The study of thermoregulatory vasodilation of blood vessels by imaging photoplethysmography

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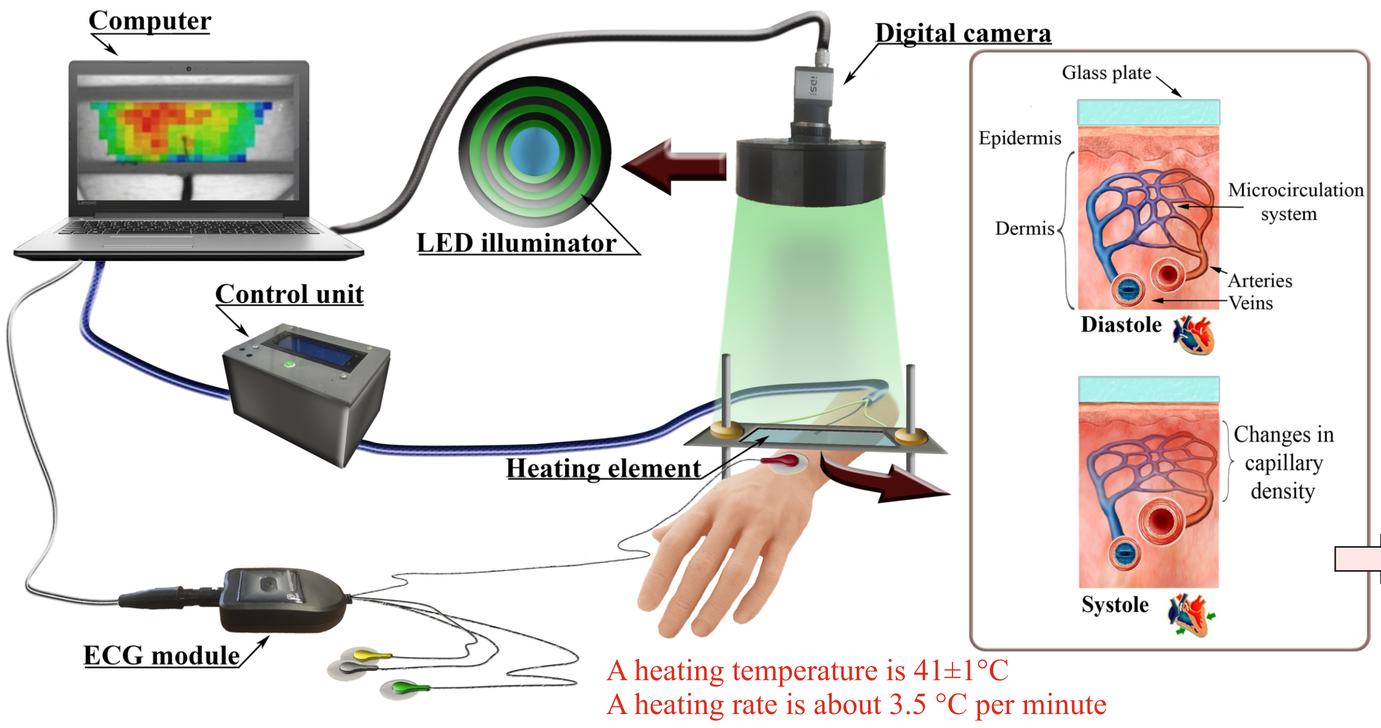

The vascular endothelium regulates vessel tone through the release of vasoactive substances such as nitric oxide (NO), prostacyclin, endothelial hyperpolarizing factors, and vasoconstrictors. Assessment of the vasodilatory properties associated with NO production, can provide information on the integrity and functional reserve of the endothelium, and has an important prognostic value for determining the causes of the disease and treatment outcomes.

The light modulation at the heart rate occurs by a mechanical change in the density of capillaries in the dermis due to pulsations of nearby arteries and arterioles.

Kamshilin A.A., et.al. A new look at the essence of the imaging photoplethysmography. Scientific Reports. - 2015. - Vol. 5. - p. 10494.

Figure 1. *Schematic of the multimodal system for assessing blood perfusion during the local heating. Measuring system consisted of three computer-controlled modules (iPPG, heating, and ECG).*
Kamshilin, A.A., et.al. Novel Method to Assess Endothelial Function via Monitoring of Perfusion Response to Local Heating by Imaging Photoplethysmography. Sensors. - 2022. - 22(15). - 5727.

The beginning of each pulse of the photoplethysmography (PPG) signal is aligned with the corresponding R-peak of the ECG to obtain a reliable pulse wave signal. The amplitude of light modulation at the heart rate (amplitude of the pulsatile component, APC) characterizes the local perfusion of the area under study and is defined as the difference between the maximum and minimum values of the photoplethysmography signal.

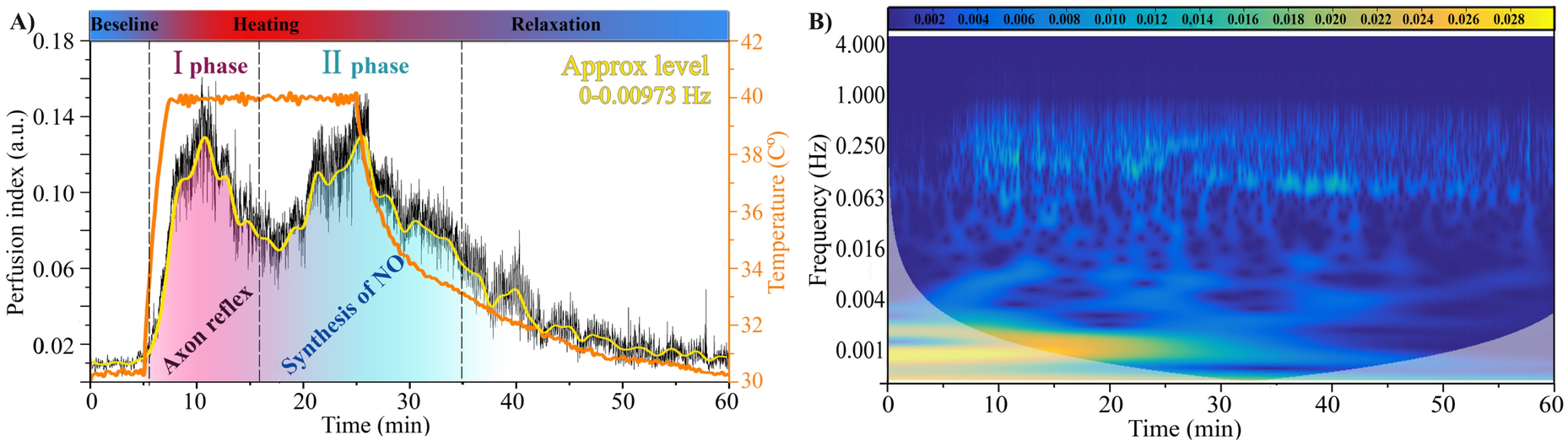

Figure 2. *A) The variations of the perfusion amplitude. The pink color shows the first phase of the perfusion response caused by the axon reflex in response to reactive heating; blue color shows the second phase due to the activation of the endothelial component during vasodilation with NO production. B) Scalogram of the APC signal.*

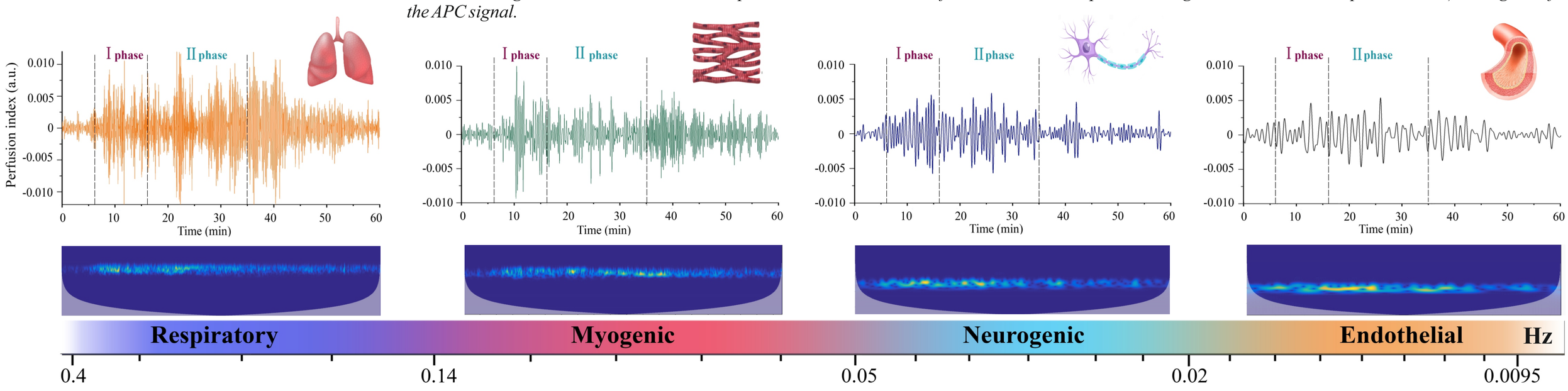

Figure 3. *The frequency series of APC signal corresponding to various mechanisms of blood flow regulation: respiratory, myogenic, neurogenic and endothelial. The APC signal was normalized to the trend line (Approx level, yellow curve Figure 2.A.) and analyzed in the wavelet basis.*

Twenty-two non-smoking volunteers, men (control group) and twenty-two volunteers, men with different smoking status were examined (Table 1).

SMOKING VOLUNTEERS			
	Age, years	Body Mass Index	Kmax, a.u.
AVERAGE VALUE	48.32	28.18	7.71
RMSD	10.36	4.69	3.35
NON-SMOKING VOLUNTEERS			
	Age, years	Body Mass Index	Kmax, a.u.
AVERAGE VALUE	45.16	28.04	7.99
RMSD	24.41	3.53	3.03

Table 1. *Characteristics of subjects participating in the study.*

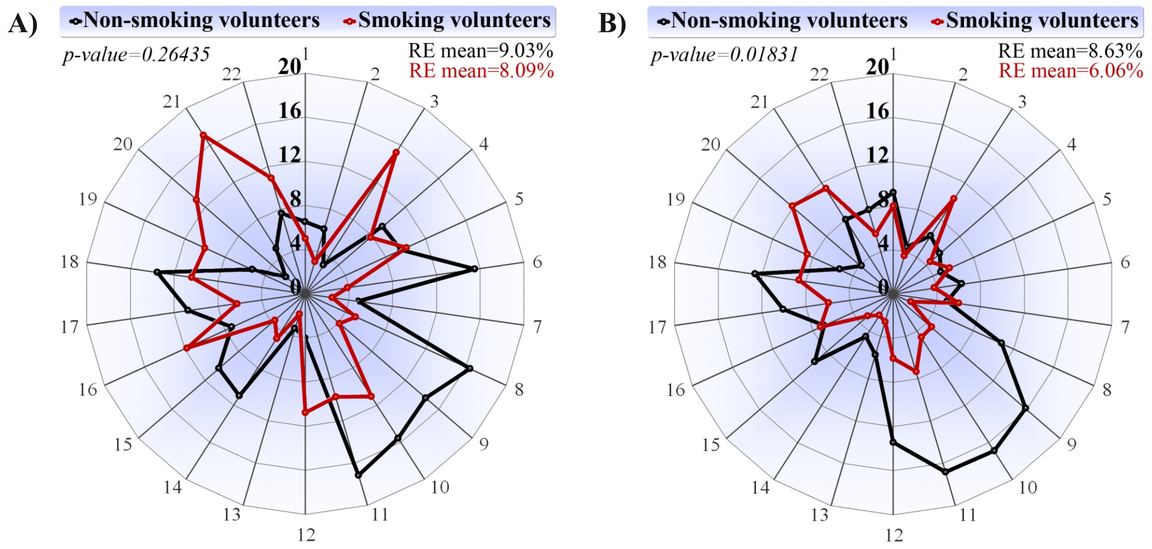

Figure 4. *Relative energy distribution diagram for the first (A) and second (B) phases.*

The difference in the value of the average level of relative energy (RE_{mean}) of endothelial fluctuations for the selected groups of volunteers was revealed. It was found that in case of smoking the RE_{mean} value is lower than in the control group in each phase of the perfusion response. However, the difference was statistically significant (Wilcoxon signed-rank test, p-value = 0.02) only for the second phase, which indicates that the smoking factor leads to a decrease in endothelium-dependent vasodilation due to insufficient NO production in case of smoking. This can be used as a diagnostic indicator of disturbances in certain regulatory mechanisms of the microcirculatory system.

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