Okayama University Medical Research Updates （OU-MRU） 2022.10 Vol.106

Source: Okayama University (JAPAN), Public Relations Division

For immediate release: 20 October 2022

Okayama University research: The skin electrically modelled

(Okayama, 20 October) **Researchers at Okayama University report in *Advanced Biomedical Engineering* a practical method to measure the thickness and the water content of the outermost layer of the human skin. These are important quantities in the context of understanding and monitoring the skin's barrier function.**

The outermost layer of the human skin, called the stratum corneum, protects the body against potentially dangerous substances. But for the stratum corneum to function properly as a barrier, it has to have a certain thickness and a certain water content. Measuring these by conventional methods, however, is time-consuming and not practical. Now, Professor NAKAMURA Takao, Assistant Professor KUSUHARA Toshimasa from Okayama University, UEHARA Osamu from ALCARE Co., Ltd. and colleagues have developed a simple method to estimate the thickness and the water content of the stratum corneum. The method, relying on an electrical-circuit model of the skin, is expected to help detect skin barrier function deterioration, which can cause allergies or skin conditions.

The researchers based their approach on the notion that the stratum corneum has a particular electric response — it 'resists' an electrical current. They modelled the outer skin layer as an electrical component: a resistance (*R*) and a capacitance (*C*) placed in parallel. The numerical values of *R* and *C* depend on the thickness and the water content of the stratum corneum; Professor NAKAMURA and colleagues proposed mathematical formulas describing this dependence. These formulas were then used to obtain expressions of thickness and water content as a function of *R* and *C*.

The scientists developed a practical device that, by holding it against the skin of the forearm, provides values of the electrical impedance of the skin, which can be easily converted into values of *R* and *C*. (The electrical impedance is the 'opposition' of a circuit component to an applied alternating current.) These estimates for *R* and *C* could then be used for calculating thickness and water content by means of the established mathematical relationships between them.

Professor NAKAMURA and colleagues then tested how well the impedance-based estimates compared to values of thickness and water content directly measured using conventional (but non-practical) methods called confocal laser microscopy and confocal Raman spectroscopy, respectively. They performed skin measurements on 16 individuals. Impedances were measured for two alternating-current frequencies (500 Hz and 100 kHz). Statistical analyses of the comparisons between estimates and conventional measurements showed good agreement: the correlation coefficients were 0.931 and 0.776 for thickness and water content, respectively. (The closer a correlation coefficient is to 1, the better the agreement.) To

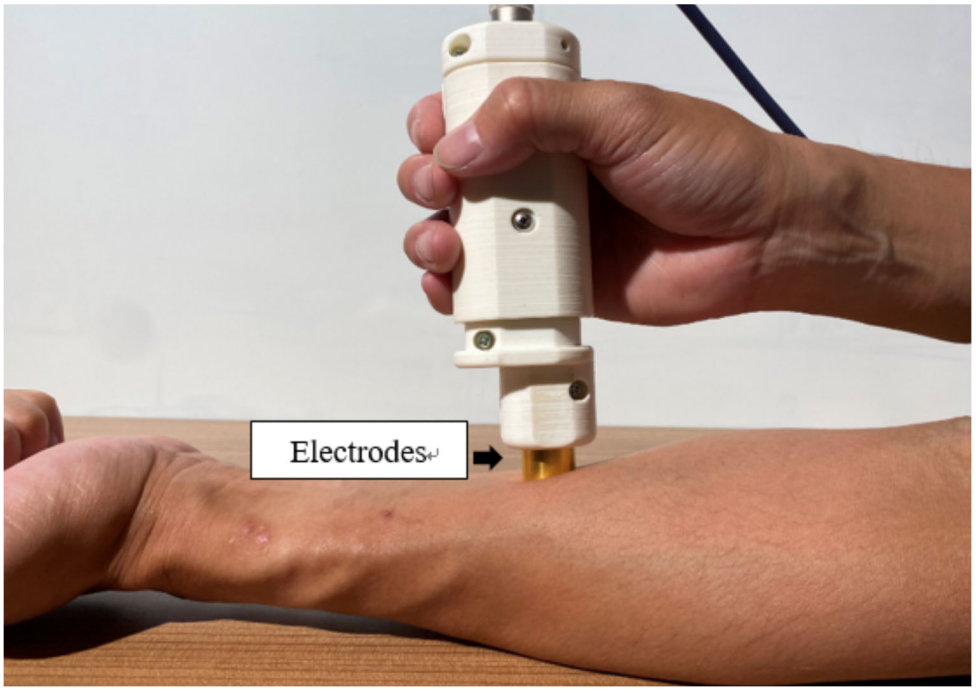
explain the deviations, the scientists suggest that measurements of the skin electrical impedance may be influenced by several factors, including measurement time and sweat on the skin.

Measurements on an increased number of participants are necessary to confirm the results of the current study. Nevertheless, quoting the researchers, “it is … expected that the [resistance–capacitance] model can be used as a simple model capturing the state of the stratum corneum”.

Background

The stratum corneum is the outermost layer of the human skin. It is formed by dead tissue and has protective and regulatory functions, including impact resistance, hydration regulation, and blocking of toxic substances, irritants and allergens. It functions as a barrier, shielding underlying cells from mechanical stress, infection, and harmful chemicals.

Qualitatively characterizing the stratum corneum is important for understanding and checking its barrier function. Specifically, its thickness and its water content are two relevant parameters; measuring them, however, is not easy. Professor NAKAMURA Takao, Assistant Professor KUSUHARA Toshimasa from Okayama University, UEHARA Osamu from ALCARE Co., Ltd. and colleagues have now developed a practical method to measure these two quantities. The method is based on measuring electric impedances of the skin by means of an easy-to-use device held against the forearm. By modelling the stratum corneum as a simple electrical circuit consisting of a resistance and a capacitance placed in parallel, estimates for its thickness and its water content can be calculated using formulas involving the measured impedances.



Figure

Measurement of the electrical impedance of the skin.

Reference
Osamu Uehara, Toshimasa Kusuhara, Kenichi Matsuzaki, Yoshitake Yamamoto, Takao Nakamura. Skin electrical impedance model for evaluation of the thickness and water content of the stratum corneum. *Advanced Biomedical Engineering*, Vol. 11, p.98-108, 2022.
DOI：https://doi.org/10.14326/abe.11.98
https://abe-journal.org/issues/2022/04/27/682

Correspondence to
Professor NAKAMURA Takao, Ph.D.
Department of Radiological Technology,
Graduate School of Health Sciences, Okayama University,
2–5–1 Shikata-cho, Kita-ku, Okayama 700-8558, Japan
E-mail: nakamura@md.okayama-u.ac.jp
https://www.cc.okayama-u.ac.jp/~nakamura/index.html

Professor NAKAMURA Takao

Further information
Okayama University
1-1-1 Tsushima-naka , Kita-ku , Okayama 700-8530, Japan
Public Relations Division
E-mail: www-adm@adm.okayama-u.ac.jp
Website: http://www.okayama-u.ac.jp/index_e.html
Okayama Univ. e-Bulletin: http://www.okayama-u.ac.jp/user/kouhou/ebulletin/
We love OKAYAMA UNIVERSITY:
https://www.youtube.com/watch?v=7cXlttQIk3E
Okayama University Image Movie (2020):
https://www.youtube.com/watch?v=vQxeL0ztSLA
Okayama University supports the Sustainable Development Goals: https://sdgs.okayama-u.ac.jp/en/

Okayama University Medical Research Updates （OU-MRU）
The whole volume: OU-MRU (1-)
Vol.1：Innovative non-invasive 'liquid biopsy' method to capture circulating tumor cells from blood samples for genetic testing
Vol.2：Ensuring a cool recovery from cardiac arrest
Vol.3：Organ regeneration research leaps forward

Vol.4 : Cardiac mechanosensitive integrator
Vol.5 : Cell injections get to the heart of congenital defects
Vol.6 : Fourth key molecule identified in bone development
Vol.7 : Anticancer virus solution provides an alternative to surgery
Vol.8 : Light-responsive dye stimulates sight in genetically blind patients
Vol.9 : Diabetes drug helps towards immunity against cancer
Vol.10 : Enzyme-inhibitors treat drug-resistant epilepsy
Vol.11 : Compound-protein combination shows promise for arthritis treatment
Vol.12 : Molecular features of the circadian clock system in fruit flies
Vol.13 : Peptide directs artificial tissue growth
Vol.14 : Simplified boron compound may treat brain tumours
Vol.15 : Metamaterial absorbers for infrared inspection technologies
Vol.16 : Epigenetics research traces how crickets restore lost limbs
Vol.17 : Cell research shows pathway for suppressing hepatitis B virus
Vol.18 : Therapeutic protein targets liver disease
Vol.19 : Study links signalling protein to osteoarthritis
Vol.20 : Lack of enzyme promotes fatty liver disease in thin patients
Vol.21 : Combined gene transduction and light therapy targets gastric cancer
Vol.22 : Medical supportive device for hemodialysis catheter puncture
Vol.23 : Development of low cost oral inactivated vaccines for dysentery
Vol.24 : Sticky molecules to tackle obesity and diabetes
Vol.25 : Self-administered aroma foot massage may reduce symptoms of anxiety
Vol.26 : Protein for preventing heart failure
Vol.27 : Keeping cells in shape to fight sepsis
Vol.28 : Viral-based therapy for bone cancer
Vol.29 : Photoreactive compound allows protein synthesis control with light
Vol.30 : Cancer stem cells' role in tumor growth revealed
Vol.31 : Prevention of RNA virus replication
Vol.32 : Enzyme target for slowing bladder cancer invasion
Vol.33 : Attacking tumors from the inside
Vol.34 : Novel mouse model for studying pancreatic cancer
Vol.35 : Potential cause of Lafora disease revealed
Vol.36 : Overloading of protein localization triggers cellular defects
Vol.37 : Protein dosage compensation mechanism unravelled
Vol.38 : Bioengineered tooth restoration in a large mammal
Vol.39 : Successful test of retinal prosthesis implanted in rats
Vol.40 : Antibodies prolong seizure latency in epileptic mice
Vol.41 : Inorganic biomaterials for soft-tissue adhesion
Vol.42 : Potential drug for treating chronic pain with few side effects
Vol.43 : Potential origin of cancer-associated cells revealed
Vol.44 : Protection from plant extracts
Vol.45 : Link between biological-clock disturbance and brain dysfunction uncovered
Vol.46 : New method for suppressing lung cancer oncogene
Vol.47 : Candidate genes for eye misalignment identified

OKAYAMA University
1-1-1 Tsushima-naka, Kita-ku, Okayama 700-8530 Japan

OKAYAMA University
1-1-1 Tsushima-naka, Kita-ku, Okayama 700-8530 Japan

Vol.86：Plates and belts — a toolkit to prevent accidental falls during invasive vascular procedures
Vol.87：Therapeutic potential of stem cells for treating neurodegenerative disease
Vol.88：Nanotechnology for making cancer drugs more accessible to the brain
Vol.89：Studying Parkinson's disease with face-recognition software
Vol.90：High levels of television exposure affect visual acuity in children
Vol.91：Meeting high demand: Increasing the efficiency of antiviral drug production in bacteria
Vol.92：Numerical modelling to assist the development of a retinal prosthesis
Vol.93：Repurposing cancer drugs: An innovative therapeutic strategy to fight bone cancer
Vol.94：A berry vine found in Asia proves useful in combating lung cancer
Vol.95：A new avenue for detecting cancer in the blood
Vol.96：Automated cell image analysis
Vol.97：Artificial intelligence helps to determine cancer invasion
Vol.98：Okayama University launches clinical trials of a jawbone regeneration therapy using human BMP-2 transgenic protein derived from *Escherichia coli*.
Vol.99：A rapid flow process that can convert droplets into multilayer polymeric microcapsules
Vol.100：Understanding insect leg regeneration
Vol.101：Oral tumor progression mechanism identified
Vol.102：Controlled cell death by irradiation with light
Vol.103：High-quality growth
Vol.104：The determinants of persistent and severe COVID-19 revealed
Vol.105：The dynamics of skin regeneration revealed

「Junko Fukutake Hall」 Kazuyo Sejima + Ryue Nishizawa / SANAA
Okayama University (Shikata Campus, Okayama City)
http://www.okayama-u.ac.jp/eng/access_maps/index.html

TOP GLOBAL UNIVERSITY JAPAN | Japan. Committed to the SDGs | SUSTAINABLE DEVELOPMENT GOALS | 岡山大学 OKAYAMA UNIVERSITY

Okayama University supports the Sustainable Development Goals

OKAYAMA University
1-1-1 Tsushima-naka, Kita-ku, Okayama 700-8530 Japan

◆About Okayama University

Okayama University is one of the largest comprehensive universities in Japan with roots going back to the Medical Training Place sponsored by the Lord of Okayama and established in 1870. Now with 1,300 faculty and 13,000 students, the University offers courses in specialties ranging from medicine and pharmacy to humanities and physical sciences.

Okayama University is located in the heart of Japan approximately 3 hours west of Tokyo by Shinkansen.

Website: http://www.okayama-u.ac.jp/index_e.html

Japan（日本）

Hirofumi Makino, M.D., Ph.D.
President , Okayama University

Japan. Committed to SDGs | 岡山大学 OKAYAMA UNIVERSITY | SUSTAINABLE DEVELOPMENT GOALS

"Okayama University supports the Sustainable Development Goals"

Okayama University Integrated Report => **click**

An integrated report is intended to explain how an organization creates value over time through an organic integration of the vision and the combination of financial information and other information. Through this report we hope to promote greater interest in Okayama University among readers everywhere. In order to help us make improvements in future editions, we encourage you to contact us with any comments and suggestions you may have.

OKAYAMA University
1-1-1 Tsushima-naka, Kita-ku, Okayama 700-8530 Japan