National Research Programme NRP 69
Healthy Nutrition and
Sustainable Food Prodution

Measuring fat metabolism and energy balance

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New measuring device helps patients lose weight

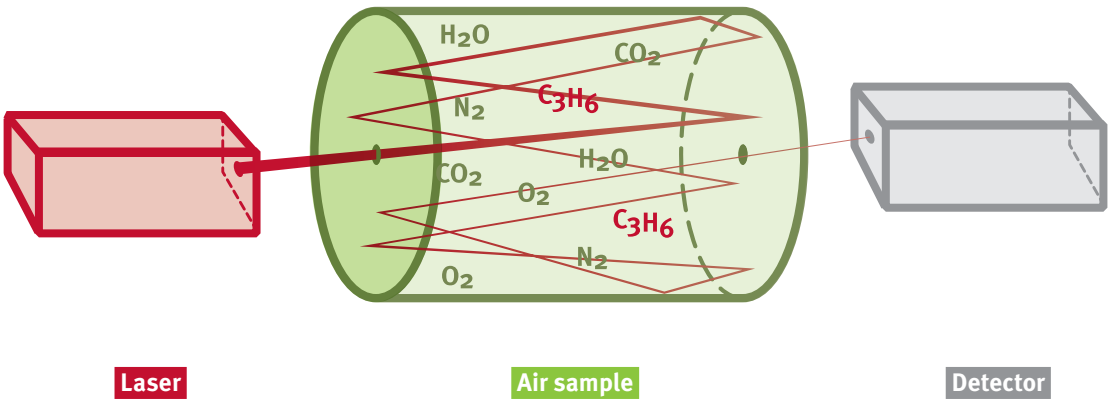
The energy balance in the human body can now be monitored with a new method. Researchers participating in NRP 69 have developed an analytical device capable of measuring the concentration of acetone molecules in the breath by laser spectroscopy. These volatile organic substances are produced by the human body when it uses up more energy than it takes in. The instrument is designed to help, in the future, obese patients monitor their weight loss more effectively and adjust their treatment accordingly if necessary.

Obesity is a risk factor for chronic illnesses in our society. The primary goal of treatment is to lose weight. The theory is simple: in order to lose weight, obese patients must seek to achieve a negative energy balance by taking in less energy in their body than they use up. In practice, however, this is a long and costly exercise that often fails to achieve the desired objective. One reason for this is that patients find it difficult to assess whether their dietary efforts are sufficient to ensure that they lose body fat, because noticeable changes in body weight are often only observed after several months. Until now, no reliable method has been able to measure the energy balance continuously.

Scientists at Empa, the University of Lausanne and the University of Applied Sciences and Arts Northwestern Switzerland participating in NRP 69 have now developed a measuring device capable of monitoring dietary and exercise behaviour simply via the breath. In future, this measuring method could support overweight patients achieve their weight goals.

In developing this new instrument, the researchers focused on a substance that is produced in the human body when it uses up more energy than it takes in – acetone. This volatile organic compound is an indicator of fat metabolism. Acetone is transported through the bloodstream to the lungs, where it is then released. Using their method, the scientists can quantify acetone molecules in the breath, even at extremely low concentrations (down to 13 parts per billion). This is made possible by laser spectroscopy. The wavelength of the laser can be adjusted so that the emitted light is absorbed only by certain mole-

Measuring the concentration of acetone molecules in the breath by laser spectroscopy



The concentration of acetone molecules in the breath can be determined by laser spectroscopy. The wavelength of the laser can be adjusted so that the emitted light is absorbed only by acetone molecules (C_3H_6); the other particles in the air sample do not absorb the laser beams. Lower light intensity on the detector thus indicates a higher acetone concentration in the investigated air sample.

cules – in this case acetone molecules. Lower light intensity on the detector thus indicates a higher acetone concentration in the investigated air sample. This method has the advantage of dispensing with the need for the time-consuming preparation of samples in the laboratory and can produce the measurements within minutes.

Tests suggest that the acetone levels reflect the energy balance: the higher the acetone concentration in the breath, the greater the energy deficit in the body.

In a second step, the researchers tested the ability of the new method to assess the energy balance in a small group of healthy volunteers. In these tests they modelled both negative and positive energy balances and measured the acetone content in the breath of the test subjects at hourly intervals. They then compared these with the corresponding blood test results that had been recorded in parallel. It emerged that the acetone concentration in the breath and the blood increased continuously when the test subjects fasted for 18 hours. These fat metabolism indicators subsequently decreased again when the volunteers ate some food. This finding was observed regardless of the fat content of the food, and correlated with the concentration of beta-hydroxybutyrate, an indicator for the energy balance as determined in the blood. These initial tests suggest that the acetone levels reflect the energy balance: the higher the acetone concentration in the breath, the greater the energy deficit in the body. By contrast, no accelerated increase in these values was observed during the tests involving physical exercise. The tests also suggest that the burning of fat resulting from physical activity can be detected in the breath only after a delay.

Further clinical tests are needed in order to refine the new method for measuring the physical energy balance. However, the initial analyses are very promising and confirm that the acetone content in the breath is a suitable biomarker for measuring the energy balance. Corresponding measuring instruments could therefore help obese patients monitor their efforts to lose weight and support them in achieving their weight goals.

Further information:
www.nrp69.ch

Application

Range of use not restricted to energy balance

The measuring instrument developed during the project offers great potential for future use in preventive medical treatments for obesity. Further tests will aim to show the conditions under which weight loss measures can be monitored continuously by breath analysis and how related treatments can be adapted. Continuous monitoring of therapeutic progress can also help motivate patients to continue their efforts. Furthermore, the non-invasive measuring method is easy to use and allows the energy balance to be assessed within minutes. It is conceivable that further developments of the technology may enable patients in future to use such analytical instruments individually as portable devices.

This measurement method is not restricted to monitoring energy balance indicators. As well as acetone, other molecules in breath – e.g. nitrogen monoxide, isoprenes, methane or alcohol – can also be measured, suggesting that the analytical instrument could be used to measure other indicators, such as those for cardiovascular or pulmonary diseases. A wide variety of applications in medical diagnosis is conceivable.