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CONTINUOUS EKG RECORDING OF HELICOPTER INSTRUCTOR PILOTS - AN INTERIM EVALUATION

By

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April 1969

U. S. ARMY AEROMEDICAL RESEARCH LABORATORY
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   b. Automobile driving (85.5) beats per minute
   c. Eating (90.1) beats per minute
   d. Flying (92.0) beats per minute

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4. Means of "lowest heart rate recorded" and "highest heart rate recorded" for each subject were reported (means of 71.8 and 140.4 respectively). The activities in which the subjects were engaged at the time is reported.

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7. Four of the 53 subjects showed arrhythmias at some time during the recording; one had 38 unifocal ventricular premature contractions during the recording period; three had atrial premature contractions.

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APPROVED: Robert W Bailey

ROBERT W. BAILEY
LTC, MSC
Commanding

CONTINUOUS EKG RECORDING OF HELICOPTER INSTRUCTOR PILOTS - AN INTERIM EVALUATION

INTRODUCTION

One lead of EKG was examined from each of fifty-three (53) helicopter instructor pilots while each was engaged in his regular daily activities. All of this group engaged in flight training of students at some time during the period of EKG recording. This study constitutes one of a group of studies underway in our laboratory to evaluate the interaction between man and the flying systems and environment in an attempt to improve our understanding of the responses of the cardiovascular system to flying.

METHOD

The subjects came to our laboratory in the morning, before reporting for duty. At that time bisternal electrodes were attached, one over manubrium sterni, and the second over corpus sterni at the level of insertion of the 5th costal cartilage. A single lead of EKG, comparable to lead V_2, was recorded on 1/4 inch 0.5 mil mylar magnetic recording tape by a 3 1/2 lb self-contained tape recorder at a tape speed of 7 1/2 inches per minute. The pilot then reported for regular duty. During the day he filled in a questionnaire covering his duty assignment, general physical condition, flying experience and accident record, and kept a log of his activities. These were used during data reduction to relate to heart rate and rhythm. At the end of his duty day he returned to the laboratory to have the equipment removed.

Tapes were read in the following manner:

1. A continuous write out of heart rate expressed as beats per minute was obtained for each record.

2. Each record was scanned at 1:60 time ratio for observations of rhythm and pattern.

3. All periods of special interest were either viewed upon an oscilloscope screen or recorded on standard EKG paper at a 1:1 time ratio.

Mean pulse rate for each selected period was determined from the continuous write out of heart rate. Heart rates were measured for each minute of the period under observation and the arithmetic mean to represent that period was calculated from these accumulated, all-inclusive samples.

CALIBRATION[3]

Each strip of magnetic tape was calibrated at the beginning of the recording day with a 1 millivolt signal at a frequency of 1 signal per second. In addition, the recording tape decks were calibrated weekly with a calibration tape to a tape speed of 7 1/2 inches per 60 seconds. Read out equipment was calibrated with 60 Hertz oscillation of line voltage and correlated with the 60 signals per minute calibration on the magnetic tape. On the basis of these precautions, plus the manufacturer's specifications for the equipment, it is our opinion that the estimates of heart rate are correct to $\pm$ 2%.

TECHNIQUES[3]

Some points of technique may be of interest.

1. We regularly shaved the chests of our subjects with a number 40 blade of a standard small animal clipper. Only with shaving were we able to maintain stable electrode contact.

2. We took some effort in the preparation of the skin. After shaving, the skin was cleansed vigorously with technical acetone, and rubbed dry. This effectively defatted the skin, which made it possible for our adhesive to hold the electrodes in place for the entire period of study. In addition, the aggressive rubbing produced good skin erythema, and some cutaneous decornification, thereby decreasing skin resistance.

3. As a conductor between the silver electrodes and skin we used bentonite. In preliminary studies we noted lower resistances with silver-silver chloride suspensions, and with sodium chloride in water soluble base; however, these materials were rather fluid, and after activity, the electrode paste tended to pump out of the cup electrodes causing electrode slippage and considerable electrode artifact. Bentonite was more viscid and even after dilution with sweat, did not escape as readily from the electrode cups.

4. Electrodes were held in place using standard 3-inch surgical Elastoplast, reinforced by Blenderm to prevent peeling of the edges.

5. The electrodes were placed bisternally with the reference electrode over manubrium sterni, and the recording electrode over corpus sterni at the level of the attachment of the 5th costal cartilage. This provided a clear P wave, permitting a clear evaluation of rhythm, and a strong signal which was helpful in records in which interference was a problem since it improved our signal to noise ratio.

6. In every subject skin impedance between electrodes was measured with a standard VOM multimeter just after the electrodes were placed, and just before the electrodes were removed. In most instances initial impedances were in the range of 10K-100K ohms, and final impedances were in the range of 1K-10K ohms.

RESULTS

Analysis of the Population Studied:

Fifty-three (53) helicopter instructor pilots actively engaged in student training during the period of study.

TABLE I

	Range	Mean	Standard Deviation
Age	22-46	30.3	5.2
Total accumulated flying hours	700-8200	2208.5	1490.1
Average number of hours flown/month	15-180	53.8	28.8
Number of previous accidents	0-2	0.5	0.6
Number of hours recorded in test	5.25-11.5	7.7	1.4
Number of hours flown in test	0.75- 6.9	3.65	1.13

Analysis of Heart Rates:

TABLE II

	Range	Mean	Standard Deviation	Estimated Energy Expended
Administration	65-108	87.2	10.4	1.8 kcal/min[1]
Driving	69-110	85.5	11.2	1.3 kcal/min[1]
Eating	70-115	90.1	11.1	2.1 kcal/min
Flying	68-125	92.0	13.7	1.7 kcal/min[2]

Analysis of variance was conducted using completely randomized block design.

Analysis of Variance Summary Table:

TABLE III

	SS	df	MS	F
Between individuals	22,195.8821	52	426.8438	10.1806**
Between treatments	1,011.6413	3	337.2137	8.0428**
Error	6,540.6087	156	41.9269	
TOTAL	29,748.1321	211		

** $= p \leq 0.01$

Tukey's test for multiple comparison of means as described by Winer[4] was conducted upon four (4) mean heart rates.

TABLE IV

	92.0	90.1	87.2	85.5
92.0	0	1.9	4.8**	6.5**
90.1		0	2.9	4.6**
87.2			0	1.7
85.5				0

** = $p \leq 0.01$

Records were evaluated to determine the lowest and highest heart rates recorded which were sustained for at least 1 minute, and the specific activity of each subject during this period.

TABLE V

	Range	Mean	Standard Deviation
Lowest Heart Rate	50-90	71.8	9.7
Highest Heart Rate	100-195	140.4	20.0

Activities associated with these rates are as follows:

Lowest Rate

Driving	20 subjects
Administration	19 subjects
Flying	4 subjects
Eating	4 subjects
Riding in car	1 subject
Pre-flight	1 subject
Sitting	1 subject
Viewing T.V.	1 subject
Yard Work	1 subject
Reading	1 subject
	53 subjects

Highest Rate

Walking	21 subjects
Flying	15 subjects
Pre-flight	5 subjects
Driving	5 subjects
Administration	5 subjects
Eating	1 subject
Running	1 subject
	53 subjects

A qualitative estimate was made of the physical condition of the subjects using these criteria:

Class 1 — No regular schedule of physical training or sport activities.

Class 2 — Participation in physical training or sporting activities, to and including two times each week.

Class 3 — Participation in physical training or sporting activities three times per week or more.

"Physical training or sporting activities" was arbitrarily defined for this study as any such activity which required expenditure of at least 6.0 kcal/min or more for a period of five (5) minutes or more. Energy expenditure rates were derived from tables or studies referenced in "Bioastronautic Data Book".

38 subjects (71.7%) were in Class 1

5 subjects (9.4%) were in Class 2

10 subjects (18.9%) were in Class 3

An 11 x 11 correlation matrix was computed in an attempt to show existing correlations within the accumulated data. With an n of 53 and r of:

| 0.228 | is significant to the 0.10 level

| 0.271 | is significant to the 0.05 level

| 0.357 | is significant to the 0.01 level

| 0.456 | is significant to the 0.001 level

The only significant correlations indicate that persons with high heart rates during any one type activity tend to have high heart rates during all tested activities, and vice versa, a finding which is readily apparent from preliminary reading of the tapes; and as one might expect, total accumulated flying hours relates directly with age.

In four of our subjects arrhythmias were noted. One exhibited unifocal ventricular premature contractions. Thirty-eight (38) were noted in the period recorded. Three exhibited atrial premature contractions. Five, twelve and twenty-two were noted in the period recorded respectively.

Scanning of the records showed marked axis shift and ST and T wave variability, most often related to heart rate, i.e., as heart rate increased, axis shifted to the right and T wave decreased in amplitude, and vice versa. Figure 1 illustrates examples of axis shift and ST-T changes seen during a single eight (8) hour period in one of our subjects. Changes of this magnitude were present in 16 (30.2%) of the 53 subjects we studied. Review of these variable

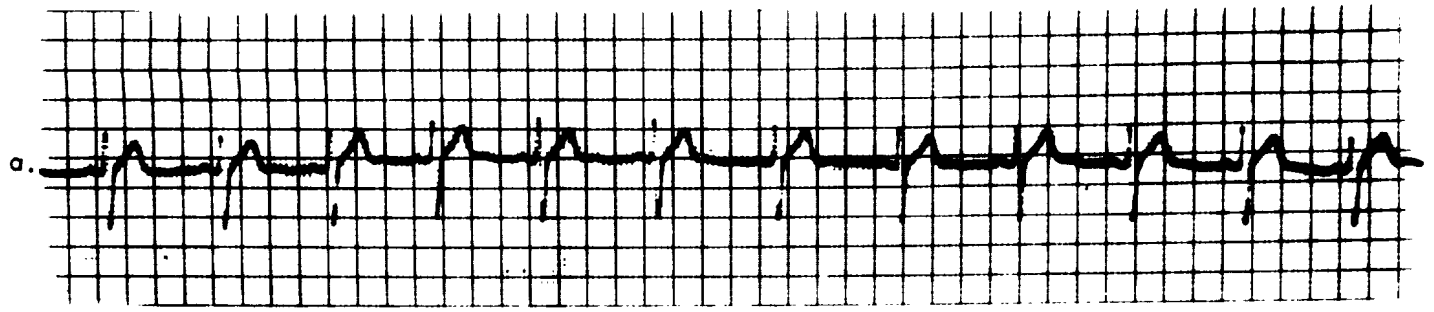
TABLE VI

CORRELATIONS

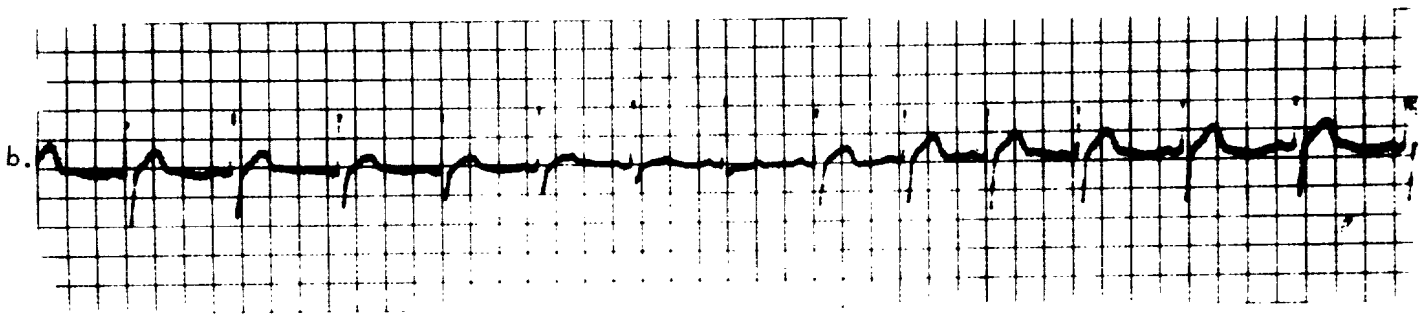
	1	2	3	4	5	6	7	8	9	10	11
1.	+1.000	-0.0117	+0.0114	+0.7875	+0.0027	-0.0102	+0.0182	-0.0620	-0.0640	+0.0022	+0.0145
2.		+1.0000	+0.2610	+0.0120	+0.1203	+0.0850	-0.0370	+0.0359	+0.0378	-0.1069	-0.0901
3.			+1.0000	+0.1376	+0.1006	-0.1248	-0.0754	-0.1133	-0.0898	-0.1381	+0.2107
4.				+1.0000	-0.0385	-0.0535	-0.0203	-0.1227	-0.0085	-0.0109	-0.0216
5.					+1.0000	-0.1409	-0.1055	-0.0966	-0.0464	-0.0413	+0.0167
6.						+1.0000	+0.8190	+0.7396	+0.7427	+0.7696	+0.4940
7.							+1.0000	+0.7890	+0.7226	+0.7480	+0.5294
8.								+1.0000	+0.6771	+0.6560	-0.4788
9.									+1.0000	+0.7269	+0.4510
10.										+1.0000	-0.6522
11.											+1.0000

1. Age
2. Hours flown per month
3. Physical condition
4. Total accumulated flying hours
5. Number of accidents
6. Lowest heart rate recorded
7. Administrative rate
8. Driving rate
9. Eating rate
10. Flying rate
11. Highest heart rate recorded

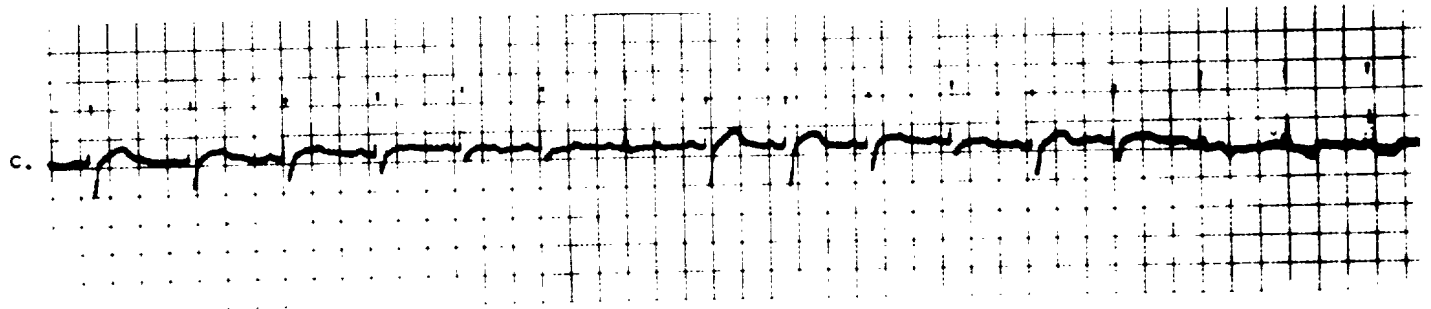
FIGURE 1



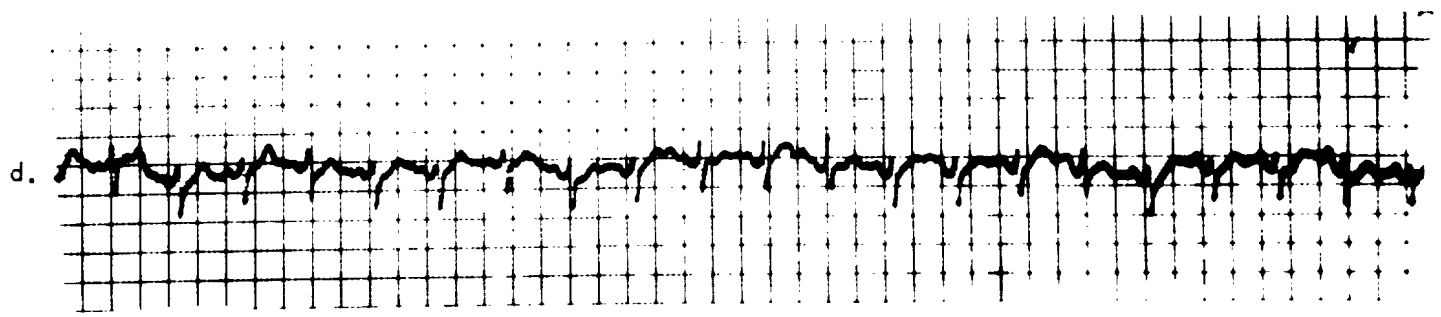
a. Resting record.



b. Rotational changes, probably related to respiration.



c. Rotational changes and T wave inversion.



d. Transient decrease in amplitude of the entire complex with a lowered J point in a tachycardia of 130 beats per minute.

records suggests that the changes are preponderantly positioned, either by change of heart axis, or amplitude changes caused by interposition of the lingula between the heart and chest wall during period of hyperventilation.

DISCUSSION

This brief resume of a pilot evaluation of an on-going project raises a number of questions. The most important of these relates to the impact of helicopter flying upon cardiovascular physiology. In the instructor pilots studied it appears that the heart rates during periods of flight instruction are significantly higher than heart rates during the performance of administrative tasks and during automobile driving, even though these three activities have comparable energy expenditures.[1,2] Fifteen (28.3%) subjects had their highest heart rates recorded during period of flying. In spite of this, the mean increase in heart rate during periods of flying was modest, only 7.5 beats per minute greater than the lowest mean heart rate noted, and certainly can not be viewed with alarm. The infrequent occurrence of ectopic beats, and their innocuous nature is reassuring.

Three points noted during this study are of particular interest:

1. The significant difference ($F = 10.1506$, $p < .05$) between individuals; in fact, a higher difference than that noted between treatments.

2. The high correlations between heart rates of any particular individual during the varied activities recorded. It appears that there are individuals who regularly have heart rates higher than the mean, and that this relationship obtains regardless of activity, and conversely that there are people who have heart rates lower than the mean regardless of activity.

3. The consistent occurrence of counter-clockwise rotation and decrease in T wave amplitude as heart rate increased.

SUMMARY

1. Fifty-three (53) instructor pilots were studied with one lead of EKG for a full work day.

2. Mean heart rates were tabulated from the record during:

   a. Administrative work (87.2) beats per minute

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