28 GHz exposure of rat dorsal skin modulates body temperature and distal blood flow

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Millimeter waves (MW) are now widely used in 5th generation wireless systems (5G) and automotive radar systems. However, there are concerns that exposure to radiofrequency waves may have adverse health effects on the human body because little information has been reported on the reproducible biological effects of MMW. Several studies have investigated the biological effects of local exposure to 5G-MMWs. These have mainly focused on the effects on the eyes and cultured cells, but not on the whole body. In particular, a few studies reported changes in whole-body temperature and blood flow, which are important parameters to evaluate biological effects. The aim of this study was to evaluate how much increase in temperature and blood flow were detected during widely MMW exposure on the rat dorsal skin.

To investigate the biological effects of MMW exposure, we designed the systems consisting of a signal generator, amplifier, and lens antenna to expose the rat dorsal skin to 28 GHz MMW and to measure body temperature and skin blood flow. The antenna input power was set at 0, 20, and 40 W, corresponding to absorbed power densities (APD) of 0, 146, and 282 W/m^2 at the rat dorsal skin. Male Sprague-Dawley rats (8-9 weeks old) were used to measure temperatures in three regions (rectum, dorsal skin, and tail skin) and skin blood flow during 28 GHz MMW exposure. Rats were restrained in an acrylic holder while awake and exposed to 28 GHz-MMW from the dorsal side for 40 minutes. All experimental procedures were conducted in accordance with the ethical guidelines for animal experiments of Kurume University School of Medicine.

During 28 GHz MW exposure, temperature increases were observed in the rectum, dorsal skin, and tail skin with a dose dependence on exposure intensity. At the end of the 40 min exposure, significant temperature changes were observed in both exposed groups compared to the sham-exposed group. According to the ICNIRIP guideline [1], it is defined that MMW exposure (< 30 GHz) at an APD of 200 W/m^2 could increase the temperature in dorsal tissues by about 2℃. Under our experimental condition, the temperature increase was estimated to be about 1.64℃ at 200 W/m^2 exposure, therefore, our finding in rat dorsal skin could help to consider the validation of the guideline.

Focusing on the skin blood flow, interestingly, there was no obvious increase in blood flow in the dorsal skin. In contrast, tail blood flow was significantly increased at the end of the exposure, even though the amount of exposure to the tail was negligible. These results suggest that exposure of the dorsal skin to 28 GHz-MMW results in systemic thermoregulation that dissipates the heat accumulated in the body through the tail rather than the dorsal skin. This possibility is consistent with old physiological studies, showing that body temperature in rodents is modulated in the tail.

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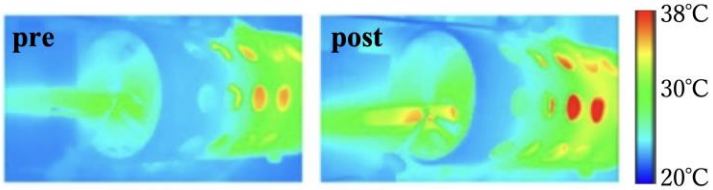

Figure 1. Temperature changes in the rat dorsal and tail skin under 28-GHz exposure. pre: before exposure, post: after 40-minutes exposure

References

[1] "Guidelines for Limiting Exposure to Electromagnetic Fields (100 kHz to 300 GHz)," *Health Phys.*, vol. 118, no. 5, pp. 483–524, May 2020.