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**HEART RATE VARIABILITY FOR
ASSESSMENT OF TOXIC - RELATED
HEALTH RISK**

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INTRODUCTION

The assessment of the effect of human exposure to toxic (or other) stressogenic ecological and work related agents needs introduction of new, easy to be performed, sensitive and validated biomarkers. Our long-term lasted practice in developing of electrophysiologically-based methods for human monitoring after chronic contact with occupational stressors (1,2) proved that the deviations in vegetative equilibrium are one of the best biomarkers for early detection of health hazard. The most direct access to vegetative functioning can be achieved by following up of heart rate variability (HRV).

Nowadays the main stream of medical society accepts the decrease in HRV as one of the predictors of nonspecific health risk associated with a variety of chronic diseases, morbidity, mortality and ageing (3). First Danev et al (4) find a strong positive relationship between HRV decrease and mental effort in a series of laboratory well controlled experiments. Recently HRV is used for assessment of the harmful effect of a large class of stresses including ergonomical disadvantages (5), dietary problems (6), psychosocial discomfort or behavioral disorders. We proved that HRV reflect also the risk for development of different kinds of carcinomas (7). In this particular study HRV-based measures were obtained in 2147 practically healthy workers from both sexes (217 men and 1435 women) of working age. The epidemiological study completed 4 years later, proved that the workers, with a chronic drift in sympathetical - to - parasympathetical balance towards a sympathetical prevalence, are exposed to a higher health risk for developing cancer ($p < 0.01$). In the second part of the same investigation the HRV measures collected in 247 cancer patients (154 men and 93 women with a mean age of 38 years), from the Bulgarian Oncological Center and the same measures collected in a control group being representative of the country's population (3 852 men and 4 254 women, with a mean age of 39.5 years) were compared. The comparison revealed that the autonomic balance in cancer patients was found to be much more sympathetically oriented ($p < 0.001$).

For practical employment of HRV method in environmental and occupational aspect original software and hardware facilities were created, named DanevTest.

METHOD

DanevTest is a computerized electrophysiological method, using ECG, plethysmogram or breathing recording. From these signals, **HRV** analysis and analysis of spectral coherence are performed.

HRV is modulated by the activity of both branches of the autonomous nervous system: sympathetic and parasympathic (vagus). Generally, the increased sympathetic tone is connected with a diminution of the HRV, whereas the increased parasympathetic input increases HRV.

DanevTest gives the following parameters:

- *Time-domain based HRV* parameters (heart rate, standard deviation of times between successive heart beats - R-R intervals etc.). They are used for assessment of the physical stress level (overstress, distress).
- *Frequency-domain based HRV* parameters (total spectral power, long waves/short waves ratio, etc.). They are used for assessment of mental stress level (chronic psychic fatigue).
- *Coherence based parameters* (amplitude and phase spectral coherence between HRV and plethysmogram (resp. breathing) spectra). Coherence informs about psychosomatic capacity for adaptation towards stressors. Increased coherence means augmented capacity and vice versa.
- *ECG based parameters* (number of ECG events suspected to be supraventricular or ventricular premature heart beats, some pathological deviation of QRS complex or “T” wave, etc.).

All these parameters can be influenced by toxic agents.

A statistically significant correlation was found existing between the results obtained by **DanevTest** and by some others clinical, paraclinical, physiological and psychological investigations parallelly done. The advantage of **DanevTest** is its higher informativeness and easier performance.

It is proved that the persons with increased health risk score (according to **DanevTest**) develop (in some years) more likely different kinds of pathological processes, when compared with controls.

DanevTest can be adapted to the specific demands of all-medical (clinical and prophylactic) branches, sport, nutrition and psychology.

DANEVTEST HARDWARE is a pocket format electronic device. It receives the ECG, plethysmographic or breathing signals as analogue curves and can process them or transmit them to PC.

The hardware can be used alternatively in three ways:

- *First*, emitting both analogue signals directly to PC for complete analysis.
- *Second*, processing ECG or plethysmogram and presenting on its fluid crystal display the most important results as: pulse, extrasystoles and physical stress (a quick assessment based on physical stress score).
- *Third*, memorizing data accumulated for a time period not longer than 40 min of both analogue signals and transmitting them to PC later for statistical evaluation.

*Fig. 1. Functional presentation of **DanevTest** Hardware*

1. Connecting cable to PC
2. Display with two channels: ECG and plethysmogram (or breathing)
3. 4 buttons: channels selection (1+2)(1)(2); selection of sampling frequencies (in Hz) 100, 250, 400, 600; memory cleaning; mode selection ("test" or "record")
4. On/off button
5. First channel (ECG sensors). ECG sensors are 3 standard electrodes
6. Second channel:
 - a). Plethysmographic signal. Plethysmographic sensor can be ear or finger type clips (infrared light based).
 - b). Respiration signal. Respiration sensor (temperature – humidity based) is attached to a small tube to be inserted in the front part or right or left nasal aperture.
7. & 8. Control lamps of ECG and plethysmographic signals
9. ECG potentiometer.

DANEVTEST SOFTWARE consists of two tests and two program products:

1. **Stress test** for assessment of pulse, extrasystoles, physical and mental stress.
2. **Fitness test** for assessment of physical fitness (training).

3. **Health risk program** for assessment of health risk associated with overstress, cardiac rhythmic disturbances and lowered physical fitness. Health risk assessment is an outcome of the data obtained by Stress and Fitness tests.
4. **Data Base program** for statistical evaluation of mean groups values.

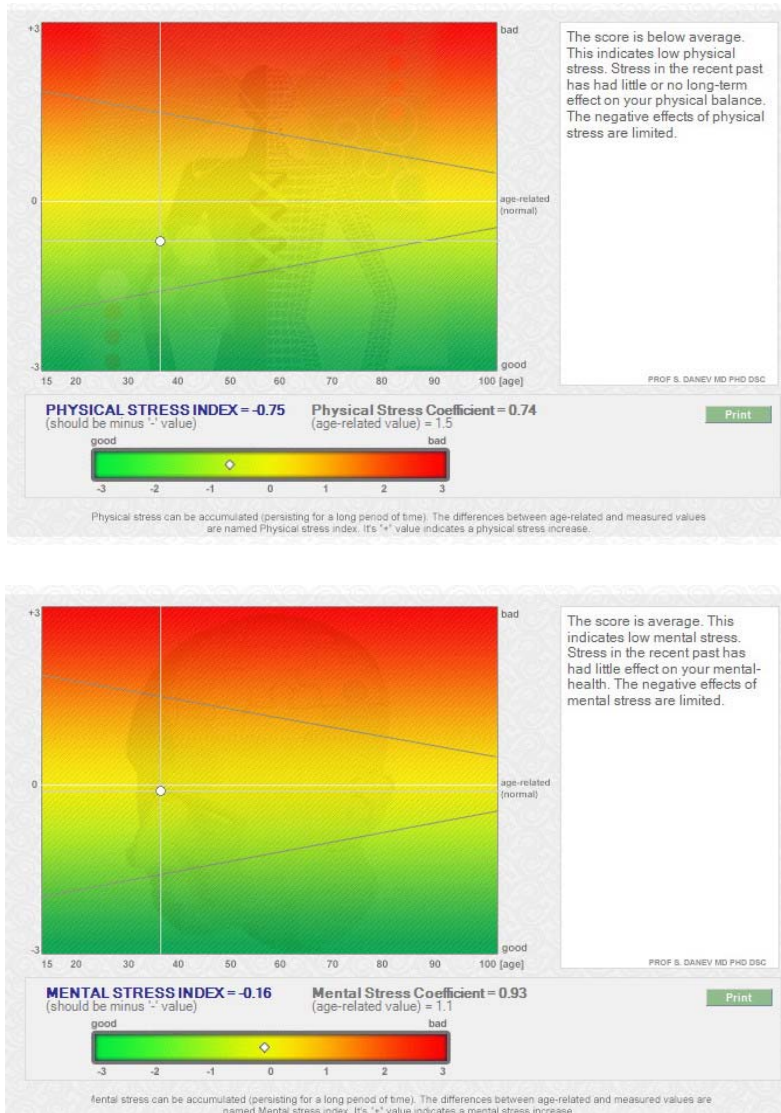


Fig. 2. Assessment of physical stress

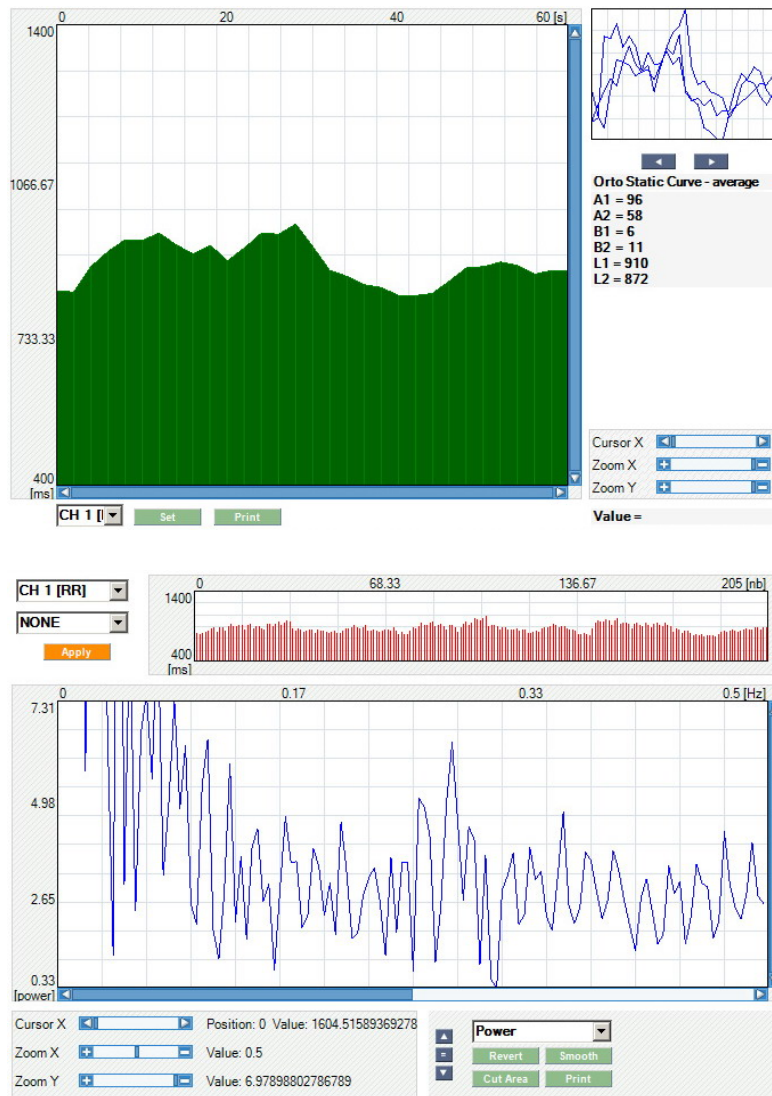


Fig. 3. Assessment of physical fitness. A. Tachogram, B. Spectrum

RESULTS

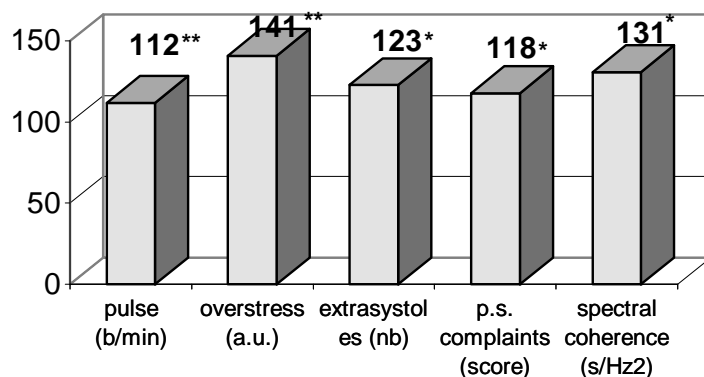
DanevTest is not providing the exact diagnosis, but the decreased body ability to adapt towards different stress agents. In order to compare the obtained results in experimental groups with controls, the biological constant of the DanevTest parameters were established by following up of more than 10 000 subjects from different age pentages. DanevTest was used for assessment of the degree of disadaptation in different industrial branches.

1. COPPER PRODUCTION (COPPER PLANT “SREDNOGORIE”).

Working conditions - mosaic microclimat (too hot or too cool) in metallurgic department; noise and vibrations over MAL; toxico-chemical agents as SO₂, SO₃, arsen, lead oxides, metal aerosoles (Cu, Pb, Cd, Zn) namely in department of electrolysis; Se oxides in departments of gold and silver; dust; electromagnetic fields (from electrolyses) and electroinductive melting apperations - fluctuating EMF 12-20 kA/m, night schedule etc. Some of these factors (e.g. dust) were highly exceeding MAL.

Subjects: 207 workers (176 m and 31 w, m.a. 37.2 yr) where followed up by DanevTest. Fig. 4. gives the obtained results.

Fig. 4. DanevTest parameters (%) in workers from cooper production plant compared with country mean values accepts as 100%



* p < 0.05, ** p < 0.01

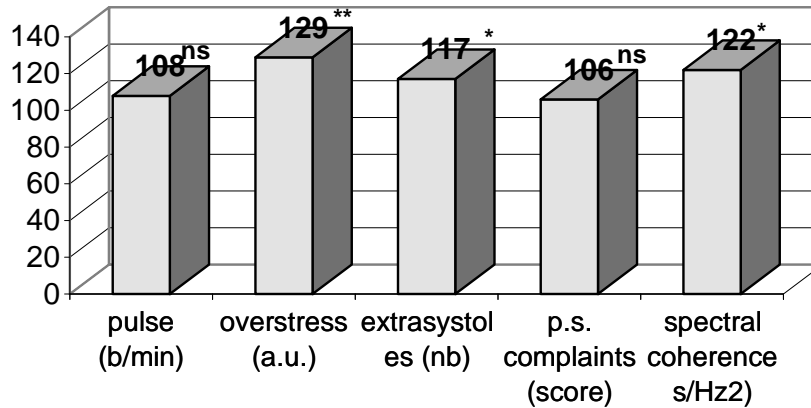
Four years later the morbidity of the followed up persons was compared by dividing them in three groups: first - 50 subjects with “bad” DanevTest results; second - 50 subjects with “good” DanevTest results; third - 107 subjects outliers. It was found that the number of persons with diffuse pneumonia, toxic pneumosclerosis, chronic bronchitis, asthma, cardiovascular diseases, Pb in the blood, 5-ALK and As excretion with urine in the first group is increased, whereas the data from blood tests (Rbc, Wbc, Hb, Pbc) are decreased, (p < 0.05-0.01) as compared with second group.

2. POPULATION LIVING IN AREA SURROUNDING THE PLANT

The area was polluted with dust and chemical agents similar to these described in 1.

Subjects: 163 (94 m, 76 w, m.a. 41.4 yr). Fig. 5 gives the obtained results.

Fig. 5. DanevTest parameters (%) in population living in ecologically polluted area (around copper smelter plant “Srednogorie”) compared with mean country values.



* $p < 0.05$, ** $p < 0.01$, ns - not significant

3. ELECTRONIC PRODUCTION

Lead is considered to cause adverse subclinical effects even at exposure levels below threshold limit values. Only few years ago these values were accepted as safe (8). The biological threshold limit is 400-600 mg/l.

Subclinical lead toxicity is expressed in glomerulo-tubular dysfunction, male fertility disturbances as well as decreased HRV. That is why DanevTest was used for revealing the existence of dose-response and dose - effect relationship between Pb levels and HRV decrease in spolders.

Subjects: 64 (35 m, 29 w, m.a. 35 ± 3.27 yr, aged 22-61 yr all of them tin - lead solder workers (mean work practice 14.6 ± 1.36 yr).

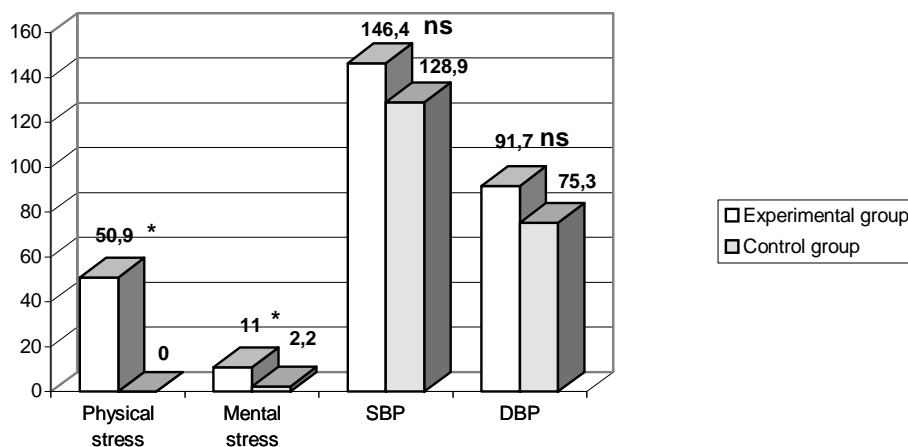
The obtained results were compared with controls: 73 age/sex matched healthy subjects (38 m, 35 w, m.a. 35.4 ± 2.53 yr aged 21-61 yr, mean work practice 13.4 ± 1.03 yr) not exposed to toxic agents. Criteria for excluding from both, experimental and control groups, were frequent drug intake or chronic systematic illnesses.

Stressors: lead condensed aerosols in the breathing zone - below threshold limit value (0.05 mg/m^3). Nevertheless traces of tin - lead alloys were actually observed.

Blood lead level and urinary excretion of δ -aminolaevulinic acid in experimental group were positively correlated (increased excretion of δ -ALA

was observed in 23.6% of the shoulders at urinary excretion between 8160 to 10 200 nmol/4h urine), when the biological constant is 3930 - 7870 nmol/4h urine. Fig. 6 presents the obtained results.

Fig. 6. Mean levels of physical and mental stress as well as of SBP and DBP in experimental and control groups.



* $p < 0.05$, ns - not significant

Scatterplots (linear regression analysis of practice duration) shows strong significant positive correlation with both stress levels.

DISCUSSION AND CONCLUSION

Recently increased attention is paid on increased health risk associated with chronic exposure to toxic agents at level considered up to now as safe. At these levels clinical effects are not well pronounced. Nonspecific, not directly connected with toxic specificity psycho-physiological changes can be the earliest sign of possible health hazard. These changes are preceding the professional and paraprofessional pathological process. The chronic increase of sympathetic tone is connected with decrease of HRV, increase of long waves-associated spectral power of HRV spectrum and with decreased psycho-physiological coherence (decreased spectral coherence between pulse and blood pressure (reflected by plethysmogram) spectra.

The proposed DanevTest is reflecting successfully these parameters. It was used also (except the described above) in chemical industry, mining, agriculture etc. production with an increasing success.

Therefore we introduce DanevTest in order to be used as an early nonspecific predictor of subclinical toxicity in the cases when toxic concentration is within (or not) the limits of the threshold value.

The assessment of the exact values of health risk reflected by DanevTest, associated with chronic exposure to toxic substances even at concentrations below threshold limit value requires future longitudinal cohort studies to determine the extent of relationship between DanevTest parameters on one side and morbidity on the another.

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DrDx

QHRV 1000
POWERED BY DANEVTEST

WELCOME DATA INPUT OPEN ANALYSIS STATISTICS TUTORIAL SETTINGS

INNOVATIVE, NON-INVASIVE, REALTIME PROCEDURAL TECHNOLOGY FOR HIGH QUALITY HEALTH CARE

overview

Heart Rate Variability Analysis, has acquired exceptional popularity over the last few years. Nowadays, the main stream medical associations around the world accept HRV analysis as one of the best predictors of non-specific health risk. Scientific and clinical studies have established its usefulness in almost all branches of medicine.

The physiological basis of HRV is the analysis of the fluctuating activity in the brain, cardiovascular vasoconstrictor and vasodilatory centers. Normally, these fluctuations are a result of baroreflex modulated blood pressure oscillation; parasympathetically mediated respiration via thoracic stretch receptors; sympathetically mediated thermoregulation via thermoregulatory peripheral blood flow adjustments and circadian biorythm. All these factors can influence the length of beat-to-beat intervals, known as cardio intervals or RR intervals. Their values are an object of mathematical estimation yielding the amount of HRV. Thus, HRV analysis becomes one of the best diagnostic tools of the modern medical practice.

acquire data

new study

open file

existing study

analysis and reports

first acquire new study or open existing results and comparison

statistics

history and evaluation

Q HRV powered by DanevTest is the result of several years of very profound scientific research by renowned Medical Doctor and Professor Danev. Dr. Danev is one of the pioneers of the HRV analysis theory and clinical verification. He was also the first President of the European Society for HRV analysis. Our innovative technology involves computer analysis of HRV, ECG, PL, Respiratory and Autonomic Function Assessment. This procedural monitoring results are absolutely useful in most clinical disciplines of medicine.

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INNOVATIVE, NON-INVASIVE, REALTIME PROCEDURAL TECHNOLOGY FOR HIGH QUALITY HEALTH CARE

Name: Turner, Vernita Gender: F Age: 48 Date: 16/08/2007 4:00:00 PM

RESULTS

- SUMMARY Most important results and parameters
- PWV ANALYSIS Blood Flow, Pressure, Vascular Arterial thickness and Flexibility
- ECG ANALYSIS Ultra-ventricular & Vascular Extrasystoles
- AUTONOMIC BALANCE Para-sympathetic and Para-sympathetic Nervous systems, Cardiac-Respiratory
- STRESS TEST Functional Age, Physical Stress, Mental Stress ...
- FITNESS TEST Cardiac output, Vascular output, Fitness (Training) Index ...
- HEALTH RISK Level of personal health risk for developing health-threatening diseases.
- DETAILS More professional health analysis

ECG graphs QRS analysis summary spectrum scatterogram spectrogram all channels

0 80 160 240 [s]

96.38 96.54 97.69 98.84 [s]

0.5 [mV]

0.3 [mV]

0.15 [mV]

0.01 [mV]

-0.17 [mV]

P max val=0.52mV **P = 110ms** **P-R = 195ms**
Q max val=0.5mV **Q = 65ms** **Q-R = 40ms**
R max val=0.7mV **R = 45ms** **R-S = 35ms**
S max val=0.42mV **S = 70ms** **R-T = 205ms**
T max val=0.51mV **T = 145ms** **QRS = 180ms**
R-R = 96.4s **Previous R-R= 835** **Next R-R= 790ms**

CH 1 [v] Set Print

Cursor X [v] Position: 96.545 Value: 494

Zoom X [v] Value: 3.465

Zoom Y [v] Value: 0.4755

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