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Development of a new device to measure different aspects of kidney function

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In this study, we analysed the transcutaneous devices which were used previously for the measurement of GFR in laboratory rodents and identified the common limitations that were encountered by various users. We quantified the occurrences of these adverse events and found significant issues of high and low signals, which were taken into this thesis as the basis and motivation. The new transcutaneous device which has been described in this study aims to solve the described drawbacks. Biomarker dosage errors can make the output signal from the device unfavourable for calculation of half-life of the biomarkers used for function estimation. Thus, the new device has been developed with specific changes in the layout of the optical components along with the electronic capability to tweak the final output signal. This device also has the electronic capability to measure two additional kidney functions (secretion and reabsorption) as opposed to only GFR estimation. The in-corporation of three wavelengths of LEDs establishes the functionality of detecting the clearance of three different biomarkers which are specific to the kidney function being measured. The placement of LEDs at different separation distances from the photodiode along with the dynamic signal amplification improves the quality of the signal. This was confirmed in this thesis with the measurement of oxygenation in the forearm. The measurements were taken with the signal being recorded after il-luminating with different LED rows as described in the previous sections. We analysed the oxygen measurements with LED-photodiode separation ranging from 0.5cm to 4.5cm and demonstrated the capability of the device to get meaningful signals.

In addition to the device layout and electronics, the use of a fixation patch was also examined in this study. The addition of fixation patch has a significant effect on the final signal which is highly dependent on the thickness of the patch used. We used patches of three different thicknesses and found that the increasing thickness causes the signal to reduce its magnitude exponentially. However, we also dis-cussed the crucial benefits and need for the use of such a patch. In addition to providing an even and stable fixation of the device to the skin surface, the patch al-so facilitates insulation from various ambient lights. It also protects the skin surface from direct contact with electronics components.

Successful measurement of oxygenation documented in this study on human forearm and animal experiments establishes the completion of a working device with the possibility of taking into consideration the signal resulting from different depths into the skin based on the chosen LED-Photodiode distance. The three-color (wavelength) LEDs give the basis for the measurement of three kidney functions in the future. In combination with appropriate biomarkers, it should be possible for the de-vice to sequentially (if not simultaneously) measure the secretion and reabsorption in addition to the GFR. The developed windows application can also be modified and used to calculate the half-lives of the biomarkers.