

Centrifuge Training for Aircrew

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High G training on human centrifuge for aircrew flying high performance aircraft has been proved to be a valuable method of increasing awareness of the effects of G stress and allows aircrew to practice an anti-G straining manoeuvre (AGSM) in a safe, controlled environment. In the Indian Air Force, high-G centrifuge training for our fighter aircrew has commenced since March 1991 at the Institute of Aerospace Medicine (IAM), Bangalore. The course conducted at IAM is of 5 days duration and consists of a didactic portion, followed by centrifuge training. The latter consist of gradual onset run (GOR), rapid onset runs (ROR), and simulated aerial combat manoeuvre (SACM). In all these profiles, main emphasis is placed on teaching aircrew to perform AGSM correctly under high-G. The aim and contents of the centrifuge training as conducted at IAM is discussed in detail in this paper. Centrifuge training of aircrew flying high performance aircraft has received a big boost in recent years all over the world since it leads to enhancement of aircrew +Gz tolerance. High sustained Gz training on centrifuge is a valuable method of increasing awareness of G stress effects, and allows aircrew to practice an anti-G straining manoeuvre in a safe, controlled environment.

Anti-G straining manoeuvre (AGSM) has been widely utilised to combat G loads by fighter aircrew the world over for several decades. However, protective benefits of the AGSM are only as much as the effectiveness of its performance, i.e., a poor AGSM provides little or no protection, whereas a very efficient and effective AGSM can provide G protection upto +9Gz and higher¹. It has been shown² that only subjects trained on centrifuge had a significantly higher G tolerance (~+7G compared to ~5.5G) when performing L-1 manoeuvre, a type of AGSM². Parkhurst et al³ demonstrated that a G level upto 9 G applied for 45 seconds was sustained by a group of centrifuge subjects wearing standard personal protective clothing, and using maximum voluntary M-1 manoeuvre, another type of AGSM. The amount of protection afforded to the subjects at high G levels in this study was found to be dependent on (a) the quality of instruction given to the subject in the performance of the M-1 straining manoeuvre and (b) amount of experience and confidence of the subjects in performing the M-1 manoeuvre.

Impressed by the success of the centrifuge trained experimental subjects in raising their G tolerance, high G centrifuge training has been introduced for fighter aircrew in several countries, viz., for aircrew of USAF^{4,5,6}, for aircrew of Japanese Air Self Defense Force in 1982⁷; for aircrew of US Air Force in Europe (USAFE) on the Dutch centrifuge at Soesterberg, Netherlands⁸; Navy and Marine aviators of the US Atlantic fleet in 1988 at Naval Development Centre⁹; Canadian pilots in June 1989¹⁰ and others.

In the Indian Air Force also, we have started high-G centrifuge training for our fighter aircrew since March 1991.

AIM of the Centrifuge Training

The aim of centrifuge training is fourfold with the first of the following points listed being the primary aim and the other three as secondary aims⁴.

1. Improving the skill in proper performance of AGSM during exposure to high G resulting in increase in G tolerance.
2. Better understanding of the physiological mechanisms of G stress and G tolerance.
3. Greater appreciation and respect for the hazards associated with the high-G environment.
4. Increased confidence in the ability to tolerate high-G stress.

Contents of the centrifuge Training Course

The high-G centrifuge training course conducted at IAM is of five days duration. The contents of the course daywise are as follows:-

Day 1:

- (a) Didactic portion consisting of two lectures: one on high-G physiology, and the other

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on various preventive/protective measures to combat high-G.

(b) Briefing about the centrifuge in the Department of Acceleration Physiology with detailed instructions on the gondola, task required to be performed by aircrew, monitoring facilities in control room etc.

(c) All aircrew on the course are given familiarisation runs on the centrifuge with rapid onset rate of 0.5 to 1 G/sec with peak G sustained for 15 seconds and offset rate of 0.2 G/sec. Aircrew are instructed to stay relaxed and their relaxed PLL (peripheral light loss 52° - 56°) tolerance is determined. This requires 3-4 runs for each aircrew during which they get accustomed to the centrifuge rides/gondola environment.

Day 2 and 3

(a) Aircrew are instructed in detail about the AGSM. The instructor demonstrates a few cycles of properly executed AGSM in the 1G environment only. However, it is not done continuously since at 1G, a good straining manoeuvre elevates head level blood pressure to well over 200 mg Hg, which is not desirable⁴. Then all aircrew are told to perform AGSM one by one and their technique perfected. They are also shown video tape recording demonstrating properly performed AGSM in the high G environment.

(b) Each Aircrew is then subjected to six standard training profiles on the centrifuge out of the which first four are mandatory (Table I). These profiles are as follows :-

(i) Warming up profile consisting of onset rate of 1 G/sec upto 3.5 G for 15 sec with an offset rate of 0.2 G/sec.

(ii) Gradual onset Rate (GOR) profile consisting of onset rate of 0.1/sec upto 9.0 G for 2 sec with an offset rate of 0.3G/sec. During the GOR (second run), aircrew's anti-G suit is not inflated. He is instructed to ride the centrifuge while he is completely relaxed initially and fixate his eyes at the central red light while switching off the peripheral lights which are coming on randomly. When he greys out to the point where he no longer perceives the inner pair of peripheral lights (52° - 56°), he says

"Now" and begins to perform AGSM. He is helped via the the intercom in the performance of AGSM in which the instructor gives a count 1,2,3 and 4 and the aircrew is expected to co-ordinate his inspiration, straining and expiration as instructed in the beginning of the run. The GOR continues, with the trainee doing his straining manoeuvre more and more vigorously as G load increases until he no longer sees the peripheral lights (52° - 56°) even while straining as hard as he can. At that point, he again says "Now" when the medical controller brings the gondola to a halt, gradually slowing it down at the rate of 0.3 G/sec. If the trainee can still see the peripheral lights by the time GOR reaches the 9-G run limit, the centrifuge starts decelerating after 2 seconds at peak as per the pre-programmed profile. The medical controller then offers constructive criticism of the aircrew's straining manoeuvre after the gondola comes to a halt.

(iii) Rapid Onset Runs (ROR) consisting of onset rate of 1 G/sec with peak G of 6 G and 7 G lasting for 15 seconds with offset rate of 0.3 G/sec. These runs (3rd and 4th) are given after interval of 3-5 minutes between the 2nd and 3rd and then the 3rd and 4th runs so as to enable the aircrew to recover from the previous run. The gondola canopy is opened in between the runs and the subject is given water if required. In RORs, aircrew's anti-G suit is inflated and he is told to perform AGSM during these runs. Aircrew's AGSM technique is perfected during these runs. RORs are started from 6 G onwards since the 6 G level is sufficiently low to cause G-LOC in aircrew who perform imperfect AGSM. We have fixed minimum G tolerance standard as 7 G for 15 seconds, and if aircrew is unable to complete the 7 G ROR on the first attempt, he is re-instructed about the correct technique of the L-1 manoeuvre and the run is repeated after a break or on the following day. This training goal has been chosen based on the NATO standardisation Agreement (STANAG) 3827 AMD, which states that aircrew who do not successfully complete a rapid onset +7Gz, 15s centrifuge profile with anti-G suit and straining manoeuvre, will be considered to have low G tolerance¹¹. USAFSAM's experience with G-tolerance testing and high-G training within the US Air Force has also revealed that a G-tolerance standard of +7Gz for 15s is not stringent for trained fighter pilots who are actively

flying¹². Thus we expect all our fighter aircrew to complete this run without complete loss of peripheral vision if they have learned how to do an effective and proper AGSM.

(iv) Rapid onset runs (ROR) at an onset rate of 1G/sec with peak G of 8G and 9G lasting for 10 seconds and 5 seconds respectively with offset rate of 0.3 G/sec. These runs (5th and 6th) are given after interval of 3-5 minutes between the 4th and 5th, and then the 5th and the 6th runs. These runs are our training goals as in these, G-stress is sufficient to challenge most aircrew to give their best effort, as G-LOC can easily result from lack of concentration, vigour or efficiency in performing straining manoeuvre⁴. Because even current generation fighter aircraft are unlikely to operate in sustained 9-G environment, it is felt that an aircrew who successfully completes 8G-10 seconds/ 9G-5 seconds training goals, has demonstrated that he can tolerate any sustained high-G loads that he might encounter in flight.

Table 1: G-Profiles

Typed Profile	Rate of onset [G/sec]	Peak G		Rate of offset [G/sec]
		Magnitude	Duration	
Warm-up	1	3.5	15	0.2
GOR	0.1	9.0	2	0.3
ROR1	1	6.0	15	0.3
ROR2	1	7.0	15	0.3
ROR3	1	8.0	10	0.3
ROR4	1	9.0	5	0.3

Day 4 and 5

(a) Lectures on physical conditioning programme with practical demonstration on the multi-gym are given.

(b) Each aircrew is subjected to simulated aerial combat manoeuvre (SACM) which gives aircrew an opportunity to practice his AGSM under somewhat more realistic conditions than those that exist during the GOR and RORs. Aircrew are subjected to a variable G profile in SACM which is repetitive, continuous and without a predetermined duration limit. The SACM acceleration profile consists of ROR with rate of onset 1 G/sec upto 4G for 15 sec, then again build up at the rate of 1

G/sec upto 8G for 10 sec, deceleration at the rate of 0.2 G/sec upto 4G, the whole profile continuing until the aircrew is fatigued, or there is peripheral light loss (PLL : 52°-56°) or G-LOC when the centrifuge would be stopped. During the SACM profile, aircrew use indigenous MK II anti-G suit and perform AGSM as required. SACM profile is chosen because it is seen that aerial combat manoeuvre (ACM) has high G levels while the pilot is manoeuvring for an effective offensive or defensive position. Also an aerial combat manoeuvre has low G level for firing air-to-air ordnance. In addition, ACM has both increasing and decreasing changes in G levels¹³. The lower G levels i.e., 4G is chosen in our profile because aircrew can relax at this level while wearing inflated anti-G suit and thus recover from the previous 8G-10 second exposure. The higher level i.e., 8G is chosen because it would require maximum straining by the aircrew to sustain his peripheral vision/consciousness at this G level. SACM tolerance is qualified as the duration in seconds that aircrew could continue with the SACM profile.

(c) After each aircrew finishes high-G centrifuge runs, the medical officer reviews with him his performance of AGSM with the help of respiratory pattern recorded on the polygraph and video recording. If some particularly instructive event such as a G-LOC episode occurs during the training, the instructor replays it on the video monitor for all the aircrew and provides appropriate commentary. To evaluate the course programme, the aircrew are given a questionnaire at the end of the course, and are told to give their comments on the utility of the course, and similarity of the centrifuge environment with their aircraft etc.

Conclusion

In conclusion, it can be said that aircrew high-G centrifuge training is the safest and most cost effective means of preventing losses of aircraft and aircrew due to G-LOC. This training is a valuable method of increasing awareness of G stress and allows the aircrew to practice an AGSM in a safe, controlled environment. Such training is well tolerated by aircrew and it is acclaimed as highly appropriate and useful, even essential.

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