Wearable sensors

Technology can be used to detect progression in MS.

by Mary E. King, PhD

What if something you wore around your wrist could tell your doctor if your multiple sclerosis is progressing by measuring tiny changes over time in how you move? That technology may be on the horizon.

Catching disease progression earlier could lead to important decisions about disease-modifying therapies before large changes in mobility occur. And reliably detecting very small changes in mobility could also speed clinical trials of new MS treatments.

A new way of sensing
Research on wearable technologies is booming, and it includes looking at their application to MS. For example, two researchers are studying the use of tiny sensors that can measure small but reproducible changes in mobility. Jennifer Graves, MD, PhD, is an associate professor of neurosciences at the University of California San Diego (UCSD) and director of the UCSD Neuroimmunology Research Program. Tanuja Chitnis, MD, is a neurology professor at Harvard Medical School and director of the CLIMB Study at the Partners Multiple Sclerosis Center at Brigham and Women’s Hospital.

The small changes are difficult or even impossible for a clinician to identify with current tests of mobility. The research sensors are like advanced versions of the sensors currently available in smartwatches and fitness trackers. The sensors can even be packaged in a wearable device that wraps onto a wrist, arm or leg, and the data can be sent wirelessly to a computer for detailed analyses.

Graves uses a wearable band that includes tiny sensors and a simple testing approach. The person with MS straps the band onto their forearm and taps a forefinger 20 times, repeating with the other forearm and forefinger. Then the person wears it on one calf, tapping that foot 20 times and repeating on the other side. The process takes less than 5 minutes. Even though it sounds simple, there's a lot of science involved.

The wearable band, which looks much like a standard fitness tracker worn on a wrist but with a longer strap, contains tiny sensors that measure specific aspects of how the fingers and feet move in three dimensions (up/down, left/right, forward/back). Sensors also measure acceleration, rotation and muscle electrical activity — nerve impulses moving through the arm/leg. All this data is sent wirelessly to a computer that can calculate additional information, like the speed of tapping and patterns of rhythm.

Currently, most MS clinicians use a standard measure of mobility — Expanded Disability Status Scale (EDSS) — that requires a trained observer, often the doctor, to identify much larger changes in walking mobility. This process may be repeated at six-month intervals, and it is only designed to pick up fairly significant mobility changes, like moving from a cane to a walker. This approach can take a year or more to demonstrate reproducible losses in mobility that may lead to adjustments in treatment.

Detecting changes in mobility

Graves recently published two promising studies with her experimental sensor device. The first looked at 117 people with MS and 30 control subjects. Researchers compared physician-scored EDSS and patient self-assessments with computer-scored assessments of the information gleaned from in-office tapping tests with the sensors. The sensor data correlated well with both physician and personal evaluations of mobility.

In the next study, Graves followed 53 individuals with relapsing-remitting MS and 15 with primary progressive MS for about a year. The results showed two things. First, the sensor data is excellent at distinguishing between relapsing and progressive MS, a clinical need. Second, the year-long study results confirm that the sensors can reliably detect smaller mobility changes that are not captured by the usual clinical tests like EDSS.

As an example of how this new approach might help in the future, Graves describes a pianist with MS who said she could no longer play the fast notes as well as she used to. This small change in physical dexterity is something that current neurological exams can't measure, Graves says. However, she says, "the experimental wearable device was able to detect very subtle changes in movement that correlated well with the pianist's self-report." Graves explains these are precisely the types of small, progressive changes that could be measured and monitored in the future.

She is excited not only for the clinical information this could give doctors deciding on an appropriate therapy, but also for speeding research. Clinical trials to evaluate new treatments typically rely on specially trained observers and clinically verified measures like

EDSS that can only identify large mobility changes, Graves says. Trials can take a long time, up to three years, to determine if a possible new therapy is working, especially in a large group of people with different degrees of MS. Something quicker, yet very reliable and observer-independent, would be a great help in speeding research. “Finding more sensitive measures to track disease progression more quickly is a priority for speeding clinical trials in progressive MS,” Graves says.

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Chitnis also used research-grade biosensors to measure movement in 25 people with MS. The study participants wore small sensors attached to nine body locations (chest, wrists, thighs, ankles, hip and back) during clinic visits. The sensor array allowed researchers to measure motion in three dimensions and capture rotatory motion — movement as you turn, Chitnis explains. The sensors measured many different aspects of gait, balance and dexterity, which meant many individual data points were collected. Complex computer analyses then distilled these data into a simpler composite readout for researchers to use. Investigators compared the composite results with EDSS and other MS mobility/dexterity measures. The participants were also monitored at home for eight weeks while wearing three sensors (wrist, ankle and chest). During the home monitoring, researchers added measures related to activity, pulse rates and sleep.

Chitnis explains that the computer analyses calculated very useful measures from the reams of sensor data. More important, these measures were significantly correlated with the typical physical assessments used by MS clinicians. Chitnis points out they could sense changes in mobility assessments measured in fractions of an inch, something that even trained observers would find difficult to detect using traditional assessments.

“This study opens up new avenues for using very sensitive biosensors to measure changes in disability, both in the clinic and at home,” Chitnis says. “In addition to identifying changes in mobility, this might include capturing falls, something people sometimes forget between routine six-month clinic visits.” She adds that previous MS studies often used a single type of biosensor measurement like balance or wrist motion. However, utilizing multiple sensors and sophisticated computer analyses allowed her team to detect many more changes and much smaller changes in disability. New technology could enable a neurologist to get a better sense of how someone with MS is doing, particularly if home monitoring is added.

Work in progress

While the results are promising, Chitnis tempers enthusiasm for any quick availability of these kinds of sensor devices with a reminder about the many lengthy steps involved in bringing a new medical device to market. For the findings to be validated, such a prototype must be used in more extensive studies and would have to be certified by the FDA for use in clinical settings, according to Chitnis. Only then can such a device be used to guide therapy, she says, something that could take a couple of years.

In the meantime, sensor technology keeps getting smaller and better, and it is being tested for many situations and medical disorders. One of the National Multiple Sclerosis Society's research priorities in promoting recovery of function is to build consensus on the best metrics and patient-reported outcomes to use in studies of wearable sensors so that their results can be compared. This would speed efforts to get these tools into clinical use.

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