

# Engineers detect health markers in thread-based, wearable sweat sensors

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Backdrop: readout of lactate in sweat during exercise. Credit: Sameer Sonkusale, Nano Lab, Tufts University

Engineers at Tufts University have created a first-of-its-kind flexible electronic sensing patch that can be sewn into clothing to analyze your

sweat for multiple markers. The patch could be used to to diagnose and monitor acute and chronic health conditions or to monitor health during athletic or workplace performance. The device, described today in the journal *NPJ Flexible Electronics*, consists of special sensing threads, electronic components and wireless connectivity for real time data acquisition, storage and processing.

Typical consumer health monitors can track heart rate, temperature, glucose, walking distance and other gross measurements. But a more detailed understanding of the health, stress and performance of an individual is required for medical data collection or high performance athletic or military applications. In particular, metabolic markers such as electrolytes and other biological molecules provide a more direct indicator of human health for accurate assessment of athletic performance, workplace safety, [clinical diagnosis](#), and managing [chronic health conditions](#).

The patch device created by the Tufts engineers performs real-time measurements of important biomarkers present in sweat including sodium and ammonium ions (electrolytes), lactate (a metabolite) and acidity (pH). The device platform is also versatile enough to incorporate a wide range of sensors capable of tracking nearly every marker present in sweat. The measurements taken can have useful diagnostic applications. For example, sodium from sweat can indicate the hydration status and electrolyte imbalance in a body; lactate concentration can be an indicator of muscle fatigue; chloride ion levels can be used to diagnosis and monitor [cystic fibrosis](#); and cortisol, a stress hormone, can be used to assess emotional stress as well as metabolic and immune functions.

Athletes could monitor a wide range of markers during [physical exertion](#) to aid in predicting performance peaks or declines during competition.

The ability to integrate the sensors into clothing is made possible by flexible threads coated with conductive inks. Different coatings alter the functionality of the threads; for example, lactate can be detected by coating a thread with an enzymatic sensing material incorporating the enzyme lactate oxidase. A pH sensing thread is coated with polyaniline that responds to acidity, and so on. The array of thread sensors is integrated into clothing or a patch and connected to a miniature circuit module and microprocessor, with wireless capability to communicate with a smartphone.

"Sweat is a useful fluid for health monitoring since it is easily accessible and can be collected non-invasively," said Trupti Terse-Thakoor, formerly a post-doctoral scholar at Tufts University School of Engineering and first author of the study. "The markers we can pick up in sweat also correlate well with blood plasma levels which makes it an excellent surrogate diagnostic fluid."

Researchers tested the device on [human subjects](#), monitoring their electrolyte and metabolite response during a maximum exertion exercise on stationary bikes. The sensors were able to detect variation in analyte levels as they moved up and down, within 5 to 30 second intervals—sufficient for most real-time tracking needs. The subjects included men and women with a range of physical conditioning, from physically active on a performance-tailored diet, to individuals who were not physically active and had no specific dietary restrictions. While the current study was not meant to determine a correlation between analyte readings and performance and conditioning, it did establish that the sensor was able to detect consistent patterns of analyte expression that could be used for future studies identifying these correlations.

"The sensor patch that we developed is part of a larger strategy to make completely flexible thread-based [electronic devices](#)," said Sameer Sonkusale, professor of electrical and computer engineering at Tufts'

School of Engineering and corresponding author of the study. "Flexible devices woven into fabric and acting directly on the skin means that we can track health and performance not only non-invasively, but completely unobtrusively—the wearer may not even feel it or notice it."

**More information:** Terse-Thakoor, T., Punjiyam, M., Matharu, Z., Lyu, B., Ahmad, M., Giles, G.E., Oweyung, R., Alaimo, F., Baghini, M.S., Brunyé, T.T., and Sonkusale, S. "Thread-based multiplexed sensor patch for real-time sweat monitoring" *NPJ Flexible Electronics* 2020 July 28; DOI: [10.1038/s41528-020-00081-w](https://doi.org/10.1038/s41528-020-00081-w)

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