

MEDICAL INCIDENCES DURING CENTRIFUGE TRAINING AND F-16 FLYING IN THE NETHERLANDS

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SUMMARY

A survey in the NAMC database containing the records of centrifuge runs of candidate and experienced pilots revealed that in 15.1 % of the centrifuge training sessions, a run was stopped. The major reasons were motion sickness (31 %), fatigue (28 %), and arrhythmias (22 %). During centrifuge training at the NAMC the prevalence of an episode of supra ventricular ectopies was 33 %. In 21 % of the runs a ventricular ectopie occurred.

In-flight ECG monitoring revealed that arrhythmias occurred in 62 % of the pilots (n=40). These arrhythmias were premature ventricular contractions in 49 %, premature atrial contractions in 41 %, ventricular bigeminy periods in 8 %, ventricular couplets in 5 %, supra ventricular tachycardia in 3 % of the pilots. A combination of arrhythmias were found in 27 % of the pilots. The number of pilots showing arrhythmias at +G_z-levels <3G did not increase at +G_z-levels >3G. However, the number of premature ventricular contractions significantly increased at +G_z-levels >3G. This effect on the number of premature atrial contractions was not found.

INTRODUCTION

Pilots of high performance fighter aircraft have to tolerate G levels for considerable periods of time. Therefore, it is generally accepted that fighter aircraft crew members should be trained in a safe environment to improve their skills in performing the anti-G straining manoeuvre (AGSM) and to familiarize in the use of high-G protective equipment.

In order to train Dutch and Allied pilots the NAMC's human centrifuge has been used since 1983. The NAMC's centrifuge can generate 20 G at onset rates of 3.5G/sec and is equipped with a computer generated outside world projected on a large screen in front of the subject. The free-swinging gondola is equipped with a F-16 type seat and life support equipment, a side stick operated F-16 simulation model, two-way audio communication and extensive medical instrumentation.

A go- no go switch is located on the simulated throttle quadrant. Medical and physiological data are stored on tape and selected channels are recorded on a paper strip chart. The (candidate) pilot is monitored by a video camera mounted in the gondola and online two lead ECG is recorded for the qualified physician on-site.

The analysis of the centrifuge ECG data will be described in this paper and the prevalence of arrhythmia will be compared with the in-flight prevalence.

TRAINING

The NAMC High Sustained G (HSG) Course was developed by Royal Netherlands Air Force in response to increasing awareness of the need to prepare aircrew for the stresses of the high-G environment of modern high-performance fighter aircraft. Until now, 3100 (candidate) pilots of different Allied nations were trained.

The primary HSG course objectives are an increase in the G tolerance resulting from an improved skill in performing the anti-G straining manoeuvre and to provide life experience with the effects of the High-G environment. All Dutch (candidate) pilots have to pass the 8 G profile for 15 seconds.

The one-day course includes interactive classroom sessions and several G training sessions. The centrifuge training sessions include three "core" profiles:

- a gradual-onset rate (GOR) run to establish the student's relaxed and straining G-tolerances;
- a rapid onset rate (ROR) run to 6 G for 30 sec, enabling practice of the AGSM; and
- a ROR run to 8 G for 15 sec, simulating extreme operational exposures.

Trainees may then elect to experience two simulated air-combat manoeuvre (SACM) profiles in the centrifuge. The NAMC HSG Course conforms to NATO STANAG 3200 (HSG Training).

MEDICAL SCREENING

All military trainees must meet the Class 1 medical

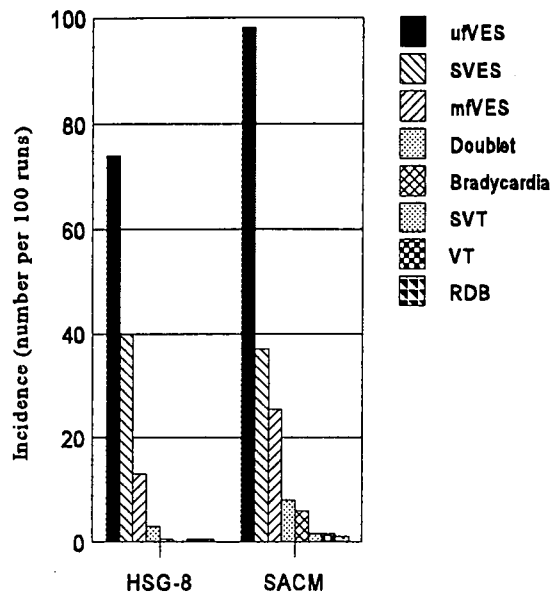


Fig. 1. The incidence of arrhythmias during centrifuge training with a HSG-8 or a SACM profile.

SVES: supraventricular extra-systole; SVT: supraventricular tachycardia; uVES: uni focal ventricular extrasystole; mVES: multi focal ventriculaire extrasystole; VT: ventricular tachycardia; RDB: rate dependent block.

standards required for flying high performance aircraft. Those suffering from medical conditions which may adversely affect centrifuge training are excluded, until medically fit. Subjects participating in research projects are subjected to the same medical standards.

STOP CRITERIA

The safety of the (candidate) pilot is a prime consideration in High-G centrifuge training. At the NAMC the following stop criteria during centrifuge training runs are used;

- release of the go- no go button
- heart rate > 200 beats per minute
- arrhythmias such as
 - multi focal premature ventricular contractions (PVC),
 - 2 or more sequential PVC's,
 - ventricular tachycardia, or doublets,
 - supra ventricular tachycardia,
 - relative bradycardia
- chest pain
- G-induced loss of consciousness

If a centrifuge run has been stopped the operations team decides, depending on the situation, in collaboration with the trainee if the training is to be continued. A record is kept of all reasons for stopping a centrifuge run.

TYPES OF MEDICAL GROUNDS FOR STOPPING A CENTRIFUGE RUN

A survey in the database containing the records of centrifuge runs of candidate and experienced pilots revealed that in 15.1% of the centrifuge training sessions, a run was stopped. The major reasons were motion sickness (31 %), fatigue (28%), and arrhythmias (22%) (Table 1).

Table 1. Grounds for stopping a centrifuge training run.

	trainees (%)	occurrence (% of runs stopped)
motion sickness	4.7%	31%
fatigue	4.3%	28%
arrhythmias	3.3%	22%
G-LOC	1.4%	9.5%
other	1.4%	9.5%

Only in 1.4 % of all the training sessions a G-LOC occurred.

ARRHYTHMIAS DURING CENTRIFUGE TRAINING

The majority of the trainees in the NAMC are EKG monitored so a large database is available of EKG recordings for the different types of centrifuge training runs. In order to investigate the incidence of arrhythmias an analysis was done on the occurrence and types of arrhythmias during the training profiles with rapid onset of +G_i; the High Sustained G profile, HSG-8 (1G/s onset, 8G for 15 s) and the Simulated Air Combat Manoeuvring profile, SACM (3G/s onset and two 10s periods of 9 and 8.5 G separated with 10s period of 4G).

The analysis yielded that for the HSG-8 profile, uni focal ventricular extrasystoles (74%) and supraventricular extrasystoles (40%) had the highest incidence of episodes having one or more arrhythmias (Fig.1). Further, multi focal ventricular extrasystoles occurred in 13.2 %, doublets in 2.8 % and ventricular tachycardias, bradycardias, and rate dependent blocks were found in 0.7% of the centrifuge training runs (1). The incidence increases during the SACM profile for ventricular extrasystoles (VES) to 98 % and for supraventricular extrasystoles (SVES) it dropped to 37% (Fig. 1). Multi focal ventricular extrasystoles occurred in 25.4 %, doublets in 7.7 %, ventricular tachycardias in 1.5 %, bradycardias in 6.2%, and rate dependent blocks in 0.8% of the SACM centrifuge training runs.

It should be noted that the incidence of arrhythmias will be an underestimation due to the fact that a selection had occurred due to the fact that some pilots were

withdrawn from further training for (medical) reasons occurring in the previous training session.

All reported arrhythmias were non-sustained and no medical intervention was never necessary during or after a training session.

Table 2. Episodes of one or more arrhythmias (% of runs) during centrifuge training (8 G profile).

	SVE	VES
Krol & Holewijn (1)	33	21
McKenzie & Gillingham (2)	41	47
Whinnery (3)	44	41

The incidence of arrhythmias during training with the NAMC's centrifuge are slightly lower than the results from other studies (Table 2). An explanation could be the occurrence of muscle artifacts and misconceived P-waves.

IN-FLIGHT ARRHYTHMIAS

In order to compare the incidence of arrhythmias found during centrifuge training a field study was performed (4). Forty pilots (median age 27 years, range 22-47 years) of the Royal Netherlands Air Force underwent in-flight 3 leads ambulatory ECG recording. The $+G_z$ -load was simultaneously recorded. Measurements were performed during basic flight manoeuvre training missions.

Arrhythmias were found in 62 % of the pilots. These arrhythmias were premature ventricular contractions in 49 %, premature atrial contractions in 41 %, ventricular bigeminy periods in 8 %, ventricular couplets in 5 %, supraventricular tachycardia in 3 %, and a combination of arrhythmias in 27 % of the pilots were found. The number of pilots showing arrhythmias at $+G_z$ -levels $<3G$ did not increase at $+G_z$ -levels $>3G$. However, the number of premature ventricular contractions significantly increased at $+G_z$ -levels $>3G$. This effect on the number of premature atrial contractions was not found. Higher grades of arrhythmias (Lown ≥ 3) were exhibited by 19 % of the pilots.

Table 3. Episodes of one or more arrhythmias (% of pilots) during in-flight situations.

	SVE	VES
Krol & Holewijn (4)	49	41
Lindqvist et al. (5)	53	67
Skytta et al. (6)	16	33

From Table 3 it can be seen that in two other studies similar results are reported.

From the results of our in-flight study (4) it is concluded that higher $+G_z$ -levels do not provoke arrhythmias in more pilots, but does increase the number of premature ventricular contractions. Furthermore, the need for a stratification of arrhythmias

by operational significance will be necessary.

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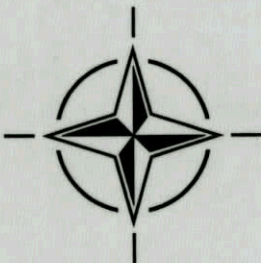
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