Novel wearable belt with sensors accurately monitors heart failure 24/7

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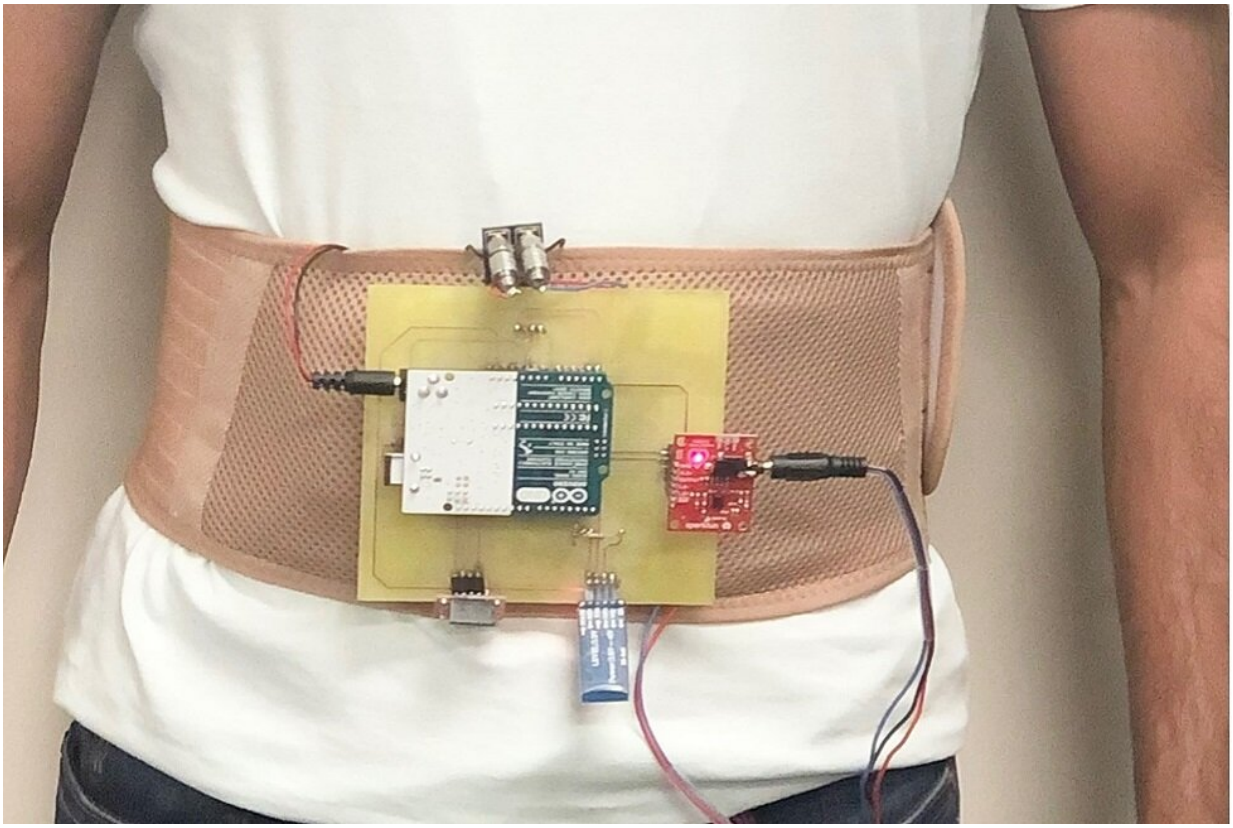

The lightweight belt continuously monitors all of the physiological parameters associated with heart failure in real time, 24/7. Credit: FAU College of Engineering and Computer Science

There are about 64 million cases of heart failure worldwide. According

to the American Heart Association, 6.2 million adults in the United States have heart failure and that number is estimated to increase to 8 million by 2030. Heart failure is a progressive clinical syndrome characterized by a structural abnormality of the heart, in which the heart is unable to pump sufficient blood to meet the body's requirements.

There are currently two heart failure monitoring systems available. However, they are costly and pose risks because they are surgically implanted under the skin. Moreover, about half of patients with heart failure do not need an implantable device or do not qualify for the thoracic (area between the neck and abdomen) monitoring these devices provide. There is a critical need for non-invasive solutions to monitor heart failure progression around the clock.

Researchers from Florida Atlantic University's College of Engineering and Computer Science in collaboration with FAU's Christine E. Lynn College of Nursing have developed a prototype of novel wearable device that can continuously monitor all of the physiological parameters associated with heart failure in real time.

The technology is based on sensors embedded in a lightweight belt conveniently worn around the waist to monitor thoracic impedance, electrocardiogram (ECG), heart rate and motion activity detection. The system uses different sensors for sensing these parameters. Thoracic impedance is a critical bio-signal to monitor heart failure progression.

Similarly, ECG is a vital bio-signal to diagnose and predict cardiovascular diseases. ECG measures electrical signals through the heart using a Holter monitor, which is not suitable for point-of-care use.

For the study, published in *Scientific Reports*, researchers tested the wearable device in different conditions including sitting, standing, lying down and walking. For each condition, results were obtained for each of

the sensors sequentially. The physiological parameters selected are significant in determining heart failure symptoms.

Findings showed that all of sensors kept track of the changes for all of the different conditions. The position sensor correctly highlighted the change in position in different conditions and could be used to identify different states of the wearer of the device. In addition, the heart rate sensor continually kept track of the heart rate. Importantly, the device correctly highlighted minute changes in thoracic impedance.

Like most ECG monitors, the ECG sensor in the wearable device was very sensitive to motion, particularly while walking. However, even while walking the ECG sensor retained its QRS complex (the electrical impulse as it spreads through the ventricles of the heart) along with R-peaks (intervals of the QRS complex), which are important indicators for left ventricular hypertrophy, indicative of an increase in the size of myocardial fibers in the main cardiac pumping chamber.

"All of the sensors we integrated into our belt module can easily be worn for a long period of time without affecting the patient's daily activities," said Waseem Asghar, Ph.D., senior author and an associate professor in FAU's Department of Electrical Engineering and Computer Science. "Importantly, continuous and real-time monitoring of heart failure symptoms could alert patients and their health care providers of the patient's declining health. In turn, health care providers could intervene with medications to avoid patient hospitalization."

The researchers expect that their technology will have higher predictive values for heart failure with increased specificity and high sensitivity.

"Approximately 1 in 4 patients with heart failure are readmitted within 30 days of discharge from the hospital and about half are readmitted within six months," said Mary Ann Leavitt, Ph.D., co-author and an

assistant professor in FAU's Christine E. Lynn College of Nursing. "Health care wearable devices such as the prototype we have developed have the potential to decrease hospital readmissions in a cost-effective way that also is safe and convenient for the wearer."

Based on the study results, the researchers are currently testing the module over a set of diverse subjects to develop an algorithm to predict heart failure over the test set.

"This wearable device to monitor heart failure is my main project in Dr. Asghar's Micro and Nanotechnology Lab in Medicine, which has important social implications for the fastest-growing cardiovascular disease in the U.S.," said Sheikh Muhammad Asher Iqbal, first author, a research assistant and a Ph.D. student in FAU's Department of Electrical Engineering and Computer Science.

"We are developing a noninvasive solution that can be used by all heart failure patients for better management, diagnosis and prognosis that will be able to serve the masses."

More information: Sheikh M. A. Iqbal et al, Development of a wearable belt with integrated sensors for measuring multiple physiological parameters related to heart failure, *Scientific Reports* (2022). DOI: 10.1038/s41598-022-23680-1

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