Heartbeat Detection using Three-axial Seismocardiogram Acquired by Mobile Phone

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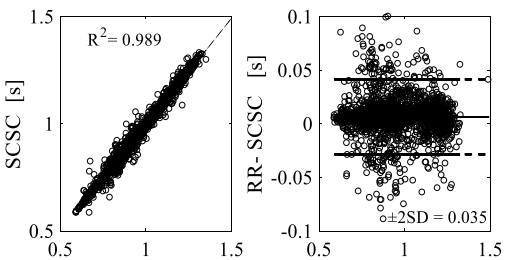
Recent studies have demonstrated the possibility to acquire the heartbeat-induced vibrations resembling the seismocardiogram (SCG) by the mobile phone accelerometer (m-SCG). On this signal, the mitral closure and aortic opening waves are known as the systolic complex (SC). As most of ECG-free beat detection algorithms are based on processing one m-SCG component only, our aim was to propose an alternative and robust method to extract beat-to-beat SC from three-axial m-SCG and test its occurrence compared to R peak of ECG.

Methods. Eleven male subjects (mean age 22±3) were recruited and m-SCG signal (50 Hz) was acquired for 5 minutes by a smartphone positioned on the chest while in supine position during a controlled breathing protocol, simultaneously with 1-lead ECG (200 Hz) acquired by a non-invasive wearable cardiac monitoring system (KINO, HeartKinetics, Bruxelles, Belgium). Newtonian equations of kinematics and continuous wavelet transform were applied to the m-SCG signal to detect beat-by-beat SC occurrence. The performance of the SC detection method was measured by sensitivity, positive predictivity and accuracy. Then, each beat duration was computed as the distance between two consecutive SC (SCSC) and compared to the corresponding RR interval of ECG by linear correlation and Bland-Altman analysis.

Results. Data from one subject were discarded due to low quality signal (feasibility 91%). High values of sensitivity (0.995), positive predictivity (0.974) and accuracy (0.96) were obtained. High R^2 value (0.989) and narrow confidence interval (CI=±35 ms, ±2SD) were obtained, as in figure.

Conclusions. Feasibility and accuracy of measuring beat-to-beat heart cycle duration using three-axial m-SCG was positively tested. The explored heart rate range (45-101 bpm) was quite wide and acceptable limits of agreement (±1 - ±6 bpm) were obtained.



Correlation and Bland-Altman results