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VARIATIONS IN THE SPECTRAL CHARACTERISTICS OF BLOOD FLOW UNDER THERMAL TEST IN DIABETIC PATIENTS

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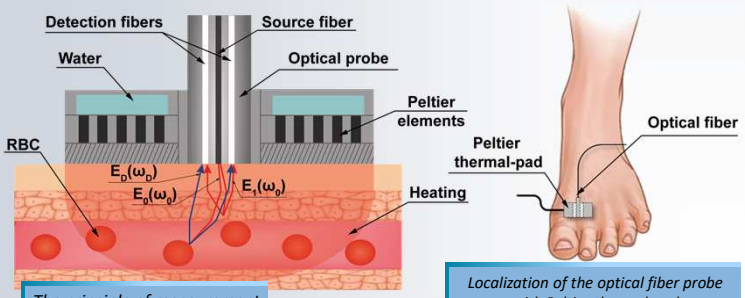
INTRODUCTION

The diabetic foot syndrome is one of the most serious complications of diabetes mellitus (DM), which reduces the quality of life and even leads to amputation at later stages. The study of the blood microcirculatory system functional state in the lower limbs of patients allows one to detect microvasculature functional abnormalities in the earlier stages. The skin blood flow can be assessed using various optical non-invasive technologies. The laser Doppler flowmetry (LDF) is one of the widely used.

EXPERIMENTAL METHOD



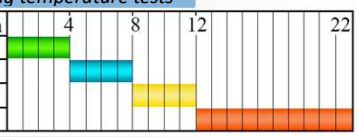
The principle of measurement

Localization of the optical fiber probe with Peltier thermal-pad

The study involved 17 patients with DM type 1 (DM1) and 23 patients with DM type 2 (DM2). The control group consisted of 40 healthy volunteers with no diagnosed diseases of the circulatory system, musculoskeletal system or connective tissue.

Research method using temperature tests

№	Test	Temperature	Duration, min
1	Basic test	–	4
2	Cooling	25°C	4
3	Heating	35°C	4
4	Heating	42°C	10



LDF signal was decomposed using a wavelet transform:

$$W(\nu,\tau) = \nu \int_{-\infty}^{\infty} f(t)\psi^*(\nu(t-\tau))dt,$$

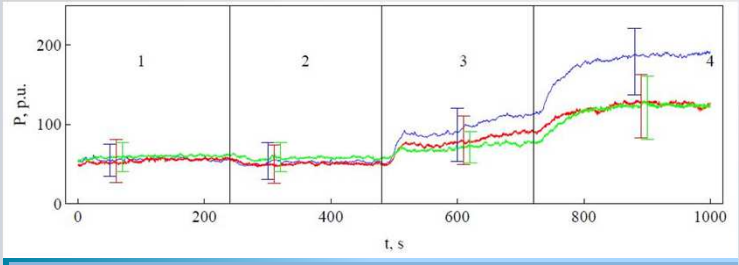
Where * means complex conjugation. The Morlet wavelet written in the form

$$\psi(t) = e^{2\pi i t} e^{-t^2/\sigma}$$

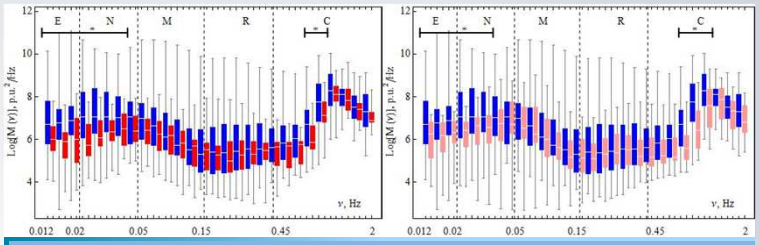
was used for the decomposition with the decay parameter σ = 1. Integrating the power over time gives the global wavelet spectrum

$$M(\nu) = \frac{1}{T}\int_0^T |W(\nu,t)|^2 dt.$$

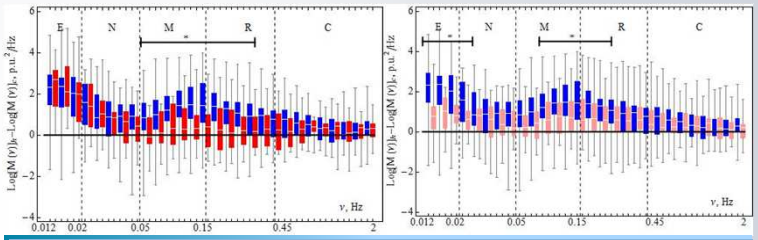
RESULTS



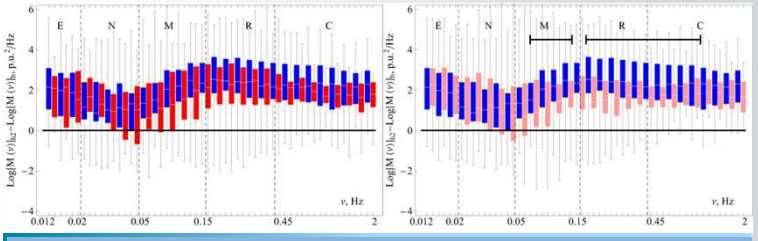
Dynamics of perfusion averaged over all measurements(blue - controls, red - patients with DM1, green - patients with DM2).



Averaged spectra of LDF samples in basal conditions. Blue rectangles – control group, red - diabetic patients (type 1 on the left panel, type 2 – on the right).



Variation of the spectral energy $(M(\nu)_h - M(\nu)_b)$ caused by the heating up to 35 ℃.



Variation of the spectral energy $(M(\nu)_h - M(\nu)_b)$ caused by the heating up to 42 ℃.

DISCUSSION

- Even in rest conditions, there is a significant difference in the microhaemodynamic parameters of healthy and pathological subjects.
- Vasodilation and its rate were impaired in DM patients in comparison with controls.
- Patients with DM have impaired low frequency vasomotions (0.01-0.05 Hz), that is the consequence of endothelial dysfunction and arterial stiffness increasing.
- The difference in the blood flow oscillations associated with cardiac activity indirectly characterizes vessels elastic properties and indicate rising arterial stiffness of diabetic patients.
- Lower values of NO mediated vasodilation in DM patients are associated with the endothelial dysfunction.

CONCLUSION

The proposed approach allows one to establish a difference of microhaemodynamic parameters of healthy people and patients with DM, as well as in groups of patients with DM1 and DM2. The use of the proposed diagnostic method may be useful in accessing of treatment effectiveness in diabetic subjects.

ACKNOWLEDGEMENTS

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