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Research Article

Stress Resistance: Diagnostic Aspects of Assessing Physiological Parameters in Response to Stress Testing

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Abstract

The development and testing of new methods for preventing the risk of stress-induced disorders are the central objectives of this study. The work showed that for effective diagnostics of the risk of developing stress-induced disorders it is advisable to use the variational cardiointervalometry test, the Khilchenko test of functional mobility of nervous processes, and the game "Asteroid". These tests measure stress load and allow to assess the level of functional reserves of the body after testing. Analysis of the dynamics of psychophysiological parameters during stress testing made it possible to divide the subjects into three groups according to the type of response to stress: from an excessive reaction to stress (high stress reactivity) to its absence (unresponsiveness). The dynamics of psychophysiological parameters within the selected groups during stress testing is described.

Keywords: Educational stress, Stress resistance, Psycho-physiological stress testing, Emotional tension, Psycho-physiological characteristics

Abbreviations: SI: Stress Index, Baevsky Stress Index; FMNP: Test of Functional Mobility of Nervous Processes; RR: Cardiointerval, Inter-Beat Interval; HRV: Heart Rate Variability; SC: Skin Conductivity; GSR: Galvanic Skin Response; ANS: Autonomic Nervous System

Introduction

The period of studies affects significantly on students' personal development, attitude towards future professional activity, psychological and physiological state. Therefore, the problem of educational stress and its impact on student's organism becomes actual. Working with a large amount of information, diverse work that needs to be completed in a short time, eliminating educational debts, insufficient knowledge in the studied disciplines, non-compliance with the day's regime, improper diet and lack of sleep are factors that contribute to stress. It is known that excessive or prolonged psycho-emotional stress that exceeds the barrier of mental stability may turn an adaptive stress reaction into a pathogenic one, which brings about disorganization of the psychosocial and psychobiological functions of the individual [1,2]. The resulting states of mental maladjustment are manifested in reduced performance, increased fatigue, abnormal personal reactions, deviant behaviour (alcohol abuse, suicidal tendencies, aggressiveness, impulsiveness, etc.), neuropsychic and psychosomatic disorders (anxiety and somatoform disorders, hypertension, gastric ulcer, bronchial asthma, skin diseases, etc.).

Therefore, the importance of improving methods for early diagnosis and prevention of functional personological abnormalities in human health in accordance with the concept of preventive medicine is increasing [3]. In this aspect the psycho-physiological component of the process based on modern bio-behavioural technologies that emphasizes the role of self-regulation mechanisms of physiological functions requires special attention

[4]. The role of developing and testing new methods for preventing the risk of stress-induced disorders appears to be crucial nowadays.

Materials and Methods

The study was approved by V. Zelman Institute for Medicine and Psychology Novosibirsk State University Review Board, and all subjects provided written informed consent to participate.

Participants

57 practically healthy 3rd-4th year students at Novosibirsk State University took part in the study, of which 35 were girls, the age of the participants was 20.3±1.9. None of them had previously taken courses to develop self-regulation skills, or were interested in computer games, i.e., didn't spend more than 2-3 hours a week on it.

Research Protocol

A session of psychophysiological stress testing is represented by trials simulating stress situations (completing tasks for accuracy and speed, emotional reaction to an inevitable loss), between which there was a rest trial, in which the process of recovery of physiological indicators after stress tests was monitored, which made it possible to assess the test subjects' reaction to stress and the degree of recovery from it. Before and after the stress tests, five-minute physiological monitoring of the participants was carried out at rest without a test load to diagnose their functional state. For background monitoring and during stress testing of the study groups, the electrocardiogram (ECG) signal in lead 1 and skin conductivity, the signal of electrical activity of the skin were recorded using the BI-03K module (COMSIB LLC). The duration of cardio intervals (RR) calculated from the ECG allows for analysis of Heart Rate Variability (HRV), its parameters reflect the body's susceptibility/resistance to stress. Electrical activity of the skin is considered a marker of emotional stress.

The participants underwent the following psychophysiological probes as stress tests:

1. Khilchenko Test of Functional Mobility of Nervous Processes (FMNP)-a dynamic variation of a complex visual-motor probe;

2. The game plot "Asteroid" with inevitable loss at the end of the game; that was used as an emotional stressor [5].

Testing was carried out using the BOSLAB system (manufactured by COMSIB LLC).

The testing session consisted of 5 trials, including: performing stress tests for approximately 2-3 minutes each (trials 2 and 4), resting for 3 minutes (trial 3) and 5 minutes of monitoring before and after testing (trials 1 and 5).

Results and Discussion

To assess stress resistance, usually recorded parameters are examined in three categories: initial signal value, reactivity, degree of recovery [6]. The normal result is considered to be changes in the values of physiological indicators during stress tests and their restoration to the original level during rest. When analyzing the psycho-physiological state and stress resistance, both the presence of an excessive reaction to stress (high stress reactivity) or lack of a reaction to stress (unreactivity), and insufficient ability to recover the monitored physiological parameters were assessed.

During the expert assessment, special attention is paid to the increases in indicators during rest after the stress test and their difference from the background values before testing. But in multivariate statistical analysis, linear models are used, in which all linear combinations in the n-dimensional space of variables are automatically analysed, therefore, for the task of identifying the most informative set of variables (the task of reducing the dimension of the variable space), as well as the internal structure of the data (the classification task), factor analysis using the principal component method based on the average values of the duration of RR intervals and skin conductance for all trials of the testing protocol. As a result of the analysis, 2 factors were identified that described 93.9% of the total variance of the analyzed variables. The following structure of the principal components was obtained, shown in (Table 1).

Table 1: Variables factor loadings based on the correlation matrix.

Variables	Factor 1	Factor 2
RR-1, ms	0,680169	-0,702952
RR-2, ms	0,681800	-0,634703
RR - 3, ms	0,657586	-0,691708
RR-4, ms	0,712168	-0,681176
RR-5, ms	0,694887	-0,662487
SC-1, mkS	-0,724235	-0,579519
SC-2, mkS	-0,733323	-0,640933
SC-3, mkS	-0,751532	-0,638144
SC-4, mkS	-0,763891	-0,625870
SC-5, mkS	-0,755782	-0,635544
Percentage of total variance	52,10%	41,78%

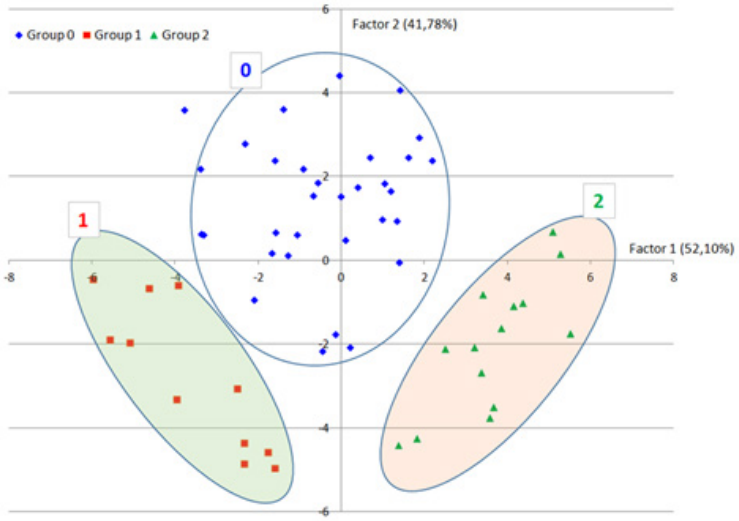

Figure 1: Scatterplot of case scores on the plot of 1 and 2 factors determined by the principal component analysis.

On the plane of the two main factors, a scatterogram of the subjects was constructed based on their factor scores (Figure 1). On this plane, three groups were clearly separated, called "Group 0" (N0=32), "Group 1"(N1=11), and "Group 2" (N2=14). Different dynamics of these groups were revealed in terms of indicators in the testing session: Baevsky Stress Index (SI, cu), Skin Conductance (SC, mkS) and duration of Cardiointervals (RR, ms). In Figure 2, blue indicates the average values of the SI, SC and RR indicators of participants in "Group 0", red - "Group 1", green - "Group 2".

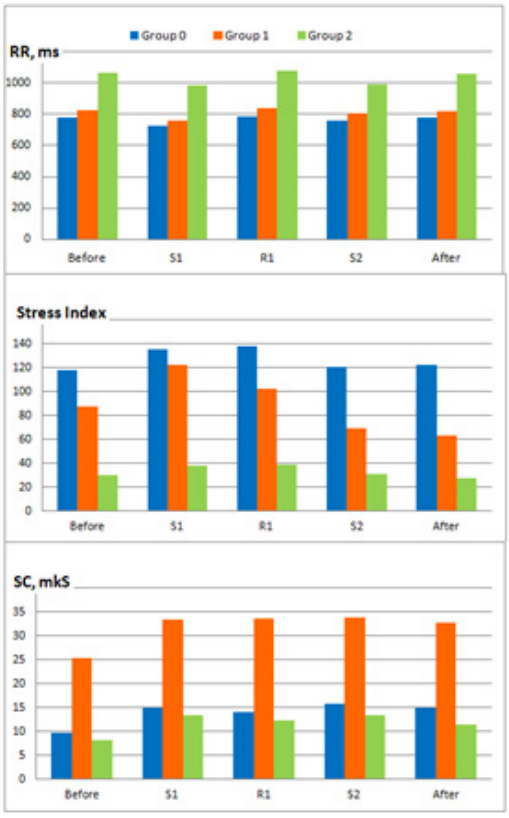

Figure 2: Changes in psycho-physiological parameters during stress testing in groups identified as a result of classification by the principal component analysis.

Further analysis of the data was carried out in order to identify the characteristics of the dynamics of psychophysiological indicators of the selected groups and describe the psychophysiological mechanisms of adaptation of the study participants.

Features of the Psycho-Physiological Characteristics of the Participants of "Group 0"

The subjects included in this group demonstrated a higher Baevsky stress index during stress testing (Figure 2), although on average it did not go beyond the limits interpreted as normal tension of regulatory systems, but with a tendency to increase compared to the background, which indicates about an increase in activation of the cardiovascular system by the sympathetic division of the Autonomic Nervous System (ANS). By the end of the testing session, this indicator in the group returned to background values, which indicates a sufficiently developed effective adaptive potential of group members.

Participants in "Group 0" are characterized by differences in the duration of cardiointervals and their wide spread when performing the "Asteroids" stress test (RR-4). The interval of quantitative values in the group is 730-820 ms, which generally corresponds to the normal tension of the regulatory systems (normocardia with an average level of variability, balanced influence of the sympathetic and parasympathetic parts of the ANS, central and autonomous regulatory circuits).

However, within the group, participants in the second and third quartiles coped more effectively with the emotional load (RR-4: 750-785 ms); with such values of the duration of cardiointervals, the functional state of the participants is assessed as optimal, with an effective response to stress.

Participants who showed minimal values of RR-4 duration (730-749 ms) were tested in a state close to overstrain of regulatory systems, which may indicate the presence of weak adaptive reactions and an increase in stress during the performance of the proposed task.

Participants in the fourth quartile (RR-4= 786-820 ms) showed the least emotional response to the proposed stimulus, which may indicate increased resistance to stress or, conversely, a lack of response to stress. Considering the type of reaction/recovery of these subjects, most likely we are observing unresponsiveness.

Features of the Psycho-Physiological Characteristics of the Participants of "Group 1»

In the study, skin conductivity was used as an indicator of emotional state. A stimulus of greater emotional significance corresponded to a more pronounced manifestation of the skin reaction (increased activity of the human sweat glands), which was reflected by SC signal increase and appearance of Galvanic Skin Response (GSR) outburst. Participants in "Group 1" demonstrated increased skin conductance values, which was due to an excessive emotional response to a simulated stress effect (Figure 2).

Increased quantitative values of the SC indicator, reflecting the emotional responses of study participants throughout all trials (SC-1-SC-5), indicate hyper mobilization of the body's adaptive resources and are physiologically expressed in the activation of the sympathetic division of the autonomic nervous system. By the end of the testing session, the participants failed to reduce SC in the group to the initial background values, which indicates an insufficient adaptive potential of the participants classified in this group. Participants in the initial monitoring showed high SC-1 values: interval 25.18-26.04mkS, while the same parameter in "Group 0" - interval 8.32 - 10.30mkS, in "Group 2" - interval 4 .31-9.03mkS. When performing stress tests, the SC indicator increased: SC-2=32.48-33.64mkS; SC-4=32.78 - 33.01mkS, which was a normal response to stress (Figure 2).

However, during the rest sessions, a decrease in the SC-3 indicator was not observed, therefore, the psychophysiological recovery of the participants did not occur; at the final background monitoring, the initial SC-1 values were not achieved by those included in this group: SC-5=31.67-32.80 mkS, which indicates a high level of stress and anxiety experienced during the testing process and, as a consequence, a pronounced disruption of adaptive regulatory mechanisms.

Features of the Psycho-Physiological Characteristics of the Participants of "Group 2"

Participants in "Group 2" are characterized by high values of the duration of cardio intervals, a low level of the Baevsky stress index, reaching ranges characteristic of a state of severe distress with a predominance of the activity of stress-limiting systems, as well as an unexpressed reactivity of skin conductivity (Figure 2). Consequently, this group can be considered the most resistant to simulated stress across the entire set of studied characteristics; however, such unresponsiveness can also be a sign of overwork. The values of the RR intervals correspond to the functional state of the participants: normo-bradycardia - moderately rare unstable pulse, there is a predominance of the parasympathetic division of the ANS against the background of a pronounced predominance of the autonomous circuit of heart rate regulation, weak tension of regulatory mechanisms.

The group participants showed different dynamics of SI during the monitoring sessions, stress test and rest: half of the participants increased the value of SI when performing the stress task FMNP, which was the correct response to stress, the other half, on the contrary, decreased SI, which represented the body's refusal effective response. Low values of the skin conductance parameter indicate minimal emotional involvement of participants in the testing process. The participants were unable to achieve the initial background values during rest; there was no psychophysiological recovery of the participants, which may indicate an insufficient available adaptation resource in these subjects.

Conclusion

The results obtained allow us to assert that the dynamics of changes in the physiological parameters of the studied groups in

response to stress testing for more accurate groups differentiation can be predicted by the initial level of a small number of variables. At the same time, it provides great opportunities for individualizing the process of physical, functional and psychological training and can be used as a basis when developing preventive/corrective programs.

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Conflict of Interest

Authors declare no conflict of interest exist.

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