The role of human centrifuge in aeromedical evaluation of aircrew

Wg Cdr PD Navathe, Wg Cdr A Krishnamurthy, Wg Cdr G Gomez, Wg Cdr H Malik

Institute of Aerospace Medicine, Vimanapura, Bangalore 560 017, India

The human centrifuge has been developed to meet the needs of aviation physiologists in understanding the stresses of flight in terms of G stresses and their effects. The centrifuge, which was initially used in animal experimentation, is now used as a tool for training of high-G fighter crews. The use of this equipment as an investigation tool in medical evaluation protocol has not been widely publicized in the literature. The use of the IAM centrifuge in medical evaluation has been reviewed and the advantages and limitations brought out. Suggestions are made as to the suitability of this investigation for specific medical conditions.

Keywords: Centrifuge, Medical evaluation, Aircrew.

The centrifuge at IAM, Bangalore, came into operation in 1966. It has a gondola fixed to the rotating 5 m arm by a single gymbal which allows the gondola to swing out passively during the rotation of the arm, thereby keeping the vertical axis of the gondola in line with the resultant.

The centrifuge was used as a research tool after its installation. With the increasing awareness of the problems of high sustained acceleration (HSG), the centrifuge has found an important role in the training of aircrew in techniques to sustain HSG. However, the use of the centrifuge in medical evaluation has always been limited. Table 1 summarizes the various applications for which the centrifuge at IAM was used during 1984–93, and Table 2 summarizes the same in the field of aeromedical evaluation.

Air sickness

The centrifuge was used to find if pilots, when subjected to confined space and subjected to radial and angular accelerations, became motion-sick. It was felt that the person who became sick on the centrifuge was more likely to become air-sick. However, since the correlation was poor, the centrifuge was never used for selecting pilots in this manner. It was, however, used in cases of air sickness in cadets who had been referred to this institute for desensitization. In such cases, a before and after centrifuge evaluation was able to prove the beneficial effects of desensitization therapy. Indeed, in the pre-desensitization centrifuge run, physiological data were available to suggest variations in the strategies for desensitization. A nausea-free post-desensitization run restored a tremendous amount of confidence in the pilot. The outcome

Table 1.

Use of centrifuge	Year									
	1984	85	86	87	88	89	90	91	92	93
Training	300 (60%)	141	37	49	66	28	14	428	914	991
Research	150 (30%)	4	24	15	–	89	111	114	137	–
Aeromedical evaluation	50 (10%)	27	103	63	10	79	66	66	84	75
Total	500	463	371	333	261	490	540	953	1864	1744

Table 2. Disabilities evaluated using the centrifuge

Disability	Year									
	1984	85	86	87	88	89	90	91	92	93
Air sickness	1	–		–	–	1	2	7	–	1
Loss of consciousness	4	3	–	–	–	2	1	–	–	–
Spinal ejection injuries		–	1	–	–	1	–	–	2	1
Cervical spine disabilities	–	–	5	2	1	4	3	2	9	5
Others	2	2	1	1	2	2	2	2	3	3
Total	7	5	7	3	3	10	8	11	15	10

of the investigation of air sickness cases in the last year is presented in Table 3.

Loss of consciousness

The cases investigated for loss of consciousness (LOC) had all undergone the episode of LOC in the air. Since the commonest nonpathological cause of LOC is G-induced loss of consciousness (G-LOC) [1], it was reasonable to subject pilots to centrifuge runs and estimate the relaxed tolerance, tolerance with anti-G suit and tolerance with AGSM. The outcome of these cases is presented in Table 4. The number of cases is very small since awareness about G-LOC has come only very recently [2]. In none of the cases investigated did LOC occur on the centrifuge. In all cases complete data regarding the event were not available and G-LOC could not be established as the cause of LOC. We feel that in all cases coming for medical evaluation after an LOC in flight, the printout of the flight data recorder, details of sortie profile, and a 48-h diary of activities including flying should be forwarded in order to enable complete evaluation.

Spinal injuries

Spinal injuries occurring due to ejection or other causes were assessed by a centrifuge run before reflighting the pilots. The average duration of the time between the injury and the centrifuge evaluation was 8–12 months. Centrifuge studies were carried out only after radiological healing and clinical normalcy. The centrifuge run was preceded by a vibration stress and the subjects taken up only if there were no problems during the vibration run. The rationale behind this evaluation was that even though bony tissue healing could be radiologically demonstrated, it was not possible to be sure about the status of the disc and other soft-tissue lesions. With the advent of new investigation tools likes the CT scan and MRI it is possible to visualize the soft tissues adequately but a dynamic loading of the spine still provides the best means of overall assessment of the bony as well as the soft-tissue components of the spine. In case of any instability which manifests itself

Table 3. Outcome of air sickness cases

Case no.	Age	+ Gz	Angular accel	Results
1 (JDS)	31	4.1	Angular accel	Nausea feeling No vomitting
2 (AG)	29	3.8	–	Slight nausea feeling No other
3 (SPT)	22	3.0	Angular accel	Nausea and vomitting at fi-- deceleration
4 (MAKK)	22	3.6	–	Nausea feeling No vomitting
5 (PCD)	22	3.8	2.5	Fit

Table 4. Outcome of loss of consciousness cases

Case no	Age	+ Gz	Result
1 (YS)	39	5.0	Normal
2 (RS)	20	5.7	PLL (56, 52°) Normal
3 (JJJ)	22	4.3	Normal
4 (KKD)	38	4.8	Fit

Table 5. Result on cases of spinal disabilities after centrifuge run

Case	Cause	Vertebra	Age (yr)	+ Gz	Result
1 (MNS)	Ejection	DV 12	39	2.5 5.0	Fit
2 (JSJ)	Accident	DV 12	30	2.5 5.0	Fit
3 (SNK)	Accident	DV 12	32	2.5 4.0	Normal
4 (GS)	Ejection	DV 12	27	4.3	Normal
5 (DJ)	Ejection	DV 11	32		
6 (JSJ)	Motor cycle accident	LV 3	21.5	2.5–5.0	
7 (VI)	Motor cycle	LV 1		4.5	Normal
8 (G)	Ejection	DV 8	26	3.8	Asymptomatic
9 (RKS)		DV 7	37	5.2	Normal
10 (UKB)		DV 6 DV 12 (old) DV 9	30	2.5 3.0	Normal
11 (SS)		DV 8 DV 11	30	3.8	Normal
12 (DRA)		D 8 D 9	30	4.0	Asymptomatic
13 (RNG)	Ejection	DV 12 LV 1	29	4.1	Normal
14 (PA)	Ejection	DV 11 LV 1 DV 12 LV 2 LV 3	23	3.5	Normal
15 (AS)	Ejection	DV-LV 1 10-12	39.5	4.5	Asymptomatic
16 (SSH)		DV 3 V 6 V 7	33	3.5	Tolerance is on lower side of normal range
17 (RC)	Ejection	D 11 LV 1 D 12	32	4.7	Normal
18 (RS)		D4–6		3.8	
19 (JKB)		Cx spondylosis	35	4.0	Normal
20 (RDL)		Cx	44	3.5	Normal

under loading, even if pain is not reported by the pilot, the spasm of the spinal muscles gives an indication of the problem. In our series, none of the cases presented with a spasm, and all were returned to flying. The details are presented in Table 5.

Neck injuries

With increasing aircraft capability and the need to move the head during combat, there has been a worldwide increase in neck injuries in fighter pilots [3, 4]. A similar increase has been reflected in the pilots of the Indian Air Force. Many cases of cervicalgia with no radiological findings are presented to medical evaluation centres and form a problem for evaluation. After these pilots become asymptomatic they are subjected to a centrifuge run in which 4, 5, 6 and 7 G levels are attained. The pilot is asked to move his head along all axes, and his cervical spinal muscles examined for spasm. In the absence of any positive finding, the aircrew can then be recommended for reflighting.

Intraocular lenses

Intraocular lens implants (IOL) are increasingly becoming a first intervention in cataracts,

and this has also arisen as a problem for aviators. Earlier cases of IOL implants (non-aircrew) were tested on the centrifuge and it was found that there were no ill-effects of up to 3 G levels. On the basis of the cases done a policy recommendation has been made to re-flight these individuals to transport and helicopter flying. On going through the earlier mediaeval data of the centrifuge, we found a few cases of pilots who were subjected to centrifuge runs after fitting of spectacles. This practice has, however, been since discontinued.

Conclusion

Since centrifuges are a very limited commodity, information on their use as a tool in medical evaluation is proportionately meagre. This paper presents the experience of the Institute of Aerospace Medicine in this area over the last three decades. We feel that the centrifuge certainly has a role in assessment of cases of spinal injuries and neck injuries, whether due to G stress or otherwise. As to its use in other disabilities, a larger series is necessary before a comment can be made on its utility or otherwise.

References

1. Malik H. +Gz environment in modern combat aircraft. *Ind J Aerospace Med* 1990;**34**:1–4.
2. Malik H, Kapur R. Centrifuge training for aircrew. *Ind J Aerospace Med* 1991 **35**:8–10.
3. Anderson HT. Neck injury sustained during exposure to high G forces in the F-16B. *Aviat Space Environ Med* 1988 **59**:356–358.
4. Biseman I. A survey of cervical spine in pilots of Belgian F-16 Air Defence Wing. Neck injury in advanced military aircraft environment. NATO AGARD 1989. AGARD CP-471.