Arthero-Space project: A model based exploration of the regulatory mechanism of the microcirculation for the prevention of orthostatic intolerance

Results in Brief

Effects of gravity on blood pressure

The cardiovascular system is dependent on a complex synergy of control mechanisms to maintain blood pressure, particularly important in the cerebral cortex. As the system can malfunction during astronauts’ re-entry from space, new studies of mechanisms could improve design of countermeasures.

Orthostatic hypotension or intolerance (low blood pressure when upright) is a persistent problem during re-entry after the microgravity of space. Particularly serious as lack of blood flow to the brain can impair function, the mechanisms are unknown. Scientists investigated the body’s response to improve countermeasures with EU funding of the project ARTHEROSPACE (Arthero-Space project: A model
based exploration of the regulatory mechanism of the microcirculation for the prevention of orthostatic intolerance).

In vivo experiments involved a tilt table inducing orthostatic stress to study interactions with the muscle constriction pump effect, forcing venous constriction. The haemodynamic response to calf muscle contraction was similar with or without orthostatic stress.

Using ballistography, the non-invasive measurement of the mechanical recoil of the body in response to cardiac activity, subjects were assessed during static squats, dynamic squats and synchronised respiration. When combined with computational models, data is expected to aid the use of ballistography in a clinical setting.

Team members also developed a 1D biomechanical model to study the role of gravity on venous blood pressure regulation. The model enables investigation of haemodynamics in three different configurations: a single-artery vein without valves, the same with valves and a configuration including superficial veins. The model has demonstrated the importance of proximal venous valves and the superficial venous system for muscle pump effectiveness.

Significant to understanding blood pressure regulation under gravitational stress, ARTHEROSPACE is currently running a study using Short Arm Human Centrifuge. Measuring the accuracy of remotely controlled vascular ultrasound assessment under centrifugation conditions, the facility measures peripheral vascular responses.

Dissemination included an international seminar attended by 50 international guests. Results of the vascular ultrasound feasibility were published in Microgravity Science and Technology, and those from the computational model in International Journal for Numerical Methods in Biomedical Engineering. There is also a website dedicated to the ARTHEROSPACE project.

The ARTHEROSPACE research group has made important progress in untangling the mechanisms associated with orthostatic hypotension. Research results can be applied to specific training programmes that maintain physical shape during long-term space missions. Overall, the research has important implications for the safe return of astronauts to Earth.

Keywords

Gravity, blood pressure, astronauts, orthostatic, ARTHEROSPACE, microcirculation, muscle pump
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Record number: 169949

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