# ASSESSMENT OF WORK RELATED STRESS IN AIR TRAFFIC CONTROLLERS FROM SOFIA AIRPORT

R. Nikolova, V. Stantchev, S. Danev

## INTRODUCTION

The work related stress of air traffic controllers (ATC) arises from considerable information processing, ergonomical disadvantages of radar displays and human-environment interaction (11, 14, 15, 23, 24, 28-30, 32, 36).

The activity of ATC is described as overloading the visual system (20, 28, 33, 37, 38). At the end of the 2 h monitoring period a shift of dark accommodation in myopic direction, removal of punctum proximum is established, as well as, increased number of visual fatigue complaints. These phenomena decrease to a certain degree but still persist after a 2 h rest period. The findings are due to performing sustained near vision tasks, inadequate lighting of the dark surroundings, negative contrast of radar displays and other (8, 17, 18, 31, 38).

The aim of the study is to elicit the relationship between Heart Rate Variability parameters reflecting work evoked strain and the functional state of the visual system.

## METHODS

57 male ATC aged 32.3+0.86 from Sofia Airport have been investigated. In accordance with the task were surveyed three groups ATC: approach, control and tower.

The procedure for the Heart Rate Variability (HRV) measurements was done twice in a 10 minute period of rest before and after a 2 h monitoring task. The HRV study was followed by an investigation of some psychological parameters. The visual indices were assessed before and after a 2 h work activity.

In the HRV analysis have been applyed the most informative parameters: 1. Cardiotachogram and Histogram of cardiointervals (R-R): X - mean value of the successive R-R; SD - standard deviation of the mean value of R-R; AMo - amplitude of the mode; HI - homeostatic index defined as ratio of the AMo to the product of the most frequent duration of R-R (Mo) and SD (fig. 1, table 1) ;

2. Power Spectral Analysis of HRV: Pt, Pbp, Pr - spectral powers of the R-R related to oscillations respectively of the thermoregulatory, regulating arterial blood pressure and respiration systems corresponding to frequency area resp.: 0.00-0.05 Hz; 0.05-0.15 Hz and 0.2-0.4 Hz; SI - Stress Index defined as ratio of spectral powers of thermoregulatory to respiratory sinus arrhythmia component of HRV; CI - classification index defined as function of the main stress induced HRV parameters (6) - (fig. 2).

Dark accommodation was examined by hand optometer (13, 21, 35). The following visual indices have been evaluated: DF - initial point of dark accommodation; DFch - change in dark accommodation after two hours of work. The subjective visual complaints: photophobia, burning, tearfulness,redening of the eyes and headache are examined by specialized questionnaire.

Psychological study was performed by NIOSH test for subjective estimation of professional stress adapted to the Bulgarian population. It interprets the scales: interpersonal conflicts in the group; interpersonal conflicts between the groups; possibility for control over the working process; social support; work satisfaction; psychosomatic complaints; self-estimation (39).

The statistical methods applied are: variation analysis; T-test of Student-Fisher; multiple correlation analysis; Spearman's rank correlation analysis; multiple stepwise regression analysis. It was used BMDP software.

## RESULTS

To determine the exact value of work-related stress computer analysis of HRV is applied (6). This method is proved to be highly sensitive in regard to stress factors with different patterns: environmental, task-related, psychosocial, medical and other (2, 3, 7, 12, 16, 19, 22, 26, 27). That is possible because HRV reflects dynamically the sympathetic and parasympathetic tone of the Autonomic Nervous System (ANS) - (4, 5, 9).

HRV parameters in ATC show increased level of neuro-psychic load when compared with the country's mean values. After 2h monitoring it is found that a significant decrease of short- and long-term HRV occurs,pronounced increase of power density spectrum of long spectral waves (bellow 0.06 Hz) and decrease of total spectral power. Mean heart rate remains unaffected. It appears that neuro-psychic stress of ATC concerns HRV parameters: time- and frequency - domain measures but not the mean heart rate.

These results show statistically significant correlations between R-R disrtiburion measures and frequency - domain measures with psychological parameters, while psychological parameters do not correlate with the mean heart rate (25). Fig. 3 shows the significant correlations between R-R distribution measures: AMo (amplitude of the mode), HI (homeostatic index) and frequency - domain measures: Pt and Pr (spectral powes in low and high frequency area), SI (stress index) from the one hand, and interpersonal conflicts between the groups, self-estimation and work satisfaction from the other hand.

Self-estimation is proved to be the main significant predictor of neuro-psychic stress assessed by HRV parameters (25) - (table 2). Such regression dependence is not found for the mean heart rate.

The determining of the dependences between HRV parameters and visual indeces, analyzed statistically by Spearman' rank correlation test, presents significant correlation between the mean heart rate and dark accommodation (fig. 4). Other significant correlations are found to exist between a number of visual complaints and neuro-psychic stress, reflected by frequency-domain measures of HRV: Pt (spectral power of R-R joined to oscillations of thermoregulatory system in the frequency area 0.00-0.05 Hz) and SI (stress index) (fig. 5, fig. 6).

## CONCLUSIONS

Neuro-psychic stress of ATC assessed by HRV parameters is considered moderately expressed. This stress influences sympathetic-parasympathetic autonomic balance in a specific manner: it changes unfavourably the time- and frequency-domain HRV parameters but it is not sufficientely strong to alter the mean heart rate. The reason is the smaller vulnerability of the mean heart rate in comparison with the former.

At this level of stress heart rate is predominantly parasympathetically modulated. This statement is in agreement with the studies of R. Somsen et al., 1988 and H. Antoni, 1986. Due to the shorter vagal latency period in regard to the stimulation of the heart rate of the order of 200 msec and to the direct mainly vagal innervation to sino - atrial (right vagal branch) and atrioventricular node (left vagal branch) the parasympathetic system is responsible predominantly for the modulation of heart rate. Such pattern has parasympathetically mediated heart rate at ATC. The mean heart rate will increase in conditions of high overstress (somatic and psychic) only if a severe requirement to the Cardio - Vascular System exists. In our air traffic control study this is not observed.

The contraction of the cilliaris muscle engaged in accommodation function is also parasympathetically modulated by impulses coming from the vagal fibres of nervus oculomotorius (10). Parasympathetical modulation is the reason for the existing significant correlation (r=0.50) between the mean heart rate and dark accommodation.

On the other hand we find significant correlations between subjective visual complaints and HRV parameters - markers of stress reaction: Pt (spectral power of R-R related to oscillations of thermoregulatory system in the frequency area 0.00 - 0.05 Hz) (r=0.46), and SI (stress index) (r=0.42). HRV parameters as well as visual complaints are sympathetically modulated. According to some authors visual complaints increase with neuro-psychic overstress (17).

The results of this study show that neuro-psychis stress influences both parasympasthetic and sympathetic function. We consider this pattern of autonomic modulation, consisting of signifficant correlations between HRV parameters and visual indices, is a result of stres sinergic action upon the Autonomic Nervous System which facilitates both parasympathetic and sympathetic autonomic activity.

We thank Professor Vera Koitcheva, Professor Nikolina Tzaneva, Dr. Liliana Tzaneva and Air Company "BALKAN" for the assistance.

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Tabl. 3. Examined visual indices

| VISUAL INDICES |
| --- |
| Initial point of dark accommodation<br>Change in dark accommodation ($DA_{ch}$)<br>Subjective visual complaints: photophobia,<br>burning, tearfulness, readening of the eyes, headache |

Tabl. 4. Examined psychological scales

| PSYCHOLOGICAL SCALES |
| --- |
| Interpersonal conflicts in the group |
| Interpersonal conflicts between the groups |
| Possibility for control over the working process |
| Social support |
| Work satisfaction |
| Psycho-somatic complaints |
| Self-estimation |

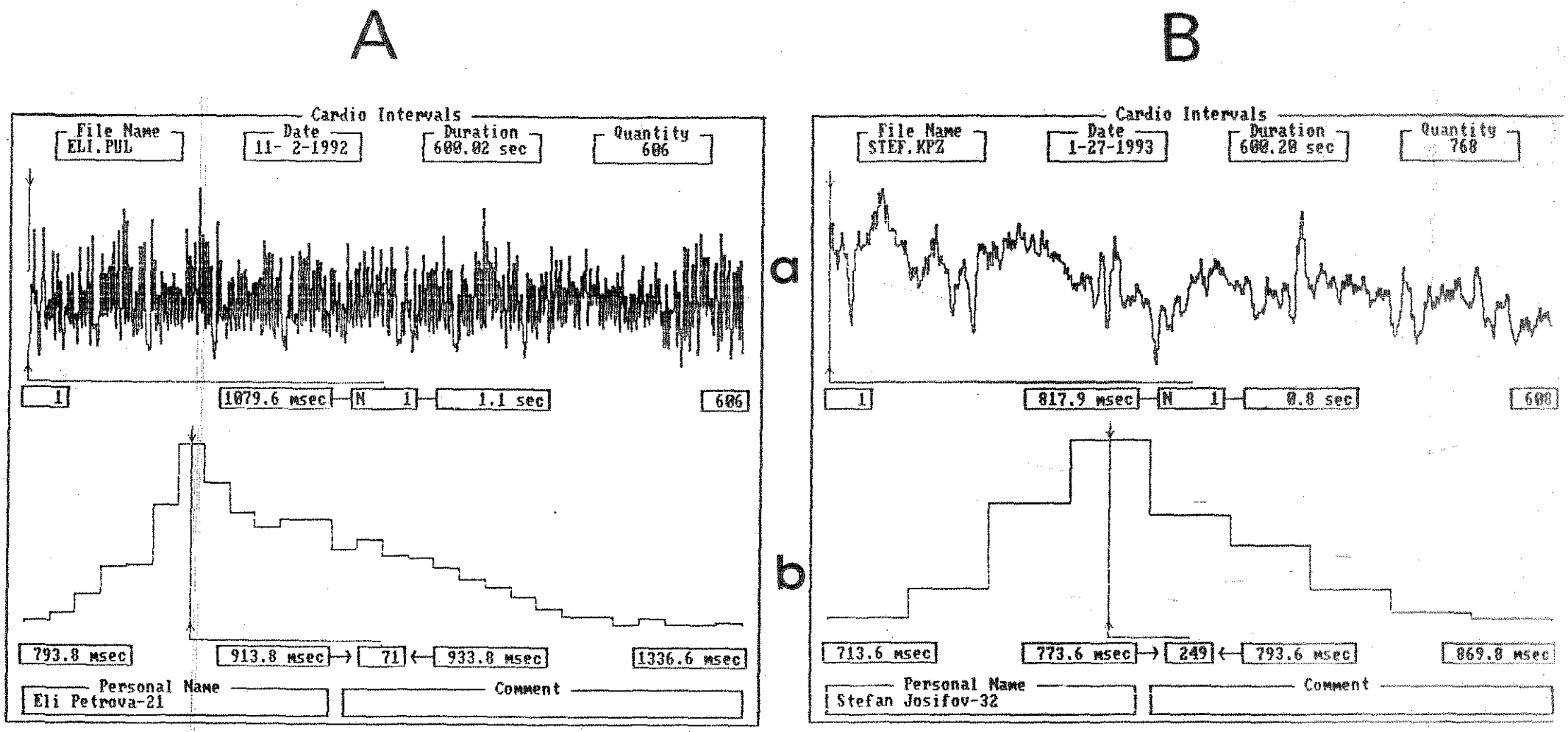



Fig. 1. Cardiotachogram (a) and histogram (b) of subjects with different functional state (A and B)

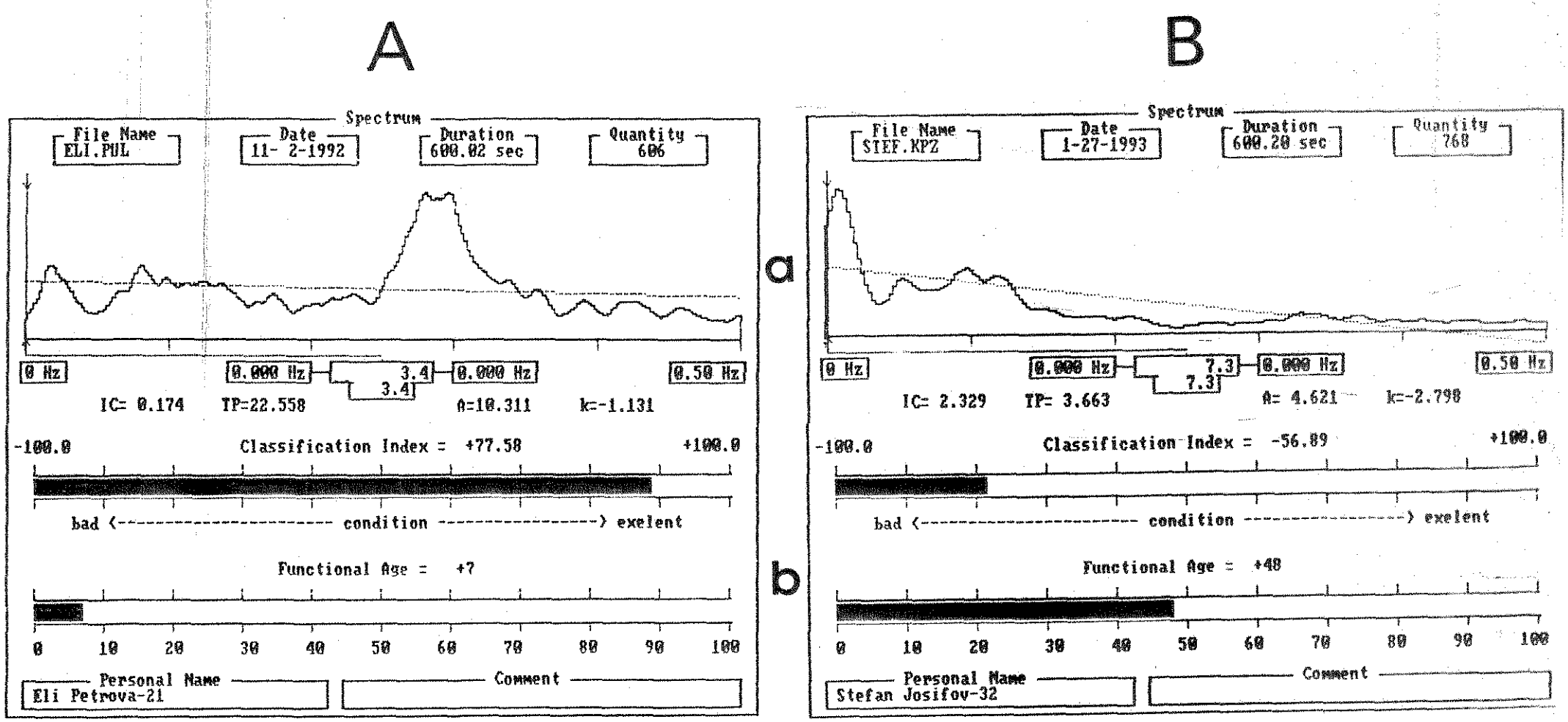



Fig. 2. Power spectral analysis of the heart rate variability (a) and classification index (b) of subjects with different functional state (A and B)

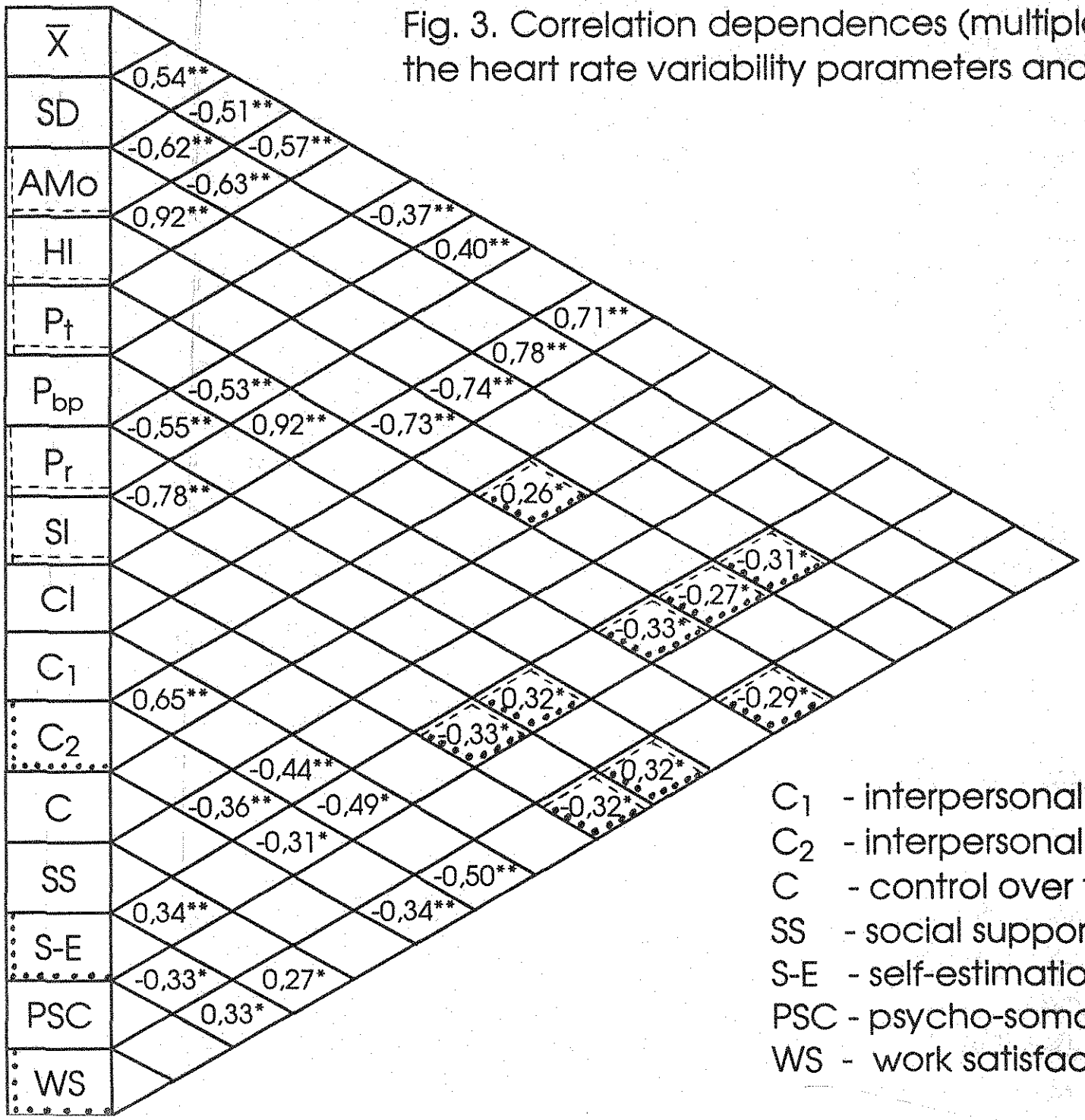
Tabl. 1. Description of heart rate variability parameters

| HEART RATE VARIABILITY PARAMETERS | FORMULA | VERBAL DESCRIPTION |
|---|---|---|
| $\bar{X}$ (msec) | $\bar{X} = \frac{\sum_{i}^{n} \frac{1}{X_i}}{n}$ | Mean value of the successive cardiotointervals |
| SD (msec) | $SD = \sqrt{\frac{\sum(X_i - \bar{X})^2}{n - 1}}$ | Standard deviation of the mean value of cardiointervals |
| AMo (%) | — | Amplitude ot the mode |
| HI ($s^{-2}$) | $HI = \frac{AMo}{Mo * SD}$ | Homeostatic index |

Tabl. 2. Regression dependences of the Hert Rate Variability parameters from the psychological scales

| REGRESSION DEPENDENCE | REGRESSION COEFFICIENT | SIGNIFICANCE OF THE REGRESSION COEFFICIENT |
|---|---|---|
| AMo = 386.13 - 5.48 · Self-estimation | -5.48 | p = 0.01 |
| HI = 186.03 - 3.44 * Self-estimation | -3.44 | p = 0.03 |
| $P_t$ = 379.96 - 3.61 * Self-estimation | -3.61 | p = 0.01 |
| $P_r$ = 184.98 + 3.96 * Self-estimation | 3.96 | p = 0.01 |
| SI = 142.30 - 1.79 * Self-estimation | -1.79 | p = 0.01 |

Fig. 3. Correlation dependences (multiple correlation analysis) between the heart rate variability parameters and the psychological scales




$C_1$ - interpersonal conflicts in the group
$C_2$ - interpersonal conflicts between the groups
C - control over the working process
SS - social support
S-E - self-estimation
PSC - psycho-somatic complaints
WS - work satisfaction

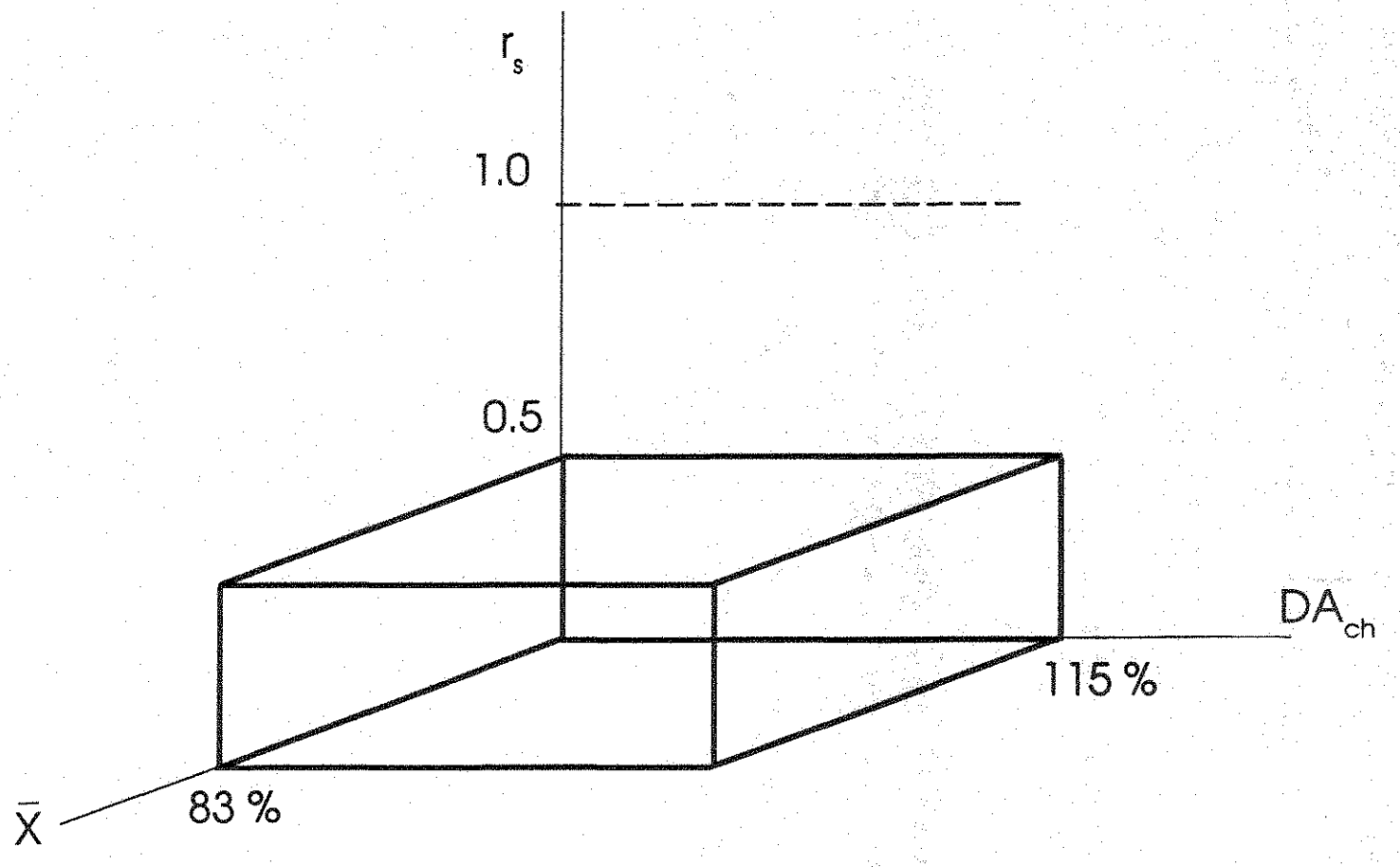



Fig. 4. Correlation (Spearman's rank correlation coefficiant $r_s$) between the mean heart rate ($\bar{X}_{\%}$) and the change in dark accommodation ($DA_{ch\,\%}$)

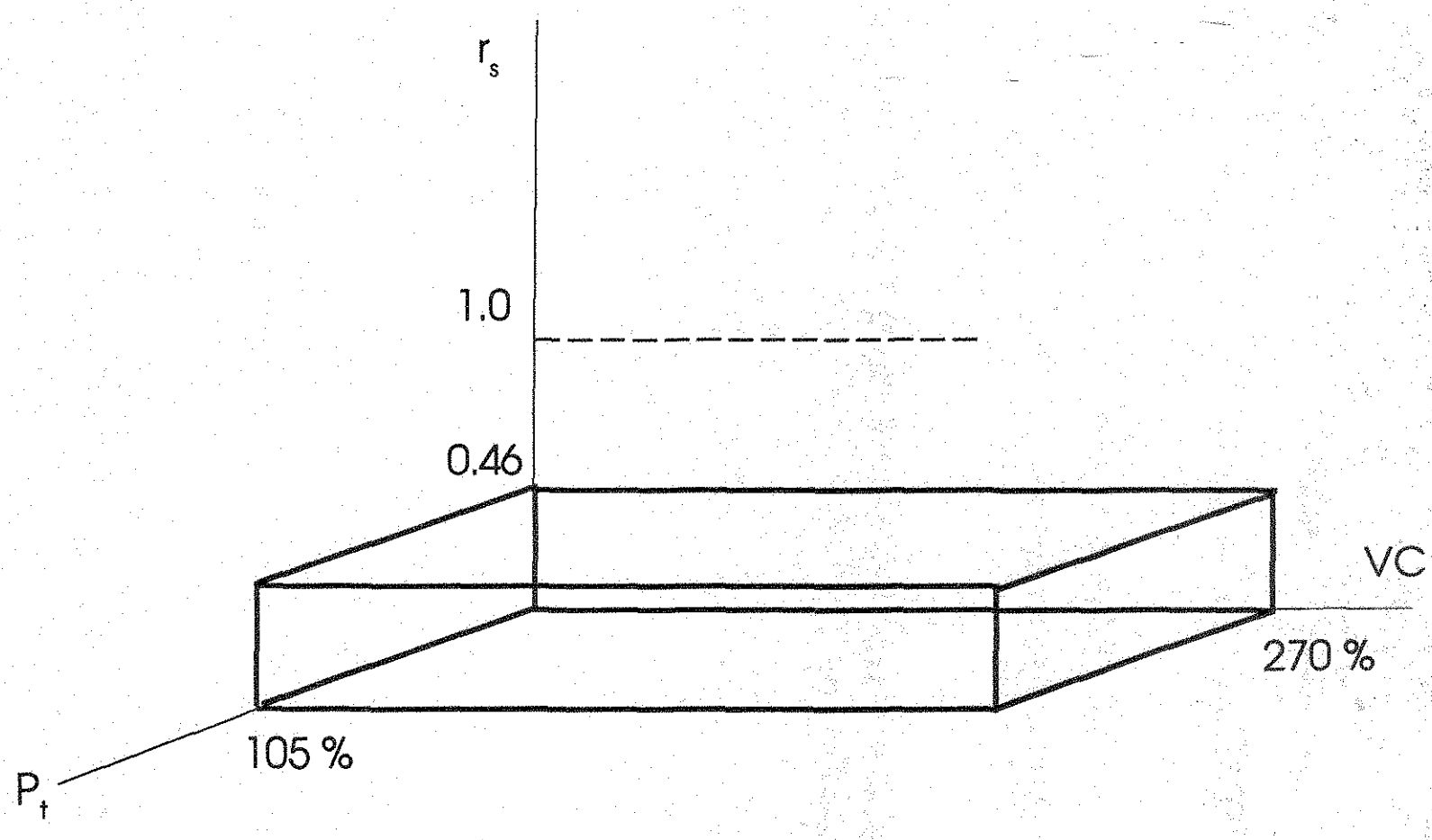



Fig. 5. Correlation (Spearman's rank correlation coefficiant $r_s$) between the spectral power of the cardiointervals related to oscillations of the thermoregulatory system in the frequency area 0.00 - 0.05 Hz ($P_{t\%}$) and the visual complaints ($VC_{\%}$)

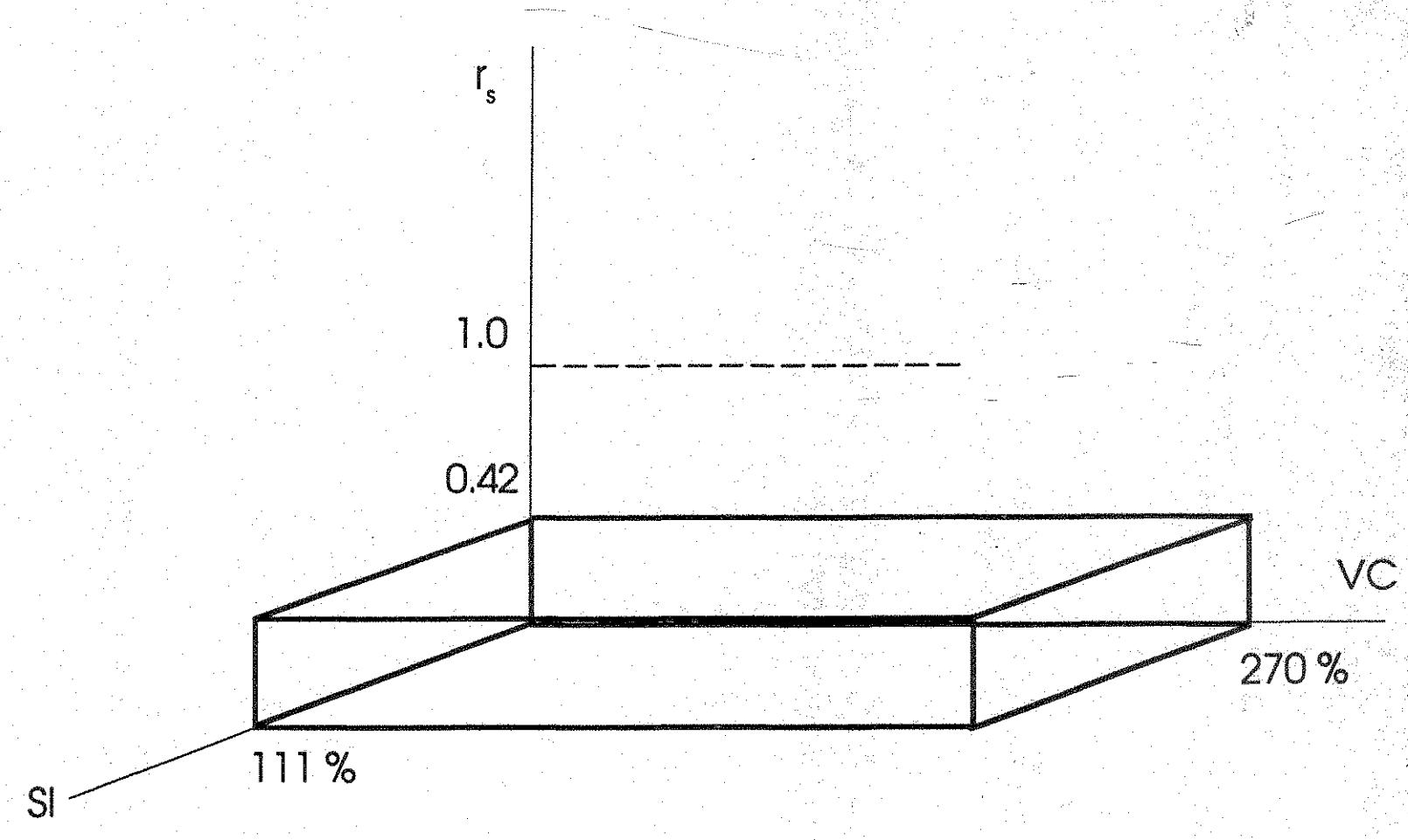



Fig. 6. Correlation (Spearman's rank correlation coefficiant $r_s$) between the stress index ( $SI_{\%}$ ) and the visual complaints ($VC_{\%}$)