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Development of Quantitative Evaluation Technique for Viscoelastic Properties of Human Skin in vivo -Investigation of skin sites, tissue structure, and effects of aging-

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Introduction

The material properties of skin change due to aging and diseases such as diabetes and pressure ulcers. In addition, those diseases occur throughout the body. In clinical practice, evaluation of skin condition is relied on the physician's experience with palpation. We speculated that quantification of the physician's sense might be beneficial in monitoring the disease control as well as early detection of disease onset. Therefore, it is necessary to quantitatively evaluate the material properties of the skin throughout the body.

In a previous study, human skin and industrial materials were measured using a rheometer and a cutometer. Significant correlations were obtained between the rheometer and the cutometer. However, the influence of skin tissue and site on viscoelasticity has not yet been investigated.
In this study, we investigated the influence of body parts and skin tissue on the material properties of skin.

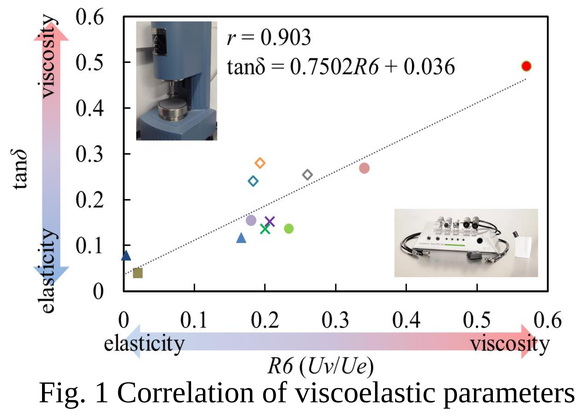


Fig. 1 Correlation of viscoelastic parameters

Materials & Methods

A total of 20 healthy volunteers (16 men, 4 women) aged 21–51 years were studied. Mechanical parameters of the skin were determined using a non-invasive suction skin elasticity meter (Cutometer).

Experiment 1

In the first experiment, the measurements were performed on a total of seven locations (back of both hands, both upper arms, both volar forearms, and right cheek), and the results were compared.

Fig. 2 Cutometer measurement

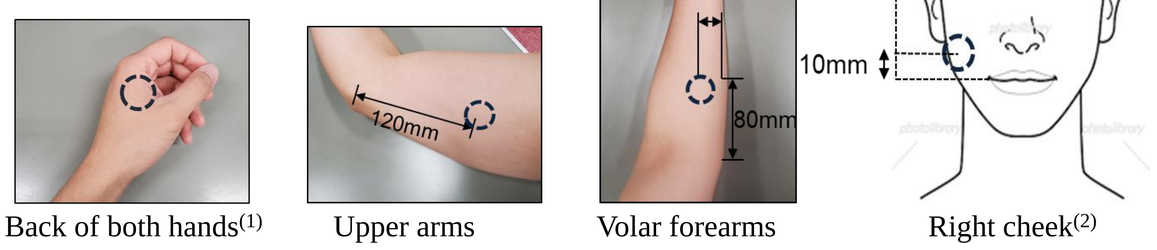
Table 1 Subject information of experiment I

Type of Experiment	The number of people	Age range	Sex ratio (Man : Woman)
Experiment I	6	21-23	6 (only man)

Table 2 Cutometer measurement conditions of experiment I

Probe size [mm]	Negative pressure [mbar]	Suction time [s]	Release time [s]
2	200	2	2

Skin viscoelasticity was assessed by *R2* (*Ua*/*Uf*), *R5* (*Ur*/*Ue*), *R6* (*Uv*/*Ue*) and *R7* (*Ur*/*Uf*).
Cutometer description (principle, parameters from official website).



Back of both hands(1) Upper arms Volar forearms Right cheek(2)

Fig. 3 Measurement spot

Experiment 2

In the second experiment, the measurements were performed on the right volar forearm by two different negative pressures (200mbar, 450mbar), the effect of the thickness of each tissue on the viscoelastic properties of the skin was investigated.

Table 3 Subject information of experiment 2

Type of Experiment	The number of people	Age range	Sex ratio (Man : Woman)
Experiment II	20	21-51	16 : 4

Table 4 Cutometer measurement conditions of experiment 2

Probe size [mm]	Negative pressure [mbar]	Suction time [s]	Release time [s]
2	200, 450	2	2

Experimental procedure

1. Marking the spot to be measured.
2. Measure each spot three times.
3. Compare measurement results using averages.

Fig. 4 Volar right forearms

Results & Discussion

Experiment 1

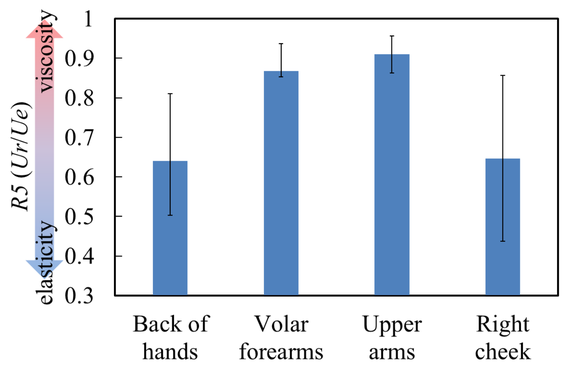


Fig. 5 Individual differences by body part in *R5*(*Ur*/*Ue*)

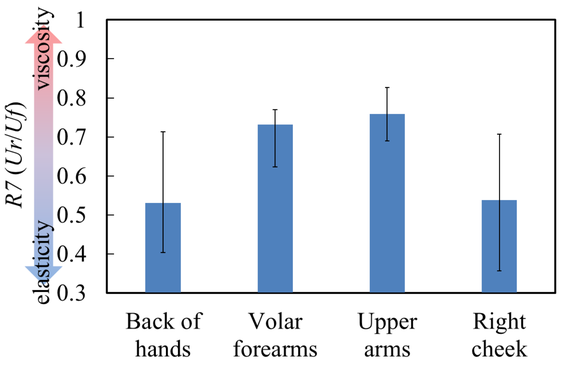


Fig. 6 Individual differences by body part in *R7*(*Ur*/*Uf*)

Back of the hand was characterized by lower values of *R5* and *R7* compared with volar forearm and upper arm. In the back of the hand and the cheek, individual differences appeared remarkably. These individual differences are expected to be caused by differences in skin thickness and muscle mass from person to person.

Experiment 2

Table 5 Maximum and minimum values for each negative pressure

	Min	Max
Displacement at 200mbar [mm]	0.265	0.392
Displacement at 450mbar [mm]	0.393	0.526

The measurement range was 0.265 - 0.526 mm when the negative pressure was varied with a probe diameter of 2 mm.
In general, the thickness of the skin is about 0.2 mm for the epidermis, 2 mm for the dermis and 4-9 mm for other subcutaneous tissues.
Compared with the results of this study, it is thought that a probe with a diameter of 2 mm can measure the area between the epidermis and dermis.
This suggests that the material properties of the dermis might be measured by using a larger cutometer probe.

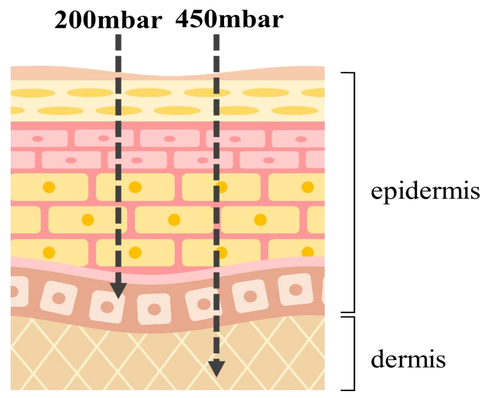


Fig. 7 Image of measuring range

Table 6 Correlation coefficient with *R*-value in *G''* (previous study)

R2	*R5*	*R6*	*R7*
-0.707	-0.304	0.0384	-0.272

In a previous study, human skin was measured with Rheometer and Cutometer. A strong negative correlation was observed between the rheometer's viscosity term G" and the cutometer's *R2*.
R2 correlated negatively with age.
These suggest that R2 might be currently the best parameter for quantifying age-related changes in skin material properties.

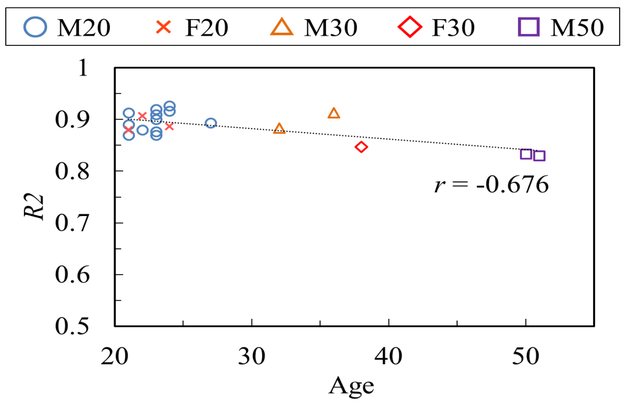


Fig. 8 Relationship between *R2*(*Ua*/*Uf*) and age

Conclusions

- Individual differences in site could be attributed to skin thickness and muscle mass.
- It was suggested that the material properties of deeper subcutaneous tissue could be measured by using larger cutometer probes.
- It was suggested that *R2* may be currently the best parameter for quantifying age-related changes in skin material properties.

Outlook for the future of research

We will use echography to visualise the subcutaneous tissue. This is expected to allow a more detailed investigation of the influence of an individual's subcutaneous tissue on skin material properties.

References

(1) Marie Kawabata, Jiro Yabuzaki, Yumika Yamakawa, Ai Oba, Sphere-drop Test : New Visualization Method for Assessing Mechanical Properties of Skin with Tactile Elements ─ Softness and Elasticity, J. Soc. Cosmet. Chem. Jpn. Vol.46, No.3 2012, pp. 205-218
(2) Toshii Iida, Mihoko Ooba, Fumio Matsuno, Nobuyoshi Koga, Skin Conditions on the Dorsal Hands of Japanese and Caucasian Women, J. Soc. Cosmet. Chem. Jpn. Vol.48, No.4 2014, pp. 278-286