
# Fitness to Fly

***Prof Michael Bagshaw***
is Visiting Professor of Aviation Medicine at King's College London and at Cranfield University. Previously Head of Medical Services at British Airways, prior to which he was Consultant in neuro-otology at St George's Hospital, London, and a GP in Berkshire. This followed a 16-year career in the Royal Air Force as a medical officer, pilot, flying instructor and test pilot. He is Honorary Civilian Consultant Adviser in Aviation Medicine to the British Army, Aeromedical Adviser to Airbus, and Medical Adviser to Netjets Europe.

***Correspondence to:***
Email: mikebagshaw@doctors.org.uk

The Cranfield web site is **www.cranfield.ac.uk**

**Further reading**

Hastings JD. *Aerospace Neurology.* In: Davis JR et al (eds). *Fundamentals of Aerospace Medicine* 4th ed. Lippincott; 2008:392-405.

Merry TG. *Neurological Disease.* In: Rainford DJ, Gradwell DP (eds). *Ernsting's Aviation Medicine* 4th ed. Hodder Arnold; 2006:683-93.

The consideration of fitness to fly after neurological injury or disease is a wide ranging subject meriting a substantial chapter in the appropriate textbook (see Further Reading). As with all aspects of aviation medicine, an understanding of the physics of the flight environment coupled with a thorough knowledge of the pathological process will assist in assessing fitness to fly. The aeromedical disposition is concerned with the likelihood of sudden or gradual incapacitation during flight as well as the effect of the injury or disease on physical and cognitive function; this is obviously of importance for a pilot being able to perform the flying task, but it is also so for the well-being of the patient flying as passenger and the effect on the safe and expeditious conduct of the flight. The prediction of future events in a disease requires knowledge of the natural history and epidemiology, which is essential for assessing the flight safety risk in the hypobaric environment and the confines of an aircraft.

## The hypobaric environment

The atmosphere is compressible and has mass. The air at the surface of the earth is supporting the mass of air above it and its molecules will therefore be pressed close together, causing the density of the air to be greatest at the surface. With increasing altitude, there is a fall in atmospheric pressure together with a decrease in density and temperature. Fortunately, the relationship between the oxygen saturation of haemoglobin and oxygen tension minimises the effect of the reduction in partial pressure of oxygen. Ascent to an altitude of 10,000ft produces a fall in the partial pressure of oxygen in the alveoli but only a slight fall in the percentage saturation of haemoglobin with oxygen. However, once altitude rises above 10,000ft the percentage saturation of haemoglobin falls quickly, resulting in the condition of hypoxia. The cabin of a commercial airliner is pressurised to maintain an equivalent altitude below 8,000ft irrespective of the aircraft's operating altitude. Occupants of light aircraft and gliders use personal oxygen equipment if flying at altitudes in excess of 10,000ft.

## Mechanical effects of pressure change

In civilian passenger and transport aircraft, the climb to cruise altitude takes about 30 minutes and involves a maximum fall of about 200mmHg (26.6kPA) in cabin pressure (to the equivalent of 8000ft (2440m)). Descent to land takes much the same time. Body fluids and tissues generally are virtually incompressible and do not alter shape to any important extent when such pressures changes are applied. The same is true of cavities such as the lungs, gut, middle ear, and facial sinuses that contain air, provided that they can vent easily. Gas-containing spaces that cannot vent easily behave differently.

The thoraco-abdominal wall can develop transmural pressures of +100mmHg or so briefly, but is normally flaccid and has a transmural pressure of a few millimetres of mercury. Gas within will usually be at a pressure very close to that outside, and must follow Boyle's law. Ascent from ground level (760mmHg) to 8000ft (2440m) (565mmHg) will expand a given volume of trapped gas in a completely pliable container by about 35%. This may cause slightly uncomfortable gut distension in healthy people but it is not an important problem.

Even very diseased lungs can vent themselves over a minute or so. In consequence, the risk of lung rupture in normal flight is extremely rare.

The cavity of the middle ear vents easily, but sometimes fails to fill because the lower part of the Eustachian tube behaves as a non-return valve, especially when it is inflamed. As a result, the cavity equilibrates quite easily on ascent but does not refill on descent, and the ear-drum bows inwards, causing pain that can be severe (otic barotrauma).

## Fitness to fly

Different medical requirements apply to the various classes of flying licence defined by the International Civil Aviation Organisation. Class 1 medical certification is required by airline transport and commercial pilots and Class 2 by private pilots. Standards are applied in the UK by the Aeromedical Section (AMS) of the Civil Aviation Authority on behalf of the European Aviation Safety Agency, using requirements originally formulated by the European Joint Aviation Authorities. In the UK there is another class of licence, the National Private Pilot Licence, for which the driving medical standards laid down by the Driver Vehicle and Licensing Authority are applied. This licence may be held by pilots of simple light aircraft, micro-lights and gliders, gyroplanes, balloons and airships. There are no statutory licence requirements for hang-glider or paraglider pilots or for parachutists, although supervision is carried out by their sport associations.

For passengers, the individual airline has a legal right to refuse carriage, with the ultimate authority resting with the aircraft captain. Many airlines employ a medical adviser, and the major companies provide website information on flying with, or after, medical conditions. The Aerospace Medical

**Table 1. Excerpt from JAR FCL-MED for Pilot Medical Requirements**

FCL 3.210 Neurological requirements

(a) An applicant for or holder of a Class 1/2 medical certificate shall have no established medical history or clinical diagnosis of any neurological condition which is likely to interfere with the safe exercise of the privileges of the applicable licence(s).

(b) Particular attention shall be paid to the following (see Appendix 11 to Subpart B):

(1) Progressive disease of the nervous system,

(2) Epilepsy and other causes of disturbance of consciousness,

(3) Conditions with a high propensity for cerebral dysfunction,

(4) Head injury,

(5) Spinal or peripheral nerve injury.

(c) Electroencephalography is required when indicated by the applicant's history or on clinical grounds [(see Appendix 11 to Subpart B)] .

Appendix 11 to Subparts B and C - Neurological requirements

1 Any stationary or progressive disease of the nervous system which has caused or is likely to cause a significant disability is disqualifying. However' in case of minor functional losses' associated with stationary disease the Aeromedical Section (AMS) may consider a fit assessment after full evaluation.

2 A history of one or more episodes of disturbance of consciousness of uncertain cause is disqualifying. In case of a single episode of such disturbance of consciousness' which can be satisfactorily explained' a fit assessment may be considered by the AMS' but a recurrence is normally disqualifying.

3 Epileptiform paroxysmal EEG abnormalities and focal slow waves normally are disqualifying. Further evaluation shall be carried out by the AMS.

4 A diagnosis of epilepsy is disqualifying' unless there is unequivocal evidence of a syndrome of benign childhood epilepsy associated with a very low risk of recurrence' and unless the applicant has been free of recurrence and off treatment for more than 10 years. One or more convulsive episodes after the age of five are disqualifying. However' in case of an acute symptomatic seizure' which is considered to have a very low risk of recurrence by a consultant neurologist acceptable to the AMS' a fit assessment may be considered by the AMS.

5 An applicant having had a single afebrile epileptiform seizure which has not recurred after at least 10 years while off treatment' and where there is no evidence of continuing predisposition to epilepsy' may be assessed as fit if the risk of a further seizure is considered to be within the limits acceptable to the AMS. For a Class 1 fit assessment a multi-pilot (Class 1 `OML') limitation shall be applied.

6 Any head injury which has been severe enough to cause loss of consciousness or is associated with penetrating brain injury must be assessed by the AMS and be seen by a consultant neurologist acceptable to the AMS. There must be a full recovery and a low risk (within the limits acceptable to the AMS) of epilepsy before a fit assessment is possible.

7 Assessment of applicants with a history of spinal or peripheral nerve injury shall be undertaken in conjunction with the musculo-skeletal requirements' Appendices and Manual Chapter.

8 The assessment of malignant conditions in this system is also explained in the Oncology Chapter of the Manual which provides information regarding assessment and should be consulted together with the Chapter specific to this system. All intracerebral malignant tumours are disqualifying.

Association and the International Air Transport Association provide similar web-based information, as does the UK Civil Aviation Authority.

For pilots, aeromedical disposition following any injury or disease is predicated on the so-called 1% rule, which is an attempt to quantify risk assessment. By seeking to ensure that no individual with an incapacitation risk of over one per cent per annum operates as a pilot, it aims to achieve a target fatal accident rate of 0.1 fatal accidents per one million flying hours for commercial aviation. For non-commercial private aviation, the acceptable risk is greater and an arbitrary 2% risk of incapacitation may be acceptable. This rule is not used in assessing fitness for the UK National PPL.

**Neurological Conditions**

It is impossible in a short paper to provide a comprehensive guide to fitness to fly as affected by all neurological conditions. As in any clinical situation, the following questions should be considered:

1. Is the condition affected by reduction in ambient pressure or hypoxia?
2. Is the condition static? If so, what is the degree of functional incapacitation?
3. Is the condition progressive? If so, is the course predictable or unpredictable?
4. Can the condition be monitored successfully?
5. Can the condition result in sudden incapacitation?
6. Can the condition result in subtle incapacitation?
7. In the case of assessing fitness to fly as a passenger, does the condition impede mobility?

***Pilots***

The regulatory authority approves a network of aeromedical examiners (AMEs) who have undergone specialist training in aviation medicine, and are often pilots themselves. These AMEs perform the regular recurrent medical assessments required for maintenance of Class 1 and 2 licences, as well as the initial medical examination for Class 2 private pilots, and a bond of understanding and trust develops between the pilot and AME. Statutory licence holders have a legal duty to inform the Aeromedical Section (AMS) if they become unfit to exercise the privilege of their licence through injury or illness, and they frequently do this via the AME.

There is a partnership between the pilot, the AME and the AMS and in the event of illness or injury, the partnership extends to include the GP and/or the specialist. The AMS requires specialist reports from the treating clinician which assist in the assessment of fitness to return to flying. This decision is taken by the AMS after considering the clinical and operational factors affecting flight safety. It is the pilot's responsibility to ensure that the appropriate reports are sent to the AMS. An excerpt from the relevant medical requirements for neurological conditions is given in Table 1.

For recreational pilots holding a UK National PPL, the procedure is different. Medical assessment does not use the network of AMEs, but relies on a declaration of medical fitness by the pilot. To validate this declaration, and to prevent concealment of disease, it has to be endorsed by a doctor with access to the pilot's medical records, usually the GP. The paperwork is reviewed by the National PPL Medical Advisor at the CAA Medical Department.

Following neurological disease, the pilot's state of health is compared with the DVLA medical standards of fitness to drive. If the pilot wishes to carry passengers (maximum of three) then the standards for DVLA Group 2 professional drivers must be met. For solo flight, DVLA Group 1 standards will suffice. DVLA standards are available on-line via www.dvla.gov.uk/at_a_glance/content.htm

***Pilots with disabilities***

People with a wide range of disabilities may learn to fly. The British Disabled Flying Association aims "to get people with crutches

and wheelchairs into the air", for which they have some modified training aircraft and qualified instructors. A number of scholarships are offered annually, and individuals with severe disabilities have gone on to gain their private pilot's licence. Each case is assessed individually by an AME representing the CAA. The web site is http://www.bdfa.net/index.html

### *Cabin Crew*

Cabin crew in the UK do not hold a statutory licence with an associated medical certificate. However they are required to be fit to carry out their safety function which includes the ability to open doors, operate fire fighting equipment, deploy escape slides, and control and evacuate passengers. They work in a dry hypobaric environment and experience sleep disruption and circadian dysrhythmia. The employer has a duty of care to ensure fitness for employment in the particular environment, and this function is normally discharged by the occupational health adviser in consultation with the employee's GP and/or medical specialist.


The British Disabled Flying Association are a registered charity offering flight experiences and full flying training to PPL/NPPL, for disabled people, together with aircraft hire for disabled BDFA members. The aircraft fleet includes Piper PA28s adapted with hand rudder controls to allow pilots with spinal injury, lower limb weakness, amputation or spasticity to fly in safety. Pilots and student pilots with widely varying disabilities are catered for, enabling them to share the uniquely stimulating challenges provided by flying light aircraft. www.aerobility.net

Photograph: Francis Lees, and Nathan Doidge (seated) – student pilots.

### *Passengers*

Medical clearance is required when:

- fitness to travel is in doubt as a result of recent illness, hospitalisation, injury, surgery or instability of an acute or chronic medical condition;
- special services are required (e.g. oxygen, stretcher or authority to carry or use accompanying medical equipment such as a ventilator or a nebuliser).

Medical clearance is not required for carriage of an invalid passenger outside these categories, although special needs (such as a wheelchair) must be reported to the airline at the time of booking.

It is vital that passengers remember to carry with them any essential medication, and not pack it in their checked baggage.

Deterioration on holiday or on a business trip of a previously stable condition, or an accident, can often give rise to the need for medical clearance for the return journey. A stretcher may be required, together with medical support, and this can incur considerable cost. It is important for all travellers to have adequate travel insurance.

### *Assessment criteria*

The passenger's exercise tolerance can provide a useful guide on fitness to fly; if unable to walk a distance greater than about 50m without developing dyspnoea, there is a risk that the passenger will be unable to tolerate the relative hypoxia of the pressurised cabin.

As well as the reduction in ambient pressure and the relative hypoxia, it is important to consider the physical constraints of the passenger cabin. A passenger with a disability must not impede the free egress of the cabin occupants in case of emergency evacuation. There is limited leg space in an economy class seat and a passenger with an above-knee leg plaster or an ankylosed knee or hip may simply not fit in the available space. The long period of immobility in an uncomfortable position must be taken into account, and it is imperative to ensure adequate pain control for the duration of the journey, particularly following surgery or trauma. Even in the premium class cabins with more available leg room, there are limits on space. To avoid impeding emergency egress, immobilised or disabled passengers cannot be seated adjacent to emergency exits, despite the availability of increased leg room at many of these positions. Similarly, a plastered leg cannot be stretched into the aisle because of the conflict with safety regulations. There is limited space in aircraft toilet compartments and, if assistance is necessary, a travelling companion is required. Cabin crew cannot provide individual personal assistance.

The complexities of the airport environment should not be underestimated, and must be considered during the assessment of fitness to fly. The formalities of check-in and departure procedures are demanding and can be stressful, and this can be compounded by illness and disability as well as by language difficulties or jet lag. The operational effect of the use of equipment such as wheelchairs, ambulances and stretchers must be taken into account, and the possibility of aircraft delays or diversion to another airport must be considered. It may be necessary to change aircraft and transit between terminals during the course of a long journey, and landside medical facilities will not be available to a transiting passenger. At London's Heathrow Airport, for example, transfer traffic accounts for more than 40% of all passengers.

There is often a long distance between the check-in desk and the boarding gate. Not all flights depart from or arrive to jetties, and it may be necessary to climb up or down stairs and board transfer coaches. It is thus important for the passenger to specify the level of assistance required when booking facilities such as wheelchairs.

Guidance can be found on the websites of the Aerospace Medical Association (www.asma.org), the International Air Transport Association (http://www.iata.org/ps/publications/medical-manual.htm) and the British Thoracic Society (www.brit-thoracic.org.uk/docs/flyingguidelines.pdf), as well as individual airlines.

### Training in aviation medicine

In the UK, aviation medicine is considered a sub-specialty of occupational medicine. The prime post-graduate qualification is the Diploma in Aviation Medicine awarded by the Faculty of Occupational Medicine of the Royal College of Physicians. Diploma is a misnomer for what is a high level qualification requiring six months full time study at King's College London (KCL) and the Royal Air Force Centre of Aviation Medicine (RAFCAM), prior to the academic examination. This is recognised by KCL with the award of an MSc in Aerospace Physiology & Health following satisfactory completion of a further six months research project.

KCL also offers a Basic and an Advanced Aviation Medicine course, each of two weeks duration, intended for medical practitioners wishing to be appointed as AMEs. These courses are ideal for those wishing to gain an understanding of the practical principles of aviation medicine. The website is www.kcl.ac.uk

Cranfield University offers a taught module in aviation medicine as part of the MSc in Human Factors & Safety Assessment in Aeronautics. The module is a two week taught course followed by a written examination in the Department of Systems Engineering and Human Factors. ◆