

Our Experience with Centrifuge Training

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28 fighter pilots of the Indian Air Force with a mean age of 25.98 yr (22-30 yrs) and flying experience of 776.32 hr (300-1200 hr) underwent high 'G' training course at IAM in 1991. Their relaxed tolerance with gradual onset rate (GOR) was 4.88 G (SD 0.71) while wearing uninflated anti-G suit. The mean straining GOR tolerance of the group was 8.06 G (SD 0.65 G). The mean relaxed tolerance of the group to Rapid Onset Run (ROR) was 4.2 G (SD 0.44) without anti-G suit. The mean straining ROR tolerance with anti-G suit inflation was found to be 8.41 G (SD 0.58 G). All these pilots attained the minimum tolerance standard of 7 G for 15 sec (ROR) with AGSM and anti-G suit inflation, whereas 20 pilots sustained 8 G and only 10 pilots could withstand 9 G. 27 pilots could tolerate SACM profile for an average of 181.1 sec (109-369 seconds) with alternating peaks between 4 G and 8 G. 15 episodes of G-LOC were recorded. The average duration of loss of consciousness was 20.9 sec (10-54 sec) followed by an average of 20.1 sec (8-77 sec) period of relative incapacitation. 100 % of the pilots found the course useful and 77.5 % favoured a refresher course of shorter duration.

The potential for G-LOC has increased dramatically, with the introduction of the highly manoeuvrable fighter aircraft since 1970s. Search for methods to prevent G-LOC led Leverette et al to the discovery that with suitable centrifuge training, the human subjects could tolerate upto +9 Gz for 45 seconds. The subjects could do so by practising the technique of anti-G straining manoeuvre (AGSM) in the safety of centrifuge (1). The centrifuge training started in USAF in 1972 was, however, soon given up due to lack of understanding of its importance. It was only in mid 1980s that the centrifuge training was resurrected and given its due importance. By then, many precious lives had been lost in accidents, believed to be caused by G-LOC. Today, centrifuge based physiological training in the effects of high 'G' stress and in the performance of adequate AGSM is considered as the safest and most cost-effective means of preventing losses of aircraft and aircrew due to G-LOC (2). After the upgradation of the human centrifuge at IAM in 1988, similar training has been introduced in IAF in 1991. Our

experience, though limited so far, in high-G training of fighter aircrew, is being presented here. The details of training protocol used have been given in another paper.

Results and Discussion

28 fighter pilots of IAF have undergone high-G training at IAM in 1991. The subject data is given in Table I.

Table I Subject Data (n=28)

Parameter	Mean	Range
Age (yr)	25.98	22-30
Height (cm)	172.39	164-183
Weight (kg)	65.14	56-80
Fly. Exp. (hr)	776.32	300-1200

Only 2 out of the 28 trainees (7 %) admitted having prior experience of G-LOC in actual flying. The mean relaxed gradual onset rate (GOR) tolerance of the group while wearing un-inflated anti-G suit was 4.88 G (SD 0.71 G) as shown in Table II. This value is significantly lower ($p < 0.1$, unpaired t-test) than the relaxed tolerance of 5.51 G (SD 0.91 G) recorded for the 62 TAC pilots trained at USAFSAM in the F-16 configured seat in 1983 (3). This difference may be due to the difference in seat configuration (30 deg seat back tilt with elevated rudder pedals in F-16 configured seat vs 13 deg seat back tilt used in our study) and due to difference in rate of onset used in two studies (0.067 G/sec in USAFSAM vs 0.1 G/sec in our training schedule). The mean relaxed GOR tolerance of our group was also significantly lower than that of 741 trainees who were given high-G training at USAFSAM between Jan 85 and Feb 86 (2). The mean relaxed GOR tolerance of these USAFSAM subjects was 5.17 G (SD 0.9 G) with an onset rate of 0.1 G/sec (same as in our study) in the F-16 configured seat.

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Table II G-Tolerance

GOR	Relaxed	With AGSM	Gain (G)
Mean	4.88	8.06	3.18
SD	0.71	0.65	0.51
			p<0.01

ROR	Relaxed	With AGSM & Anti-G Suit	Gain (G)
Mean	4.20	8.41	4.2
SD	0.44	0.58	0.75
			p<0.01

The mean straining GOR tolerance of the group was found to be 8.06 G (SD 0.65 G). This is lower than that reported in 741 trainees at USAFSAM (8.32 G - SD 0.85 G) (2). This difference could also be explained on the basis of differently configured seats in these studies. However, the difference between trainees' mean relaxed and mean straining GOR tolerance of 3.18 G in our study is comparable to that of 3.2 G found in the studies at USAFSAM. This difference in the relaxed and straining tolerance was entirely due to the effect of the AGSM performed by the trainees.

The mean relaxed rapid onset rate (ROR) G tolerance of the group was 4.2 G (SD 0.44 G) without wearing anti-G suit, using 52-56 deg peripheral light loss (PLL) as the endpoint. The mean straining ROR tolerance with inflated anti-G suit was 8.41 G (SD 0.58 G) using subjective fatigue/CLL/G-LOC as the endpoint. This is comparable to an earlier study (1) in which the human tolerance of the subjects wearing inflated anti-G suit and performing M-1 manoeuvre varied from 7.5 to 9.0 G (mean 8.8 G and SD 0.12 G). However, in both the studies, the values do not represent the absolute maximum tolerance since the exposures, both intensity (G level) and duration, were arbitrarily fixed. In our training schedule, there was a difference of 1 G between each ROR run to the maximum of 9 G with durations varying from 15 sec (at 6 and 7 G) to 5 seconds (at 9 G) at peak G.

100 % of the trainees were able to sustain 7 G for 15 sec., 20(70 %) of could reach 8 G and only 10 (35 %) could reach 9 G with AGSM and anti-G

suit inflation. A total of 15 episodes of G-LOC were recorded with average duration of loss of consciousness being 20.9 sec (10-54 sec) and that of relative loss of consciousness being 20.2 sec (8-77 sec). The duration of G-LOC is marginally higher than that reported by Whinnery (4). This could be attributed to the slow offset rate (0.3 G/sec) used by us resulting in longer period at high G levels. Since only 2 trainees had reported prior experience of G-LOC, the 15 episodes of G-LOC during the course were considered an eye opener by the trainees. 5 subjects experienced more than one episode of G-LOC during the course. The average level of G and the type of run in which G-LOC occurred is shown in Table III.

Table III G-Loc/type of Run (n=15)

Type of Run	No of G-Loc	Average G-Level
GOR (AGSM)	4	8.2
ROR (AGSM + Suit Inflation)	8.05	
SACM (AGSM + Suit Inflation)	2	8.0

High G measles were seen in 16 out of 28 (57 %) subjects on the forearms and feet during the high G runs. 3 subjects experienced motion sickness resulting in severe nausea/ vomiting towards the end of centrifuge run. The trainees were asked to give their subjective assessment of the utility of the course at the end. They were unanimous in appreciation of the course. 58.7 % of the trainees found the course highly useful while 39.3 % found it useful as shown in Table IV.

Table IV Subjective Assessment (n=28)

Subjective Rating	No
Highly useful	17
Useful	11
Unsure	-
Not useful	-

NEED FOR REFRESHER COURSE

YES ... 22 NO ... 6

77.5 % of the trainees wanted a refresher course of shorter duration as shown in Table IV. This indicates the high level of acceptability of the

course by the aircrew. Certain differences from the actual combat flying were listed as the drawbacks of the centrifuge training by the aircrew. These responses are summarised in Table V and are mainly related to the limitations of the centrifuge.

Table V Differences Between Centrifuge Run and Actual Flying (n= 28)

Sl. No.	FACTOR	No. of Aircrew
1.	Lack of control by aircrew	9
2.	Prolonged duration at high G	18
3.	Lack of visual references	14
4.	Lack of flying task / boredom	9
5.	Pitch up/down illusions	5
6.	Slow deceleration	11

The increase in peak G level tolerated by trainees with AGSM is significant and as 100 % of the trainees were able to sustain 7 G for 15 sec., the minimum tolerance standard was attained. 27 of the trainees (96.4 %) were able to withstand SACM with alternating peaks of 4 to 8 G, for an average duration of 181.1 sec, showing the adequacy of learning AGSM by them. Only one subject had G-LOC after 10 sec of SACM, as he discontinued AGSM.

Conclusion

Our limited experience in the centrifuge training has shown that the training is beneficial, both subjectively and objectively and helps mainly by training the aircrew in the correct performance of anti-G straining manoeuvre. It has also demonstrated that an adequately trained aircrew can easily withstand high sustained G levels likely to be encountered in the modern combat aircraft. It is recommended that all fighter aircrew should be given the benefit of high-G training on the centrifuge.

References

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