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Effects of a repeated exposure to radiofrequency on thermal regulation in rodents

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Abstract

After a repeated exposure to non-thermal radiofrequency electromagnetic fields (RF), mice and rats showed thermoregulatory changes mimicking reactions to cold. Mice were exposed to RF for 7 consecutive days, twice per day, for one hour each time in climatic chambers. Rats were exposed to RF for different durations (1, 4, and 7 days), 23 hours per day in reverberation chambers. The animal's temperature was measured using two methods: telemetry transmitters for internal temperature and an infrared camera for peripheral temperature.
Body temperature patterns in mice change synchronously with the RF exposure periods after three days, but not in the first days. Rats exposed to RF had lower peripheral temperature than control rats after 7 days of exposure, this difference was suppressed after intraperitoneal injection of a vasodilator, prazosin, confirming vasoconstriction in exposed rats. Moreover, like responses to cold stimuli, both rats and mice exposed to RF showed changes in the morphology of white and brown adipocytes. In parallel, RF exposure led to a higher plasma concentration of important factors involved in response to cold: noradrenaline, a neurotransmitter responsible for vasoconstriction and thermogenesis, and fatty acids, markers of lipolysis in non-shivering thermogenesis. There is some indication that the primary cold sensors in mammals, TRPM8 receptors, are involved in these effects, but their role and the connected biological and physiological mechanisms in RF-induced responses remain to be further explored. In conclusion, these findings indicate that 900 MHz RF exposure at non-thermal levels produces physiological effects on thermal regulation in both studied species, mice and rats, resembling reactions to cold.

1 Introduction

The rapid expansion of communication technologies based on radiofrequency (RF) raises concerns about possible impacts on public health. At intensity levels below the threshold to produce thermal effects, RF exposure has recently been reported to elicit biological effects on thermal behavior and body and tail temperature [1-5]. The objective of the present study was to investigate the non-thermal effects of 900 MHz RF at SAR of less than 0.4 $W.kg^{-1}$ on the body and peripheral temperatures in rodents and the related mechanisms.

2 Material and methods

C57BL/6J mice have been exposed to RF for 7 consecutive days, twice per day for one hour each time, in climatic chambers (Figure 1). A continuous wave (CW) 900 MHz signal was generated from a radiofrequency power source type RFS (RFPA, Artigues-près-Bordeaux, France), connected to a four-output divider which supplied four antennas Kathrein 800–10465 (Rosenheim, Germany). These antennas were set 80 cm above the mice cages and distance between antennas was 45 cm. The climatic chamber could accommodate 7 cages. Electric field was measured at 20 ± 5 $V.m^{-1}$ by EP600 Electric field Probe (Narda Safety Test Solutions, Italy) before and during RF exposure in the climatic chamber in the presence of mice. Sham mice were housed in a separate climatic chamber, with identical ambient parameters as in the RF exposure chamber and cages arranged in the same pattern without exposure to RF. An experimental dosimetry has been performed in the chambers with mouse phantoms, which allowed calculating a SAR value of 0.16 ± 0.10 $W.kg^{-1}$.

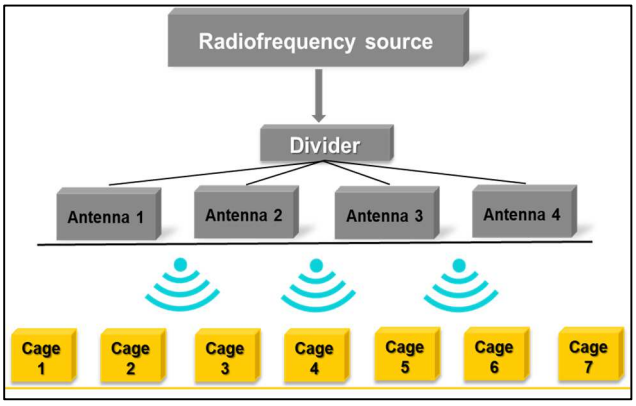

Figure 1. Schedule of the exposure setup.

Mice internal temperature was measured continuously with telemetry transmitters. On the 10th day, an antagonist of the TRPM8 receptor has been injected ip.
Wistar rats have been exposed to CW 900 MHz RF for different durations (1, 4, and 7 days), 23 hours per day in reverberation chambers at a SAR of 0.35 $W.kg^{-1}$. The tail temperature of rats was measured using an infrared camera, and ambient temperature was increased on the 7th day from 24 to 34°C. On the 10th day, a vasodilator has been injected intra-peritoneally in rats and their tail temperature has been recorded.

3 Results

Body temperature patterns in mice change synchronously with the RF exposure periods after three days, but not in the first days (Figure 2).

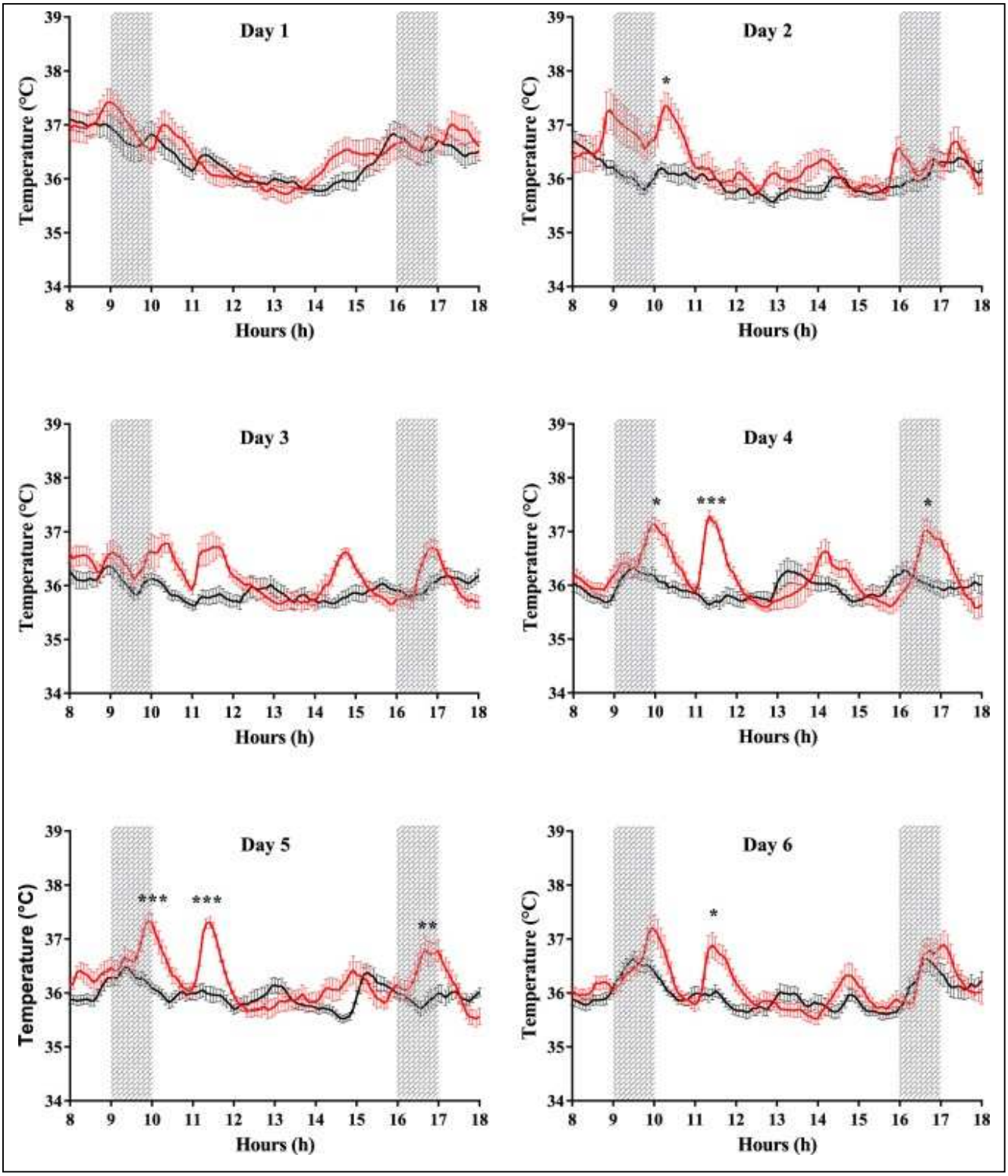

Figure 2. Mice temperature during the first 6 days of exposure (N=11/12).

Control mice injected with the TRPM8 antagonist AMG2850 showed a temperature decrease, as exposed mice did not (Figure 3).

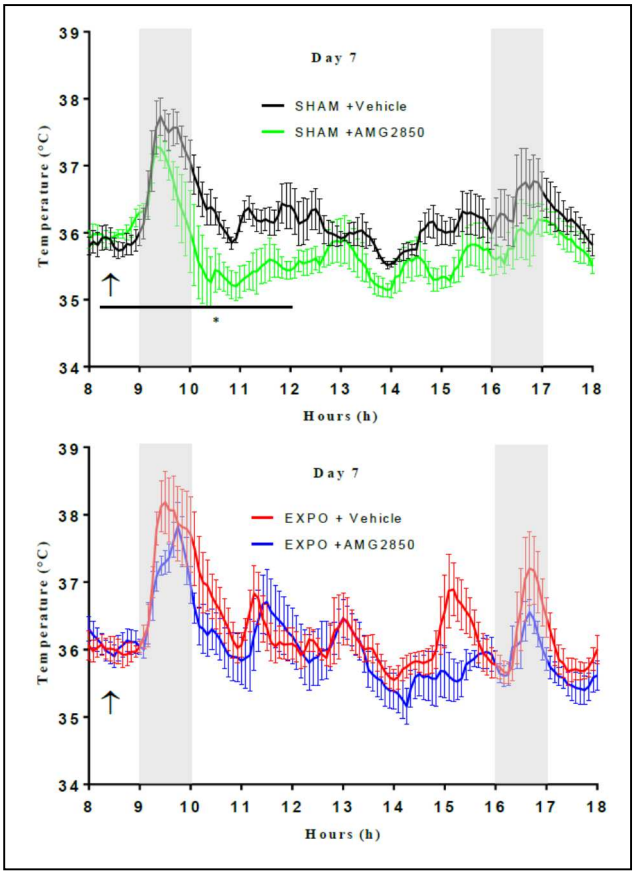

Figure 3. Mice temperature after injection of TRPM8 antagonist. Top: Sham animals (N=6/5); bottom: exposed animals (N=6/6).

Rats exposed to RF had lower peripheral temperature than control rats after 7 days of exposure (Figure 4).

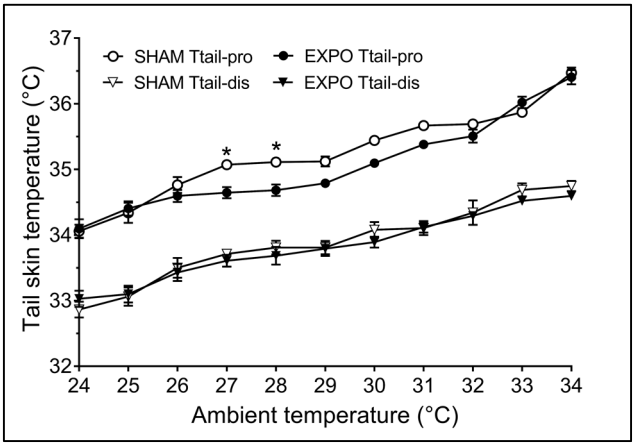

Figure 4. Skin temperature of the proximal (Ttail-pro) and distal parts (Ttail-dis) of the tail, at ambient temperatures ranging from 24 to 34 °C (N=4/4).

This difference was suppressed after intraperitoneal injection of a vasodilator, prazosin (Figure 5), confirming prior vasoconstriction in exposed rats.

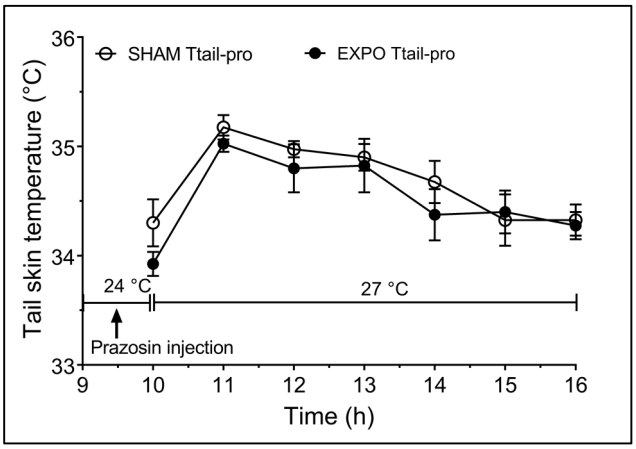

Figure 5. Tail skin temperature after prazosin injection at the ambient temperature of 27 °C (N=4/4).

Moreover, like responses to cold stimuli, both rats and mice exposed to RF showed changes in the morphology of white and brown adipocytes (Figure 6).

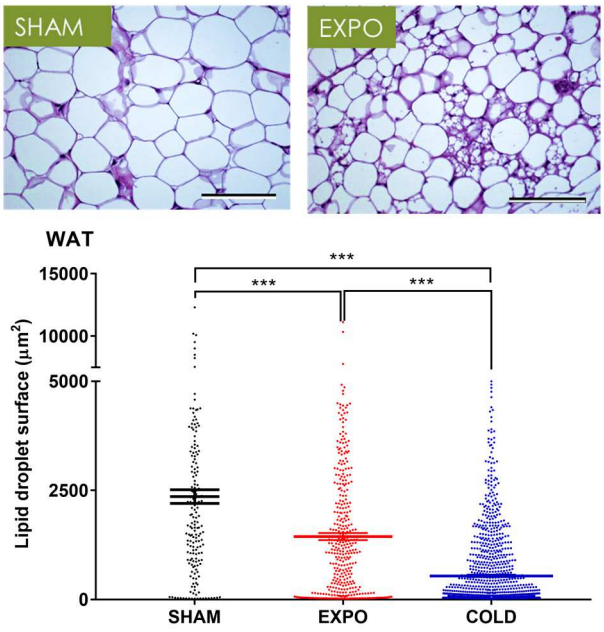

Figure 6. Change of inguinal white adipose tissue in mice: top left, sham mice; top right, exposed mice; bottom: size of lipid droplets in sham, exposed and cold control mice (N=6/6/6).

RF exposure led to a higher plasma concentration of factors involved in response to cold: noradrenaline, a neurotransmitter responsible for vasoconstriction and thermogenesis (Figure 7), and fatty acids, markers of lipolysis in non-shivering thermogenesis (Figure 8).

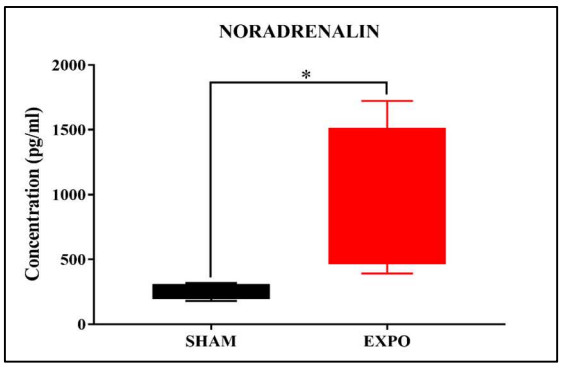

Figure 7. Plasma concentration of NA in the SHAM and EXPO groups. (Mean ± SEM; N=4/4).

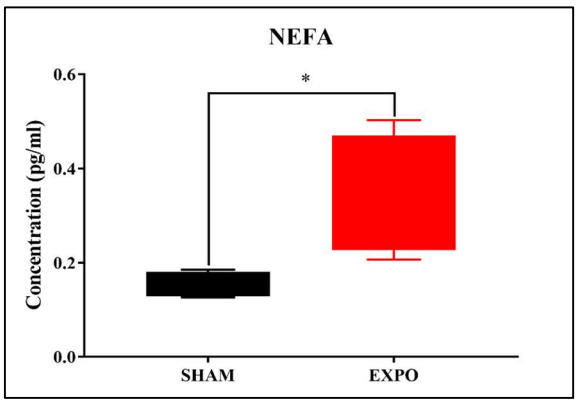

Figure 8. Plasma concentration of free fatty acids (NEFA) in the SHAM and EXPO groups. (Mean ± SEM; N=4/4).

4 Discussion and conclusion

These findings indicate that 900 MHz RF exposure at non-thermal levels produces physiological effects on thermal regulation in both studied species, mice and rats, resembling reactions to cold. The result with TRPM8 antagonist shows that the TRPM8 receptor is modified after exposure and suggests that this receptor is involved in the effects on temperature regulation, but their role and the connected biological and physiological mechanisms in RF-induced responses remain to be further explored.

6 Acknowledgements

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7 References

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