SPACE LIFE SCIENCES SYMPOSIUM (A1)
Human Physiology in Space (2)

Author: Dr. Elena Luchitskaya
Institute for Biomedical Problems, Russian Federation

Prof. Roman Baevsky
SSC RF Institute of bio-medical problems RAS, Russian Federation
Dr. Irina Funtova
SSC RF-Institute of Biomedical Problems RAS, Russian Federation
Prof. Jens Tank
Hannover Medical School, Germany

MISMATCH BETWEEN CARDIAC MECHANICAL FORCES AND KINETIC ENERGY DURING LONG TERM SPACE FLIGHT MEASURED BY 3D – BALLISTOCARDIOGRAPHY

Abstract

Introduction. Mechanisms of individual cardiovascular adaptation during long term weightlessness have been a major aim of research in space medicine since the beginning of manned space flight. Nevertheless, several issues remain to be elucidated including the interaction between the left and the right ventricles as well as possible changes of energy expenditure of the heart during different phases of the flight. New technology based on smaller and more reliable accelerometers are used in the Russian flight experiment "Cardiovector" for continuous beat-to-beat monitoring of mechanical cardiac force, kinetic energy and work. Methods and Material. The device "Cardiovector" allows to record the ballistocardiogram with 6 degrees of unrestricted motion (three linear and three axes of rotation) in addition to ECG, impedance cardiography, seismocardiography and respiration. Results from twelve cosmonauts studied during ISS missions 41 to 51 will be presented. Measurements were made during a protocol including 5 minutes rest, 5 and 10 seconds breathing tests and maximum inspiratory and expiratory breath holds. Active standing tests were performed before and after flight. Data analysis includes heart rate variability analysis, estimation of thoracic blood volume and volume blood flow changes, and systolic time intervals. The mean mechanical force was calculated as the vector of the three linear accelerations, mean kinetic energy was calculated based on the integral of the linear acceleration values. Results. Preliminary analysis from 9 cosmonauts (three cosmonauts are currently on orbit) suggests that mechanical force and kinetic energy remain very stable in each cosmonaut even during 12 month in space. Unexpectedly, we found a mismatch between changes in mechanical force and kinetic energy if the data were compared to preflight values. Conclusion. The mismatch between the increase in mechanical force and the decrease in kinetic energy if compared to measurements under the influence of gravity may suggest a more efficient work of the heart in space. However, it can also simply reflect physical changes of the force and energy transfer from the heart to the surface of the body in weightlessness. Nevertheless, the fact remains interesting and needs further elucidation. We speculate that an additional accelerometer placed close to the center of mass, detailed analysis of the rotational movements, and functional imaging of the heart and the large vessels before and after space flight may help to shed light on this topic in future studies, which are planned together with international patners in the field of biophysics and biomechanics.