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DECOMPRESSION SICKNESS IN HIGH-ALTITUDE FLIGHT

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Decompression Sickness in High-altitude Flight

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Review of 5 years of a WU-2 squadron's daily records shows 36 cases of decompression sickness entirely confined to reports of bends pain among 11 crewmembers in 958 flights. Generally, 40 minutes were spent in denitrogenation in a partial pressure suit and helmet before achieving cabin altitudes of close to 29,000 feet. The majority of bends occurred within the first 3.5 hours affecting the knee joints in almost two-thirds of the cases with a tendency to recur at the same joint. Only 1 case required descent to lower altitude to afford relief from pain.

THE ETIOLOGY of decompression sickness continues to be of fascination to aerospace medicine. Neither research nor case reports of altitude chamber or in-flight reactions have demonstrated clear and precise causes of predisposing factors, other than an exposure to altitude together with inadequate denitrogenation and the engaging in physical exertion. Many previous reports have emphasized the results of low-pressure chamber operations.[1,6] Findings reported for a few in-flight reactions include itches, bends, chokes, visual changes, paralysis, unconsciousness[2,3,7,9] and death.[5,8] Few of the reports of decompression sickness encountered in an operational squadron in daily flying have been published. With these thoughts in mind, the author received permission from the Surgeon, Strategic Air Command, to review the accumulated records of the Physiological Support Division (PSD) of the 803rd Medical Group at Davis-Monthan AFB, Arizona.

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MATERIALS AND METHODS

PSD provided support to a high-altitude weather reconnaissance squadron, integrating equipment inspection and maintenance with aeromedical support.[4] The aircraft flown was the WU-2, which achieves altitudes above 60,000 feet. The Consolidated Crew Mission Data Sheets covered the period of September 1959 through December 1964, and contained a preflight medical check, as well as a postflight debriefing. Data recorded prior to flight included the date, time of day, the crewmember's oral temperature, pulse, blood pressure, body weight, and whether he had eaten the available high-protein meal. Time spent in the prebreathing of oxygen was recorded, and debriefing included total flight time, maximum cabin altitude, duration of cabin altitude over 25,000 feet, and whether he had any symptoms or medical problems. It was also noted whether or not there were decompressions, and if so, the duration and to what cabin altitude. The preflight data was obtained by either a flight surgeon or medical technician, and the debriefing data by a personal equipment technician,

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and a flight surgeon if there was a medical problem. The information received from crewmembers was felt to be reliable. Many had flown with the squadron since its inception and had acquired considerable knowledge of and appreciation for the physiology of high-altitude flight.

TABLE I. BENDS EXPERIENCE IN ONE SQUADRON DURING 5 YEARS

Subject (Total Flights) Incidence	Flight Number	Duration Prebreathing (Min.)	Season	Time of Day	Flight Duration (Hrs.)	Time of Onset of Symptoms (Hrs.)	Maximum Cabin Altitude (Ft.x1000)	Duration Cabin Altitude >25,000 Ft.	Decompressions (No.)	Duration (Min.)	Location of Bends
A (81) 1.2%	1	40	W	AM	8.2	—	29	7.0	0	—	Right knee
B (20) 15.0%	2	50	Su	AM	7.0	4.5	29.5	5.5	0	—	Both knees
	3	40	Sp	AM	7.0	4	30	6.0	0	—	Both knees
	4	40	Sp	—	7.0	—	28.7	6.0	0	—	Left knee
C (122) 0.8%	5	40	Su	AM	7.2	4.5	28.5	6.0	0	—	—
D (44) 2.2%	6	40	Su	AM	6.8	4.5	29.5	4.5	0	—	Left shoulder
E (96) 1.0%	7	40	Su	AM	7.7	3.5	29	7.0	0	—	—
F (50) 2.0%	8	30	Su	AM	4.9	3.0	28.5	4.0	0	—	Left elbow and wrist
G (56) 1.8%	9	30	W	AM	6.7	—	>60	5.7	1	10	Right knee
H (139) 1.8%	10	40	F	AM	7.4	—	29	6.5	0	—	Right knee
	11	40	Sp	PM	5.2	2.5	29	4.2	0	—	Both knees
	12	40	F	AM	8.3	—	>60	6.0	1	20	Right knee
	13	30	W	AM	11.4	2.0	33	10.2	0	—	Right knee
I (140) 13.5%	14	40	F	AM	4.9	2.5	45	4.0	0	—	Right foot
	15	40	F	AM	6.1	—	30	5.0	0	—	Both knees
	16	40	F	AM	7.2	6.0	29	6.5	0	—	Both knees, Right ankle
	17	40	F	AM	7.0	5.0	35	6.0	0	—	Both knees
	18	40	W	AM	7.6	5.5	29	6.7	0	—	Right knee
	19	40	Sp	AM	8.2	3.0	29	7.5	0	—	Left knee and ankle
	20	40	W	AM	6.6	5.5	29	5.7	0	—	Right knee
	21	40	F	AM	7.1	5.5	29	6.2	0	—	Right foot
	22	40	F	AM	7.7	5.0	29	6.7	0	—	Left ankle
	23	40	W	AM	7.0	2.0	29	6.0	0	—	Ankle
	24	40	W	PM	5.7	3.0	28	4.7	0	—	Left foot
	25	50	W	AM	7.3	—	28	5.4	0	—	—
	26	60	W	AM	8.7	7.5	29	7.7	0	—	Right ankle
	27	60	W	AM	8.0	—	28	6.5	0	—	Knee and ankle
	28	60	W	AM	8.2	3.5	29	7.0	0	—	Both knees
	29	60	W	AM	8.3	—	28	7.7	0	—	Left wrist, both knees
	30	60	Sp	AM	8.0	3.0	28.5	7.0	0	—	Left arm
	31	60	Sp	AM	8.7	—	29	7.7	0	—	Left knee and ankle
	32	30	Su	AM	7.2	—	29	6.2	0	—	Right knee and ankle
J (113) 0.8%	33	30	W	AM	7.2	3.5	28.5	3.5	0	—	Right knee
K (97) 3.0%	34	40	Sp	AM	7.7	—	29	6.8	0	—	Right knee and ankle
	35	30	W	AM	8.5	3.5	29	7.0	0	—	Right shoulder
	36	45	F	AM	6.0	3.0	28.7	5.0	0	—	—

Crewmembers wore the MC-3A partial pressure suit with the MA-2 helmet, inflatable gloves, and unpressurized boots. Outer coveralls, a parachute, and underarm life preservers were used routinely. The seatkit contained the F-2400 oxygen regulator and emergency oxygen, along with survival equipment. About one and one-half hours prior to flight, the pilot was seen in the flight surgeon's office for his medical check. He ate the high-protein meal, if desired, and then was dressed. A check of the suit and seatkit was done, and the pilot started denitrogenation, remaining on oxygen until completion of the flight. The cockpit of the WU-2 is no larger than that of most single engine jets; hence movement is considerably restricted.

Initially the records were screened for completeness. It was hoped that the data could be coded for computer analysis. Because of the paucity of information and the few cases of decompression sickness, it was decided to examine the flights of each crewmember who had one or more incidents of decompression sickness. For these flights, all at altitudes in excess of 45,000 feet, an attempt was made to correlate the incidents with the previously mentioned factors.

During the five years, there were 36 cases of decompression sickness in eleven crewmembers. However, 19 of these episodes involved one crewmember, who frequently took mild analgesics for joint aches and pains. He also wore spectacles while flying, and it is possible that he opened his face-plate to adjust his glasses on some of the longer flights. If this pilot is excluded, *the total operational incidence of decompression sickness was 0.17 per cent, and for flights at altitudes greater than 45,000 feet, 0.20 per cent.* All cases of decompression sickness were recorded as bends. None caused a mission to be aborted, and only one case required descent to a lower altitude to continue the mission.

In analyzing the flights of each individual, no correlations could be made between bends and body temperature, pulse, blood pressure or weight. Similarly, there was no relation to the preflight meal, duration of flight,

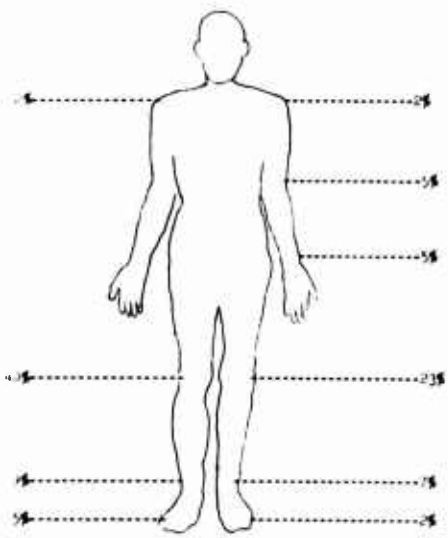

Fig. 1. Frequency of involvement by site (43 occurrences).

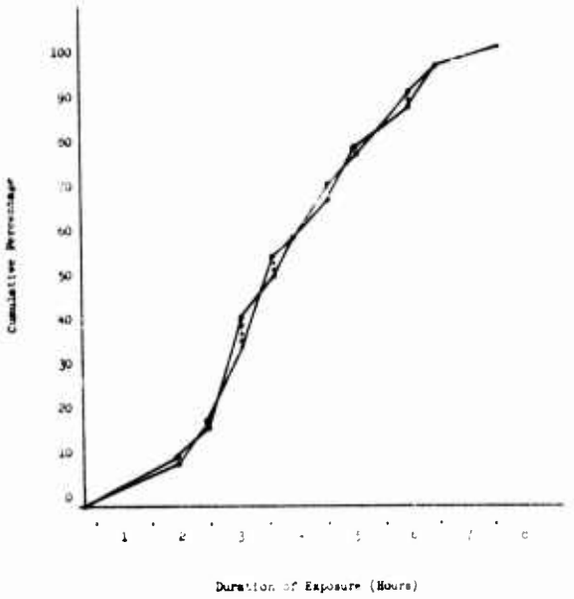

Fig. 2. Time of onset of symptoms.

cabin altitude and duration above 25,000 feet. Only two cases of bends occurred in flights having decompressions (flights 9 and 12) and during only one of these did the pilot notice the onset of his symptoms at that time.

These eleven crewmembers flew 958 flights at altitudes greater than 45,000 feet. Of these, 116 or 12 per cent were in the last twelve hours of the day, while only 6 per cent of the bends occurred then (Table I). It is also of interest to note that more cases (38 per cent) occurred in the winter (21 December to 21 March) than in other seasons.

The relationship between bends and prebreathing of oxygen, excluding the one unduly susceptible individual, is listed in Table II.

As expected the incidence decreases with longer prebreathing.

The anatomical location of the bends in the eleven subjects is noted in Figure 1. Eighty-nine per cent of the cases occurred in the lower extremities and fourteen per cent in the upper extremities (both upper and lower extremity pain occurred in flight 29). Crewmembers who had multiple episodes of bends tended to have these recur in the same location.

This is demonstrated in Table III with three of the four subjects who had recurrences.

In 24 of the reported cases of bends, time of onset of symptoms was noted (Figure 2). Joint pain appeared as early as two hours, and as late as seven and one-half hours after take-off, with 50 per cent occurring in the first three and one-half hours.

DISCUSSION

The records of 958 WU-2 flights were examined and analyzed in close detail with respect to decompression sickness. Bends was the only manifestation of decompression sickness found, occurring 36 times in eleven different crewmembers. This is in contrast to previous reports[3,7] in which symptoms ranging from itching or paresthesias to collapse were seen.

TABLE II. RELATIONSHIP OF TIME OF PREOXYGENATION TO INCIDENCE OF BENDS

Time of Preoxygenation	Number of Flights	Incidence
50 - 60 min.	114	.009
40 - 49 min.	556	.020
30 - 39 min.	139	.036

TABLE III. SITE OF RECURRENCE OF BENDS

Subject	Number of Episodes	Location	Number of Occurrences
Subject B	3	Right knee	2
		Left knee	3
Subject H	4	Right knee	4
		Left knee	1
Subject I	16	Left arm	1
		Left wrist	1
		Right knee	8
		Left knee	7
		Right ankle	3
		Left ankle	4
		Right foot	2
Subject K	2	Right shoulder	1
		Right knee	1
		Right ankle	1

Analysis of the data showed a significantly greater proportion of bends in the lower extremities as opposed to the upper extremities. Other investigators have found, in chamber flights, that the opposite was true[1,6,9] and there is no ready explanation for this finding. There was a greater incidence in the morning hours, and during the winter months. When bends recurred, they tended to recur in the same joints. Though the usual time of preoxygenation only varied from 30 to 60 minutes, the additional time seemed to afford better protection against bends. However, when bends occurred, the majority appeared within three and one-half hours of take-off (Figure 2). Continued reporting of operational experiences is need to provide more complete information about inflight decompression sickness.

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