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APPLICATION OF OPTICAL NON-INVASIVE METHODS TO DIAGNOSE THE VIABILITY OF THE LOWER LIMB TISSUES IN PATIENTS WITH DIABETES MELLITUS

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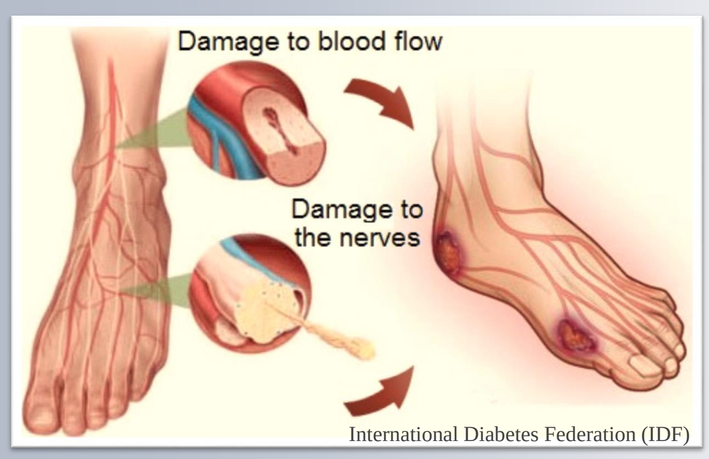
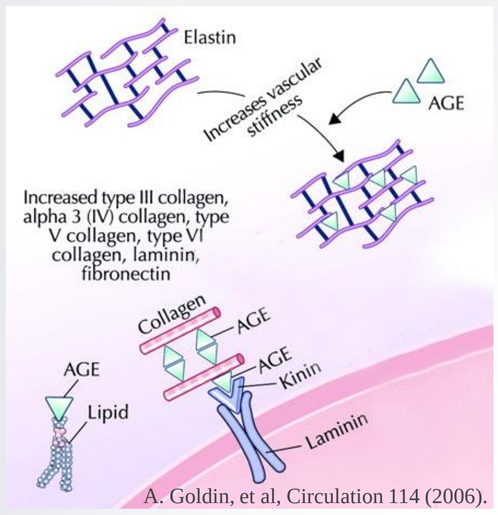
INTRODUCTION

Currently, the problem of diagnosis in the early stages of diabetes mellitus (DM) and its complications, which significantly reduces the life level of patients, is acute. One of the prospective directions in the diagnosis of diabetes complications is the study of the functional state of patient lower limbs by non-invasive optical methods, such as laser Doppler flowmetry (LDF) and fluorescence spectroscopy (FS).



International Diabetes Federation (IDF)

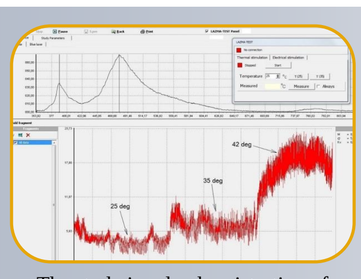


A. Goldin, et al, Circulation 114 (2006).

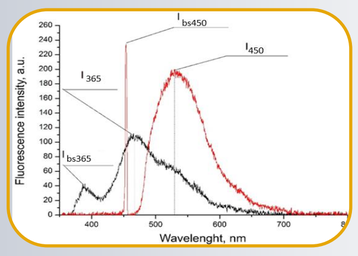
The aim of this work was to evaluate the possibilities of simultaneous application of laser Doppler flowmetry and fluorescence spectroscopy methods for identify at an earlier stages of trophic disorders in the skin feet of patients with diabetes mellitus.

EXPERIMENTAL METHOD

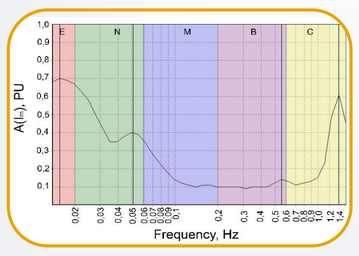
Measurements were carried out on **76 patients** diagnosed with diabetes and **46 healthy volunteers**.



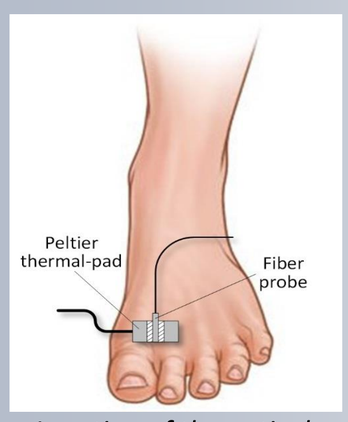
The study involved registration of changes in blood flow and the biological tissue coenzyme fluorescence during 4 of the successive stages.



Permanent registration of the perfusion and a pair of fluorescence spectra at the excitation source with wavelengths of 365 nm and 450 nm were recorded at each stage.



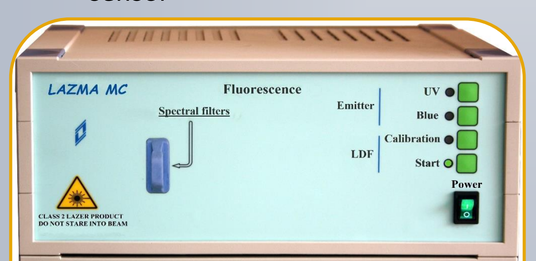
LDF-grams of each phase of the study were subjected to adaptive wavelet analysis by LDF 3.0.2.384 program.



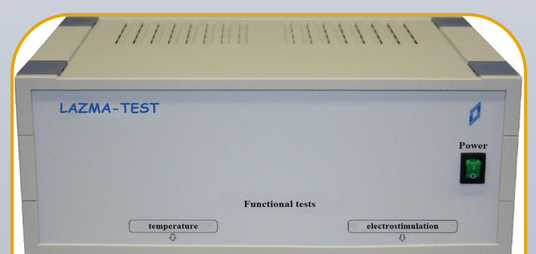
Location of the optical sensor

Research method using temperature tests

№ of stage	1	2	3	4
Name of stage	Basic test	Local cold test	Local heating test	Local heating test
T°C	Body temperature	25	35	42
Duration	4 min	4 min	4 min	10 min

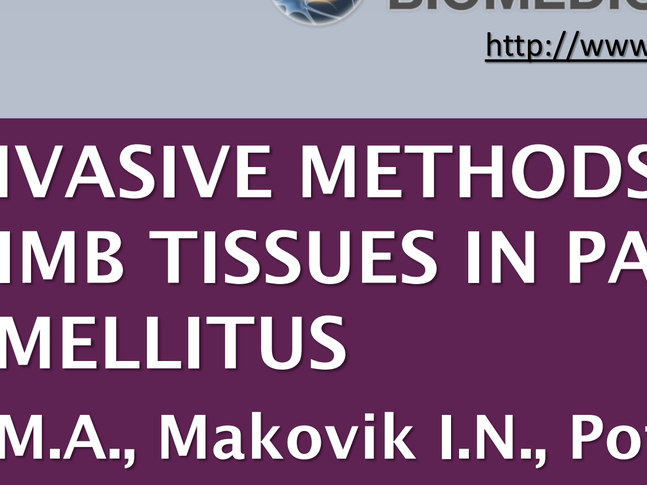


"LAZMA-D"



"LAZMA-TEST"

RESULTS AND DISCUSSION

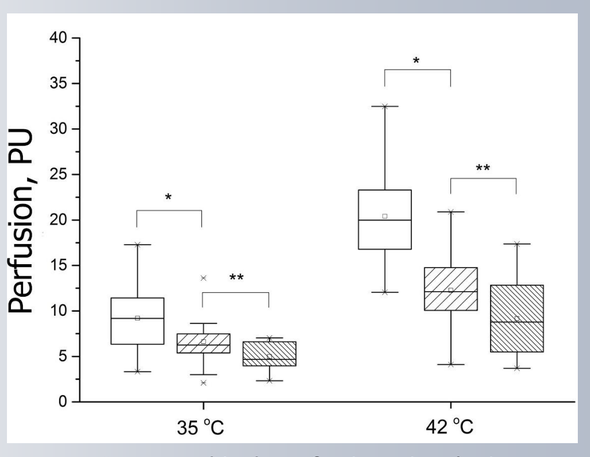


Normalized fluorescence intensity

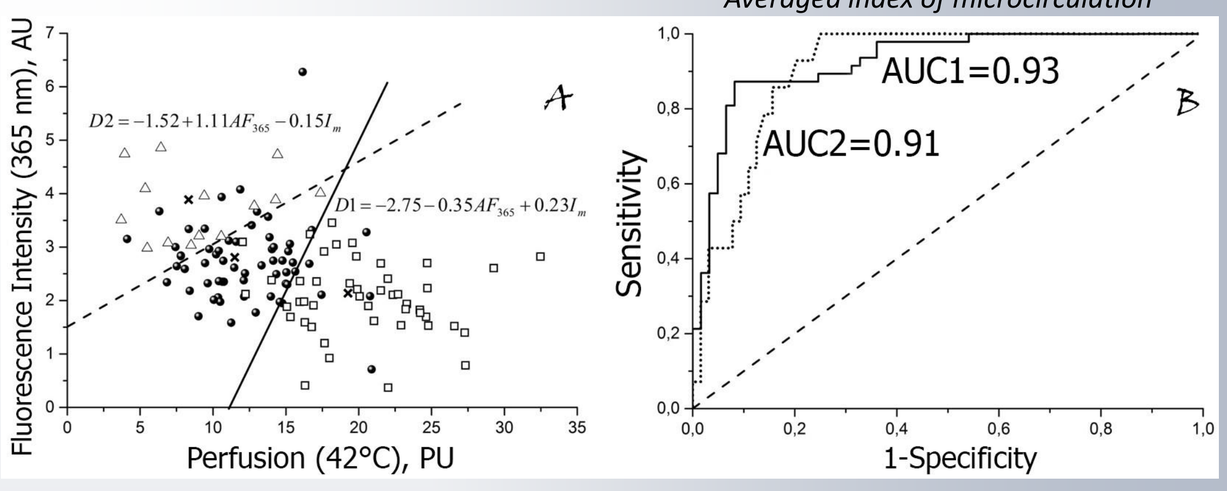
The results of the study revealed that diabetic patients have elevated values of normalized fluorescence amplitudes in comparison with the control group. This increase in fluorescence can be due to the accumulation of advanced glycation end products that may initiate expression of collagen genes and other proteins of the capillary membrane and skin.

- patients without ulcers;
- control group;
- patients with ulcers.

At the same time, rate of the perfusion and nutritive blood flow upon heating to 35 and 42° C for patients are statistically smaller. It may indicate sensory nerve fibers dysfunction and deficit of endothelium-dependent vasodilation mechanisms. The immediate diagnostic criterion is the classification model (discriminant function) that allows us to classify the functional state of the diagnosed region.



Averaged index of microcirculation



The results of linear discriminant analysis (a) and ROC-curves for assessing the effectiveness of discriminant analysis (b)

The fact that the experimental data can be grouped, means that variations in indicators of biological tissue disorders (skin fluorescence and perfusion) relative to the control group, are sufficiently reproducible and similar for all patients. The value of area under ROC-curve equal to 0.91-0.93 indicates a good quality of classification model.

CONCLUSIONS

- The combined use of LDF and FS methods and the use of wavelet transform in the analysis of LDF-grams allows us to predict the development of trophic disorders and diabetic foot syndrome in the early stages.
- The proposed methodology allows us also to determine possible causes of disorders, by evaluating adaptation processes during thermal tests and by comparing them with the results obtained in the control group.

ACKNOWLEDGEMENTS

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