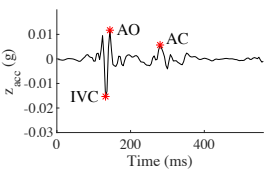
Assessing Cardiac Electro-Mechanical Deconditioning During Bed Rest Using Smartphone's Inertial Sensors

Sarah Solbiati*, Alessia Paglialonga, Lorenzo Costantini, Boštjan Šimunič, Rado Pišot, Marco V Narici, Enrico G Caiani

National Research Council of Italy, Institute of Electronics, Information Engineering and Telecommunications, Milan, ITA

Aim. Thanks to its embedded sensors, smartphones could be useful in cardiac health monitoring. Our aim was to test the feasibility of monitoring cardiac activity and its possible deconditioning induced by prolonged horizontal bed rest (HBR) by using smartphone-acquired seismocardiographic (SCG) signals.

Methods. Ten healthy volunteers were enrolled in a 10-day HBR at the Hospital of Izola (Slovenia). By positioning the smartphone on subject's chest, 1-minute SCG (triaxial accelerometer and gyroscope, f_s=100Hz) was acquired at subject's awakening in supine position before HBR (PRE), the 10th day of HBR (BR10), and one day after re-ambulation (R+1). After pre-processing, beats were automatically identified and beat-to-beat measurement was obtained, from which heart rate (HR) and HR variability indices (SDNN, RMSSD, SDNN/RMSSD) were calculated. A median beat template was obtained from the accelerometer z-axis (figure), from which isovolumetric contraction (IVC), aortic valve opening (AO) and closure (AC) points were used to compute t_{IVC-AO} and t_{IVC-AC} time intervals, AMP_{AO-IVC} amplitude and AMP_{AO}/AMP_{AC} amplitude ratio, and IVC-AO slope. Also, beat-to-beat integrals of linear and rotational kinetic energy were computed, and the ratio of their median values (iK_{lin}/iK_{rot}) was calculated. Changes compared to PRE, and between BR10 and R+1, were assessed by Wilcoxon test.



Results. At BR10, HR and SDNN/RMSSD increased compared to PRE (9% and 50%, respectively). Also, AMP_{AO-IVC} increased (40%). At R+1, HR and SDNN/RMSSD further increased by 17% and 15% compared to PRE, mainly due to decreased RMSSD. Compared to BR10, AMP_{AO-IVC} (-28%), IVC-AO slope (-40%) and AMP_{AO}/AMP_{AC} (-35%) reduced. The iK_{lin}/iK_{rot} remained unaltered during HBR, increasing at R+1 compared to PRE (213%) and BR10 (190%).

Conclusions. Ten days of HBR caused alterations in cardiac electro-mechanical activity, increasing sympathetic HR modulation and affecting SCG morphology. At HBR termination, changes in SCG morphology recovered, while iK_{lin}/iK_{rot} increased. Using smartphone sensors to follow deconditioning appears feasible.