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ECG FINDINGS DURING CENTRIFUGE TRAINING IN DIFFERENT AGE GROUPS OF TURKISH AIR FORCE PILOTS

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INTRODUCTION

One of the important reasons for starting centrifuge training was that G-LOC was found to have an increasing role in aircraft accidents. Turkish Aerospace Medical Center began high sustained G (HSG) centrifuge training for jet pilots in 1991. ECG monitoring has been done from the beginning, but ECG data was collected for further research for only the last 2 years.

Cardiac dysrhythmias occurring during centrifuge training, which are physiologic responses to high acceleration, have been reported by many investigators (3-6). Sekiguguchi et al. (2) found that over 50 % of pilots from the Japanese Air Self Defense Force had dysrhythmias during high G training. Whinnery (7) has reported that treadmill stress testing and exposure to +Gz forces produce a comparable incidence of dysrhythmias, but that G forces have a tendency to produce more serious dysrhythmias, such as ventricular tachycardia.

These dysrhythmias usually are asymptomatic and resolve rapidly when the subjects return to 1-G environment. In this study we analyzed the ECG abnormalities occurring during centrifuge training (1).

METHODS

All pilots and pilot candidates are certified to Turkish flying medical standards, as a prerequisite for their duties. According to Turkish Air Force (TUAF) regulations, each jet pilot has to undergo centrifuge training every three years. During the last 2 years, 486 jet pilots and pilot candidates underwent high

G training. All of them were healthy and passed cardiac test and physical examination.

The Centrifuge provides an average onset rate of 6 Gz per second from a baseline of 1.2 Gz to a maximum of 9 Gz. The centrifuge seat can be configured to resemble the seat in an F-16 aircraft (30-degree seatback angle and elevated rudder pedals) or in a conventional fighter aircraft (13-degree seatback angle). All trainees wore an anti-G suit. On the centrifuge, all pilots were monitored by means of ECG, closed-circuit television and continuous voice communication. Pilots did not wear a helmet or oxygen mask.

The high G training starts with a Gradual Onset Run (GOR) profile with an onset rate of $0.1 \text{ G}\cdot\text{s}^{-1}$ to a peak of 8-9 +Gz. During this profile, the trainee pulls the stick back himself and sits relaxed while looking at the light bar ahead of him. This straight light bar is 71 cm long with a small green light (2.5-cm diameter) at each end. The center of this light bar has a 2.5-cm diameter red light. Then, as soon as he loses peripheral vision he should start to perform AGSM.

After a couple of minutes rest following the GOR, Rapid Onset Run (ROR) profiles are carried out with an onset rate of $6 \text{ G}\cdot\text{s}^{-1}$. The first ROR is at +6 Gz for 30 seconds. During this profile, the trainee improves his AGSM under the supervision of the physiological training officer. The next ROR profile is at +7 Gz for 15 seconds. The final run is at 8-9 +Gz for 15 seconds, which is the training goal. During all runs, pilot controls the centrifuge (Fig-1).

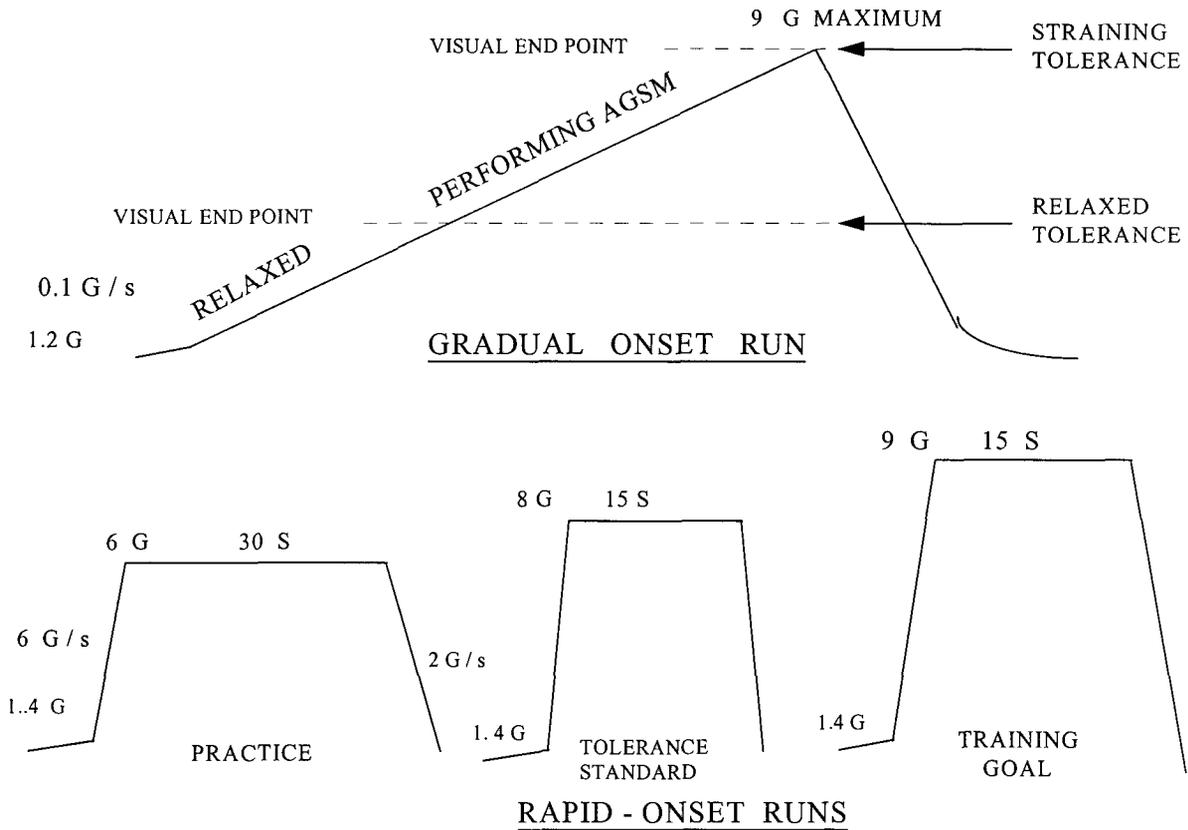


Figure 1: Rapid Onset Runs Profiles Used During Centrifuge Training

During these runs, two ECG leads (sternal and biaxillary) were recorded continuously at 25 mm/s throughout the training period and assessed by a cardiologist.

RESULTS

ECG tracings of good quality were achieved during GORs until the subjects started AGSM. However, artifacts became a problem during the intensive muscular contraction and unavoidable chest movement of the L-1 maneuver.

All tracings have shown sinus tachycardia during centrifuge run. The mean heart rate was 172 for the 22-30 age group at 6-7 and 8-9 Gz. It was 159 at 6-7 Gz and 162 at 8-9 Gz for the 31-42 age group (Table I).

Dysrhythmias were recorded in 143 (29.4%) of 486 fliers. The dysrhythmias classification was derived from the terminology used by the individual medical

monitors when they recorded the dysrhythmias. It includes ventricular ectopic beats (VEBs), couplet VEBs, atrial ectopic beats (AEBs), supraventricular tachycardia (SVT), and sinus arrhythmia and sinus arrest.

The most common finding was ventricular ectopic beats (19.5% VEBs; 95 of 486). The 36% of the older group showed VEBs at 8-9 Gz. This rate was significantly higher than the younger group ($p < 0.05$).

Table I: Heart rates of pilot during centrifuge training

AGE	G - LEVEL	HEART RATE			
		Between 110-140	Between 141-160	Between 161-180	Between 181-200
22 - 30 (n : 398)	6-7 G (n : 229)	5 (2.2%)	47 (20.5%)	153 (66.8%)	24 (14%)
	8-9 G (n : 169)	3 (1.8%)	32 (19%)	120 (71%)	14 (8.2%)
31 - 42 (n : 88)	6-7 G (n : 38)	8 (21%)	13 (34.2%)	14 (36.8%)	3 (7.9%)
	8-9 G (n : 50)	9 (18%)	12 (24%)	28 (56%)	1 (2%)

Couplet VEBs were seen in 6 fliers of 486(1.2%). AEBs were noticed in 15 fliers of 398 (3.8%) in the younger group. We did not see any AEBs cases in older group.

SVT was in 15 fliers (3%) and sinus arrhythmia was in 6 fliers (1.2%) of the total group. Sinus arrest was seen in 5 fliers of 398(1.2%) in the younger group (Table II.).

Table II: ECG findings during centrifuge training

AGE	G - LEVEL	VEBs	Couplet VEBs	AEBs	SVT	Sinus Arrhythmia	Sinus Arrest
22 - 30 (n : 398)	6-7 G (n : 229)	18 % (41)	-	3.5% (8)	4.8% (11)	2.6% (6)	1.3% (3)
	8-9 G (n : 169)	17.7 % (30)	1.7% (3)	4.1% (7)	1.2 % (2)	-	1.2% (2)
31 - 42 (n : 88)	6-7 G (n : 38)	15.8 % (6)	2.6% (1)	-	2.6 % (1)	2.6% (1)	-
	8-9 G (n : 50)	36* % (18)	4 % (2)	-	2 % (1)	-	-
Total		19.5 % (95)	1.2 % (6)	3 % (15)	3 % (15)	1.4 % (7)	1 % (5)

(* p<0.05)

CONCLUSION: Centrifuge training may cause ECG abnormalities. Although these are common in high G environment, majority of them is not indicators of any cardiac diseases.

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