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Video-Based Pulse Arrival Time can track Dynamic Blood Pressure Changes

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Extended Abstract

1. Background

The standard method for non-invasive blood pressure (BP) measurement is the brachial cuff-based method. However, cuff-based BP methods are occlusive and intermittent. Estimating BP from pulse arrival time (PAT) by image-based photoplethysmography (iPPG) using a video from skin is of increasing interest due to the possibility of cuffless and contactless measurement and potential for BP measurement to be built into portable devices such as mobile phones. In recent years, the relationship between PAT extracted from iPPG (iPPG-PAT) and BP has been investigated during stable BP at rest or immediately following a dynamic change in BP (e.g. post-exercise). However, to date, this relationship during continuous BP changes as are encountered in daily life, detection of which is the main aim of such potential devices, has not been investigated. The objective of this study was to quantify the sensitivity of iPPG-PAT to dynamic shifts in BP to assess if iPPG-PAT can indeed track changes in BP.

2. Method

This study investigated the correlation between iPPG-PAT and diastolic BP (DBP) during 1-minute seated rest and 3-minute isometric handgrip exercise to induce a steady BP rise. 15 healthy participants (9 female, 34±13 years) were recruited. Video was recorded from subjects' faces at 30 frames per second using a standard web-camera under ambient lighting conditions with simultaneous measurement of the electrocardiogram and noninvasive finger BP (Peňáz technique). Two iPPG waveforms for each participant were derived from the averaged green channel intensity of two regions: the forehead and cheek. The iPPG intensity, was band-pass filtered between 0.66-3 Hz, corresponding to a 40-180 bpm heart rate range. PAT was calculated from the R-wave of the electrocardiogram to the peak of the iPPG waveform. PAT was also calculated to the foot of the finger BP waveform for comparison. 12 participants completed the handgrip exercise two times giving a total of 27 subsets for finger-PAT and 54 subsets for iPPG-PAT (with two regions of interest, forehead and cheek). A linear mixed model with maximum likelihood was used where subject and subject×DBP interaction were modelled as random effects, whilst DBP was modelled as the fixed effect. The number of subsets with a significant individual PAT/DBP correlation was also calculated.

3. Results

Handgrip exercise caused a steady increase in systolic pressure from 117±15 to 135±24 mmHg ($p<0.0001$) and in DBP from 75±9 to 86±14 mmHg ($p<0.0001$). Beat-to-beat iPPG-PAT and DBP were negatively correlated (mean±SE -1.004±1.12 ms/mmHg, $p<0.0001$) as was finger-PAT (-0.65±0.55 ms/mmHg, $p<0.0001$). The proportion of individual subsets with significant negative regression slopes between DBP and finger-PAT (n=14 out of 27) and between DBP and iPPG-PAT (n=19 out of 54) was not significantly different ($p=0.15$). Only one subset in iPPG-PAT and one subset in finger PAT subsets had positive regression slopes.

4. Conclusion

Almost all subjects had negative regression slopes between PAT and DBP though 35% were significant for iPPG-PAT and 52% significant for finger-PAT. The low proportion of significant results using both iPPG and finger BP techniques indicates that investigation into the physiological relationship between BP and PAT is required to increase accuracy if PAT is to be used to measure BP in the individual. However, the total cohort analysis showed a significant correlation between PAT and BP whether using iPPG or finger BP indicating that despite the high variability among subjects, iPPG-PAT can track dynamic changes in BP in a cohort of people. Future work moving from PAT to transit time measurements using iPPG may open the way for contactless estimation of BP.