxygenated and deoxygenated hemoglobin and thereby also the changes in blood flow in the tissue (the sum of oxygenated and deoxygenated hemoglobin is a measure of total blood volume of the tissue). NIRS can however, not distinguish if the oxygen concentration is carried by myoglobin or hemoglobin.

During exercise, the blood flow to the muscles increases due to increased demand for oxygen in the muscle. The muscles ability to utilize this oxygen is dependent on several factors. However, NIRS is a method to monitor the availability of blood and oxygen in the muscle, as well as the muscles ability to utilize this oxygen. In the middle and bottom graph of Figure 2, the rate of both the ratio of oxygenated hemoglobin (middle graph) as well as the blood flow (bottom graph) is changing as the load is increasing. This clearly illustrated the status of the muscles and their ability to perform the exercise at the different loads. Heart rate (top graph) increases linearly with increasing load, which does not provide information about the ability to sustain load, contrary to the muscle oxygenation and blood flow data.

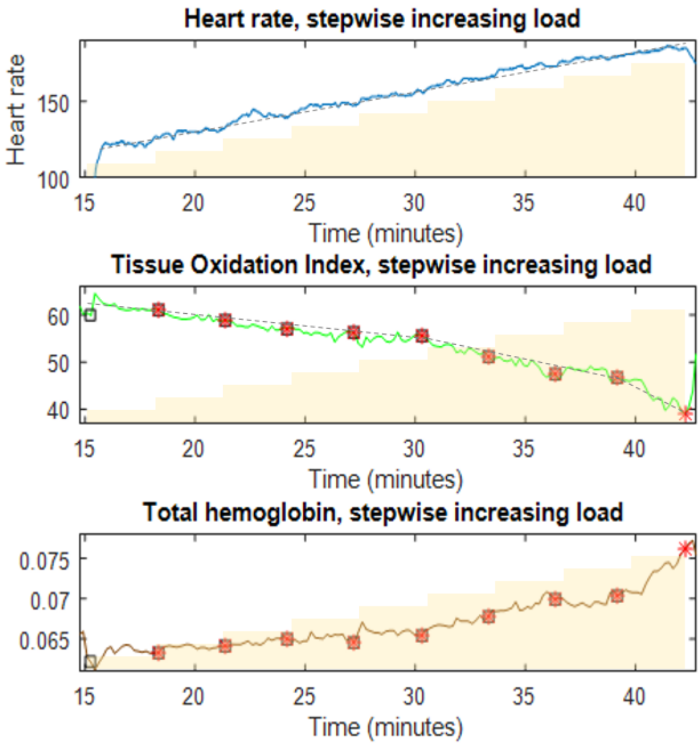

Figure 2. Heart rate and NIRS data from an athlete performing an increment exercise with increasing load until failure. In the top graph, heart rate is increasing linear with increasing load. In the middle graph, the ratio of oxygenated hemoglobin is decreasing with increasing rate as the load is increased. Likewise, the rate of which blood flow is increasing is also changing by increasing load (bottom graph).

Criteria

The NIRS probe (Figure 3) must be firmly connected to the skin above the muscle of interest to avoid movement artefacts and displacement of the probe. Additionally, it is important to eliminate the external light around the probe as much as possible as this will otherwise interfere with the signal and reduce the quality of the data.

Figure 3.EMG and NIRS integrated into exercise tights and socks. Left picture shows the EMG textile electrodes on the left and the NIRS probe on the right. Middle picture and right picture shows the integration from the outside of a pair of exercise tights and socks.