Aviation Medicine

Special forms of flight

I: Balloons, gliders, and hang gliders

RICHARD M HARDING, F JOHN MILLS

"*Engines for flying, a man sitting in the midst thereof, by turning onely about an Instrument, which moves artificial Wings made to beat the Aire, much after the fashion of a Bird's flight.*"[1] (Roger Bacon, c. 1214-94).

Man has always sought to emulate the flight of birds, and the ubiquity of modern aviation is evidence of his success.

Balloons

Two hundred years ago the Montgolfier brothers first demonstrated to the world that man-carrying "engines for flying" were possible. Their vehicle, however, did not have "artificiall Wings" but was a balloon filled with hot air. (A Brazilian, Bartolomeu de Gusmao, had flown a small unmanned hot air balloon 74 years earlier.[1]) After successful unmanned demonstrations the first recorded free flight by man took place on 21 November 1783, when Jean-Francois Pilatre de Rozier, a doctor, and Francois Laurent, Marquis d'Arlandes, undertook a 25 minute flight over Paris in a Montgolfier balloon (in contrast to a Charlier balloon, which is one filled with a gas that is lighter than air and also flew manned in the same year).[2] Since that auspicious beginning man has landed on the moon and sent machines to other planets. Non-powered balloon flight has played a vital part in this amazing advance and still retains a place of its own in modern aviation.

Notwithstanding Pilatre de Rozier's contribution, the history of aviation medicine can truly be said to have begun in 1875. In that year—again in France—a balloon flight to 28 820 ft (8784 m) by three young scientists, Croce-Spinelli, Sivel, and Tissandier, ended in tragedy when they failed to use their oxygen equipment properly.[3] Only Tissandier survived, the others becoming the first victims of aviation hypoxia. Subsequent ascents over the next 60 years showed conclusively—and again sometimes tragically—that flights above about 42 000 ft (12 802 m) were not possible, even when breathing 100% oxygen; the risks and limitations imposed by lack of oxygen, and also by the extreme cold of altitude, were overwhelming.[2] The solution to these two problems, and thus the possibility of higher flights, was pioneered by Auguste Piccard, who in 1931 designed, built, and flew the first ever pressurised cabin—suspended beneath a gas filled balloon—to an altitude of 51 762 ft (15 781 m).[2] The gondola was pressurised to one atmosphere and had its own oxygen supply and a means of eliminating carbon dioxide. Temperature was controlled in later flights by painting the top of the gondola white and the underneath black. This created an acceptable internal temperature of 19·4°C when the outside temperature was −55°C. A similar colour scheme was adopted in the extant high altitude record ascent to 113 700 ft (34 656 m) by Ross and Prather in 1961. On this occasion thermal control was achieved by alternating the exposure of black and silver (aluminium) venetian blinds.[4] The problem of direct and excessive solar heating of objects within enclosed capsules was overcome in the Apollo space programme by slowly rotating the space craft about its longitudinal axis—so called passive thermal control.[2]

After Piccard's breakthrough, larger gas filled balloons capable of flying to altitudes beyond 100 000 ft (30 480 m) were developed —mainly by American and Russian military organisations—to test and prove a variety of equipment for future manned space programmes. Research ballooning of this type is now limited, although high altitude unmanned balloons continue to provide vital physical and meteorological information.

Nearer to earth, hot air sport ballooning in open gondolas is a popular and growing activity stemming from the development in the 1950s of new lightweight materials and of balloons equipped with propane gas burners (lighter than air gas balloons are seldom used for sport). Although this sport usually takes place at relatively low altitudes, the major problems facing today's balloonists are the same as those encountered by the research pioneers of the past—namely, lack of oxygen and cold. Thus any flights above 10 000 ft (3048 m)—such as altitude record attempts or during mountain balloon meets—are clearly those for which expert advice on oxygen equipment and thermal comfort should be obtained. Simple oxygen systems are available which will provide adequate protection up to an altitude of 25 000 ft (7620 m), and protective clothing—such as that worn for skiing—is recommended. Those who wish to go higher than 25 000 ft run the additional major risk of decompression sickness and again should seek expert advice before flight.

Hot air ballooning has proved to be exceptionally safe; in recent years there have been no fatal accidents in Britain. This probably reflects the high professional and medical standards required of balloon pilots, who are expected by the Civil Aviation Authority to hold a pilot's licence and a medical certificate.

Gliders

Gliders are non-powered craft which are heavier than air and capable of sustained flight. Since their first use in the 1890s their design and performance have been progressively improved, and they have been used extensively—particularly in the past 50 years—for aeronautical and meteorological research and during the second world war as troop transports. Today they are most often flown for sport, and there are over 100 000 devotees worldwide.[5]

RAF Institute of Aviation Medicine, Farnborough, Hants
RICHARD M HARDING, MB, DAVMED, squadron leader
F JOHN MILLS, MB, PHD, squadron leader

Correspondence to: Squadron Leader R M Harding.

In the United Kingdom the Civil Aviation Authority does not require glider pilots to have either a pilot's licence or a medical certificate (although pilots of motor gliders must have a licence) despite their susceptibility to many of the medical and safety problems that beset their powered colleagues—such as problems of altitude, cockpit workload, and in particular altered perception. For example, difficulties of look out are exacerbated in the often very crowded thermals over popular gliding sites. This, combined with the problem of internal reflections from the highly curved cockpit transparency, adds to the pilot's visual workload. At moderate altitudes freezing expirate on the canopy may further impair vision. All of these aspects are given scant attention by many instructors, and only recently has any advice been available in gliding magazines.[6-8] Even the sport's governing body, the British Gliding Association, recommends only that oxygen should be carried during flights above 12 000 ft (3656 m); it neither explains the need for, nor encourages, its use. Carrying parachutes is also just a "recommended practice."[9]

It is the problems of restraint and protection from impact, however, that are most obviously connected with gliding safety. In 1980 there were 60 notifiable accidents involving gliders on the British register resulting in five fatalities (in 1979 there were four fatalities in the 48 accidents notified).[10] The British Gliding Association compiles its own more extensive annual register of accidents and incidents and has identified an increased risk during training, which is reflected by a disproportionately high number of dual seat gliders in the accident figures.[11] Virtually all gliding accidents occur during landing (68% in 1980) or take off (12%),[10] although the latter is more likely to have a fatal outcome and has accounted for nearly half the fatalities over the past five years.[12] Most landing accidents are survivable, probably because of the low landing speed combined with effective harness restraint. There is, however, no cause for complacency, and we hope that the association may consider some degree of formal aviation medicine training for its members while striving to maintain and improve safety standards—for example, most glider pilots do not wear protective helmets. Furthermore, stricter medical requirements, which at present consist only of a signed declaration of physical fitness, should be imposed, or perhaps the Civil Aviation Authority should reconsider whether to include glider pilots in its medical licensing scheme.

Hang gliders

Since the 1970s hang gliding has become a growing and fashionable sport, which in Britain is carefully controlled by the British Hang Gliding Association. The association lays down training requirements and recommends appropriate safety equipment[13]—such as a protective helmet (which is mandatory for association members during training and when flying in competitions), a high quality harness, adequate clothing—in particular strong footwear—and a parachute. Although heavy, oxygen equipment is a requirement for high altitude hang gliding. In North America, however, where cross country hang gliding is often carried out at 14 000 ft (4267 m) or above, the cavalier attitude to such protection occasionally defies belief: ". . . at 18 500 ft . . . I was now on oxygen. I didn't have a mask, so I just stuck the tube in my mouth and this worked tolerably well."[14] A British hang gliding enthusiast, having attended an aviation medicine training course, displayed a more commendable attitude and indeed even commented on the relevance of disorientation during hang gliding.[15] Most medical interest in this sport has, however, centred on the injuries sustained and suggestions for preventing or reducing them. During the second half of the 1970s, in the wake of an increasing number of serious accidents, hang gliding accidents in various parts of the world were analysed.[16-20] Of reported accidents—and at that time reporting was not mandatory in many countries (and often is still not)—4-10% were fatal. Most fatalities were caused by head injuries, although the frequency of these was relatively low, probably because of the widespread use of protective helmets. Most major injuries were fractures or fracture-dislocations of the arms (36%) or legs (43%), and most (82%) occurred during take off or landing. Human error was to blame in most cases, often as a result of inexperience leading to poor choice of take off or landing sites, poor landing technique, and incorrect assessment of wind conditions, altitude, and speed.[17 21] Nevertheless, experienced pilots were not exempt.[19 20] Recommendations regarding licensing, ground training, and the use of safety equipment[17 19] have largely been adopted by the association (as outlined above), and, although the sport remains dangerous, it is possibly no more so than many other activities—such as motor cycling, skiing, rock climbing, and horse riding.

Microlight aircraft

Microlight aircraft are the most recent entrants to sport flying and may best be described as powered hang gliders. These small lightweight machines can cruise at 70 mph (112 kph) and fly to altitudes above 16 000 ft (4877 m); the implications of these for aviation medicine are obvious. Perhaps at least partly as a result of public concern over hang gliding accidents and the increasing number of fatal microlight accidents, the Civil Aviation Authority has since September 1982 required microlights to be registered and their pilots to hold either a valid pilot's licence or to be flying under the supervision of a qualified flying instructor. Pilots must also hold a medical certificate, to which the usual disqualifying conditions apply. Whether such statutory requirements are able to reduce the morbidity and mortality of this pastime remains to be seen.

Next week's article covers the medical aspects of helicopter flight.

We thank Dr A J F Macmillan, head of the altitude division, RAF Institute of Aviation Medicine, for his help in the preparation of this manuscript.

References

1 Taylor JWR, Munson K, eds. *History of aviation.* London: New English Library, 1975;506.
2 Engle E, Lott AS. *Man in flight—biomedical achievements in aerospace.* Maryland: Leeward Publications, 1979;1-29.
3 Ernsting J. Prevention of hypoxia—acceptable compromises. *Aviat Space Environ Med* 1978;**49**:495-502.
4 Ross MD. We saw the world from the edge of space. *National Geographic* 1961;**120**:670-85.
5 Barnett C, Parker I, Wilkinson J. Flight without power. *Flight International* 1980;**118**:186-92.
6 Scull B. Workload management and flying to the limits. *Sailplane and Gliding* 1982;Feb/Mar:19.
7 Anonymous. Disorientation in flight. *Sailplane and Gliding* 1980;Feb/Mar: 18-9.
8 British Gliding Association. *Accidents to gliders,* 1979. Leicester: British Gliding Association, 1980.
9 British Gliding Association. *Laws and rules for glider pilots.* 8th ed. Leicester: British Gliding Association, 1979.
10 Civil Aviation Authority. *Accidents to aircraft on the British register* 1980. London: Civil Aviation Authority, 1981. (Civil Air Publication 438:vi.)
11 British Gliding Association. *Accidents to gliders*—1978. Leicester: British Gliding Association, 1979.
12 British Gliding Association. *Accidents to gliders*—1977-1981. Leicester: British Gliding Association.
13 Welsh A, ed. *The BHGA pilot handbook.* Taunton, Somerset: British Hang Glider Association, 1979.
14 Pollard, M. Rendezvous with a glider. *Wings!* 1982;Mar:20-2.
15 Hudson JA. Twenty-five thousand feet gentlemen—uncouple your oxygen. *Wings!* 1981;Jun:14-5.
16 Krissoff WB, Eiseman B. Injuries associated with hang-gliding. *JAMA* 1975;**233**:158-60.
17 Yuill GM. Icarus's syndrome: new hazards in flight. *Br Med J* 1977;i: 823-5.
18 Tongue JR. Hang-gliding injuries in California. *J Trauma* 1977;**17**:898-902.
19 Margreiter R, Lugger L-J. Hang-gliding accidents. *Br Med J* 1978;i: 400-2.
20 Anonymous. Hang-gliding accidents [Editorial]. *NZ Med J* 1979;**89**:481-2.
21 Anonymous. Hazards of hang-gliding [Editorial]. *Br Med J* 1978;i:388.