

Supplementary Material

The participants were asked to fill out a questionnaire about their skin routine and condition, e.g. Fitzpatrick skin type, skin diseases, water consumption, and use of moisturizers. The responses in the questionnaires assisted in the categorization and interpretation of the results. For example, when looking at the contrast between the hydration profile of healthy skin and dry skin, we categorized participants without any skin conditions, not in use of medications and not applying moisturizer on their volar forearms into the category of 'normal skin'. Then we categorized participants having skin conditions including eczema, dermatitis, psoriasis and dry skin but didn't moisturize their volar forearms into the 'dry skin' group, compared to those in the group of 'dry skin with moisturizer' who have the aforementioned skin conditions and used moisturizer. We also recorded other variables that may affect the skin hydration, including the last time they drank caffeinated drinks and exercised and whether they have been swimming or had a bath in the past 12 hours.

Table S.1 Questionnaire for skin categorization

Category		No of participants
Gender	Female	108
	Male	206
Year of Birth	2000-2004	125
	1990-1994	132
	1980-1989	26
	1979 and before	34
Dominant arm	Right handed	284
	Left handed	33
Ethnicity	White	226
	Chinese	24
	Black	11
Skin conditions	Normal skin	256
	Dry skin w/o moisturizer	46
	Dry skin w moisturizer	12
Water consumption	Less than 1L	43
	Between 1L and 2L	128
	Between 2L and 3L	120
	More than 3L	24

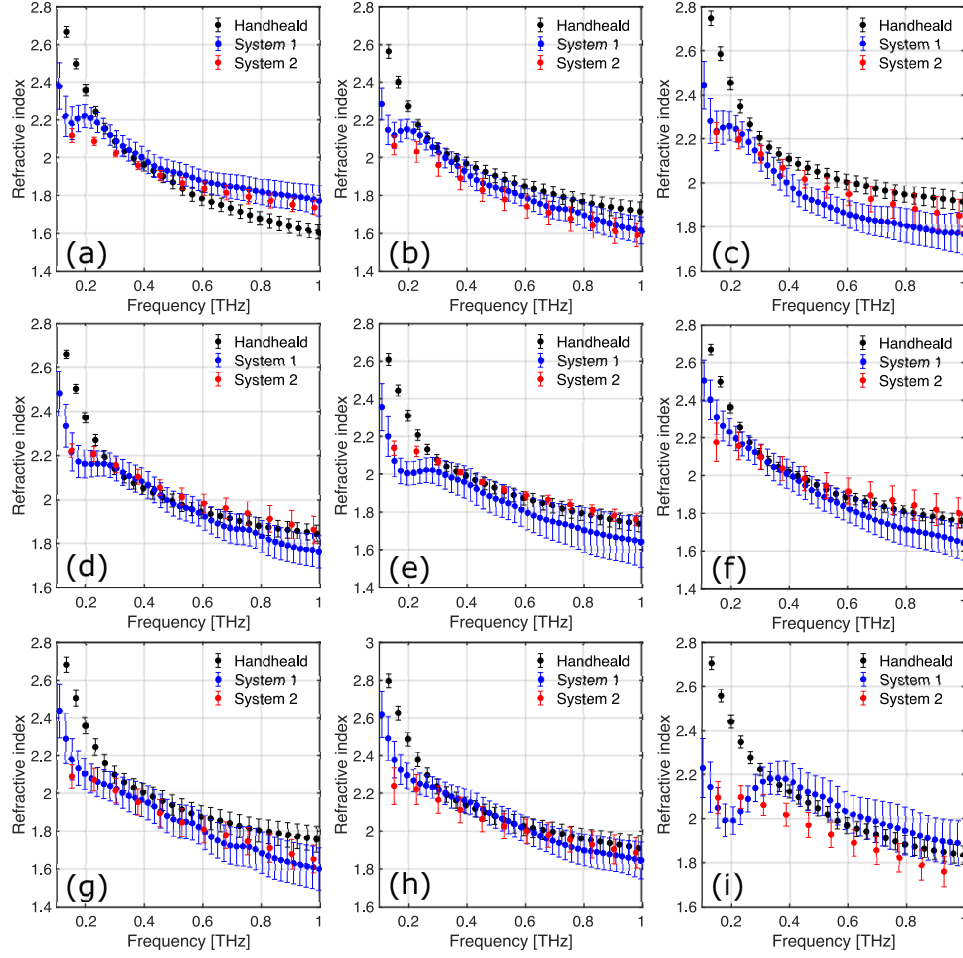


Fig S.1 Refractive index comparison. The panels illustrate the comparison of the real part of the refractive index of the volar forearm for nine volunteers using the proposed handheld system and the other two systems. The results shown are the average of 20 measurements (dots) from between 55 and 60 seconds of occlusion and the corresponding standard deviation (error bars).

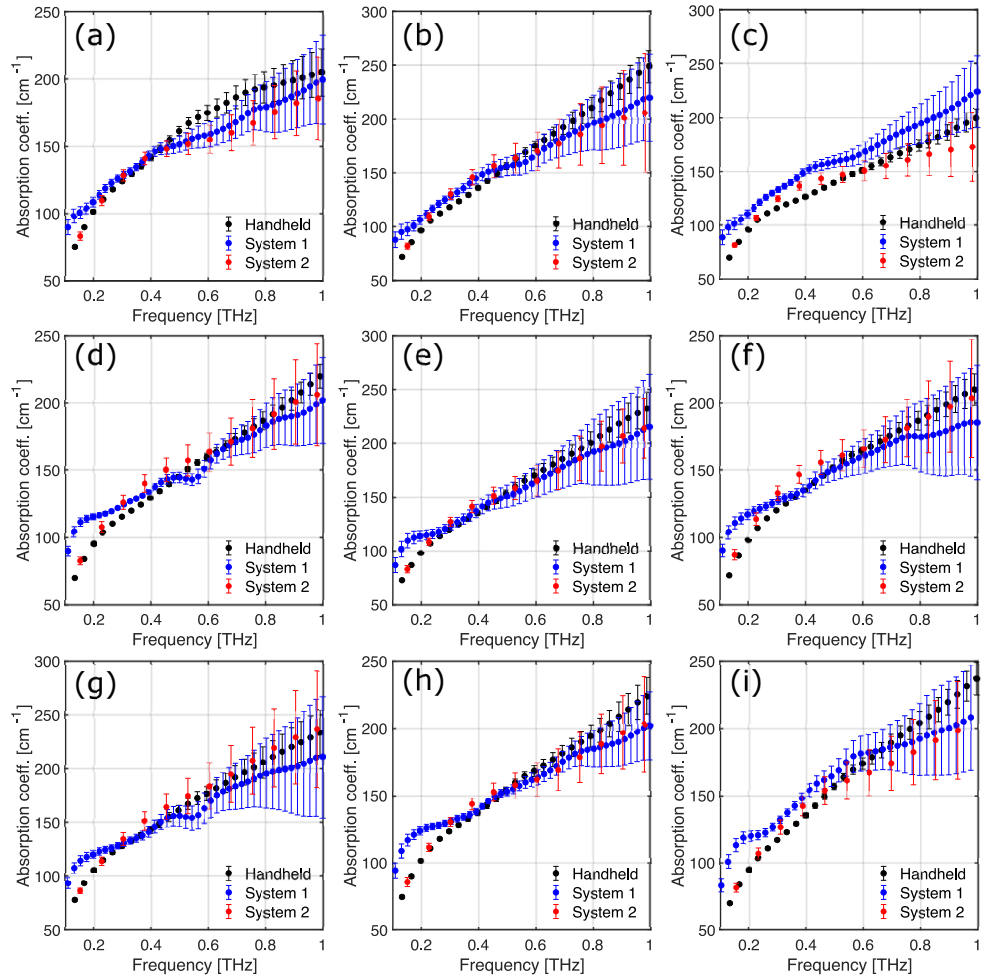


Fig S.2 Absorption comparison. The panels illustrate the comparison of the absorption coefficient of the volar forearm for nine volunteers using the proposed handheld system and the other two systems. The results shown are the average of 20 measurements (dots) from between 55 and 60seconds of occlusion and the corresponding standard deviation (error bars).

Visible images of dry and normal skin

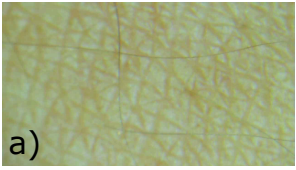
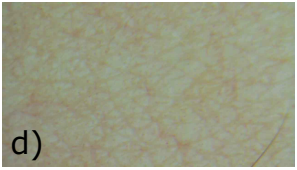
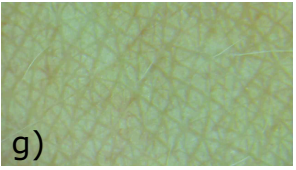
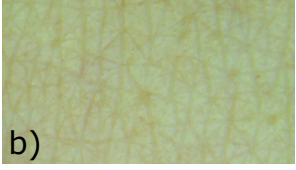
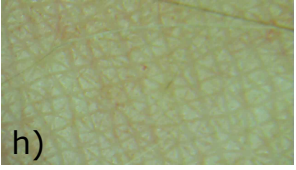
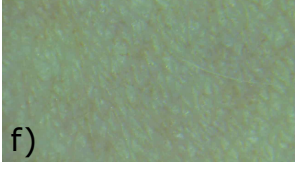
Dry skin	Normal skin	Dry skin	Normal skin
 a)	 d)	 g)	 j)
 b)	 e)	 h)	 k)
 c)	 f)	 i)	 l)

Fig S.3 Visible light photographs were taken of twelve distinct volunteers, showcasing instances of both dry and normal skin. In the photographs featuring dry skin, the skin’s roughness, specifically the furrows, is more pronounced compared to those with normal skin.

Technique	Mechanism	Pros	Cons
THz-TDS [2, 4, 5]	Reflected THz signal	• Non-invasive; • Handheld probe; • Sensitive to change in water content; • Measures both phase and amplitude (easy to acquire n and α); • Spectral fingerprints; • Low scattering effect;	• Small penetration depth: 100-300 μm; • Low axial resolution: 75 μm; • Expensive equipment: up to £80k; • Sensitive to environmental factors (e.g., temperature, humidity); • In contact with the skin;
OCT [3, 6, 8]	Low-coherence interferometry Near-infrared light	• Non-invasive; • Non-contact; • Handheld probe; • High resolution cross-sectional images;	• Small penetration depth: 1 mm; • Low axial resolution: 15 μm; • Does not provide quantitative information on skin hydration; • Scattering effect; • Expensive equipment: up to £70k;
Confocal Raman Spectroscopy [1, 8]	Inelastic light scattering	• Non-invasive; • Provides information on molecular composition; • Axial resolution: 5 μm;	• Small penetration depth: hundreds of μm; • Expensive equipment: up to £80k; • Equipment is bulk in size;
MRI [7, 8]	Strong magnetic field	• Non-invasive; • Penetration depth: full body;	• Low axial resolution: hundreds of μm; • Not suitable for patients with metal implants; • Time consuming; • Expensive equipment: at least £120k;
Ultrasound [9]	Echoes of sound waves	• Non-invasive; • Inexpensive equipment: £12k - £40k; • Penetration depth: 8 mm;	• Low axial resolution: hundreds of μm; • Lacks chemical specificity;
Corneometer [6]	Electrical capacitance	• Non-invasive; • Easy to perform; • Inexpensive equipment: £1k - £4k;	• Small penetration depth: around 20 μm; • Sensitive to environmental factors; • Capacitance can be influenced by other biophysical factors; • Can not provide hydration profile across the skin; • Occludes the skin;
TEWL [8, 9]	Water evaporation from skin	• Non-invasive; • Effective for assessing skin barrier integrity; • Inexpensive equipment: £0.4k;	• Doesn't directly measure skin water content; • Sensitive to environmental factors;

- [1] Caspers, Peter. *In vivo skin characterization by confocal Raman microspectroscopy*. 2003.
[2] Pickwell, Emma. *Biological applications of terahertz pulsed imaging and spectroscopy*. Diss. University of Cambridge, 2005.
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[4] Sun, Qishuo. *Development of Terahertz Analysis Techniques for Biomedical Applications and Enhanced Material Characterization*. The Chinese University of Hong Kong (Hong Kong). 2019.
[5] You, Bowen, et al. "Frequency-dependent skin penetration depth of terahertz radiation determined by water sorption-desorption." *Optics express* 28:18 (2018): 25922-25923.
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[7] Plan, Qi, et al. "Multimodal biomedical optical imaging review: towards comprehensive investigation of biological tissues." *Current Molecular Imaging (Discontinued)* 3:2 (2014): 72-87.
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[9] Chirikhina, Elena. *Human Face Mapping Based on TEWL, Hydration and Ultrasound*. Diss. London South Bank University, 2022.

Fig S.4 Table comparing between different techniques for the assessment of skin hydration and thickness.