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EDITORIAL

Extraterrestrial autonomic function

Thomas G. Smith[1]

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More than 100 billion people are thought to have lived on Earth [2], but only 12 have set foot on another celestial body. There has been no selection pressure from alternative gravitational environments, and when we encounter such environments, our normal 1 G homeostatic mechanisms must manage as best they can. This has rarely been a problem, as alternative gravitational environments are hard to find—only around 550 people have been to space and 12 have walked on the Moon—although many industry insiders genuinely expect this to change over the next decade. With the US government strongly committing NASA to 'boots on the Moon' in the 2020s, the European Space Agency (ESA) publicly pursuing a 'Moon village' concept, and companies such as SpaceX successfully developing commercial launch systems and other infrastructure, returning to the Moon has become a realistic prospect.

Detailed physiological studies were not conducted on the Apollo moonwalkers, but the effect of microgravity on the autonomic nervous system has been studied for decades in astronauts during orbital spaceflight, mostly during short-duration Space Shuttle flights (typically up to ~ 2 weeks). Many questions remain, but it appears that 0 G generates an orthostatic stress somewhere between that of the supine and upright posture on Earth [4]. One aspect of autonomic function that is of particular interest on Earth is the response to postural changes relative to gravity. Unlike in orbital spaceflight, where such changes of course do not exist, the unfamiliar gravitational environment on other moons or planets will naturally provoke their own version of this, which is interesting to study, not least because it could one day be relevant for astronaut explorers and eventually colonists from Earth. In work published in this issue of *Clinical Autonomic Research*, Dr. Beck and colleagues [1] have endeavoured to do this using parabolic flights to provide the relevant gravitational environments.

Parabolic flights involve an aircraft (Fig. 1) flying repeated parabolic trajectories, which provide periods of freefall during which occupants experience 'zero gravity' for approximately 20 s. This is analogous to throwing a rock through the air, which naturally follows the arc of a parabola—in this case, the aircraft's engines 'throw' the occupants on a similar arc, and the pilots fly the aircraft around them as they float. Importantly, this is not a simulation of microgravity, it is the real thing—the net forces acting upon the occupants are balanced so that gravito-inertial acceleration is zero; hence they feel weightless, just as in orbit [3]. The obvious difference is that this cannot be sustained because, as for a rock thrown through the air, eventually the aircraft will impact the surface of the Earth. So the pilots pull up, during which increased g-forces are experienced (up to ~ 1.8 G) while commencing the next parabola. Each flight consists of many parabolas (e.g. 30–40), and it is commonly thought that this must feel something like a roller coaster ride, but surprisingly this is not the case at all. The windows are covered, so there are no external visual cues, and although the aircraft changes pitch repeatedly (flying upwards and downwards), the pitch angular velocity barely reaches the threshold of detection of the vestibular system [3]. This means that occupants are not aware of any changes in direction or motion and are only aware of a changing G level along the vertical axis perpendicular to the floor. In other words, it feels like gravity is simply being switched on and off, which is incidentally a very pleasing sensation. It is also possible to fly shallower trajectories and achieve G levels between 0 G and 1 G, and Beck et al. [1] made use of this to explore cardiovascular responses to active standing manoeuvres during lunar gravity (0.16 G for ~ 25 s per parabola) and Martian gravity (0.38 G for ~ 32 s) as well as hypergravity (1.8 G) during the pull-up phase.

✉ Thomas G. Smith
thomas.g.smith@kcl.ac.uk

1 Centre for Human and Applied Physiological Sciences, King's College London, London SE1 1UL, UK

Fig. 1a–b The modified A310 aircraft currently used by Novespace (Bordeaux, France) to carry out parabolic flight campaigns for ESA and the French (CNES) and German (DLR) space agencies. Photo credits: DLR (**a**: exterior) and Novespace (**b**: interior)

Parabolic flights offer useful scientific opportunities but also present several inherent challenges to conducting high-quality physiological research. The short duration of each gravity condition clearly limits what can be studied and for how long, and with continually alternating gravity phases there is always the potential for one condition (high or low G) to confound the next. Sample sizes are often small as flight opportunities are limited, and many participants are affected by motion sickness or by the effects of scopolamine (hyoscine) that is customarily administered to prevent it. Also, as for any commercial airline flight, there is a degree of hypoxia caused by the reduced cabin pressure that has its own physiological effects [5].

From their findings, Beck and colleagues [1] suggest that in some respects the haemodynamic response to active standing may not be proportional to gravitational load, but may instead be optimal under the orthostatic stress of planet Earth. The effects were modest and subject to all the limitations described above, but these preliminary findings are interesting to consider as humanity once again looks to explore other worlds. Could the simple and necessary act of standing up conceivably present difficulties? How else might autonomic function impact on physiology and performance in such unforgiving circumstances? It is remarkable that we may have answers to these questions within a decade.

Compliance with ethical standards

Conflict of interest The author declares that he has no conflict of interest.

References

1. Beck P, Tank J, Gauger P, Beck LEJ, Zirngibl H, Jordan J, Limper U (2018) Modeling human orthostatic responses on the Moon and on Mars. Clin Auton Res. https://doi.org/10.1007/s10286-018-0527-x
2. Haub C (1995) How many people have ever lived on earth? Popul Today 23:4–5
3. Karmali F, Shelhamer M (2008) The dynamics of parabolic flight: flight characteristics and passenger percepts. Acta Astronaut 63:594–602
4. Mandsager KT, Robertson D, Diedrich A (2015) The function of the autonomic nervous system during spaceflight. Clin Auton Res 25:141–151
5. Turner BE, Hodkinson PD, Timperley AC, Smith TG (2015) Pulmonary artery pressure response to simulated air travel in a hypobaric chamber. Aerosp Med Human Perform 86:529–534