How does the immune system react to altered gravity?

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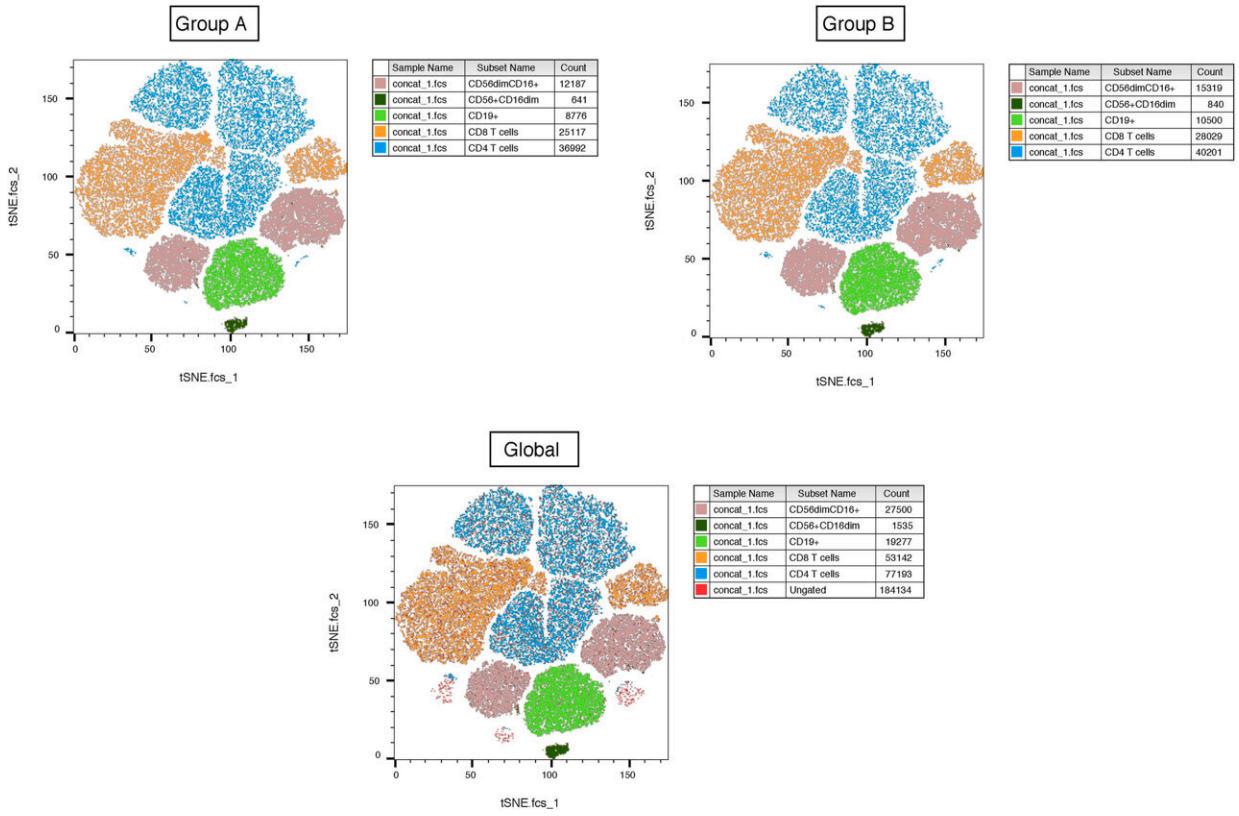

tSNE displays of CD3, CD4, CD8, CD19, CD56 and CD16 markers expression showing merged conditions (A + B), experimental condition (A) and control group (B). Credit: *Acta Astronautica* (2023). DOI: 10.1016/j.actaastro.2023.02.012

Space travel has always tested the human body by the effects of the new

conditions of altered gravity on biological systems. It has long been known that continuous exposure to microgravity conditions human physiology and causes effects that compromise muscular, sensory, endocrine and cardiovascular functions. But is it also risky to be exposed to altered gravity for short periods of time?

Now, a paper published in the journal *Acta Astronautica* examines the effects of microgravity generated by a parabolic flight on the human immune system. After a short exposure to altered gravity, there were no significant changes in the defensive capacity of blood cells in the volunteers who took part in the study. In addition, the study found no evidence of aggregation processes in erythrocytes—the cells that transport O_2 and CO_2 to the cardiovascular system—after the parabolic flight.

The study was coordinated by Ginés Viscor, professor at the Department of Cell Biology, Physiology and Immunology of the Faculty of Biology of the UB, and it included the participation of experts Jordi Petriz, from the Germans Trias i Pujol Research Institute (IGTP), and Antoni Pérez-Poch, from the Technical University of Catalonia-BarcelonaTech (UPC) and the Institute of Space Studies of Catalonia (IEEC), among other authors. The first author of the study is the researcher Abril Gorgori-González (UB).

Parabolic flights: A simulated gravity laboratory

Space travel is the ideal scenario to study the effect of microgravity on the human body. These trips make it possible to study the consequences of long-term exposure to microgravity on different astronauts simultaneously, but they require a high cost in terms of time, funding and infrastructure.

Without leaving the Earth's atmosphere, it is also possible to simulate

simulated gravity conditions on different platforms. For example, through parabolic flights in aircraft, which make it possible to study the effect of altered microgravity in the short term—even for a few seconds—at an affordable cost.

"Artificial platforms such as parabolic flights in aircraft provide valuable but more limited results, as they only allow the effects of altered gravity to be studied in the short term (seconds or minutes). Therefore, the profiles of physiological changes that can be recreated with parabolic flights are immediate and transitory changes that microgravity generates in the human body," says Ginés Viscor, head of the Adaptive Physiology Group: Exercise, Hypoxia and Health at the UB.

As part of the study, a 20-minute parabolic flight was conducted with the Mudry CAP10 aircraft—a 2-seat aerobatic training aircraft—during which fifteen parabolas were performed. "Each parabola allows a period of microgravity to be reached for approximately eight seconds, which is followed and preceded by hypergravity phases of about two seconds," says the researcher Antoni Pérez-Poch, from the Department of Computer Science at the UPC, and lecturer of the School of Engineering of Barcelona East (EEBE) of the UPC and the IEEC.

These parabolic flights with an aerobatic plane—a pioneering method in the world, developed in Catalonia—were operated by the Aeroclub Barcelona-Sabadell and are the result of an aeronautical research carried out in collaboration with the UPC.

"This innovative technique has a good ratio of time achieved in microgravity compared to the cost of maintenance, which is very favorable compared to the greater use of aircraft, although it also has some limitations (logistical and space). In the case of parabolic flights with a larger aircraft, a more expensive operation that has been used since the beginning of the space race by agencies such as NASA or ESA

(European Space Agency), up to 25 seconds per parabola could be achieved," says Pérez-Poch.

Immune function under pressure

The immediate effects of microgravity on the blood system derive from the redistribution of blood volume, blood flow and body fluids to the upper body. "Cardiovascular adaptations consist of an altered cardiovascular response causing abnormalities in body orientation and balance, poor response to orthostatic stress, decreased cardiac function and inadequate cardiovascular response to exercise," says Ginés Viscor.

One of the most vulnerable physiological systems to any change in environmental conditions is the immune system, and this is explained by its great plasticity and responsiveness to internal and external imbalances. In scientific literature, there are still no conclusive results on the immune response to short exposure in flights with altered gravity, and in some cases the conclusions are even contradictory.

In this study, the team analyzed the response of the immune system to short exposure to microgravity based on several parameters: erythrocyte and leukocyte counts, hemoglobin concentration, phagocytic capacity and oxidative metabolism.

"The results reveal that the human blood samples' exposure to altered gravity conditions in parabolic flight did not involve negative effects in relation to samples that were left parallelly on the ground during the experimental study. There are also no significant changes in peripheral blood cell counts," says Jordi Petriz (IGTP).

"Except for the monocytes—a type of leukocyte—no significant differences have been observed in the functionality of immune cells in terms of either their oxidative metabolism or their phagocytic capacity,"

says researcher Abril Gorgori-González (UB). "Hypothetically, if there were changes in the functionality of leukocytes when exposed to an altered gravity, the immune function and defense against external infections or tumor processes would also be compromised."

The team has applied the technique of flow cytometry with acoustic focusing with little manipulation of the volunteers' blood samples. According to the authors, the sample limitation typical of acrobatic flight studies—with logistical constraints—does not allow general conclusions to be drawn. Therefore, the goal now is to continue research on the human immune system with other microgravity simulation platforms to study physiological alterations, avoid complications and anticipate risk situations.

Space tourist warning

Space tourism is an activity of great economic interest for some business sectors. However, one of the main differences between space tourists and astronauts is the physical and psychological preparation prior to the trip.

"Altered gravity or the constant lack of gravity is one of several changes in the environment faced by these space travelers. The human body has evolved under the conditions of Earth's gravity and is not adapted to the absence of this attractive force. In space travel, other factors such as ionizing radiation, constant noise, isolation, confinement, a total distortion of circadian rhythms and short exposure to extreme temperatures during the return to the atmosphere have to be considered," the experts warn.

"Long-term metabolic, osteoporosis and ophthalmological problems have also been described. Although the effect of space travel on untrained space travelers has not been studied, it is possible that all the stressors of

the physical environment could negatively affect the health of space tourists. Therefore, for the time being, 'outer space visits' are designed to be of short duration," the team concludes.

More information: Abril Gorgori-González et al, Effects of rapid gravity load changes on immunophenotyping and leukocyte function of human peripheral blood after parabolic flight, *Acta Astronautica* (2023). DOI: 10.1016/j.actaastro.2023.02.012

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