



Mars500 project – salt balance of the Mars 'astronauts'

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For 205 days in 2011, Jens Titze, Professor of Electrolyte and Circulatory Research at the University of Erlangen-Nuremberg, and his team strictly controlled the diet for the Mars500 test subjects during their virtual flight to Mars. Sometimes the selected food contained a lot of salt, sometimes very little. The unexpected result of the longest sodium metabolism study to date was that the assumption that the human body would excrete the salt within 24 hours was incorrect. Instead, the human body stores salt for much longer before releasing it – an important discovery for medical research and patient care. "We were very surprised that the body follows a multi-day biorhythm with its salt balance. The 24-hour urine testing that is standard practice is apparently inadequate for assessing how much salt an individual has consumed," says Titze. Titze's research was one of 11 German Mars500 experiments sponsored by the German Federal Ministry of Economics and Technology (Bundesministerium für Wirtschaft und Technologie; BMWi) via the German Aerospace Center (Deutsches Zentrum für Luft- und Raumfahrt; DLR). The results of the research have been published in the scientific journal 'Cell Metabolism'.

"This is a crucial discovery because our fundamental understanding of salt balance in medicine is based on the idea that the salt in our food is excreted very quickly through our urine. This is supposed to keep the body's salt content constant, to control blood pressure," explains Titze. "With Mars500, we are now seeing that humans store and release salt rhythmically over weeks and months, regardless of diet – and without affecting blood pressure." The first isolation experiments on this subject were carried out in the 1990s; Mars500 has now confirmed their findings.

Controlled living conditions in the 'spaceship'

To reveal this unexpected rhythm, the test subjects had to follow a carefully prescribed daily diet and provide a urine sample every 24 hours, for a period of months. Titze had gathered some data during preliminary experiments in 2009, in which test subjects spent 105 days in isolation. Besides Europeans Oliver Knickel, Cyrille Fournier, Diego Urbina and Romain Charles, five Russians and one Chinese also took part in the German experiment. "We are very grateful to the test subjects for their great discipline and cooperation," says Titze. Doctors had not previously had an opportunity to specifically study the salt balance in humans over an extended period. "Under everyday conditions, it is almost impossible to determine how much salt a person has ingested over weeks and months." But on the Mars500 crew's simulated spaceship, Titze and his team of Natalia Rakova, Kathrin Jüttner and Friedrich Luft could know and control the living conditions of the test subjects. "We could keep all the other components constant and just vary the quantities of salt in the food." As the experiment progressed, the scientists reduced the amount of salt from 12 grams a day initially, to nine and finally six grams. They then analysed the salt content in the urine samples collected, along with the hormones aldosterone and cortisol.

Competition for the kidneys

The results surprised even the researchers; the body excretes the salt it has consumed in a weekly rhythm. Furthermore, it stores and releases sodium over a period of months, regardless of the salt intake. Two hormones, aldosterone and cortisol, appear to play an important role in regulating this rhythm. Doctors had previously assumed that they acted in similar ways. However, the Mars500 research data shows that the two hormones are more like opponents in their association with the storage and excretion of sodium over the longer term. "This makes it

clear that the kidneys are not the only excretory organs involved in regulating salt content; other, previously neglected body tissues are involved as well."

However, new questions are arising from the discoveries, and the scientists will have to find answers to these in the future. Why, where and how does the body store sodium? Why does the hormone cortisol function in precisely the opposite way to previous expectations? And do women have the same salt balance as men? Only men took part in the one-and-a-half year study; there is no comparable data on the reactions of female bodies. "Once we have got over the initial shock of the unexpected discovery, we will address these questions," says Titze. His team was able to confirm one existing assumption during Mars500 – reducing the salt content in food does reduce blood pressure, even in healthy Mars 'astronauts'.

From space to Earth

During the simulated flight to the Red Planet, the six test subjects provided data for numerous experiments, of which 11 involved research carried out in Germany. How do stress and isolation affect individuals? How do relationships develop within a group living in isolation for so long? Which factors affect blood pressure? Which physical and mental training concepts are most effective under extreme conditions? "This research for spaceflight also provides an opportunity to acquire knowledge applicable to everyday life on Earth," says Peter Gräf, German project leader for the Mars500 mission. "The individual projects help to understand how the human body functions and thus make significant contributions to sustaining the health and capabilities of not just astronauts but also of people in a mobile and ageing society here on Earth."

One thing that has emerged for a flight to Mars – the interaction of an international crew during the extended isolation could work well. One of the things the mission has shown medical research is that the type of investigation previously used for human salt balance is inadequate. The simulated flight delivered one other astonishing result – people and cyanobacteria are not as different from one another as might be thought. The cyanobacteria also have a multi-day rhythm for excreting salt. "At least we have the reassurance that such rhythms have been found in other organisms, albeit single-cell ones," says Titze.

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Meal plans for the Mars 'flight'



Natalia Rakova, a member of Jens Titze's team, explains the composition of their diet to the Mars500 volunteers. The Space Administration of the German Aerospace Center (Deutsches Zentrum für Luft- und Raumfahrt; DLR) funded the experiment on the salt balance of the 'Marsonauts'.

Credit: IBMP/Oleg Voloshin.

Menus for the Mars500 crew



During the first year of the Mars500 mission, the cosmonauts ate a fixed menu in which the salt content was progressively reduced.

Credit: ESA.

Strictly controlled diet



For the start of the isolation experiment on 3 June 2010, Jens Titze, of the University of Erlangen-Nuremberg, created detailed meal plans for the six subjects and reduced the amount of salt from 12 grams a day initially, to nine and finally six grams.

Credit: ESA.

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