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Weight-watcher textiles

Piling on the pounds or shedding them – it all boils down to calorie intake and energy consumption, namely physical activity. Swiss researchers are developing monitoring systems that are integrated in clothing and help overweight people to watch their waistlines.

TEXT: Rainer Klose / PICTURES, ILLUSTRATION: Empa

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Empa-researcher Lukas Scherer testing the function of a textile light sensor, stitched from threads. Such sensors can be used to measure the oxygen level in the blood.

2
The textile light sensor in action. The sensor is flexible and washable and can be incorporated into a monitoring t-shirt.

3
Prototype of the ECG sensor, which is composed of metal-coated threads.

4
How the monitoring t-shirt works:
a) Six ECG sensors (one on the back, blue) monitor the circulation
b) Flexible fiber-optic threads measure the respiratory volume
c) Light sensors record the oxygen concentration in the arteries and veins.

Obesity is a mass phenomenon. The proportion of overweight people in Switzerland (people with a body mass index of 25 and above) has risen from 30 to 37 percent in the last 15 years. The diseases directly associated with the condition are responsible for healthcare costs of almost 4 billion Swiss Francs a year. And it doesn't look much rosier in the neighboring European countries, either, let alone the USA.

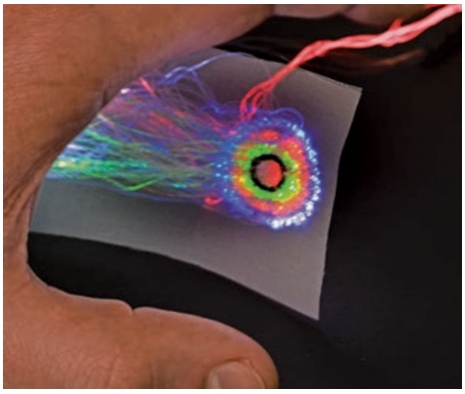
Keeping tabs on the body and its metabolic physiology could help to prevent subsequent diseases such as cardiovascular complaints and provide specific clues as to how the individual can lose weight. Under the research initiative Nano-Tera (www.nano-tera.ch), several Swiss universities and research institutes have teamed up to develop a monitoring system and launch it on the market.

A key element of the project called "Obesense" involves sensors that are attached directly to the skin and provide useful readings without bothering the wearer. This is precisely where Lukas Scherer, a textiles researcher at Empa in St. Gallen and head of the Medical Textiles group, comes in.

Scherer's team brings its expertise for three technically completely different sensors that are supposed to record the patients' body data in everyday life to the table. The analysis, which is calculated in real time, informs the patient around the clock about caloric intake, energy consumption and circulatory values and should (ideally) enable the affected person to change their diet and lose weight.

Silver coated fibers measure ECGs

"Firstly, there's the ECG sensor," explains Scherer, "for which we use an electrically conductive tissue made of silver-coated fibers." The conductive electrode needs to be in close contact with the body and is covered with a hydrating membrane. The reason: it also has to take reliable readings when there is no layer of sweat stuck to the body. While ECGs are very straightforward to measure for sportsmen, it gets more difficult with older



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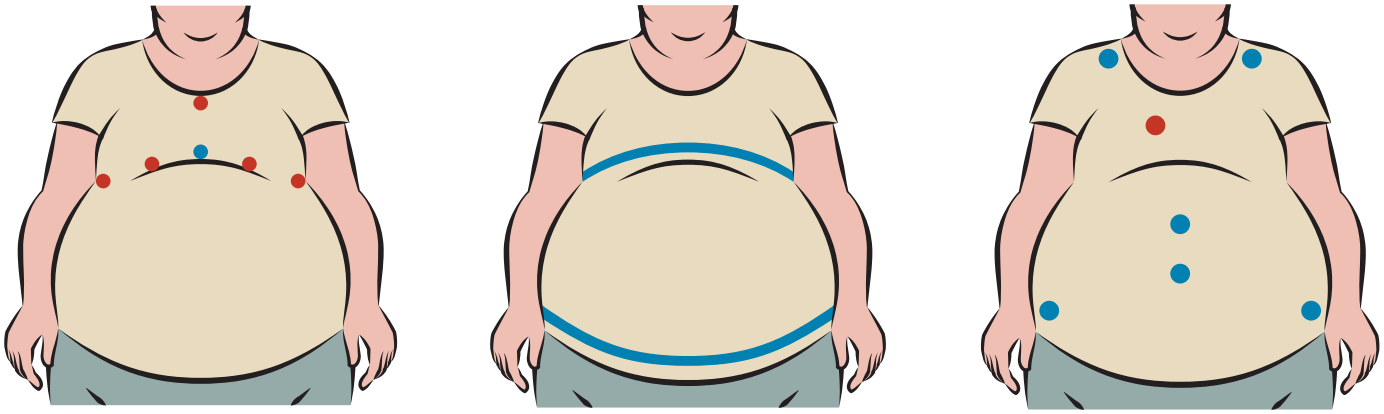

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a) Walking ECG

b) Respiratory volume

c) Oxygen saturation

people as they sweat far less. The machine-washable, silver-coated fibers are manufactured using a method developed at Empa and the idea for the "dry" ECG sensor was also conceived here.

The second sensor that Scherer's team is developing should determine the patient's respiratory rate and volume – a critical reading to calculate energy consumption as it takes oxygen to burn calories. The more a person breathes, the more calories they can burn. "We want to use a light-conducting, elastic copolymer that stretches across the patient's stomach in the form of a knitted fabric and is illuminated with an LED," explains the Empa researcher. "When the patient breathes, the elastic fiber gets stretched and alters its optical permeability. Less light reaches the integrated light sensor." Based on this optical motion measurement on the stomach, the respiratory volume – the researchers hope – can be determined with sufficient accuracy. Such a measurement would be a tremendous step forward with regard to monitoring energy consumption around the clock as, until now, this value could only be determined if the patient was wearing a respiratory mask.

There is another way of measuring oxygen consumption that also requires sensors from the Empa labs. The measurement based on the so-called Fick principle needs three parameters: the blood volume pumped by the heart as well as the oxygen saturation in both arteries and veins.

Woven illuminating sensors for oxygen

Two of these parameters, the heart rate and the oxygen saturation in the arteries, are relatively easy to determine with a pulsoxymeter. Today, this is usually performed with a clip that lights up on the patient's finger, toe or earlobe. In new-born babies, the ball of the foot or the wrist is often illuminated, too. Oxygen-bound hemoglobin absorbs light of a different wavelength to free hemoglobin, which can be used to calculate how much oxygen is bound in the blood.

As the oxygen saturation in the veins differs greatly at many points in the body, it is much more difficult to determine. The sensor shirt the patient is supposed to wear thus needs to have several measurement spots in the infrared range in order to be able to gauge the amount of consumed oxygen with sufficient accuracy. Scherer's team has already developed an illuminating sensor out of woven threads that could be integrated in such a sensor shirt. The analysis of the signals requires special electronics, which is currently being developed at the CSEM (Centre Suisse d'Electronique et Microtechnique) in Neuchâtel.

At the end of the Obesense project, there should be a shirt tailored to suit every patient that hugs the body, is pleasant to wear and easy to wash. It is expected to yield body data on the patient all day long and help them to change their habits without bothering them in day-to-day life. This latter prerequisite is no small feat for Empa's textiles research. Not only does the final product have to be produced with extreme precision; it also needs to be comfortable. Otherwise, it will merely gather dust in the wardrobe. //