OPTICAL NON-INVASIVE DIAGNOSTICS OF MICROCIRCULATORY DISORDERS IN PATIENTS WITH DIABETES

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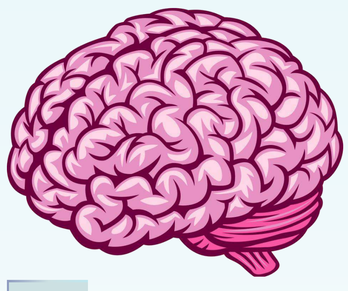
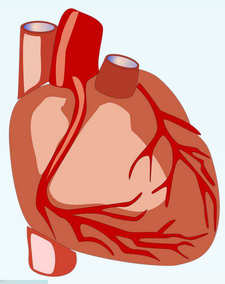
THE PROBLEM OF MICROCIRCULATORY COMPLICATIONS IN DIABETES

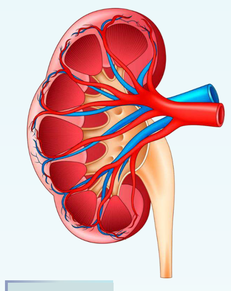
1 in 11 adults have diabetes (425 million)



Brain Increased risk of stroke and cerebrovascular disease (transient ischemic attack, cognitive impairment).

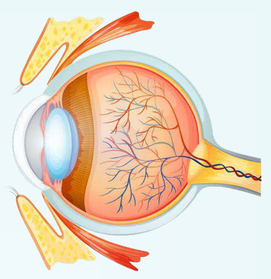


Heart High blood pressure and insulin resistance increase risk of coronary heart disease.

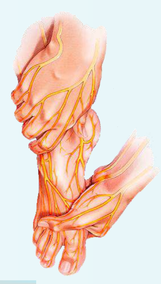


Kidneys Excess blood glucose overworks kidneys, resulting in nephropathy.

Nerves Damaged nerves result in pain and numbness, feet wounds may go undetected and lead to gangrene.



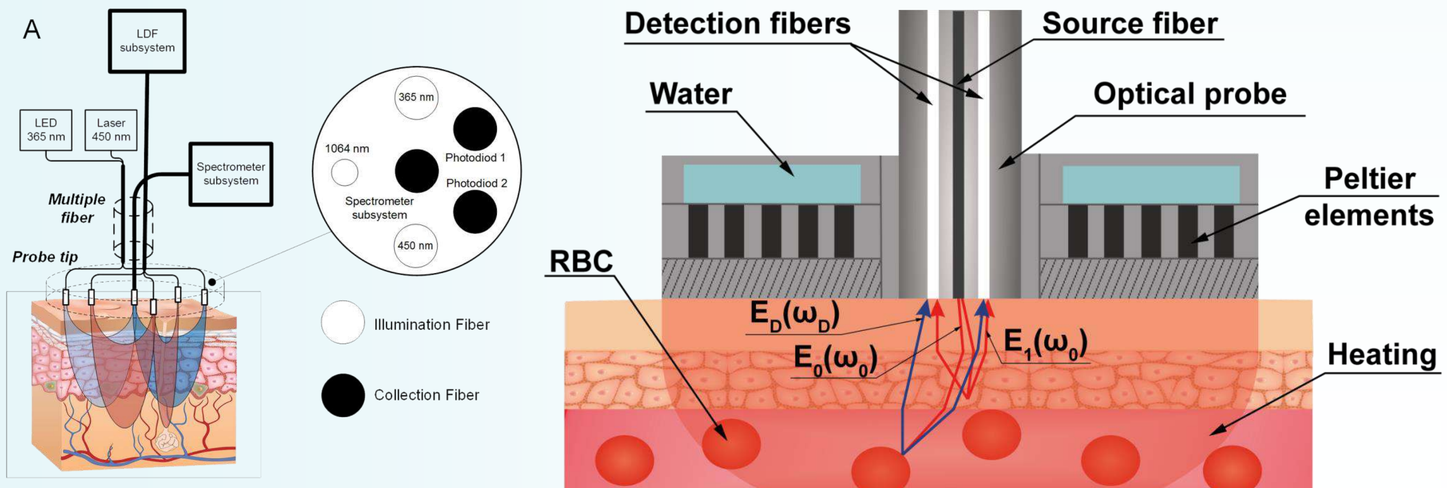
Eyes Damaged eye blood vessels cause retinopathy, cataracts and glaucoma.



Limbs Peripheral vascular disease results from narrowing of blood vessels.

MATERIALS AND METHODS

Measurements were carried out on 76 patients diagnosed with diabetes and 46 healthy volunteers.

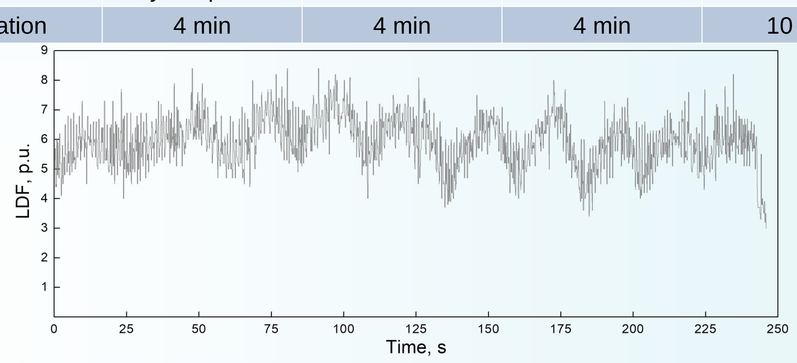


The principle of measurement

LDF signal was decomposed using a wavelet transform: $W(\nu,\tau) = \nu \int_{-\infty}^{\infty} f(t)\psi^*(\nu(t-\tau))dt$, where * means complex conjugation. The Morlet wavelet written in the form $\psi(t) = e^{2\pi i t} e^{-t^2/\sigma}$ was used for the decomposition with the decay parameter σ = 1.
Integrating the power over time gives the global wavelet spectrum: $M(\nu) = \frac{1}{T}\int_0^T |W(\nu,t)|^2 dt$.

Research method using temperature tests

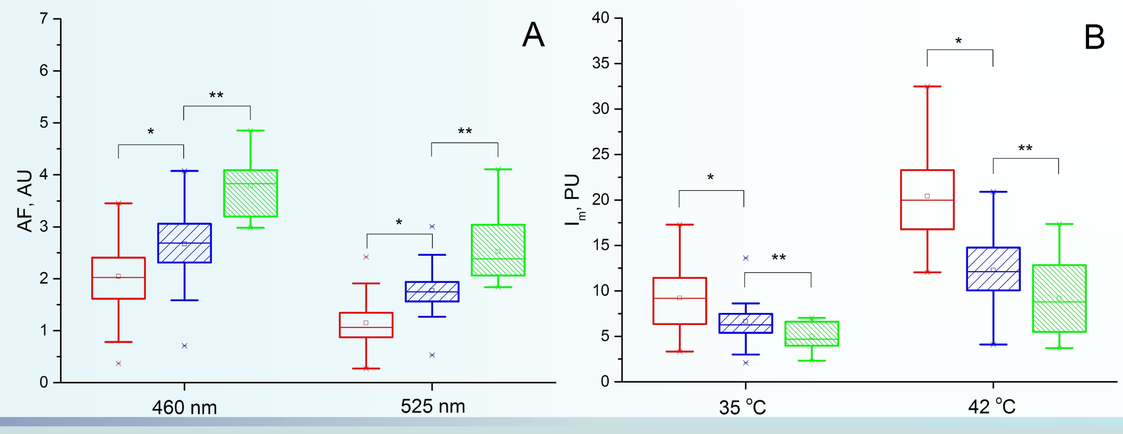
№ of stage	1	2	3	4
Methods	FS+LDF	LDF	LDF	LDF
T, ^oC	Body temperature	25	35	42
Duration	4 min	4 min	4 min	10 min



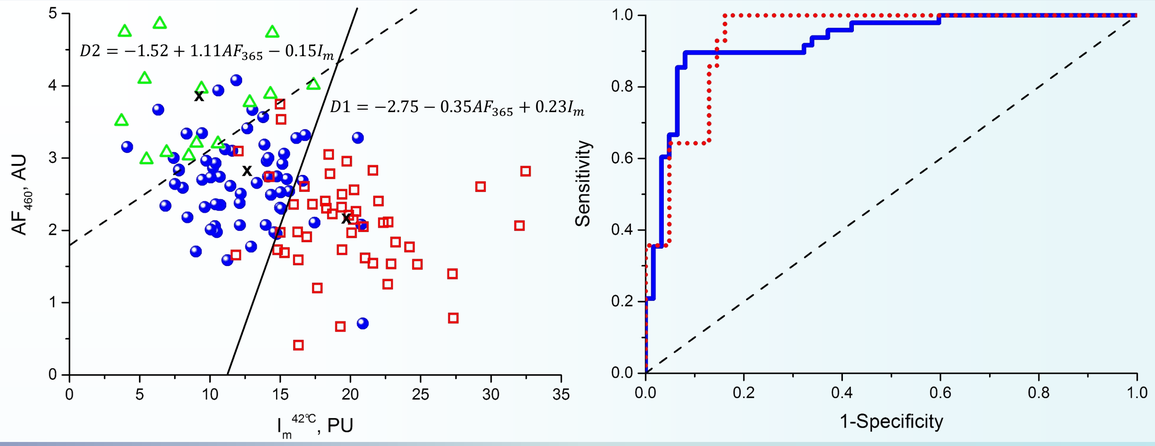
The typical view of the LDF signal for a 4-minute recording

Spectral ranges of the oscillations in fine structure of capillary blood flow:
- Pulse band (0.6-2 Hz) – heart activity;
- Respiratory (0.145-0.6 Hz) – movement of the thorax;
- Myogenic (0.052-0.145 Hz) – vascular smooth muscle cells reaction;
- Neurogenic (0.021-0.052 Hz) – sympathetic vasomotor activity;
- Endothelium vascular tone regulation (0.0095-0.021 Hz).

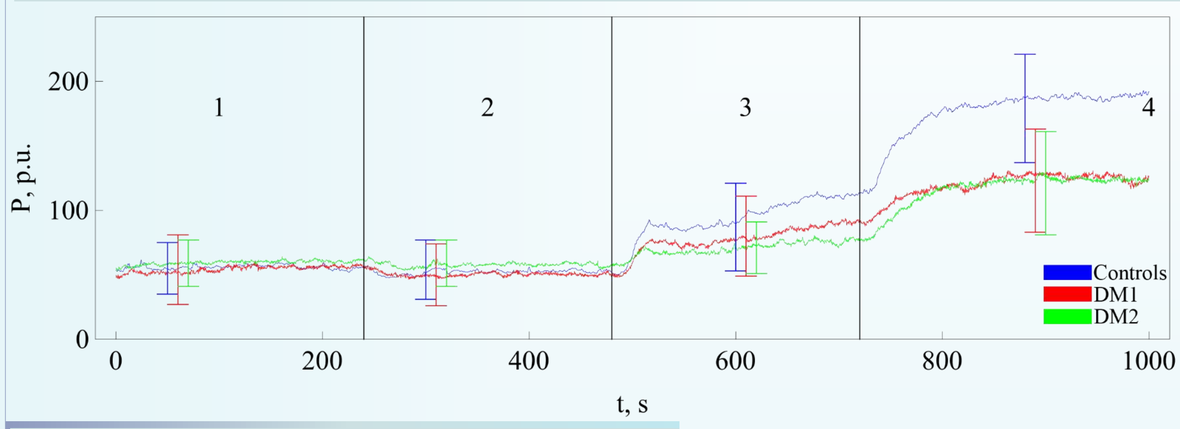
RESULTS AND DISCUSSION



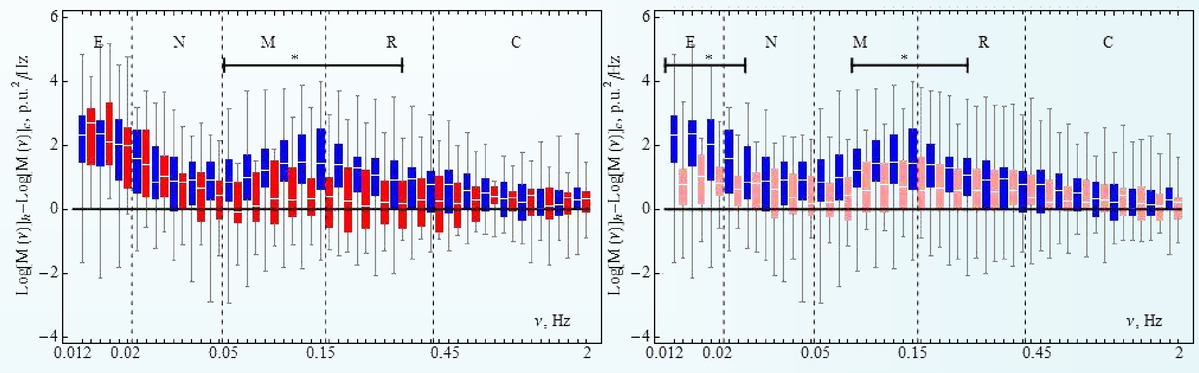
Normalized fluorescence amplitudes (A) and the average perfusion in the stages of heating to 35 and 42 ^oC (B) for control (empty red bars), diabetic (loose blue shading) and diabetic with ulcers (tight green shading) groups.



The scatter plot with applied discriminant lines (A) and ROC-curves (B). Squares correspond to the control, circles – diabetic, triangles – diabetic group with ulcers.



Dynamics of perfusion averaged over all measurements



Variation of the spectral energy (M(v)h −M(v)b) of LDF records caused by the heating up to 35 °C. Blue areas correspond to the control groups, red – patients with diabetes mellitus type 1, light red – patients with diabetes type2.

CONCLUSIONS

- Reduced perfusion growth under heating in patients indicates violations in mechanisms regulating vasodilation. Increased fluorescence intensity in patients in comparison to control group may indicate disorders in tissues oxidative metabolism.
- The use of the proposed diagnostic method may be useful in accessing of treatment effectiveness in diabetic subjects.

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