C2 Integrated Analysis Package | Visualization tools

3 GOOD HEALTH AND WELL-BEING

Peripheral arterial stiffness measurement

Basic phase > Application Phase > Implementation phase   Patent 5062809

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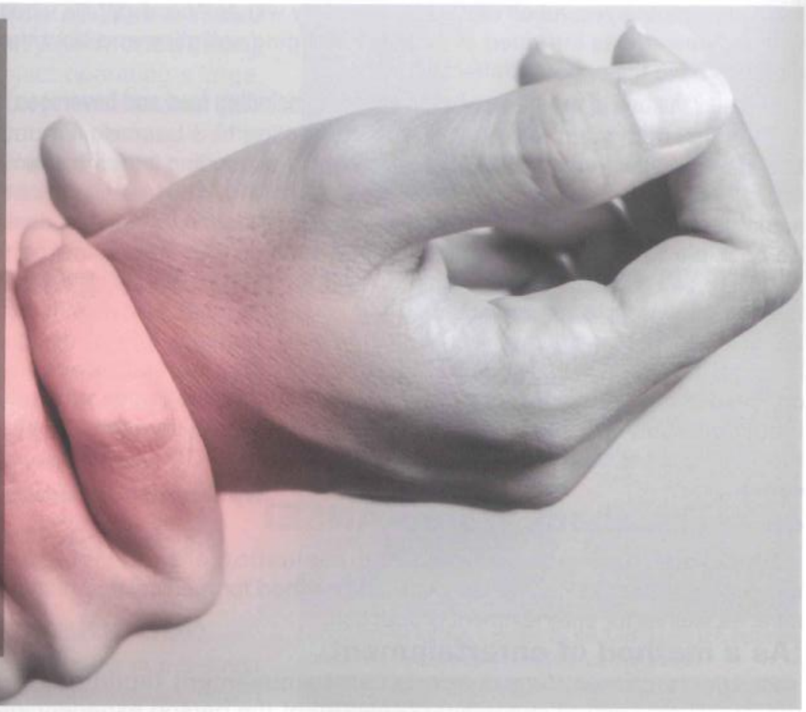
Non-invasive, real-time measurement of peripheral arterial stiffness to visualize anxiety and pain.

This is the world's first technology that can quantitatively evaluate the stiffness of blood vessels in real time by measuring blood pressure and blood vessel volume with a device worn on the fingertip or wrist. The wearable device, which can measure blood pressure and pulse, can acquire data to evaluate stress, pain, and so on over time. Information on health and mental health can be obtained easily.

Applications: Healthcare devices, diagnostic equipment, marketing, and product development, risk management, and so on.



Toshio Tsuji

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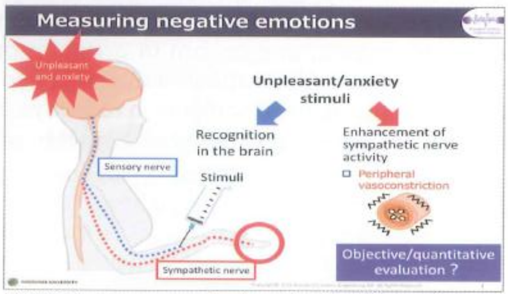
Dr. Tsuji was born in Kyoto, Japan, on December 25, 1959, and has been a Full Professor at Hiroshima University since 2002. During 1992-1993, he was a Visiting Professor at the University of Genoa, Italy. His research interests range from engineering to human science with focuses on cybernetics, medical electronics, computational neural sciences, and particularly biological Kansei modeling. Dr. Tsuji has received 52 academic awards including the IEEE King-Sun Fu Memorial Best Transactions Paper Award (2003) and Good Design Award, Japan, (2006). He has published 157 international journal papers, 182 Japanese journal papers, and 330 international conference papers (as of September 1, 2021).

"Pain" is very important information for the diagnosis and treatment of diseases, but the intensity of pain cannot be quantified or evaluated objectively. This tool was developed in an effort to quantify pain. The key is the stiffness of the peripheral blood vessels (peripheral arterial stiffness). When exposed to pain or unpleasant stimuli, the walls (muscles) of peripheral blood vessels stiffen with sympathetic activity. Since the greater the pain, the greater the value of the peripheral arterial stiffness, this can be used as an indicator of pain. We confirmed that mental stress also causes changes in peripheral arterial stiffness. The value of peripheral arterial stiffness is calculated from blood pressure and blood flow, and these two data can now be easily obtained noninvasively. A wearable device such as a smartwatch can also have a function to measure peripheral arterial stiffness, and we are developing a prototype. Quantitative evaluation of the intensity of pain and anxiety is useful in the diagnosis and treatment of painful diseases and in the field of mental health. It can also be used to measure the stress people feel in various aspects of society and help realize a society where everyone can live comfortably. In addition, by measuring changes in peripheral arterial stiffness due to aging and lifestyle, it is expected that prevention and early treatment of cardiovascular diseases such as arteriosclerosis will become possible.



KANSEI measurement using arterial stiffness (image)

Practical use level

By wearing the blood pressure and blood flow measuring device on the fingertip or wrist, the stiffness of peripheral blood vessels can be evaluated in real time (evaluation of changes over time). The time required for the measurement is less than one second.

With a high-performance blood pressure monitor, arterial stiffness can be measured in milliseconds.

Scenes of use

●Healthcare, mental healthcare (depression prevention, and so on)
●Diagnosis and treatment of painful diseases
●Monitoring evaluations (products, services, videos, entertainment, and so on)
●Improvement in productivity and acquisition of skills
●Nursing care, nursing, and education

Technology Overview

The walls of blood vessels expand and contract according to the rhythm of the heart. When the blood vessels are stiff, the stretch degree is small and the blood volume change is small; when the blood vessels are soft, the stretch degree is large and the blood volume change increases. In other words, if blood pressure and blood volume can be measured simultaneously, the stiffness of the peripheral blood vessels at that point can be calculated using a relatively simple formula. Blood pressure fluctuates from high to low at each beat. There are blood pressure monitors on the market that can continuously measure blood pressure, including the values from the highest and lowest. Therefore, we can use a blood pressure monitor with the necessary functions and accuracy. Blood volume is measured by shining light with a wavelength that is well absorbed by blood onto the area to be measured (finger, palm, and so on) and detecting the light transmitted to the opposite side by a photodiode. We confirmed that changes in peripheral arterial stiffness due to pain stimulation can be used as an indicator of pain in experiments using fMRI to measure brain activity.

■Equipment required for measurement

A blood pressure monitor capable of continuous measurement was worn on the arm, and a plethysmogram (measuring blood volume change) was worn on the fingertip. The acquired data are processed by a laptop computer or other devices, and the value of the arterial stiffness can be displayed in real time.

《We are developing a wearable device》 We are now developing a device that adds a blood flow measurement function based on an existing smartwatch that can measure blood pressure. The smartwatch can calculate and display the data. This can be used for health management by continuously measuring the device 24 hours a day and synchronizing the data with a smartphone/PC.

■Output data

The output is the "Standardized Arterial Stiffness" βart value, which represents peripheral arterial stiffness (vessel stiffness).

The output data includes continuous changes in almost real time.

If a high-performance blood pressure monitor was used, it was possible to acquire 1000 data per second.

《Output according to application》 As with measuring instruments, it is possible to develop systems that acquire, visualize, and output data according to the application.

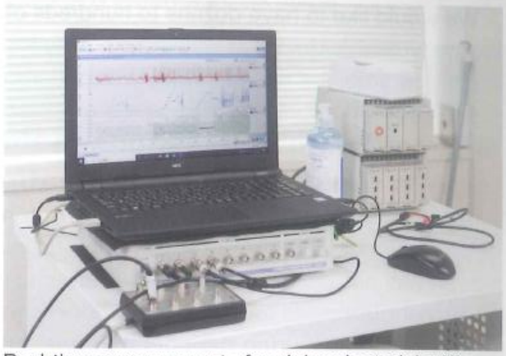
■Measurement method

Measurements can be taken immediately after installation without calibration. However, depending on the subject, it may take some time for the changes in blood pressure and heart rate to appear due to tension and physical activity.

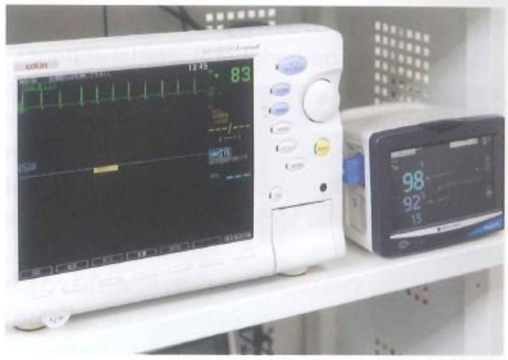
■Integrated analysis with other recommended tools.

●KANSEI meter
●Face KANSEI camera to measure the face blood flow and heart rate.
●Facial expression recognition analysis

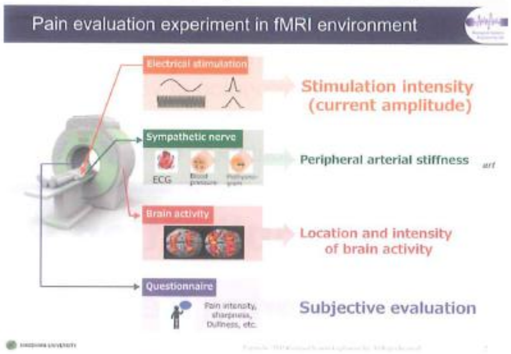
High-precision blood pressure monitor used in the laboratory



Real-time measurement of peripheral arterial stiffness



Measurement display screen of blood pressure



The accuracy of the index was confirmed by simultaneous measurements using fMRI and subjective evaluation

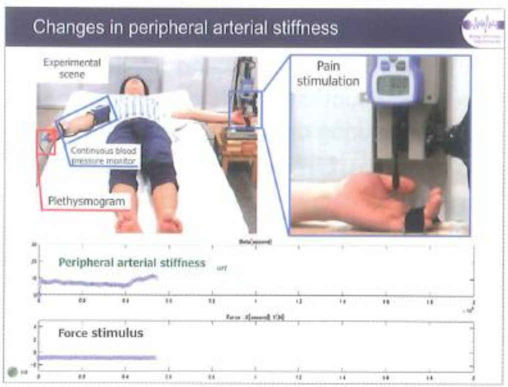


Image of the experiment

Initiatives for social implementation

●Development of a prototype wearable device

An increasing number of people are using wearable devices as tools for health management and lifestyle improvement. In addition to heart rate and activity level, products that can measure body temperature, SpO2 (blood oxygen level), and body fat percentage are now available.

In response to this trend, we are developing a wearable device that can continuously measure peripheral arterial stiffness. While the latest technology is needed to accurately measure blood pressure at the wrist, blood volume change can be easily measured using special LEDs and photodiodes.

We would like to have dozens to hundreds of participants wearing the prototype wearable device at all times to verify its accuracy and functionality; at the same time, we would like to collect daily data from healthy people for future applications of peripheral arterial stiffness measurement technology.

Wearable device (image)

●Considering applications in the medical field

[Use in the diagnosis and treatment of pain]

There are many diseases for which the intensity of pain and its increases or decreases are important information for diagnosis and treatment. Until now, it has not been possible to measure pain objectively, so patients have had to endure pain, and as a result, their treatment has sometimes been delayed. By measuring peripheral arterial stiffness, it will be possible to quantify pain and use it as a basis for diagnosis and treatment.

The intensity of pain and its increase or decrease is important information (Image)

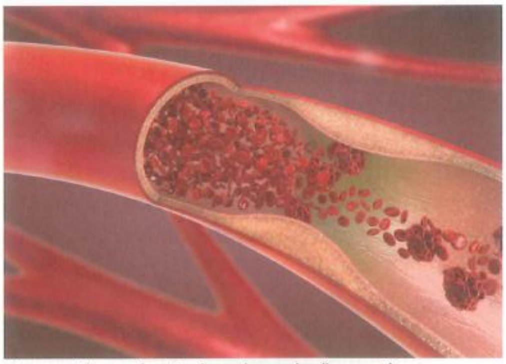
[In anesthesiology and pain clinics]

My research on peripheral arterial stiffness measurement started when I was consulted by an anesthesiologist who wanted to measure pain. Anesthesiologists are responsible for "pain control," which is important in the treatment of chronic painful diseases and terminal care. For this purpose, information obtained by measuring peripheral arterial stiffness is effective. Peripheral arterial stiffness values can also be used for anesthesia during painful surgery.

Use of the device in the medical field (image)

[Used to prevent arteriosclerosis]

Vascular endothelial cells (the cells lining the inside of blood vessels) release substances to maintain the health of blood vessels. When endothelial function declines, arteriosclerosis progresses, causing a variety of blood-related diseases. Blood vessels with arteriosclerosis cannot return to their original state completely, but vascular endothelial function can be improved. If the deterioration of vascular endothelial function can be detected at an early stage by continuously measuring the peripheral arterial stiffness, it can greatly contribute to the provision of preventive medicine.



Prevention of arteriosclerosis (image)

Future Application Possibilities

Step1: Monitoring Health and Stress

By wearing a wearable device with a peripheral arterial stiffness measurement function, stress and vascular health can be continuously monitored.

[To know your own stiffness of peripheral blood vessels under normal conditions]

If data are collected beforehand in regards to the normal peripheral arterial stiffness when healthy and relaxed, and by detecting the range of the day-to-day fluctuations, it is possible to accurately assess levels of pain and stress during disease development.

[To find out if you are stressed]

In addition to pain, stress and tension can cause blood vessels to stiffen. If the peripheral arterial stiffness is measured and it is determined that you have been under tension for a long time, you will know that you need a change of scenery to improve your work or study efficiency or to prevent problems while driving.

Peripheral arterial stiffness can be measured in daily life (image)

[Understanding Age-Related decline in blood vessels]

By continuing to measure peripheral arterial stiffness over several years, it will be possible to detect declines in endothelial function and other signs of vascular deterioration. This can contribute to preventive medicine by suggesting lifestyle improvements and health checkups.

Step 2: Exploring dissatisfaction with products and workplaces

Measuring dissatisfaction and stress about products, services, or environments such as workplaces can be useful for developing products and services and improving the environment.

[For the evaluation of products and services]

By measuring the level of stress when using products and services, it is possible to develop products and services with a high level of satisfaction. Peripheral arterial stiffness can be assessed in real time to determine when and in what situations people feel stressed or tense as they actually use or experience products or services, allowing for detailed improvements to be made.

[For risk management and rationalization in the workplace]

Continuous measurement of peripheral arterial stiffness in manufacturing and other workplaces can help identify potential risks and areas for improvement in the workplace. In any workplace, there are places and equipment that are difficult to use and situations that are dangerous; however, the workers may not be aware of them or do not consider them to be major problems.

Peripheral arterial stiffness measurements can be used to identify and improve situations where staff members feel stressed or tense, thereby increasing workplace safety, efficiency, and comfort.

Step 3: Opening up the future with Big Data

Measuring the value of peripheral arterial stiffness to understand the state of mental and physical health is an unprecedented idea, and no one knows what kind of data can be obtained if the peripheral arterial stiffness is measured continuously for 24 hours. We can measure responses to stimuli other than pain and anxiety. However, this is still in the research stage. In other words, it is unknown how these data can be utilized. As the development of wearable devices progresses, we want to build big data by collecting anonymized data with the consent of users.

We also hope to contribute to the realization of a better society by using peripheral arterial stiffness measurements for the prevention, diagnosis, and treatment of various diseases, as well as reducing stress, anxiety, and risk in all aspects of people's lives.

Example of the device detecting stress and recommending a change of scenery or a break (image)

Visualize even the slightest stress in daily life (image)

To prevent mental health crises in the workplace (image)

◆**Article1 / Journal :** Scientific Reports, **Title:** Quantita tive Evaluation of Pain during Electrocutaneous Stimula tion using a Log-Linearized Peripheral Article 1 / Journal : Scientific Reports, Title: Quantitative Evaluation of Pain during Electrocutaneous Stimula tion using a Log-Linearized Peripheral Viscoelastic Model, **Authors:** Hiroki Matsubara, Hiroki Hirano, Harutoyo Hirano, Zu Soh, Ryuji Nakamura, Noboru Saeki, Masashi Kawamoto, Masao Yoshizumi, Atsuo Yoshino, Takafumi Sasaoka, Shigeto Yamawaki, and Toshio Tsuji

◆**Article2 / Journal :** Scientific Reports, **Title:** Peripheral Arterial Stiffness during Electrocutaneous Stimulation is Positively Correlated with Pain- related Brain Activity and Subjective Pain Intervention-related Brain Activity and Subjective Pain Intensity: an fMRI study, **Authors:** Toshio Tsuji, Fumiya Arikuni, Takafumi Sasaoka, Shin Suyama, Takashi Akiyoshi, Zu Soh, Harutoyo Hirano, Ryuji Nakamu ra, Noboru Saeki, Masashi Kawamoto, Masao Yoshizumi, Atsuo Yoshino, and Shigeto Yamawaki