Investigation of Pulse Transit Times (PTTs) utilizing multisite reflectance photoplethysmography under conditions of artificially induced peripheral vasoconstriction

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Heart attack and stroke are the two prominent causes of death worldwide, and are both a direct consequence of increased vascular resistance. In recent times, non-invasive measurement techniques such as Pulse Transit time (PTT) has been used to index these cardiovascular risks. PTT is defined as the time it takes for pressure pulsations to travel between two arterial sites. However, the reliability of PTT as a marker for cardiovascular risks and its inverse relation to beat-to-beat blood pressure is still being investigated.

In order to validate the technique as a reliable marker of vascular resistance, PTT measurements were made using photoplethysmographic (PPG) signals obtained from multiple measurement sites in 12 healthy volunteers undergoing a cold pressor test. The volunteers underwent a right hand immersion in an ice bath (0^{o}C) for thirty seconds. Infrared PPG signals were obtained from both right (RH) and left (LH) hands and the ear canal (EC) [1]. Peripheral temperature of both hands and an electrocardiogram (ECG) were also recorded throughout the study. Offline analysis was performed to measure PTTs using the R-wave of the ECG and the foot of the PPG signals. Mean PTTs were calculated for all locations before, during, and after the ice immersion.

Activation of the sympathetic nervous system during the ice water immersion caused an increase in vascular resistance, which is associated with an increase in mean arterial pressure and a decrease in PTT in all measurement sites. However, the change in PTT was much larger in the RH (195.86 ± 26.3 ms vs 165.61 ± 41.9 ms) when compared to the LH (214.32 ± 37.2 ms vs 191.61 ± 42.1 ms) and the EC (134.06 ± 25.9 ms vs 122.82 ± 23.42 ms). This demonstrates the cerebral flow auto-regulation and the profound peripheral vasoconstriction seen in the RH. After the ice immersion period, the mean PTT measured from the EC (134.06 ± 25.9 ms vs 134.34 ± 32.1 ms) and the RH (195.86 ± 26.3 ms vs 187.36 ± 40.5 ms) returned to baseline, whereas the LH PTT exceeded baseline values (214.31 ± 37.2 ms vs 240.82 ± 48.2 ms). This is due to the local vasodilation resulted from the activation of a thermoregulation mechanism.

From these observations, it is suggested that PTT measurements made using PPGs from different locations can be used as an effective parameter for estimating local vascular resistance and hence as a potential diagnostic tool for cardiovascular diseases.

[1] K. Budidha and P. A. Kyriacou, “The human ear canal: investigation of its suitability for monitoring photoplethysmographs and arterial oxygen saturation, *Physiological Measurement*, 35, 111-128, 2014.