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THREE-DIMENSIONAL BALLISTOCARDIOGRAPHY IN MICROGRAVITY AT 20 YEARS INTERVAL: A LONGITUDINAL CASE REPORT AND VALIDATION OF THE ESA-B3D PROJECT.

Abstract

Three-dimensional Ballistocardiography (3D-BCG) is a wearable non-invasive cardiac performance monitoring technique that is at a current regain of interest. It is based on the measure of 3D-accelerations of the human body that result from the cardiac contraction, ejection and motion of blood into the large arteries. The ESA three-dimensional ballistocardiography in microgravity (B3D) project aims at measuring 3D-BCG on astronauts taking part to long duration missions to the ISS. The B3D experiment is a joint collaboration with Cardiovector, a Russian space flight experiment started in October 2014. Here we present results from the validation study conducted during parabolic flight campaigns from ESA and the DLR. Here we present the comparison between data obtained in a single astronaut at 20 years intervals. The same astronaut took part in a similar free-floating protocol for the recording of 3D-BCG. In 1993, during the Spacelab-D2 mission, after 8 days in orbit, ECG, respiration and 3D-BCG data were

acquired with a high precision tri-axial accelerometer taped to the subject's lumbar region, close to the center of mass (CoM). Cardiac output (CO) was determined by the inert gas rebreathing technique and was 6.2 L/min while stroke volume (SV) was 88ml, HR 70 bpm and age 42. In 2013, during the DLR 22 parabolic flight campaign, data were recorded on the same free-floating subject, then aged 62, in the A300-zéroG airplane of NOVESPACE during the microgravity phases of the DLR 22nd parabolic flight campaign. The engineering model of the Cardiovector device from the IBMP team was used to record 3D-BCG (with the sensor placed close to the CoM and between the scapulae (Scap)), ECG, and respiration. CO was 6.07 L/min SV 63.6 ml and HR 95 bpm. 3D-BCG allows calculating the magnitude of the acceleration vector, the maximum force (Fmax) of the heart during the systolic phase as well as kinetic energy and work. In sustained microgravity Fmax was 3.96 N while 20 years later in transient microgravity Fmax was 3.23 N. We found also that: the CoM-BCG has a phase lag compared to Scap-BCG. Despite small differences, probably due to aging and sustained vs. transient microgravity difference, the results are remarkably consistent. This is the first longitudinal study of 3D-BCG in microgravity. Our results provide important physiological information on the stability of 2D-BCG over time and confirm its usefulness for remote cardiac function monitoring.