Blood and Oxidative Stress (BOS)

On Earth, the body constantly produces natural substances that can cause damage to cells and also tissues, the so-called prooxidants and/or free radicals. These can be caused by smoking or exposure to sunlight, drugs etc.

However, the body has an antioxidant system made up of enzymes and molecules that protects against the damage caused by prooxidants by converting them into safe compounds. Examples of antioxidants are vitamins E, A, C and beta-carotene. These are available through diet or in nutritional supplements.

Oxidative stress, a pronounced prooxidant state, is caused by the excessive production of free radicals or from the weakening of the antioxidant defence system, and is the cause of many pathologies, ageing processes and is believed to be a possible cause of cancer.

The space environment is obviously very different to that of Earth. The body has to adapt to weightlessness and the effect of background radiation. Nowadays, around six months is considered a safe amount of time to spend in space, allowing astronauts to carry out their functions as normal and allowing their bodies to readapt on return to Earth.

Loss of red blood cell mass, volume of blood plasma, and haemoglobin has been continuously observed in astronauts during space missions. This phenomenon has been termed “spatial anaemia” and the underlying mechanisms causing this are still not clear. This could be due to suppressed production of red blood cells or increased destruction of red blood cells.

Many studies have demonstrated that red blood cells exposed to weightlessness have a modified flow and undergo damage to the cell membrane causing the release of haemoglobin to a greater degree.

This experiment aims to determine the degree of ‘stress’ that the red blood cells have undergone to bring about cell damage, the quantity of substances in blood serum that would prevent this damage (antioxidants), the damage that the red blood cell membranes have undergone, and the time it takes to recover. This will be done by measuring the antioxidant status of astronauts prior to and after space flight, and the time it takes to recover from oxidative stress occurring during space radiation exposure. Moreover red blood cells will be analysed to evaluate their membrane composition and the activities of the enzymes involved in antioxidant defences.

This experiment will provide results that will help in finding methods to reduce the current effects of oxidative space anaemia by, for example integrating appropriate dietary elements and natural compounds that act as antioxidants. These results will also impact on future longer-term space missions to, for example, Mars.

How is it done?

Relevant comparisons will be made from blood samples taken from the astronaut before and after the mission. Blood samples of 5ml will be taken one time prior to launch and three times after landing. These will be stored under refrigerated conditions in special tubes to avoid clotting and freezing. As soon as a sample is taken, it will be shipped for analysis.

The first sample will be taken as close as possible to the launch date. A sample will also be taken as soon as possible after landing. Hereafter one sample will be drawn 15 days after landing and the last sample will be drawn 30 days after landing.

Once in the laboratory the blood samples will be analysed for different parameters. Total blood will be analysed to quantify oxidative stress of the subject and to measure levels of antioxidants, which help to prevent cell damage.

Blood plasma will be separated by centrifugation and be analysed to determine fatty acid composition and levels of molecules that cause cell damage such as free radicals and oxidized compounds. Red blood cells will be analysed for enzymatic proteins, which help to break down elements that cause cell damage and injury.

Team Members:
B. Berra [(1)], A. Rizzo [(1)], M. Giardi [(2)]

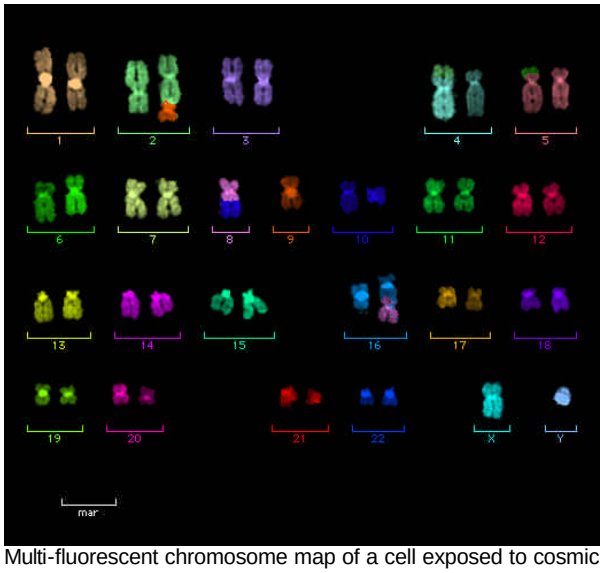
(1) Università di Milano
Milan, Italy
E-mail: bruno.berra@unimi.it
Angelamaria.rizzo@unimi.it

(2) CNR Research Area of Rome
Rome, Italy
E-Mail : mariateresa.giardi@mlib.cnr.it

Biodosimetry in astronauts (BDS)

On Earth, our atmosphere provides some form of protection from the intense levels of radiation emanating from space. In space, however the absence of this protective shield exposes astronauts to these higher levels of radiation. Even though astronauts find themselves within spacecrafts, the habitable modules usually have skins that are a few millimetres thick, and thus do not provide sufficient protection from this radiation.

It is known that DNA is damaged by ionising radiation, which may lead to chromosomal aberrations (i.e. malfunction or malformation of chromosomes). This in turn could lead to elevated risks of cancer and other disorders and syndromes. More results regarding the effects of radiation are still needed to fully understand its effects on the human body, and possibly to come up with suitable countermeasures.



Multi-fluorescent chromosome map of a cell exposed to cosmic radiation (Image: M. Durante)

How is it done?

This experiment has the objective of measuring the frequency of chromosomal aberrations pre- and post-flight in two tissue samples from the astronauts.

As has already been demonstrated in a previous flight, no significant increase in the yield of aberrations after a short-term space flight is expected. This corresponds to a very low dose.

However, aneuploidy in buccal epithelial cells (cells of the membranous tissue within the mouth) after space flight will be tested for the first time. Aneuploidy refers to the chromosomal state of a cell with abnormal numbers of specific chromosomes or chromosome sets.

Samples of blood lymphocytes (a type of white blood cell involved in the human body's immune system), collected pre-flight and post-flight, will also be irradiated in vitro to measure the radiation sensitivity of blood cells and to compare these curves with previous radiation sensitivity measurements performed in the same astronauts in past missions.

The results will help clarify the DNA damaging action of space radiation, and the role of the space environment in modifying the radiation sensitivity of the bodily system of organs and tissues, primarily the bone marrow, spleen, tonsils, and lymph nodes, involved in the production of blood.

Blood samples of 10ml will be drawn approximately 15 days before launch and 24 hours after landing. On both occasions exfoliated cells from within the mouth will be collected by scraping the inner side of both cheeks using a toothbrush.

Team Members:
M. Durante , G. Gialanella, G. Grossi, P. Scampoli, M. Pugliese

Università di Napoli "Federico II"
Naples, Italy
E-mail: durante@na.infn.it

Sympatho

The SYMPATHO experiment is an ongoing study of adrenal activity of the sympathetic nervous system in weightlessness. The sympathetic system is that part of the nervous system that accelerates the heart rate, constricts blood vessels, and raises blood pressure.

The experiment will test the hypothesis that after initially low adrenal activity in the first 24 hours in space, the adrenal activity increases due to a fall in the blood volume in the cardiovascular system.

Sympathetic activity is of major importance for the regulation of the cardiovascular system in human subjects especially in the upright position. This is due to gravitational stress, which results in pooling of the blood in the lower part of the body.

Ground based experiments have shown that the sympathetic activity is decreased in response to displacement of the blood from the lower part of the body to the heart-lung area after changing from the upright or sitting position to the supine position.

In space, sympathetic activity was expected to be decreased but experiments have shown that it actually increases during weightlessness. More results need to be collected to study this phenomenon further, in the hope that they will provide clues to why this type of behaviour is manifested in space.

The conflicting results obtained from the studies that have been carried out thus far, highlight the fact that we do not as yet have a clear understanding of the mechanisms involved in the sympathetic nervous system. Since this system controls the physiological elements that are linked to stress, clear scientific results can provide useful information in the clinical research of physical and mental stress patterns in patients.

How is it done?

The results of the SYMPATHO experiment rely solely on blood samples of the crew. The Italian Soyuz Mission will see the end of this experiment, which has already been performed with other astronauts on previous flights. Blood samples will be taken before flight and shortly after landing then analysed to complete the overall study.

Team Members:
N. Christensen

University of Copenhagen
Copenhagen, Denmark
E-mail: nijc@herlevhosp.kbhamt.dk