6GEM

WP4.8: 6G.Bioelectromagnetics Interactions

Electromagnetic Power Absorption in Skin Tissues : Ethnic and Gender Variations Across 5G/6G Frequencies

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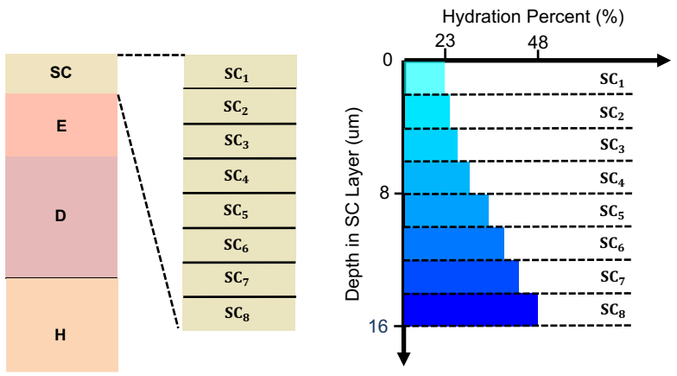
1. Introduction

This study involves the modeling of male and female skin probes (abdomen) from three ethnic groups (Chinese, Korean and Turkish). The skin is modeled using five homogeneous tissue layers – stratum corneum (SC), epidermis (E), dermis (D), hypodermis (H) and muscle tissue (M) – and exposed to electromagnetic plane waves in the 5G/6G frequency range (1-300 GHz). Comprehensive analyses are carried out using the Finite Element Method (FEM)-based COMSOL Multiphysics simulation software. The results provide realistic data on the absorbed power in each tissue layer (together with the associated penetration depths of the electromagnetic field in the skin probes), showing gender- and ethno-specific variations in the absorbed power.

2. The Stratified Skin Model and Dielectric Properties

■ The dielectric properties of each skin layer:

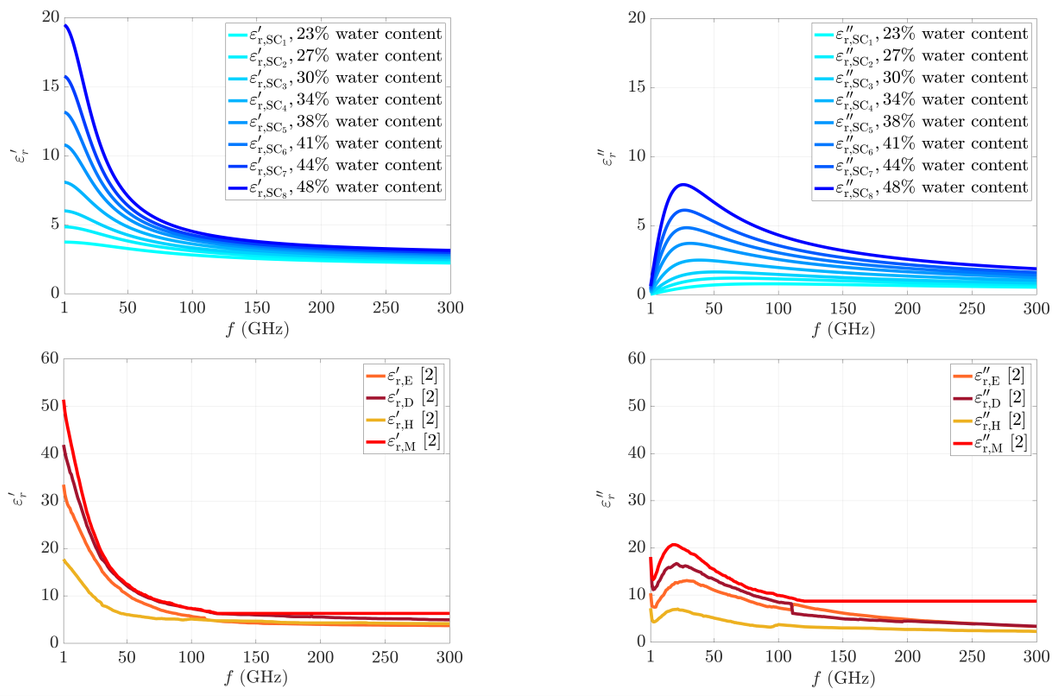


- The dielectric properties of each sublayer of SC were calculated using Bruggeman's Effective Medium Theory [1] across the frequency range of 1–300 GHz.

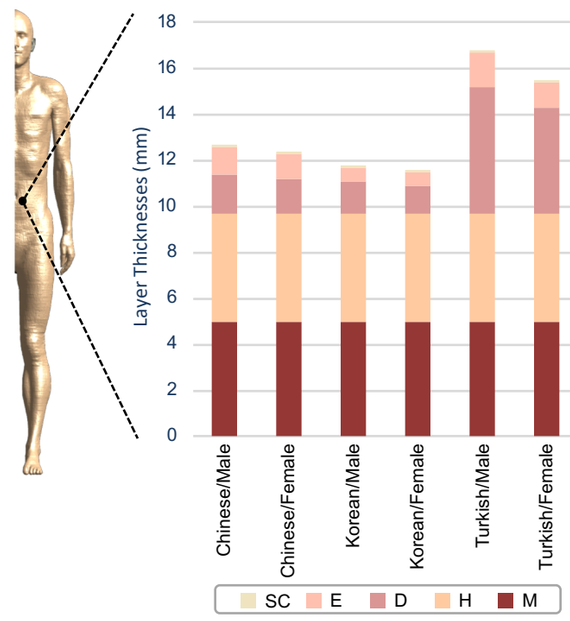
$$\eta_1 \frac{\varepsilon_1 - \varepsilon_{eff}}{\varepsilon_1 + \varepsilon_{eff}} + \eta_2 \frac{\varepsilon_2 - \varepsilon_{eff}}{\varepsilon_2 + \varepsilon_{eff}} = 0$$

- The measurement results reported in [2] were used to determine the dielectric properties of the E, D, H and M layers in the frequency region of 1-300 GHz.

■ The real and imaginary part of dielectric function of the SC, E, D, H and M tissue layer:



3. Ethnic and Gender-Based Variations in Skin Layer Thickness



- The total thickness of the SC for the skin samples is 16 um [3].
- The thicknesses of the E and D have been adopted from the mean values reported in the anatomical region of the abdomen [4-6].
- The thickness for the H layer were taken from [7], while the specifications for the M layer thickness were based on the standards outlined in [8].
- The mass densities of the SC, E, D, and H layers were sourced from [9], while the mass density of the M layer was obtained from [10].
- In all samples, the thickness of male skin probes is greater than that of female skin probes.
- The Turkish male abdomen exhibits the thickest skin (15.34 mm), while the Korean female abdomen displays the thinnest skin (11.13 mm).

4. Penetration Depths

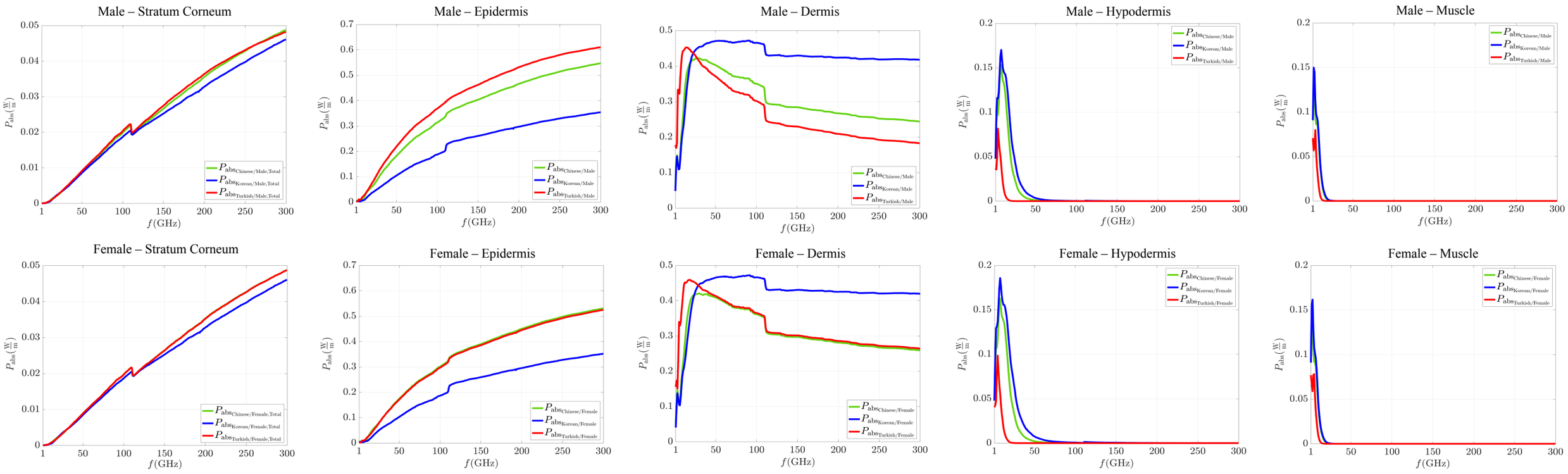
■ Penetration depths of the electric field within skin samples at 7 distinct frequencies:

Ethnicity/Gender	Penetration Depths (mm)						
	1 GHz	6 GHz	24 GHz	71 GHz	110 GHz	200 GHz	300 GHz
Chinese/Male	11.51*	9.19	1.22	0.40	0.29	0.22	0.18
Chinese/Female	11.30*	9.18	1.24	0.42	0.30	0.22	0.18
Korean/Male	11.13*	9.03	1.24	0.40	0.29	0.24	0.20
Korean/Female	10.91*	9.01	1.19	0.41	0.31	0.24	0.20
Turkish/Male	15.34*	8.85	1.11	0.31	0.23	0.16	0.16
Turkish/Female	14.36*	9.46	1.15	0.37	0.24	0.18	0.13

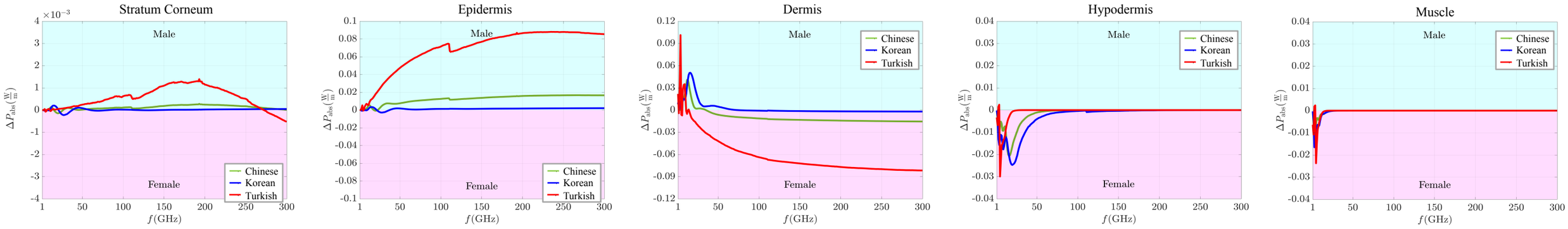
*In this case, the power density does not decay to e^{-2} of its initial magnitude, the penetration depth exceeds the layer thickness and therefore the entirety of the skin thickness is recorded.

5. The Absorbed Power in each Skin Layer

■ Ethnic variations in absorbed power across skin layers:



■ Comparative analysis of absorbed power in male and female skin layers :



6. Literature

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