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# NUMERICAL SIMULATION OF LONG-TERM MICROGRAVITY EFFECTS ON THE LIVER IN DIFFERENT SPACEFLIGHT SCENARIOS

**Abstract**

The aim of this research was to investigate which are the long-term effects of microgravity exposure to the liver. It is expected that a certain amount of fibrosis may appear in very long-term missions with gravity exposure being smaller than that on Earth.

An animal model experiment was performed during STS-135 in which it was found that mice developed Nonalcoholic Fatty Liver Desease (NAFLD) with possible signs of liver fibrosis. Furthermore, they exhibited changes to genes responsible for breaking down fats. It is known that astronauts often return to Earth with diabetes-like symptoms, but they are quickly resolved. However, with the envisaged long-term missions to Moon and Mars, and complex microgravity exposure scenarios; it is still unknown whether a liver cirrhosis may develop, or on theeee contrary, if there are underlying mechanisms that prevent significant liver damage to appear. Experimental information on the impact of spaceflight on the liver is scarce today.

Certain simulations of the pysiology of the liver have been published, including blood flow circulation and 3D modelling of the organ, however none of them took into account the effects of long-term reduced gravity on its functionality. We present results of an original model taking into account both the known alterations on the blood circulation and those resulting in an umpaired capability of breaking down fats. We describe details of this model, and the susceptibility of the parameters involved in the appearance of liver damage to microgravity exposure in different spaceflight scenarios. A final estimation of the probability of the appearance of liver failure that could put a space mission in jeopardy is given.

Results from this model show that only in space missions longer than 24.3 +/- 0.7 months a significant impairement of the liver is likely to appear ($p<0.01$). Exposure to Moon or Mars gravity in different space missions scenarios do not significantly improve the impairement. However, potential failure of the liver is unlikely to appear up to 60 months.

In conclusion, numerical modelling of the physiology of human organs in spaceflight is a useful tool to predict microgravity effects during spaceflight when experimental data is very hard to obtain. More studies are needed to empirically validate the model.