INTRODUCTION

The importance of the adiposity as a significant risk factor for an unfavourable cardio-metabolic profile, is rapidly increasing, manifesting as the arterial stiffening and thickening of the arterial intima-media layer, on young, asymptomatic persons.

There is a number of techniques for body composition assessment in clinics and in field-surveys, but in both cases the applied methods have advantages and disadvantages. High precision imaging methods are costly and non-portable, while those devised for the mass population often suffer from the lack of precision.

Subcutaneous adipose tissue (SAT) thickness measurement with optical methods potentially could provide convenience and high accuracy. The different kinds of human tissue, such as adipose tissue, skeletal muscle and skin, have a different light interaction properties at different wavelengths [1]. A few studies have been performed exploiting single wavelengths with the similar methodology using live tissue and phantoms [2,3,4].

The aim of the study was to develop and evaluate a multispectral prototype device for non-invasive SAT assessment.

METHODS

The study consisted of two stages: the first, where a device prototype, emitting a light of a single wavelength of 660nm was created and tested, and the second, a development of a multispectral device that illuminates the skin and the underlying tissues with four wavelengths – 670nm, 770nm, 870nm and 940nm.

The thickness of SAT was examined on four body sites: the upper and lower abdomen, the biceps and the triceps. Data readings were performed multiple times on all sites during the measurement, to test the replicability and stability of the signal.

In both cases the operating principles of the proposed device are based on the light-tissue interaction and on the principle that the penetration depth increases with greater source-detector (SD) distance. The prototype system consisted of three major components: a sensor probe, a processing module and a data acquisition system. The probe contained three light sources (single or multiple wavelengths) situated at different distances (SD1, SD2, SD3) from a photodetector.

Healthy, young female students (BMI 22±3.5 kg/m²; age 22±2 years) participated. The backscattered light signal was captured by a photo-detector and amplified. It consisted of signal peaks, each 150mks long, that correspond to the backscattered light intensities (SD1, SD2, SD3) detected by the PD from LEDs set on respective SDs, and were separated by a dark stage, when LEDs were switched off. For the data analysis using the single wavelength method the ratios between these intensities were calculated – R1, R2 and R3.

The B-Mode ultrasound imaging has been selected as a referent method for the SAT thickness measurement [5], thus the computed values were compared with those obtained by the reference.

RESULTS

The power of LEDs’ emitted light was set so that from the light source at SD1, it was the lowest and at SD3 it was the highest, in order to provide sufficient light penetration depth in the underlying tissues. The tendency was ascertained that in the event of thick SAT layer, when a single wavelength method was used, the backscattered light intensity from SD is lower than that from SD3, but when the SAT thickness is lower, the trend tends to be opposite.

Our results also showed a high correlation between the intensity ratios and the corresponding SAT thicknesses for the lower abdomen and the biceps (r1=0.67, r2=0.83, r3=0.80 and r2=0.70, r3=0.81 and r2=0.87, respectively). For the upper abdomen this correlation was lower (r1=0.66, r2=0.66, r3=0.64) which might indicate the effect of the respiratory cycle, as during breathing the thickness of SAT changes rhythmically. On the triceps it was mostly not significant, and that demonstrates the influence of the pressure, imposed by the operator on the probe. Therefore, in future measurements, the probe contact force, and the subject respiratory cycle must be taken into consideration to avoid the artifacts.

The lowest intensity of the backscattered light was that of the 660nm, as expected, and that indicates on a quite poor penetration depth into SAT, when compared with 770nm and 870nm, as the intensity, and light penetration as we may conclude, is substantially higher, which is especially pronounced on sites, where SAT thickness is higher. The intensity of the backscattered light was lower for the 940nm, despite it being a near-infrared wavelength. The reason behind it is that fat is highly absorbing in that wavelength, and its absorption maximum is at 930nm – close to that used in the current study.

CONCLUSIONS

The experimental outcome demonstrates that with the optical systems used in this study, the thickness of SAT can be obtained. It implies a further potential for employment of multispectral optical systems, by combining the intensities and calculating ratios between, to observe changes of SAT thickness as well as to determine the percentage of total body fat.

REFERENCES