Recent insights into physiological effects of suborbital spaceflights

Dr Thomas G. Smith[1,2] and Dr Ryan A. Anderton[3]

1. King's College London, Aerospace Medicine and Physiology Research Group, London, UK;
2. Guy's Hospital, Guy's and St Thomas' NHS Foundation Trust, London, UK;
3. UK Civil Aviation Authority, Gatwick, UK.

Summary

There is a growing requirement to establish how suborbital spaceflight affects the human body. We have recently completed detailed physiology studies during centrifuge-simulated suborbital flights in participants up to 80 years of age. While generally reassuring, the results demonstrate pronounced physiological effects that raise medical concerns for a minority of individuals and support a potential role for pre-flight centrifuge-based familiarisation and assessment.

Background

The UK Civil Aviation Authority (CAA) is the UK's regulator for aviation and space and is developing a regulatory framework for suborbital spaceflight. This includes medical considerations for both spaceflight participants and flight crew risk assessments as a requirement of the Space Industry Act 2018 and the Space Industry Regulations 2021. To develop the evidence base supporting the assessment of medical risks, the UK CAA commissioned King's College London to determine the likely physiological effects of suborbital flights. King's is an academic centre for aerospace medicine internationally with experience in advanced suborbital-related centrifuge studies.

The Suborbital Environment

Suborbital flights are likely to be well tolerated by most people, but nevertheless present a novel and robust physiological challenge. In addition to a period of microgravity, occupants experience high acceleration (high 'G forces' or 'G') during launch and atmospheric re-entry. These high-G phases combine significant G in the chest-to-back direction with a variable degree of G in the head-to-foot direction. The actual G profile depends on the spacecraft and launch platform, the flight trajectory and the seating orientation. Cabin oxygen levels may also be mildly reduced due to airline-style pressurisation. Suborbital flyers do not typically undergo the intensive medical screening associated with professional astronaut selection and may have pre-existing medical conditions that interact with the suborbital environment to present additional challenges. Determining a possible minimum regulatory medical assessment for spaceflight participants may be necessary.

Centrifuge-simulated Suborbital Spaceflights

Our recent work (published in 2022) investigated the physiological effects of dynamic G profiles representing vertically launched rocket/capsule and air-launched spaceplane platforms with various seating orientations. Our preceding work (published in 2021) used sustained static G exposures over the suborbital range to characterise underlying physiological responses. Our research additionally tested the effect of simulating airline-style cabin pressure conditions. We observed highly dynamic cardiovascular responses (heart rate and rhythm, blood pressure and cardiac output) together with reduced blood oxygen levels ('hypoxia') resulting from transient impairment of lung function. Respiratory and visual symptoms were common, including chest discomfort and partial or full visual loss ('greyout' or 'blackout'), and there was one episode of G-induced loss of consciousness (G-LOC).

Implications

The effects we have observed are likely to be benign for the majority of suborbital spaceflight participants. However, they are not trivial and have the potential to precipitate adverse effects in a small sub-set of individuals, who may benefit from tailoring pre-flight centrifuge familiarisation to include physiological evaluation in the form of a 'G challenge test'. These results can inform the development of appropriate and proportionate medical standards for suborbital spaceflight participants.

Collaborators and Funding

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