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Work in the Aviation Environment

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Physiological Problems in Air Cabin Crew

There have been a considerable number of studies carried out on airline and military pilot workload problems in this country and elsewhere, but with one or two exceptions little attention has been paid to the workload and working conditions of cabin crew in transport aircraft.

In 1969 the British Airways Medical Service was asked by BOAC management and staff to set up a small group to look into the workload and working conditions of BOAC cabin staff as there had for some time been considerable industrial unrest in that quarter. The entire life style of cabin crew was examined, and much line flying in actual operations as observers carried out.

BOAC's Operation

BOAC (now British Airways Overseas Division) is essentially a long-haul airline operating a global network using BAC VC 10 and Boeing 707 aircraft. The team did not study the Boeing 747 which was on route-proving flights at the time of the study.

Cabin crew are rostered for service on these aircraft from a central scheduling department and the staff concerned work from a card-index system which shows when the individual cabin crew members returned from their last trip. Trips are made up in accordance with the scheduling rules agreed with the trade union.

The trips concerned could be very long and take anything up to 21 days away from base and as a result cover vast areas of the world. Alternatively these could also involve multiple crossings of the North Atlantic (one of BOAC's trunk routes) with frequent adjustment to biological rhythms. In addition, the work could be a combination of both types of flying.

Physical Standards of Cabin Crew

Although not licensed by the Civil Aviation Authority, as in the case of airline pilots, cabin crew are highly selected and in addition are of a high medical standard on entry. The job entails a high standard of physical fitness throughout employment and to ensure this skilled medical care is provided by airlines for this category of staff.

Male stewards tend to make a life-time career of the occupation. Females on the other hand remain in employment for about 36 months on average. It was obvious therefore that there were widely differing levels of motivation to the job between males and females. This was also reflected markedly in casual sickness (under 3 days) in that the sickness levels in females was twice as great as that in males.

General Functions of Cabin Staff

Firstly, cabin crew are carried on civil air transport because of statutory requirements. The Air Navigation Order (Civil Aviation Authority 1972) states the conditions under which cabin crew must be carried and in what proportion to the passenger load.

Their first function is therefore a safety one in that they are responsible for opening and closing passenger doors and exits in an emergency, ensuring that passengers are strapped in, and ensuring the safe evacuation of passengers from the aircraft in an emergency.

Secondly, they are responsible for meal and cabin service, the care of the elderly, the infirm and young unaccompanied minors.

Environmental Problems

In the aircraft itself there are physiological constraints which must be taken into consideration. Due to the fact that aircraft structures cannot be pressurized to sea-level, the cabins of most civil air transport aircraft are flown

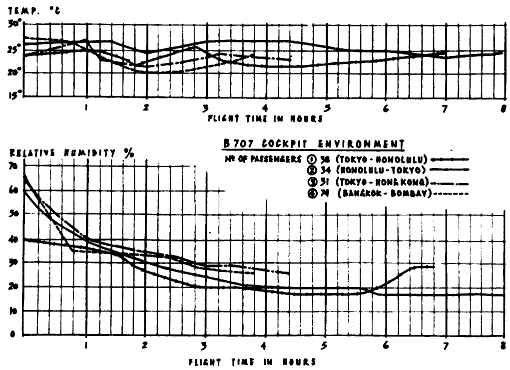

Fig 1 *Showing cockpit temperature and relative humidity levels in a Boeing 707 aircraft on four separate flights*

pressurized 5000–7000 ft (1500–2100 m) when the aircraft is at its maximum cruising height. This in itself causes a relative hypoxia due to the lowering of the oxygen partial pressure. Such altitudes, according to Ernsting (1963) can lead to a diminution in mental ability and accuracy. In addition, very dry air passes into the cabin from the cabin air compressors or directly from the compressor stage of the engines; very dry air at high altitudes is drawn into the engines, and compression drives any further water vapour off (Fig 1). In aircraft which are not humidified it is common to find that the relative humidity has fallen to 20% or less 1½ hours after take-off and on prolonged flights at altitude may fall to zero. Low humidities of this level cause drying of the skin and mucous membranes of the nose and respiratory passages and may on occasion produce oliguria and brittleness of the nails and hair. Studies have been carried out on the frequency of urinary calculi in cabin crew in these conditions (Richards 1969), but no increased incidence was observed when compared to other groups.

The radiant heat evolved from radio communication and navigation equipment tends to raise cabin temperatures and this may lead to high environmental cabin temperatures, particularly where high ambient temperatures are met with on the ground. In such conditions the cabin may take a long period to cool off in flight although the use of Auxiliary Power Units (APUs) has done much to reduce this. The long-term effects of high temperatures, low humidity and high workload may have longer, more subtle effects on the human being in relation to fatigue but as yet little work seems to have been done in this field. Urine production is undoubtedly lowered followed by an unexplained diuresis (Barnes 1973*b*) on the day following flight. This is still as yet unexplained physiologically but Barnes has suggested that overactivity of the posterior pituitary and release of increased amounts of ADH may be a factor.

Physiological Problems

Sleep: Probably the greatest problem facing the airline crew member is his inability to achieve sleep at his destination, particularly after transmeridian flight. In a global operation the problem may become acute when the crew member is continually moving on so that he never really adapts to a new time zone. We have found that there is evidence of considerable sleep deprivation in airline pilots engaged on long transmeridian routes (Preston 1973) and in the present study (Preston, Ruffell-Smith & Sutton-Mattocks 1973) on cabin crew we found that loss of sleep seems to be associated with night flights and becomes increasingly severe in some individuals as the tour progresses (Fig 2). In our findings cabin crew seemed to contain the situation until about the eighth day away from base, but after this point there are widely varying levels of sleep deficit (Fig 3). This suggested to us that such schedules should be operated fairly rapidly round

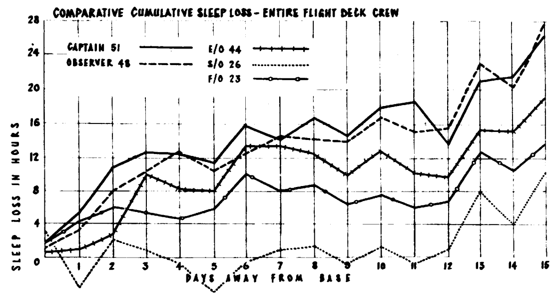

Fig 2 *Graph showing cumulative sleep loss in Boeing 707 crew on Far East schedule. Cumulative sleep represents sleep lost each day on tour as against home sleeping pattern*

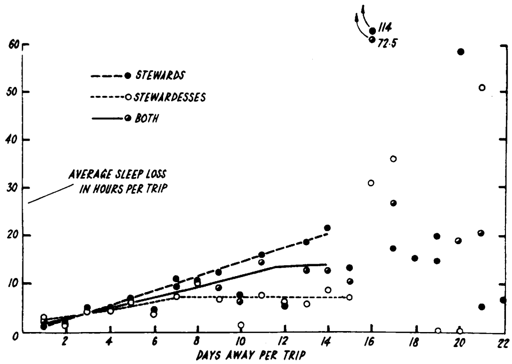

Fig 3 *Graph showing sleep loss in cabin crew during long overseas tours. After the eighth day on tour there is wide individual variation in sleep loss*

the route with a possible maximum of eight days away from base. Stopping the tour to include two or three local nights as suggested in possible future UK legislation may possibly complicate the situation in that crew members may attempt to adjust to local time due to social pressures with all the resultant physiological handicaps of circadian dysrhythmia. In this matter we are therefore in dispute with the findings of the recent Bader Committee on Fatigue (Civil Aviation Authority 1973) which has suggested two local nights off duty in every seven days away from base and three local nights in every 14 days. It is our opinion that much more work is required in this field before legislation can be promulgated; such legislation, if wrongly based, could be disastrous to the British aviation industry when compared with its international competitors.

Physical energy expenditure: During our study one of our colleagues (Barnes 1973*a*) was asked to look into the question of physical energy expenditure of cabin crew. The assistance of the Medical Research Council was sought and Dr J R Brotherhood, late of the British Antarctic Survey, was asked to advise on the best methods of measurement.

The apparatus used consisted of a Max-Planck respirometer and a Lloyd-Haldane gas analyser. The subject wore the respirometer on the back, a nose-clip and mouthpiece (Fig 4). In this way all expired gases were measured and a side-tube allowed samples to pass into a detachable plastic bag. Samples so collected were then analysed in the Lloyd-Haldane gas analyser, and the CO_2 and O_2 content was measured.

For each task the mean of the results obtained was calculated in kcal kg^{-1} min^{-1}. The expected energy expenditure of a 70 kg male and a 55 kg female was as shown in Table 1.

Table 1

Expected energy expenditure for various tasks

Task	Energy expenditure (kcal min^{-1}) Female, weight 55 kg	Male, weight 70 kg
Galley work		
First class	2.89	3.67
Economy, light meal	2.5	3.19
Economy, main meal	3.24	4.12
Serving meals		
First class	2.56	3.26
Economy, trays by hand, light meal	3.3	4.2
Economy, trays by hand, main meal	2.97	3.78
Economy, mixed MTB/ hand service, main meal	3.03	3.86
Bar service		
Dispensing	3.23	4.11
Serving	2.1	2.67
Dressing aircraft	3.47	N/A
Walking	3.56	4.12

In the case of walking the experimental mean for each sex was calculated on the basis of cabin length and number of trips up and down the cabin. Using the information gained and time and motion studies a typical working day was built up for a 55 kg stewardess and Table 2 shows how the total was calculated. Approximately half the total of 2450 kcal (10.290 kJ) was spent during working hours (1066 kcal=4477 kJ).

One of the longest scheduled trip days in BOAC is the London/Miami flight, and using the same technique for a male steward the energy expenditure would be in the region of 3260 kcal (13 690 kJ).

In summary, therefore, the energy expenditure of a stewardess on an average day would appear to be above that of an average shop assistant but

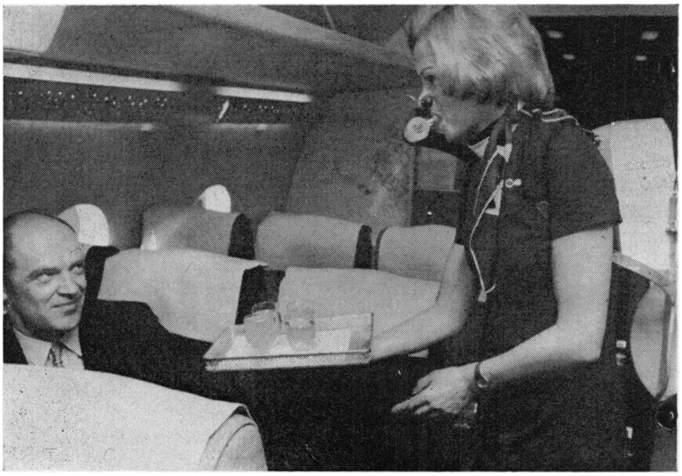

Fig 4 *Subject wearing Max-Planck respirator during normal cabin duties*

Table 2

Energy expended by 55 kg stewardess in typical working day

Time		*Energy expended (kcal)*
00.01 – 06.30	Sleeping	390
06.30 – 07.50	Bathing/dressing/breakfast	200
07.50 – 08.50	Drive to airport	102
08.50 – 09.20	Transport to aircraft	60
09.20 – 16.40	6½ hour flight	1066
16.40 – 17.50	Leaving aircraft/hotel	140
17.50 – 19.00	Room/bathing/snack/room	114
19.00 – 20.00	Unpacking/undressing	136
20.00 – 24.00	Sleeping	244
Total		2450

about that equal to a young housewife (Grieve 1967). A steward's energy expenditure on the London/Miami flight is comparable with that of a building worker or steel worker but somewhat less than that of a farmer or coal miner (Durnin & Passmore 1967).

Effects on Performance

I have already referred to the effect of a reduced oxygen tension on mental performance in all aircrew exposed to lowered barometric pressure. As a parallel study we carried out some isolation chamber experiments at the University of Manchester's isolation unit at Risley using volunteer stewardesses. This has been separately reported (Preston, Bateman, Short & Wilkinson 1973).

In volunteers exposed to two time-zone shifts of 8 hours each, we clearly showed decrements in performance of 17–32% when averaged over the whole period and 18–82% when measured on the last day of isolation. This supports the work of Hauty & Adams (1965, 1966) that it is the time-zone transition itself and not the mere fatigue or relative hypoxia of flying that is mainly responsible for impaired performance following flights along the East-West meridian.

In addition, the data gave a good relationship between body temperature and performance such that when body temperature was at its highest, performance was most efficient. Time-zone changes destroy this relationship, and a more random fluctuation of body temperature was accompanied by a lower level of performance. We have just completed a further series of studies in the isolation chamber at Risley on further groups of volunteers but the results are not yet available.

Effects on Menstrual Cycle Length

There have been a few reports on the effect of flying on the menstrual cycle. The Russians claimed that the menstrual cycle length was undisturbed although flying increased the menstrual discharge and exacerbated dysmenorrhœa (Shmidova 1966). In a retrospective study by Swissair (Cameron 1969) using questionnaires, no long-term deleterious effects could be found.

It is known that a variety of environmental stresses, including travel, can either postpone or suppress ovulation in women (Matsumoto *et al.* 1968). When the environmental stress occurs in the preovulatory phase, ovulation is inhibited or delayed and menstruation is postponed. When the same environmental change occurs in the post-ovulatory phase, menstruation occurs at the expected time; however, the subsequent ovulation may also be postponed if the environmental change still persists.

By means of specially constructed menstrual logs 29 newly-joined stewardesses kept careful records for us, some as long as one year. All the volunteers were known to have a previous history of regular cycles in their previous ground employment. The results of our study (Preston, Bateman, Short & Wilkinson 1973) left no doubt that a high proportion of stewardesses flying transmeridian routes (28%) have irregular menstrual cycles. This irregularity seems to be mainly due to occasional prolonged cycles and it is tempting to postulate that they are influenced by the stress of repeated time-zone changes. The life of the corpus luteum in nonpregnant women seldom exceeds 14 days (Vande Viele *et al.* 1970) so extended cycles are likely to be due to a prolongation of the preovulatory phase. It therefore seems significant that in our experimental attempts to interfere with the menstrual cycle by imposed time changes in the isolation chamber the only subject to show a response was in the early preovulatory phase at the time the phase-shift was applied. The use of oral contraceptives appears to cancel this effect and it must be noted that many stewardesses who have complained to their doctors about irregular menstrual cycles when employed on long-distance flying have been placed on this therapy with good result.

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Physiological and Pharmacological Studies Related to the Work of Airline Pilots

In most air transport operations aircrew have to cope with irregular duty hours. These arise from the need to maintain complex schedules and are often complicated, in the case of worldwide operations, by time zone changes. The duty hours of airline pilots are neither related to their sleep-wakefulness pattern nor to the night-day cycle of the locality, and so an irregular pattern of rest and activity emerges from which the pilot has to create an acceptable sleep pattern. For example, in daily schedules from Europe to Australia via North America there are likely to be rest periods at New York, San Francisco and Honolulu of approximately 24 hours. After each duty there is a need to sleep, as it may well have been over 16 hours since the end of the previous sleep period. The tendency is to sleep soon after the completion of duty, but this would lead to tiredness during the next duty which starts about 12 hours after the end of the sleep, and so pilots will often split their sleep during a 24 hour rest into two parts of about 3–4 hours – one sleep immediately after and one sleep immediately before duty. Other adaptations include naps and the possible physiological significance of these adaptations has been reviewed elsewhere (Nicholson 1970).

An acceptable sleep pattern can emerge only if duty hours over several days remain within certain limits. Irregular duty hours have a cumulative effect on the ability of crews to create an acceptable sleep pattern. It has been suggested (Nicholson 1972) that the total number of hours compatible with an acceptable sleep pattern bears a logarithmic relationship to the number of days on route.

In the context of aircrew coping with unusual patterns of sleep and wakefulness the use of hypnotics has presented a difficult issue. It is generally accepted that in transport operations the overall workload, in terms of duty hours spread over the schedule, should be such that aircrew can create a pattern of sleep which they find acceptable. But sometimes circumstances lead to a situation in which some assistance with sleep would prove most useful. Further, as the years go by, some aircrew experience difficulties in obtaining sleep during route flying and immediately on return from a schedule. Very careful consideration must be given to these individual problems. The question of abuse in such a sophisticated group under specialized medical care must still be borne in mind, but the most important considerations involve the choice of an hypnotic which would be used only as the occasion demanded. It would have to be an effective drug and one which would lead to little or no residual effect on performance during the next duty period.

The residual effects of drugs on performance have been studied by several workers using psychological tests, but with aircrew it is important that information should be available on the residual effects of drugs related to flying skills. Studies in man using an adaptive tracking technique have been carried out (Borland & Nicholson 1974), and it would appear that barbiturates at the maximum dose of the normal therapeutic range have an effect which impairs performance during most of the working day after overnight ingestion. It is hoped that further studies will suggest drugs which have a less persistent effect on performance.

Another area of interest is the workload which pilots experience during the approach and landing into airports. The efficiency of the crew and serviceability of the aircraft and its systems are to a very considerable extent under the influence of the pilot, but standards of air traffic control, availability of navigational aids and the runway length and lighting are usually beyond his immediate influence. Let downs with imperfect air traffic control and limited precision aids, particularly if complicated by adverse meteorological conditions, lead to a very high workload which the pilot may find difficult to assimilate. Under these circumstances difficulties could arise during the approach and landing.

An aircraft is handled during the approach in response to information from air traffic control, flight deck systems and runway lighting and the mental workload involved leads to changes in the central nervous state of the pilot which essentially create a state of preparedness for the adequate execution of the task (Nicholson *et al.* 1970). Very high workloads may elevate the state of nervous arousal above that associated with