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Председател : акад.Т.Ташев

Генерален секретар : проф.Ст.Баев

Медицинска академия - Президиум

София 1431, бул.Д.Несторов №15

Тел. 59-41-18

58-121/459/

У Д О С Т О В Е Р Е Н И Е

Ръководството на Националната секция на Балканския медицински съюз удостоверява, че доклад на тема: Evaluation du charge mental chez les operateurs de l'aeroport "Sofia" par les parametres de variabilite cardiaque .

с автори: R.Nikolova , S.Danев

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EVALUATION DU CHARGE MENTAL CHEZ LES OPERATEURS DE L'AEROPORT  
"SOFIA" PAR LES PARAMETRES DE VARIABILITE CARDIAQUE

NIKOLOVA R., DANEV S., Institut d'hygiène et de maladies professionnelles, Sofia, Bulgarie

On a analysé trois groupes d'opérateurs: des contrôleurs du trafic aérien et des contrôleurs de la tour d'observation. Les méthodes utilisées comprennent l'analyse d'ordinateur de la variabilité du rythme cardiaque, les tests psychologiques et biochimiques, etc. On a établi a) qu'il existe une différence d'âge nettement exprimée entre les opérateurs, b) que le travail des contrôleurs du trafic aérien est plus intense en comparaison avec celui des autres groupes; c) qu'il n'y a pas une grande différence entre l'équipe matinale et l'équipe d'après midi; d) la comparaison des indices lors de cet examen avec les résultats obtenus chez les opérateurs d'un autre groupe (de l'énergétique) montre que le travail des opérateurs du transport aérien peut être qualifié modérément intense. La conclusion faite est que l'analyse d'ordinateurs du rythme cardiaque est une méthode sûre pour l'appréciation du chargement de travail.

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ASSESSMENT OF THE MENTAL WORKLOAD IN AIR  
TRAFFIC CONTROL OFFICERS BY MEANS OF HEART RATE  
VARIABILITY

R. Nikolova, S. Danev  
Institute of Hygiene and Occupational Diseases,  
Medical Academy, Sofia

I N T R O D U C T I O N

How to measure mental load and mental fatigue? This problem has been an important topic in the last twenty years. Industrialization and automation had a tremendous influence on work and working conditions, but in many cases the mental load of the employees, i.e. a shift from physical to mental load is not possessing a real decrease of working demands. It has to be mentioned, that automation requires often a large scale application to be economical. This leads to the result that subtasks, which could not be automated, are grouped together, giving finally rather unsatisfactory work conditions.

According to behavioural measures, an air traffic controller appears to be doing several tasks at once: scanning radar and other displays; talking to pilots or other controllers; annotating flight strips; calling down information onto tabular displays; planning ahead and anticipating future problems; listening; up-dating or removing out-of-date information, etc. There is considerable evidence in traffic control, that reflecting routine functions will enable the controller to devote more time to decision making and problem solving(1,2).

The results of measurements of heart rate, heart rate variability, tremor activity and catecholamine secretion show that the air-traffic control task is very highly emotionally stressing(3,4,5,6,7). Air traffic control is generally conceded to be a stressful occupation.

The purpose of this study was to assess work-induced mental stress and strain in air traffic controllers from Sofia airport. Stress leads to strain in human beings not only dependent on stress but also mainly moderated by individual's characteristics. So why a large battery of physiological as well as psychological and biochemical parameters were followed up. Only the results obtained by means of computer analysis of heart rate variability (HRV) will be presented.

M E T H O D

It is well known that HRV decreases (is suppressed) by an

increase of mental load. Sinus arrhythmia was therefore investigated as a sensitive measure of workload for use of occasion when changes in over-all stress in adaptation profil of the subjects occurs.

Fifty seven air traffic controllers participated in this study. They were divided to three groups: 25 controllers of the airport control (AC); 27 flight controllers (FC) and 5 working in the airport tower main visual control point (TC). Danav's method for collection and computer analysis of HRV was implemented (8). Subjects were investigated at their working places, sitting comfortably and stoping to work for a period of 12 min. In this period EKG signal was recorded on a typerecorder (the computer processing of the signal was postponed). The following HRV measu-

res were computed: mean R-R interval ( $\bar{X}$ ), standard deviation (SD), coefficient of variation (CV), mean difference between successive cardiointervals (V), total positive successive difference (S), number of waves in the cardiotechogram (N), mode (Mo), amplitude of the mode (AMo), homeostatic index (HI =  $\frac{AMo}{Mo \cdot SD}$ ), spectral analysis of

HRV (index of vegetative balance - IVB =  $\frac{PS(t)}{PS(r)}$ , where PS(t)

corresponds to the power spectrum in spectral area 0.02 - 0.05 Hz and PS(r) is the same for 0.2 - 0.4 Hz), classification index (CI = the sum of main components of HRV multiplied by they coeffi - ante of weight).

## RESULTS

The results can be summarized as follows:

1. There exist a clear-cut age-related difference when compare all controllers divided to three age groups: 20 - 29 (N=21); 30 - 39 (N=28) and 40 - 49 (N=8). CI has being respectively +31.3; +5.5 and -37.9 (tabl.1).

PARAMETERS	1. 20-29 N=21		2. 30-40 N=28		3. 40-49 N=8		Student t-test ind. var. (p)d.		
	$\bar{x}$	Sx	$\bar{x}$	Sx	$\bar{x}$	Sx	1-2	1-3	2-3
1. $\bar{X}$	815.2	23.2	786.1	18.7	777.6	35.8	0.67	0.5	0.8
2. SD	59.1	4.0	54.0	3.0	48.3	9.1	0.3	0.2	0.5
3. V	30.3	2.7	25.0	1.7	20.5	3.7	0.08	0.05	0.2
4. S	10.9	0.7	9.7	0.5	8.1	1.2	0.5	0.04	0.1
5. N	320.8	10.9	333.1	13.1	355.6	27.2	0.5	0.1	0.5

6.	Mo	806.4	24.7	784.1	21.7	773.9	38.2	0.5	0.5	0.8
7.	AMo	15.8	1.1	17.7	0.9	23.3	2.2	0.1	0.002	0.01
8.	HI	0.45	0.07	0.57	0.08	0.91	0.2	0.2	0.005	0.06
9.	IVB	0.75	0.04	0.73	0.03	0.77	0.1	0.6	0.7	0.5
10.	CI	31.3	15.2	5.5	12.2	-37.9	18.6	0.1	0.01	0.08

2. As far as work-related distress can be evaluated by means of HRV parameters, airport controllers (AC) groups seems to be exposed to more severe strain conditions when compare with FC and TC groups (CI has being + 1.52 ; + 12.7 and +26.2), but these differences are not statistically significant, probably because of the relatively unrepresentative number of investigated subjects (tabl.2).

PARAMETERS	1.AC N=25		2.FC N=27		3.TC N=5		Student t-test ind.var.(p)		
	$\bar{x}$	$S_x$	$\bar{x}$	$S_x$	$\bar{x}$	$S_x$	1-2	1-3	2-3
1. $\bar{X}$	796.6	19.7	794.2	21.9	800.4	28.7	0.89	0.89	0.87
2. SD	51.8	3.2	55.2	3.7	60.4	5.8	0.5	0.27	0.57
3. V	24.0	1.7	27.7	2.3	32.2	6.1	0.21	0.08	0.53
4. S	9.1	0.4	10.4	0.6	12.2	1.8	0.1	0.01	0.27
5. N	325.3	11.0	339.2	14.4	324.4	17.7	0.5	0.92	0.72
6. Mo	796.9	23.2	787.5	22.9	789.4	29.9	0.76	0.86	0.92
7. AMo	16.1	0.98	18.2	1.2	14.2	1.5	0.92	0.09	0.18
8. HI	0.58	0.07	0.64	0.1	0.36	0.1	0.64	0.2	0.24
9. IVB	0.74	0.03	0.8	0.04	0.65	0.05	0.29	0.21	0.16
10. CI	1.52	12.3	12.7	14.7	26.2	22.1	0.57	0.59	0.7

3. When compare morning and afternoon shifts it is not evident that the afternoon values of the followed parameters shows bigger work-related strain influence than morning one.

4. The results obtained were also compared with the data from other professional groups (operators from electrical power station). This comparison brought evidences that the air traffic control is a rather difficult profession.

## C O N C L U S I O N

In practice changes in HRV parameters are valuable for comparing workload levels because sinus arrhythmia is more sensitive than over-all heart rate and may detect changes in workload which do not result in any variation of the pulse.

Several authors have commented adversely on the use of heart rate "per se" as the sole measure of the workload. As so many factors can influence cardiovascular responses to stress, this criticism is according to us justified. There are at least two reasons coming from this study confirming such a statement:

-age difference followed up are better pronounced when compare HRV parameters based on pulse variability than on pulse itself (see table 1).

(The existence of real "functional age" difference was confirmed by the results of a parallelly employed questionnaire-made study of psychosomatic complaints. They increase with the increasing of age).

-IVB is an indicator of the type of the "wave" characteristics of cardiogram but it is not being absolutely independent on pulse frequency. This parameter does not prove to separate statis-

tically significant AC from FC groups, what the parameter  $\bar{X}$  does not too.

The results of this study indicate that HRV parameters can be an useful tool when assessment of the "stressfulness" of the air traffic controls behaviour is considered. Stress does not only depend on the difficulties of the task but also on the physical components of the working place, social components as leadership, management relations and social support, locus of the control etc. Some of these parameters were carefully studied and the results obtained brought similar to analysis of HRV information.

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