Implications of the hypobaric cabin environment during commercial air travel for passenger fitness to fly

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In 2019, a record 4.5 billion passengers travelled by air.[1] This fell markedly during the COVID-19 pandemic, but in 2023, the industry's measure of overall airline 'traffic', revenue passenger kilometres, was back to 94% of the 2019 figures, with predictions that 2024 will see new record passenger numbers (see figure 1).[2] This highlights how common air travel is and reinforces the idea that it is highly likely that all doctors will see patients who travel by air. However, passenger fitness-to-fly considerations are not typically covered in undergraduate medical curricula or postgraduate medical specialty training programmes. This was recognised as an area of deficiency in clinical training and support to the general population by the House of Lords Science and Technology Committee.[3] In response, the UK Civil Aviation Authority set up an Aviation Health Unit, which acts as a focal point for aviation health in the UK, providing information for passengers and guidance for health professionals on assessing the fitness of their patients for travel by air.[4] These efforts also contributed to the establishment of the specialty of Aviation and Space Medicine, which was approved by the General Medical Ccouncil in 2016.[5]

A key consideration around passenger fitness to fly is the potential interaction of the air travel environment with normal physiology or pre-existing medical conditions. In the UK, unpressurised aircraft can be flown up to 10 000 ft (3048 m) without using supplemental oxygen and parachutists may be permitted up to 6 min at up to 15 000 ft (4572 m) without using supplemental oxygen (these limits vary internationally). For pressurised aircraft such as those typically used in commercial air transport, the cabin pressure altitude ranges between 5000 and 8000 ft (1524 and 2438 m).

Acute exposure to these conditions in aviation can have different effects from the perhaps more familiar responses associated with chronic exposure to altitude in the mountains.[6] Over the last 20 years, the British Thoracic Society has provided helpful clinical guidance in relation to pre-existing respiratory conditions and considerations around passenger fitness to fly. The first edition includes more detail around the physiological challenges,[7] while the latest version includes updated guidance around clinical conditions and considerations for preflight hypoxic challenge testing.[8] The current work by Trammer *et al* provides an interesting and slightly different angle in highlighting the interaction between the mildly hypobaric flight environment and both sleep and alcohol intake.[9] It also provides an opportunity to reflect on how we came to have a flight environment that exposes passengers (and crew) to a mildly hypobaric hypoxic environment of 5000–8000 ft (1524–2438 m) pressure altitude in the first place.

Trammer *et al* have shown that combined effects of mild hypoxia, such as may be seen onboard commercial aircraft, and alcohol consumption have an additive effect, which serves to exaggerate the physiological stress of this travel modality.[9] They showed, in young healthy individuals, that alcohol consumption exaggerates the drop in oxygen saturation and increase in heart rate during sleep in a mildly hypoxic environment, such as may be experienced in commercial air travel.[9] These findings highlight that the on-board consumption of alcohol may be an underestimated health risk, particularly for patients who have pre-existing cardiorespiratory compromise and is an avoidable risk for such populations. The practice implication of this study for healthcare providers is modification of fitness to fly discussions for older patients and those with pre-existing cardiorespiratory disease, including those with obstructive sleep apnoea or obesity hypoventilation syndrome. In addition to normal fitness to fly discussions, these patients should be informed about the potential added risk of alcohol consumption and to consider avoiding alcohol consumption prior to and while onboard commercial flights.

Cabin pressurisation is a compromise, balancing the competing imperatives of minimising costs (by allowing higher altitudes) while avoiding undesirable effects of hypoxia and other environmental stressors (by keeping altitudes low for those on board). There are major airports located at or near 8000 ft (eg, Mexico City), and this is thought to have been a factor in this altitude arising as a ceiling in the early days of air travel with a pressurised cabin. However, historically the primary driver of acceptable cabin altitudes has been the acceptable degree of hypoxia for pilot performance in their role as safety critical personnel.[10] This is

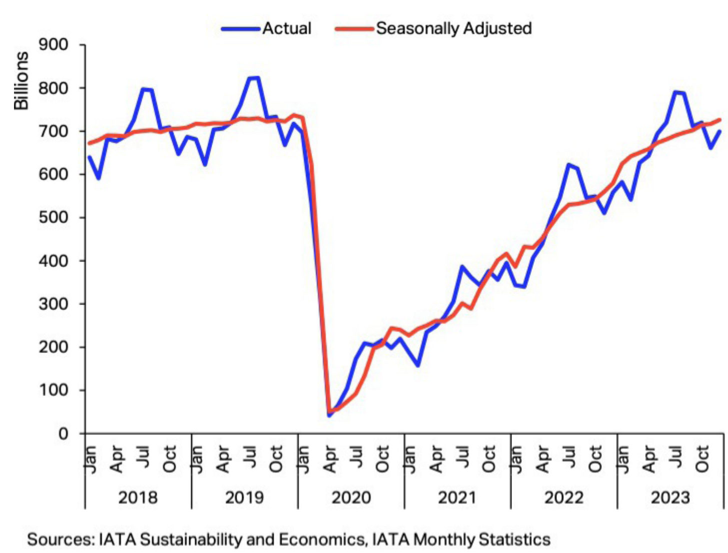

Figure 1 Global revenue passenger kilometres, a measure of global air travel activity (billions of kilometres per month). Adapted from IATA[2]: https://www.iata.org/en/iata-repository/publications/economic-reports/air-passenger-market-analysis-december-2023/.

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not always straightforward; studies on the performance effects of acute hypoxia tend to focus on population-level effects, but assuming there is a bell-shaped curve of human responses, from a flight safety perspective, it is important to understand how individuals at the extremes of this distribution will behave. Therefore, from a regulatory perspective, cabin altitude limits need to protect the majority (including outliers) rather than simply the 'average' and so tend to err on the side of caution. For example, 10 000 ft is traditionally considered the threshold for significant hypoxia effects, although performance and other effects can be observed at lower altitudes.[10] Indeed, the late Air Vice Marshall John Ernsting, the UK's leading pioneer in aviation medicine, was advocating for a maximum cabin altitude of 5000 ft (1524 m) in his seminal publications back in the 1960s and 1970s.[11 12]

In more recent years, this topic has been revisited with new evidence indicating that acute exposure (hours) to 6000–8000 ft (1829–2438 m) can be relevant to physiology and well-being even for healthy individuals, particularly when combined with physical activity.[13–15] It has also been shown that the severity and duration of altitude exposures experienced during long haul air travel can be associated with symptoms such as headache that might be considered in the spectrum of acute mountain sickness.[16] More recent interest in this subjective experience of cabin pressure effects on the body found overlap with symptoms of jet lag and found that a simulated flight at 6000 ft (1829 m) was associated with less fatigue than at 8000 ft (2438 m).[17] Of note, that study was funded by Boeing at the time of introducing their 787 Dreamliner that has a cabin altitude ceiling of 6000 ft (1829 m). Air travel has also been shown to trigger classic physiological phenomena such as hypoxic pulmonary vasoconstriction (leading to increased pulmonary arterial pressures) and increased secretion of erythropoietin.[18 19]

There are still marked limitations in the evidence base to inform guidelines for passenger fitness to fly. Furthermore, as demonstrated by Trammer *et al*, there is much more to consider in terms of potential interactions of the flight environment with combined stressors such as sleep and alcohol intake, along with any pre-existing medical conditions.[9] The authors are commended for their work, which should be held as an example to encourage further such research to better inform our understanding of the physiological (or pathophysiological) challenges associated with commercial air travel for the general population.

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