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Investigation of Doppler spectra of laser radiation scattered inside hand skin during occlusion test

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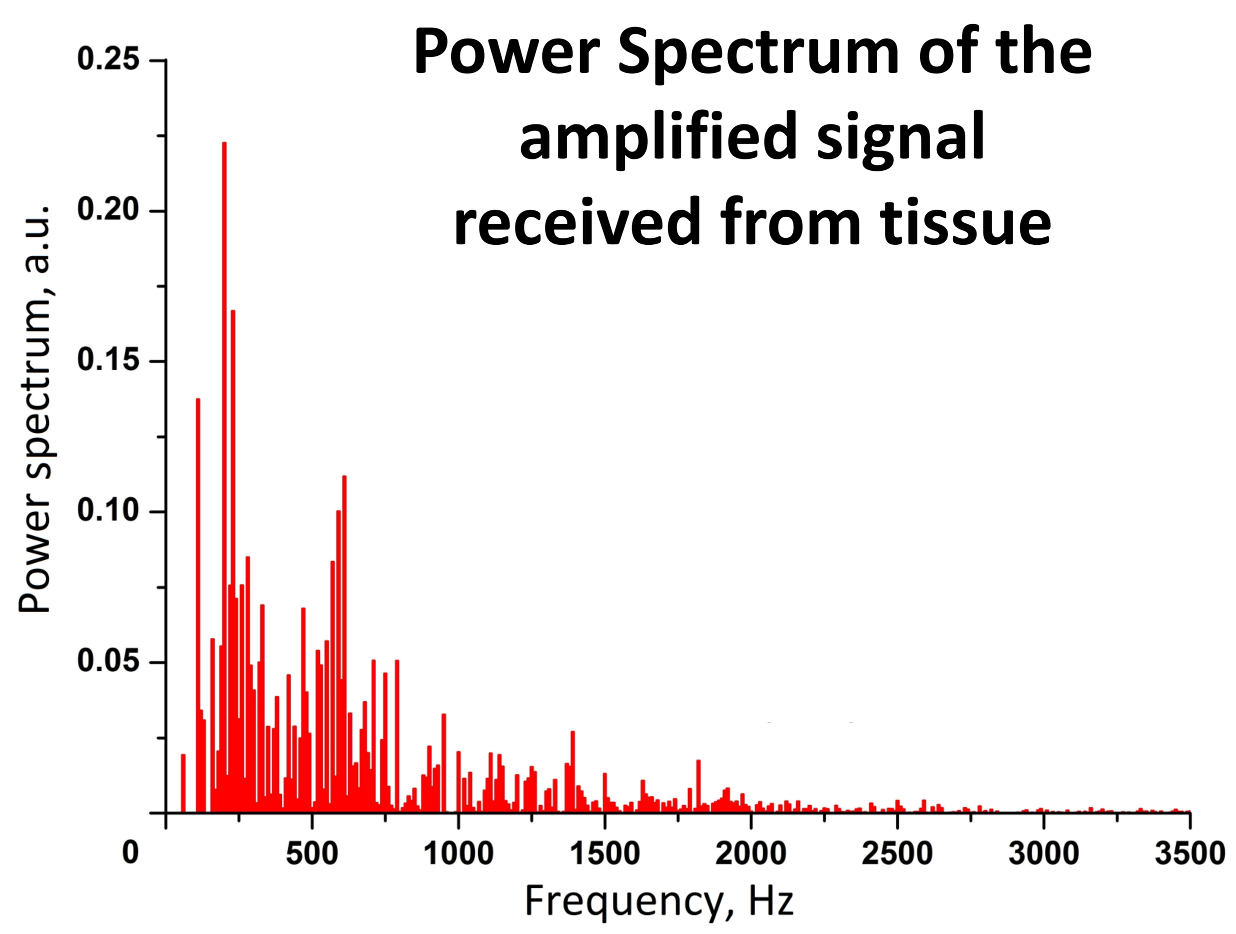
Introduction



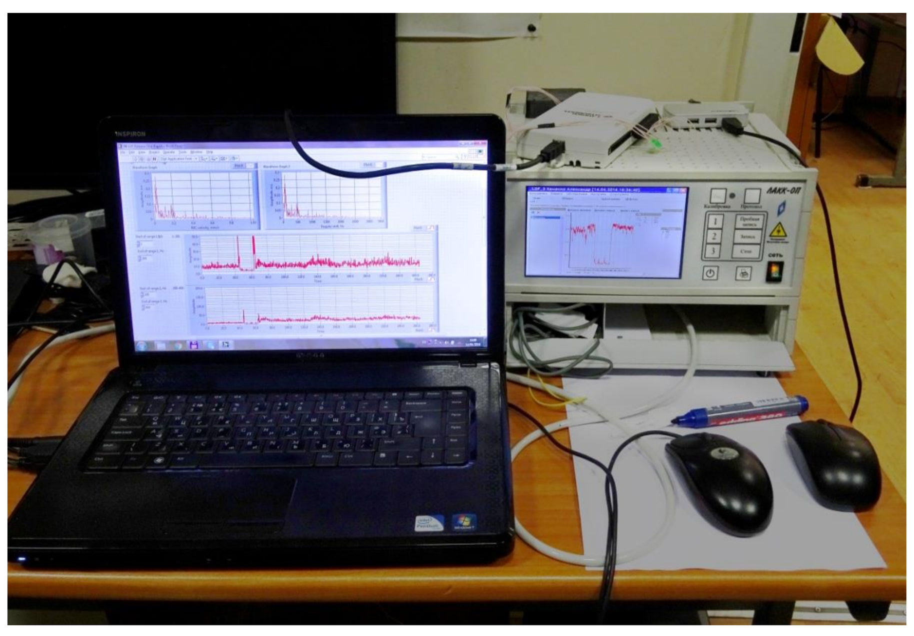
Power Spectrum of the amplified signal received from tissue

Laser Doppler flowmetry (LDF) is method widely used in diagnosis of microcirculation diseases. It is well known that information about Doppler spectrum of the laser radiation scattered by moving red blood cells (RBC) usually disappears after signal processing procedure.

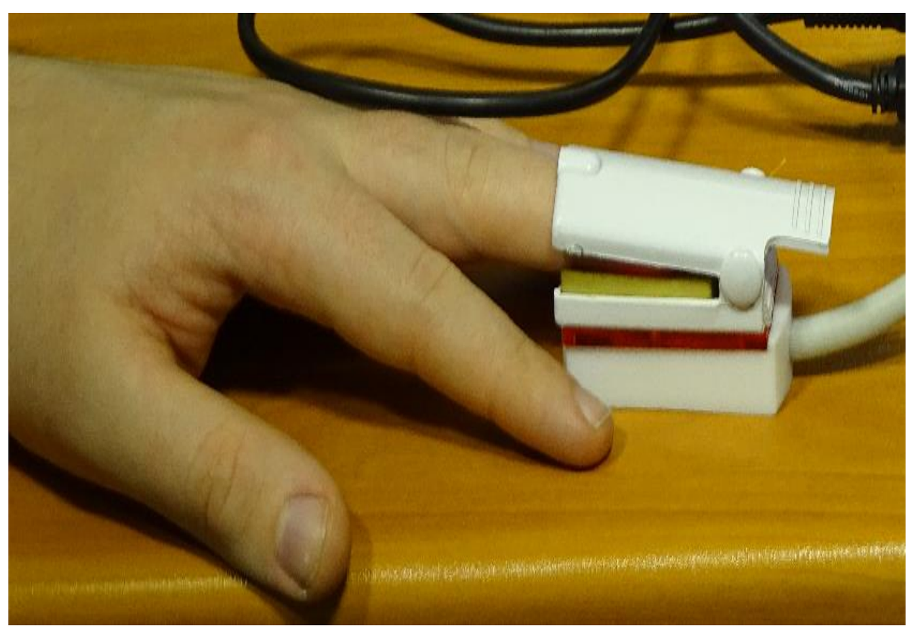
Photocurrent's spectrum distribution contains valuable diagnostic information about velocity distribution of the RBC. In this research it is proposed to compute the indexes of micro-circulation in the sub-ranges of the spectrum.

Experimental setup

Laser Doppler flowmetry setup based on "LAKK-OP" device and custom electronic board



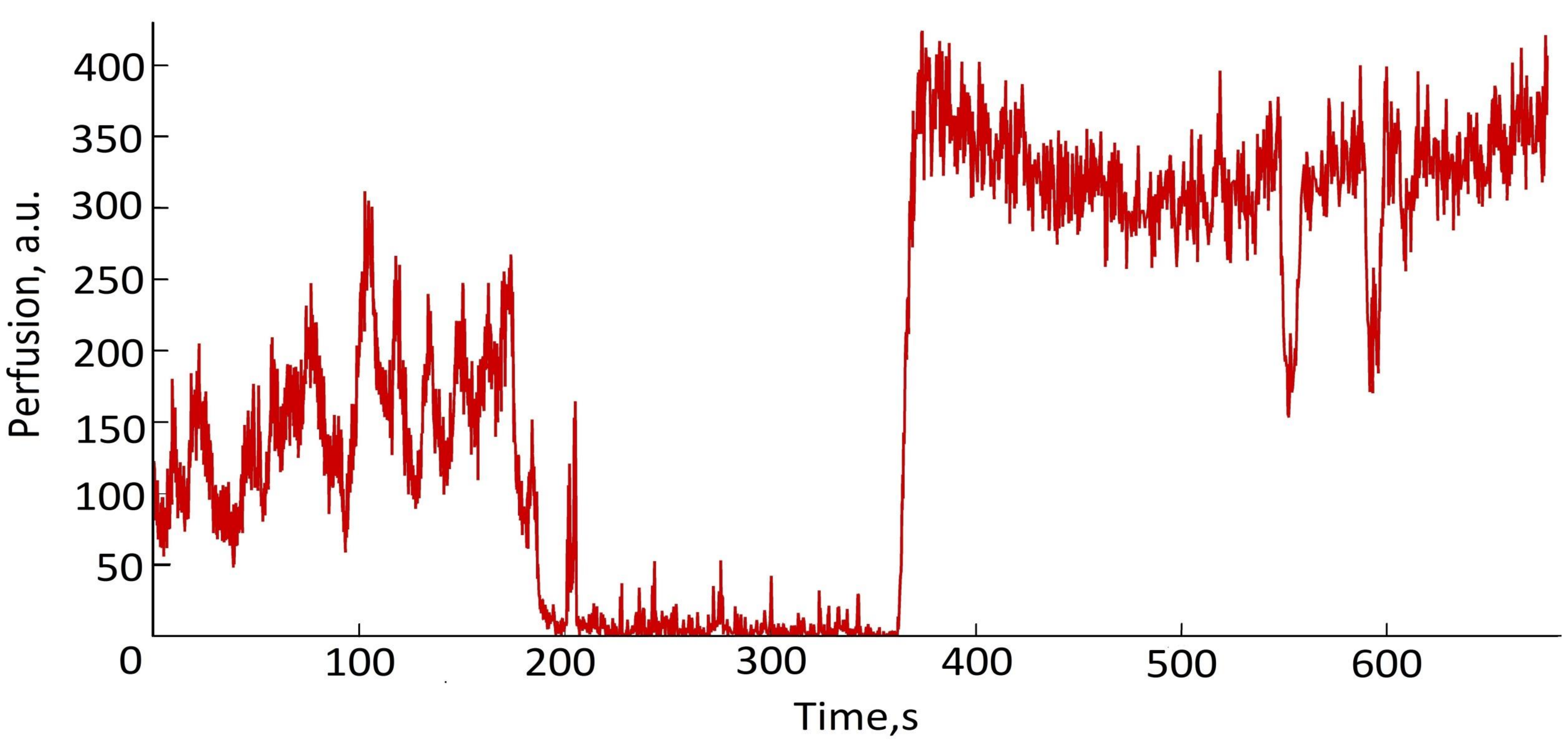
LDF-probe, placed on middle finger of left hand



Appropriate hardware and software were developed. Single mode 1064 nm laser was selected as the source of sounding radiation. Optical fibers were used to deliver radiation to the skin and to collect backscattering light. In the next step, the signal is amplified in a custom electronic board. Analog-to-digital conversion was performed by data acquisition board NI USB 6211. Finally, NI LabVIEW environment installed on PC was implemented for signal processing.

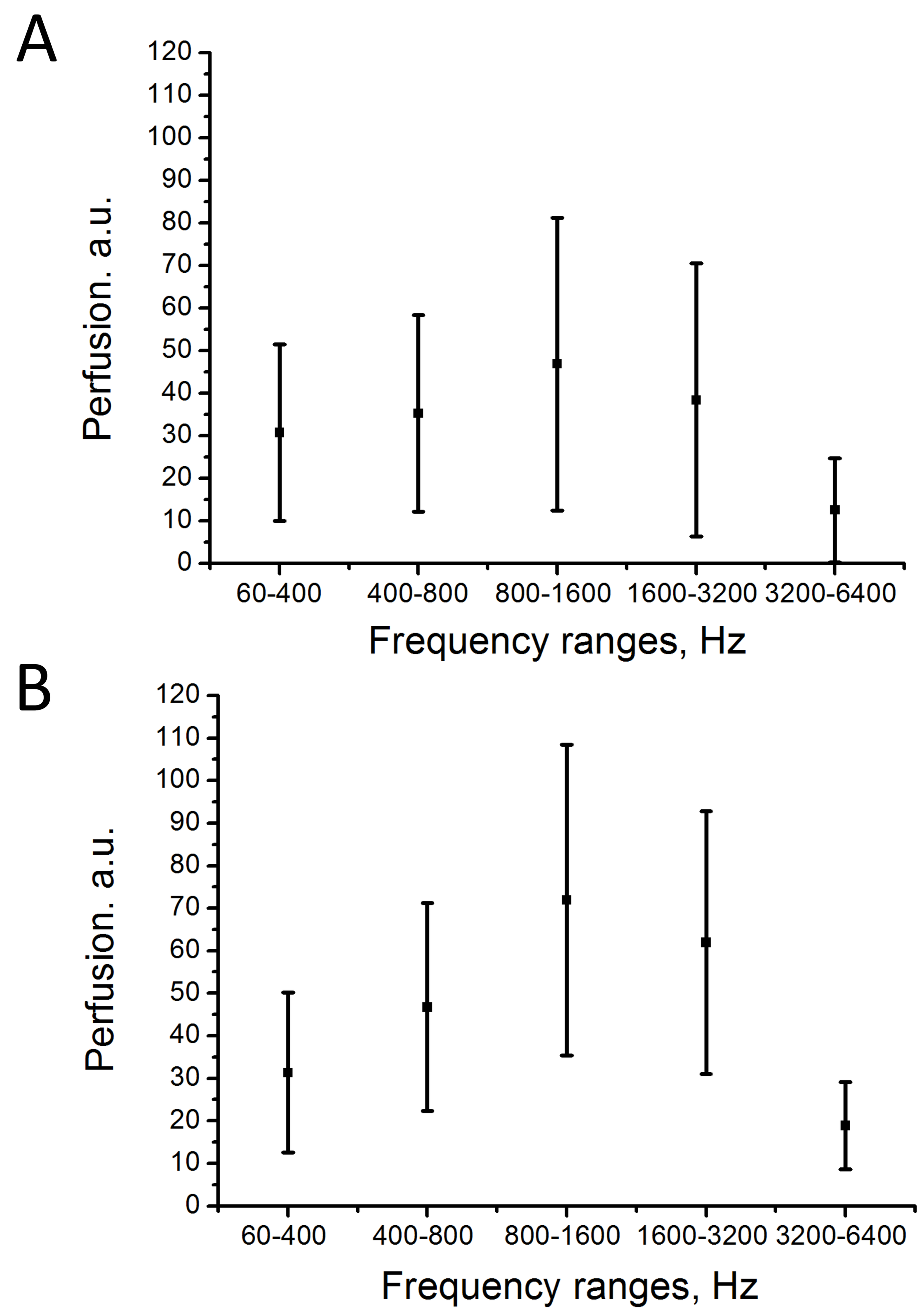
Experimental study

During the fourteen experiments simultaneously obtained parts of power spectra from finger in consecutive frequency ranges 60 – 400 Hz, 400 – 800 Hz, 800 – 1600 Hz, 1600 – 3200 Hz, 3200 – 6400 Hz were processed. Every experiment was conducted following the protocol: recording of the background level of perfusion (3 min); occlusion test (3 min); post-occlusion recording (5 min). Experiments involved only healthy volunteers.



LDF-gram of occlusion test

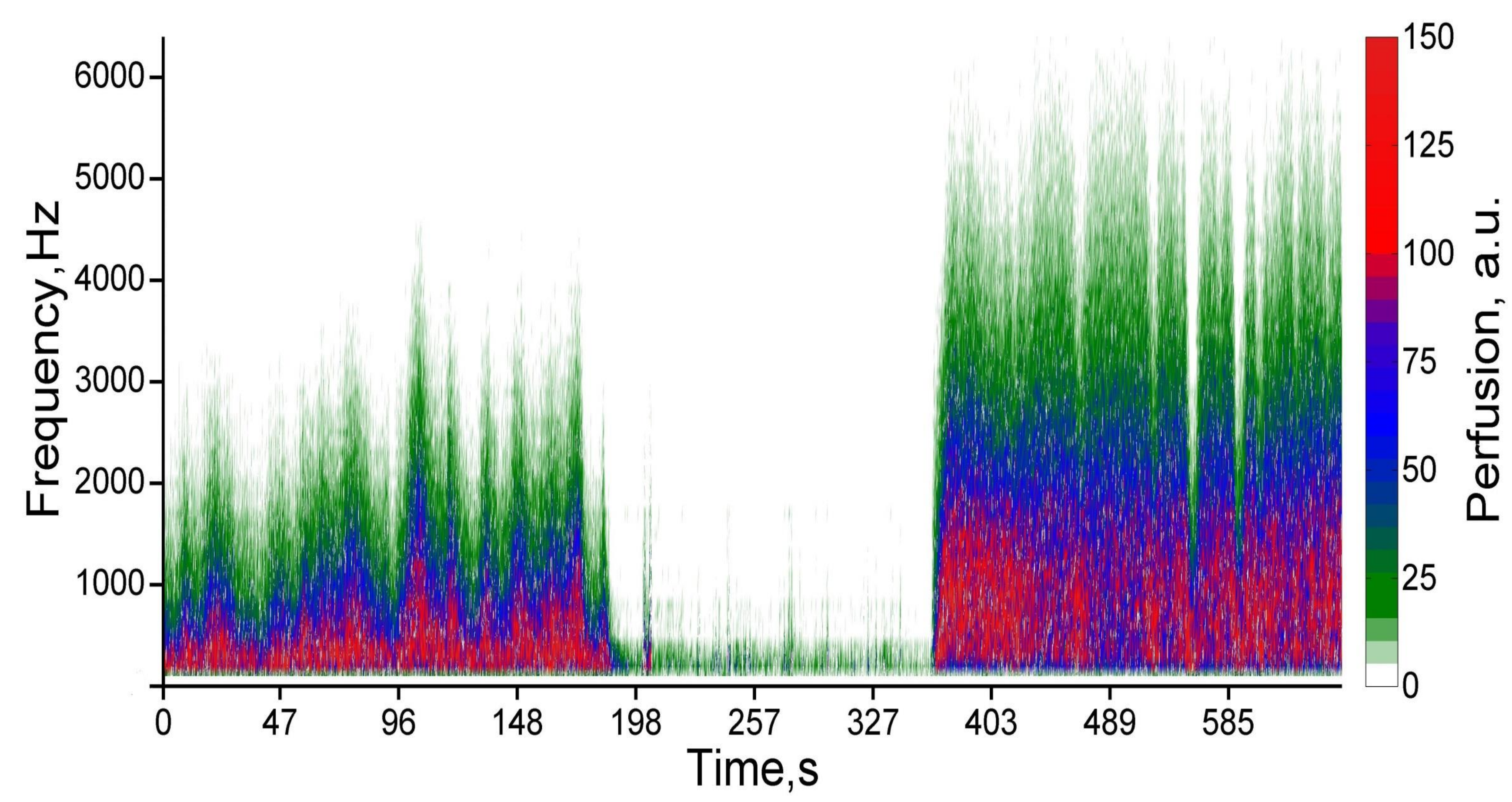
Results and Discussion



Means and standard deviations of perfusion calculated in sub-ranges:
A – pre-occlusion period;
B – post occlusion reactive hyperaemia

Processing of the obtained experimental data has shown that at the moment of the post-occlusion reactive hyperemia (PORH), Doppler power spectrum undergoes broadening and the spectrum maximum shifts to the high-frequency ranges. This effect can be explained by increasing number of ensembles of RBC with higher velocity in the optical sampling volume of the skin. The main statistical parameters (mean and standard deviation) of perfusion alteration during the occlusion test were calculated in the selected spectral ranges of power spectrum integration.

In additional, method of visualisation of perfusion distribution by frequency of Doppler shift was offered.



Visualisation of perfusion distribution on frequency of Doppler shift

Conclusion

As the result of our research we obtained transient dynamics of perfusion distribution from frequency during such provocative factor as occlusion test. Further, experimental studies in the group of patients with microcirculation diseases are planned.

Acknowledgements

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