Editors' Digest – Basic Science
A Wearable Sweat Analyzer for Continuous Electrolyte Monitoring

Kidney failure results in volume overload, electrolyte abnormalities, metabolic acidosis, and accumulation of toxins that all participate in the high mortality/morbidity associated with chronic kidney disease (CKD) (1). Regular assessment of electrolytes, acid-base parameters, and glucose levels is crucial for the care of these patients, with the inherent disadvantages of blood sampling (pain, blood loss, infection...). The development and validation of non-invasive tools to monitor key parameters is thus important for CKD patients, as illustrated by efforts to assess hemoglobin and urea levels, for instance (2,3).

The recent report in *Nature* of a wearable sensor array for continuous analysis of multiple parameters, including sodium, potassium, and glucose, in human sweat represents a major leap toward non-invasive monitoring (4). Sweat has long been used to provide insights into human health, e.g. measuring chloride levels for the diagnosis of cystic fibrosis (5). Sweat has minimal impurities, is less prone to contamination than other biofluids, and can be collected non-invasively, representing a rapid and easy source of information that can be used by physicians, patients, and athletes (6). Sweat analysis has long been restricted to medical labs, hindering its broad usage. Wearable sensors were developed later, but these generally lacked precision and were limited to monitoring a single analyte at a time.

In their landmark study, Gao *et al*. describe a wristband containing sensors able to measure an array of biomarkers from sweat and delivering the results in real time, with a high degree of accuracy (5). The wristband has a series of miniaturized, selective sensors that provide specific and simultaneous screening of a panel of biomarkers. These include sensors for skin temperature, ion-selective electrodes to measure sodium and potassium, and oxidase enzymes to measure glucose and lactate levels. The enzymatic sensors autonomously generate a current signal that is proportional to the abundance of corresponding metabolites and do not require an external power source to be activated. Bluetooth technology is incorporated in the device, allowing wireless data transmission and real-time measurement of analytes. The performance of each sensor has been tested using specific solutions, demonstrating high selectivity and repeatability of the measurements for at least several weeks. The device, which can be worn on the wrists, arms, and forehead, was tested during prolonged indoor (cycle ergometer) and outdoor (running) activities for parameters (sodium, potassium, lactate, glucose) relevant for human physiology. In particular, substantial increases in the levels of sodium in sweat were associated with dehydration episodes in test subjects.

Clearly, significant hurdles should be cleared up before devices monitoring sweat analytes can be considered to be of clinical use in CKD patients. The independent value of sweat parameters, the correlations between blood and sweat concentrations, their kinetics of variation, as well as the sensitivity and performance of sweat monitoring in patients with different skin types, underlying diseases, or amounts of sweat production should be carefully established. These obstacles are balanced by the intrinsic advantages of the technology, including non-invasiveness, almost real-time analysis, continuous monitoring, and the possibility for multiplex monitoring of parameters including electrolytes, hormones, and drug metabolites. Progress in miniaturization and in quality of sensors and biomaterials will probably further improve the practicality and reliability of wearable sensor devices, offering real perspectives for clinical applications and individualized medicine.

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