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ПСИХОФИЗИОЛОГИЧЕСКАЯ РЕАКТИВНОСТЬ В УСЛОВИЯХ ЭМОЦИОНАЛЬНОГО СТРЕССА У ЗДОРОВЫХ ЛИЦ: ВЛИЯНИЕ ТИПА ЛИЧНОСТИ Д, УРОВНЯ ДЕПРЕССИИ И СТРАТЕГИЙ СОВЛАДАНИЯ

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ORIGINAL STUDIES

Основные положения

• Проведено исследование, в ходе которого изучалась взаимосвязь между типом личности Д, а также другими параметрами профиля личности, и психофизиологической реактивностью при воздействии стресса с использованием комплекса биологической обратной связи по ряду физиологических параметров, которые ранее не отслеживались в аналогичных исследованиях. По результатам исследования, у представителей типа личности Д наблюдается более высокая активность симпатоадреналовой системы при воздействии стресса по сравнению с остальной популяцией. Эти данные могут быть полезны при разработке стресс-лимитирующих воздействий. Возможность использования тех или иных психофизиологических маркеров в программах биологической обратной связи для лиц с типом личности Д требует дальнейшего изучения.

Цель	Изучить влияние типа личности Д, уровня депрессии, предпочитаемых копинг-стратегий на изменение психофизиологических показателей в условиях эмоционального стресса.
Материалы и методы	Испытуемыми явились 79 студентов Кемеровского государственного медицинского университета в возрасте от 18 до 32 лет (средний возраст 20,7 ± 2,4 года). Оценивался психологический статус исследуемых (с помощью опросников DS-14, HADS, WCQ и CSI) с оценкой типа личности Д, уровня депрессии и преобладающих копинг-стратегий. Стресс-тестирование проводилось с помощью комплекса БОСЛАБ, при этом регистрировались электромиограмма, электрокардиограмма, температура тела, дыхание, кожно-гальваническая реакция и фотоплетизмограмма; протокол процедуры включал в себя тест на устный счет и тест Струпа. Сравнивались результаты стресс-тестов в группах с наличием/отсутствием типа Д и депрессии.
Результаты	У всех испытуемых при стресс-тестировании отмечались маркеры симпатической активации по следующим параметрам: увеличение частоты сердечных сокращений и укорочение интервалов R-R ($p < 0,001$), повышение кожной проводимости ($p < 0,001$). У лиц с типом личности Д наблюдалось достоверно большее увеличение показателя адекватности процессов регуляции (ПАПР) при выполнении теста на устный счет ($p = 0,026$) и теста Струпа ($p = 0,031$). Наличие как типа личности Д, так и депрессии предрасполагало к выбору дезадаптивных стратегий совладания.
Заключение	В когорте испытуемых выявлена высокая распространенность типа личности Д и депрессии. У представителей типа личности Д наблюдались более высокие показатели активации симпатико-адреналовой системы при стрессорном воздействии по сравнению с остальной популяцией. Выявленные данные необходимо учитывать при разработке стресс-лимитирующих воздействий для представителей типа личности Д. Требует дальнейшего изучения возможность использования в этом отношении комплекса психофизиологических показателей в программах биологической обратной связи.
Ключевые слова	Психоэмоциональный стресс • Тип личности Д • Стресс-реактивность • Сердечно-сосудистая система • Психофизиологические показатели

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PSYCHOPHYSIOLOGICAL REACTIVITY TO MENTAL STRESS IN HEALTHY INDIVIDUALS: THE INFLUENCE OF PERSONALITY TYPE D, DEPRESSION LEVEL AND COPING STRATEGIES

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Highlights

• A study was conducted that examined the relationship between personality type D, as well as other personality profile parameters, and psychophysiological reactivity when exposed to stress using a biofeedback complex for a number of physiological parameters that had not previously been monitored in similar studies. According to the results of the trial, representatives of personality type D have higher activation rates of the sympathetic-adrenal system of stress exposure compared to the rest of the population. When developing stress-limiting effects, these data should be taken into account. The possibility of using a set of psychophysiological parameters in biofeedback programs for individuals with personality type D requires further study.

Aim	To examine the influence of personality type D, depression level, preferred coping strategies on changes in psychophysiological parameters during mental stress tests.
Methods	The study involved 79 students of Kemerovo State Medical University aged 18 to 32 years (mean age 20.7 ± 2.4 years). The patients' psychological status was assessed (DS-14, HADS, WCQ and CSI questionnaires) with an assessment of personality type D, depression level and prevailing coping strategies. Psychophysiological diagnostics was performed using the BOSLAB complex, electromyogram, electrocardiogram, body temperature, respiration, galvanic skin response and photoplethysmogram were recorded. The stress testing protocol included a mental arithmetic test and a Stroop test. The results of the stress tests were compared in groups with/without type D and depression.
Results	All subjects showed markers of sympathetic activation during stress testing to the following parameters: increased heart rate and shortening of R-R intervals ($p < 0.001$), increased skin conductivity ($p < 0.001$). There was a significantly greater increase in Indicator of the Adequacy of processes of Regulation (IAPR) when performing the mental arithmetic test ($p = 0,026$) and the Stroop test ($p = 0,031$) in individuals with personality type D. The presence of both type D and depression predisposed to the choice of maladaptive coping strategies.
Conclusion	A high prevalence of personality type D and depression was revealed among the surveyed cohort. Representatives of personality type D have higher activation rates of the sympathetic-adrenal system of stress exposure compared to the rest of the population. This should be taken into account when developing stress-limiting effects. The possibility of using a set of psychophysiological parameters in biofeedback programs for individuals with personality type D requires further study.
Keywords	Mental stress • Personality type D • Stress reactivity • Cardiovascular system • Psychophysiological indicators

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Introduction

Long-term or intense stress reactions can cause psychosomatic diseases and psychological disorders [1]. Psychological and physical reactions to psychological stress, especially strong negative reactions, can aggravate an existing human disease or cause a relapse. The cardiac reactivity hypothesis suggests that maladaptive cardiovascular responses to psychological stress, which can be exaggerated, prolonged or reduced, can contribute to the development of cardiovascular diseases [2]. Not surprisingly, when studying the body's response to stress, cardiovascular reactivity is usually studied, which is characterized by changes in blood pressure, heart rate and cortisol due to internal or external stimuli [3]. Cardiovascular reactivity depends on both the nature and intensity of the stressor [3–5] and the initial psychological state of individuals. Among such psychological factors should be taken into account the emotional state of individuals [6, 7], the presence of manifestations of psychological distress [5, 8–10], predominant coping strategies to overcome stress [11–15], and personality traits [9, 16, 17].

Among the latter factors, personality type D has recently been studied, which is characterized by the simultaneous manifestation of negative affectivity in response to events in everyday life and the suppression of its manifestation in social interactions [18]. The close attention of researchers to this personality type is explained by the fact that its presence leads to the development and progression of psychosomatic pathology [19]. Thus, personality type D is associated with an unfavorable prognosis for cardiovascular diseases [20, 21], with a decrease in the quality of life [22] and a more frequent development of symptoms of anxiety and depression [23].

Within the framework of the patient-oriented approach proclaimed by modern medicine, which consists, among other things, of striving to achieve an improvement in the quality of life of patients, it is important to take into account the behavioral characteristics of patients as a factor that has a significant impact on the formation of their lifestyle and stress status. In particular, strategies for coping with difficult life situations (or coping strategies) are important in this regard, the association of which with personality type D and depression has also been previously studied in separate studies, where it was shown that personality type D and depression are often associated with a preference for less effective, maladaptive coping strategies. Thus, patients with coronary heart disease and depression more often preferred the following coping strategies: seeking social support, avoidance, and problem solving, and less often – a confrontational strategy; while patients with coronary heart disease and depression with type D personality less often used the self-control coping strategy and more often – an escape-avoidance strategy [63]. In addition, healthy students with type D personality had a preponderance of inadequate coping strategies: the strategies associated with personality type D was the escape-avoidance, and with the type of non-D – the positive reappraisal. – [31]. Therefore, the topic of maladaptive coping strategies as an unfavorable prognostic factor for cardiovascular pathology requires further attention and study.

Also, it is known that patients with personality type D have increased cortisol levels against the background of acute pathological conditions [24], which reflects a maladaptive response to stress associated with the development of the disease. Further studies in individuals with personality type D have shown that they are characterized by inadequate hemodynamic reactions to stress, both with increased [4] and smoothed [16] hemodynamic response. Therefore, there is a need to clarify both the nature of stress reactivity in personality type D and possible ways to correct its inadequate manifestations. Among the possible causes of various inadequate reactions to stress, it is necessary to take into account the stressogenic level of laboratory stressors [4], as well as the possible influence of not only the personality type, but also other prevailing accompanying psychological factors (coping strategies, the presence of psychological distress) [12, 13, 15]. In addition, it is advisable to take into account not only hemodynamic parameters, but also other psychophysiological indicators in such a study. Thus, for this purpose, it is convenient to use biofeedback devices, which allow expanding the studied list of psychophysiological parameters. For example, the study of such parameters as electromyography, pulse, blood volume, respiratory rate, peripheral temperature and skin conductivity during a psychophysiological stress test made it possible to develop an index for measuring human resistance to stress [25, 26]. Accordingly, the aim of this study was to examine the influence of personality type D and other psychological factors (depression level, coping strategies) on changes in a set of psychophysiological indicators (electromyography, pulse, heart rate variability, respiratory rate, peripheral temperature, and skin conductivity) during mental stress.

Methods

Study Conditions and Participants

The study was conducted from October to December 2024, and included 79 subjects – second-year students of the Kemerovo State Medical University. The number of men and women among the study participants was 31 (39.2%) and 48 (60.8%), respectively, age – from 18 to 32 years (20.8; [19.0; 22.0]). All subjects completed psychological questionnaires and underwent psychophysiological examination during mental stress. The study was conducted in accordance with the principles of the Helsinki Declaration of the World Medical Association. The study protocol was approved (date of approval was obtained from: 15 October 2024) by the Local Ethical Committees of the Research Institute for Complex Issues of Cardiovascular Diseases and the Kemerovo State Medical University, each of the (Protocol No. 20241015). All study participants signed an informed consent to participate form.

Assessment of the psychological status of the subjects

To assess the psychological parameters of the study participants, the following scales (adapted and validated Russian-language versions) were used: the DS-14 questionnaire, created to identify personality type D [27], HADS (Hospital Anxiety and Depression Scale) [28], Ways of Coping Questionnaire (WCQ) [29] and Coping Strategies Inventory (CSI) [30] – to assess coping strategies. A detailed description of the psychological testing methodology was presented by us earlier [31].

The DS-14 Questionnaire

The following patterns are characteristic of this personality type: a tendency to deeply negative emotional experience of difficult situations and a tendency to reduce the manifestations of their emotional manifestations in social interactions with other people. This creates conditions for the individual to be in a chronic state of stress, and makes him susceptible to health risks associated with psychoemotional stress. The test consists of 14 questions and two subscales: NA (negative affectivity) and SI (social inhibition), with 7 questions in each. Personality type D is diagnosed if at least 10 points are scored on each of the subscales.

HADS (Hospital Anxiety and Depression Scale)

The scale is designed to diagnose anxiety and depression, and assess their severity. It consists of 14 questions (7 for assessing the level of anxiety and the level of depression in the corresponding subscales). A subclinical level of anxiety or depression is diagnosed when a score of at least 8 points is obtained on the subscale, clinically ex-pressed – when a score of at least 1 point is obtained. When a score of 7 or less points is obtained, the indicators are considered to be within normal limits. In our study, participants were divided into groups with or without depression, starting from the sub-clinical level (i.e. when a score of 8 or more points is obtained on the depression sub-scale).

Ways of coping questionnaire

The questionnaire allows determining the preferred ways of behavior of an individual in difficult situations in various spheres of life and contains 8 subscales: “Confrontation”, “Distancing”, “Self-control”, “Search for social support”, “Acceptance of responsibility”, “Escape-avoidance”, “Problem solution planning” and “Positive reappraisal”. Depending on the number of points scored on each specific scale, it is possible to characterize the subject’s behavioral profile when faced with difficulties. Methods for assessing the test results may include establishing the level of preference for a specific coping (according to the number of points scored on the subscales, it can be low, moderate, or pronounced), or calculating the level of tension of coping. We used the last option, the level of coping intensity was calculated using the formula: X = (sum of points on the scale/maximum possible score on the scale) × 100.

Coping Strategy Indicator Questionnaire

This questionnaire also allows you to identify the dominant behavioral strategies of the individual when faced with problem situations. It contains 3 subscales: “Problem Resolution Strategy”, “Social Support Search Strategy”, “Avoidance Strategy”. The levels of coping preference are assessed as “very low”, “low”, “medium” and “high” de-pending on the number of points scored on the subscale. In the course of performing comparative calculations for the study, we used absolute numbers, the number of points scored on each subscale.

Evaluation of physiological parameters of subjects and their stress reactivity

The aim of the study is dictated by the need, in addition to the psychological status, to also evaluate the somatic parameters of the subjects were assessed. Namely, such characteristics that would reflect the body’s response to psychoemotional stress load, as well as the ability to quickly recover from such a load. Such studies were conducted, the parameters of their implementation were standard: morning hours, laboratory conditions, consistently good health, at least 2 hours after eating.

To conduct such an examination, a multichannel complex “The BOSLAB professional plus” complex based on BI-012-2 was used (OOO “Computer Biocontrol Biofeedback Systems”, Russia), during which designed for multichannel psychophysiological monitoring and biofeedback training, was used for this examination. This 10-channel device allows recording electroencephalography, electrocardiography (ECG) indicators were taken from the subjects, electromyography, photoplethysmography, respiratory movements were recorded, photoplethysmography (PPG), electromyography (EMG) from the frontal muscles, peripheral, skin temperature, and galvanic skin response. The 10-channel physiological signal recording module BI-012-2 includes the following: electroencephalography (2 channels), electromyography (2 channels), electrocardiography (1 channel), temperature (1 channel), respiration (2 channels), galvanic skin response (1 channel), photoplethysmography (1 channel). The BOSLAB Professional Plus software allows for not only patient rehabilitation, but also psycho-physiological diagnostics.

The following physiological indices were calculated based on the signals received cardiovascular system functioning indices [32]:

– R-R intervals;

– heart rate (HR);

– respiratory sinus arrhythmia (RSA);

– ratio of low – and high-frequency waves of the heart rhythm (LF/HF), an increase in the index reflects an increase in sympathetic influences on the heart rhythm, a decrease – parasympathetic;

– Baevsky’s strain index (SI), an increase reflects a tendency toward centralization of the mechanisms of heart rhythm regulation and indicates an increase in the level of stress load on the body;

– Baevsky's indicator of the adequacy of regulation processes (IARP), shows the ratio of sympathetic influences on the heart rhythm and the leading function of the sinus node).

Indicators reflecting the state of the vascular bed:

– pulse wave propagation time (PWPT), an increase characterizes an increase in the elasticity of the main vessels);

– amplitude of the systolic wave of the PPG, shows the volumetric blood flow at the registration site, characterizes the state of the arteries of the microcirculatory bed.

Indicators of the functional state of the respiratory system:

– respiratory rate (RR);

– breathing mode frequency (BMF);

– duration of the respiratory cycle (RCD);

– ratio of the duration of inspiration to the duration of expiration (Rio);

– number of R-R intervals in one respiratory cycle (NNbc).

Other indicators:

– integral index of tension from the frontal muscles (iEMG);

– skin conductivity (SC);

– skin temperature on the Fahrenheit scale.

Rio is the ratio of the duration of inhalation to the duration of exhalation and is also known as the inspiratory-expiratory ratio, usually normal meaning is typically 1:3 – 1:4 and depends on the physiological condition (including pathological), on physical exertion and stress. An extended exhalation stimulates the Vagus leading to parasympathicotonia, which causes many benefits psychophysiological effects, including effects on heart rate variability, inflammation regulation, cognitive condition, etc. [33].

NNbc – is a number of full R-R intervals during one respiratory cycle. This term is not generally accepted and widely used, but it is another parameter that reflects the relationship between heart rate and respiratory characteristics, in particular, expressed in respiratory arrhythmia.

PPG amplitude is the amplitude of the systolic wave of photopletismography. PPG reflects the relationship between the functional state of the microvascular bed and a wide range of parameters, such as activation of the sympathetic or parasympathetic nervous system, the functional state of the cardiovascular system as a whole, etc. [34].

Integral electromyography is a method of assessing muscle activity, which is calculated as the area under the curve of the rectified electromyogram (EMG) signal over a certain period. It is used to assess the level of muscle tension in a given area. It can be considered as a marker related to stress levels and has been well studied in this regard for a long time [35].

Skin conductance is an indicator of the tone of the sympathetic nervous system, reflecting an increase in sweating and a change in the electrical resistance of the skin. It increases with emotional excitement and an increase in stress levels [36].

Peripheral skin temperature is an indicator of sympathicotonia, since activation of the sympathetic nervous system causes peripheral vasospasm, which leads to a decrease in peripheral skin temperature [37].

Stress Testing Procedure Protocol

The stress testing procedure consisted of five sessions (Figure 1):

– initial rest session for one minute (to record initial physiological parameters);

– cognitive task on oral arithmetic for three minutes (as a mild stressor);

– one minute of rest;

– the second cognitive task "Stroop-test" (verbal-color interference technique) for three minutes;

– final rest session (to assess the processes of physiological parameter recovery).

Statistical analysis

We used the application software packages "Statistica 10.0 for Windows" (StatSoft Inc., USA) and SPSS 17.0 (IBM, USA). The distribution of quantitative variables was tested for normality using the Kolmogorov–Smirnov test. Since the distribution of all quantitative characteristics differed from normal, they are presented as the median (Me), lower (LQ) and upper (UQ) quartiles. Groups were compared using the Mann–Whitney criterion. To compare the dynamics of the physiological parameters of the participants throughout the study, the Friedman ANOVA criterion was used. To assess the relationship between various psychological factors and the dynamics of psycho-physiological indicators during mental tests, a binary logistic regression analysis (For-ward Stepwise LR method) was conducted. The following variables were selected as dependent variables: the presence of type D, the presence of depression, and levels of coping strategies above the median for each scale. The indicators of psychophysiological indicators during mental tests were included in the models as independent variables. The critical level of significance (p) was taken to be 0.05.

Results

First of all, it should be noted that the percentage of individuals with personality type D (43 people out of 79 who took the DS-14 test, or 54.43%) and with depression (41 people out of 74 who took the HADS test, or 55.41%) in the cohort of students surveyed was

Figure 1. Stress testing procedure flow chart

generally high. This is a phenomenon that requires further study and, possibly, broader research into the psychological profile of the population, in particular among young people.

Results of psychological tests in the individuals with/without type D and depression

Individuals with depression significantly scored higher on the NA subscale of the DS-14 questionnaire ($p < 0.001$), while individuals with personality type D scored higher on the anxiety ($p = 0.003$) and depression ($p = 0.015$) scales of the HADS (Table 1).

When comparing preferred coping strategies according to the WCQ scale, it was found that individuals with personality type D had greater coping intensity compared to individuals without personality type D for the strategies of "confrontation" ($p = 0.008$), "distancing" ($p = 0.021$), "accepting responsibility" ($p = 0.009$) and "escape-avoidance" ($p < 0.001$). While the presence of depression was associated with higher coping intensity only for the "escape-avoidance" strategy ($p = 0.034$). According to the CSI scale, type D individuals scored higher on the "avoidance strategy" scale and lower on the "problem-solving strategy" scale than individuals without type D. In general, it can be said that both the presence of type D and depression predisposed to the choice of maladaptive coping strategies; however, the influence of type D personality in this regard was more significant and extended to a wider range of coping strategies (Table 2).

Dynamics of psychophysiological indicators during mental stress tests in individuals with/without type D and depression

To assess the differences in psychophysiological indicators, as well as the dynamics of these indicators during mental stress, the subjects were divided into 2 groups based on the presence/absence of type D personality, and also into 2 groups based on the presence/absence of depression.

All subjects showed sympathetic activation markers during stress testing against the background of mild stressors (performance of test tasks). This was manifested by the dynamics of the following

Table 1. General characteristics of young healthy individuals in groups with/without type D personality and depression

Indicators (Me [LQ; UQ]) or n (%)	Non-Type D (n = 36)	Type D (n = 43)	p	Not depressed (n = 33)	Depressed (n = 41)	p
Population characteristics						
Age, years	20.8 [19.0; 22.0]	20.8 [19.0; 22.0]	0.640	21.1 [19.0; 22.0]	20.7 [19.0; 22.0]	0.480
Men	16 (44.4%)	15 (34.9%)	0.389	15 (45.5%)	15 (54.6%)	0.440
DS-14						
Negative affectivity, points	6.6 [3.0; 9.0]	15.3 [12.0; 18.0]	< 0.001	7.0 [3.0; 13.0]	13.0 [11.0; 17.0]	< 0.001
Social inhibition, points	9.28 [7.0; 11.5]	14.8 [12.0; 16.0]	< 0.001	13.0 [9.0; 15.0]	12.0 [10.0; 15.0]	0.807
HADS						
Anxiety, points	7.0 [5.0; 9.0]	10.0 [7.0; 11.0]	0.003	6.0 [5.0; 8.0]	10.0 [8.0; 12.0]	< 0.001
Depression, points	6.0 [4.0; 10.0]	9.0 [7.0; 11.0]	0.015	5.0 [3.0; 6.0]	10.0 [9.0; 12.0]	< 0.001

Note: *ME [LQ; UQ] – median with upper and lower quartile.*

Table 2. Distribution of coping strategies in young healthy individuals in groups with/without type D personality and depression (according to the WCQ and CSI questionnaires)

	Not-Type D (n = 36)	Type D personality (n = 43)	p	Not depressed (n = 33)	Depressed (n = 41)	p
Ways of Coping Questionnaire (WCQ). Level of the tension of the coping (Me [LQ; UQ])						
Confrontation	44.4 [30.6; 55.6]	55.6 [44.4; 66.7]	0.008	55.56 [38.9; 61.1]	50.0 [38.9; 63.9]	0,969
Distancing	44.4 [33.3; 61.1]	61.1 [38.9; 77.8]	0.021	50.0 [33.3; 66.7]	50.0 [33.3; 69.4]	0.903
Self-control	61.9 [50.0; 71.4]	61.9 [52.4; 81.0]	0.384	66.7 [52.4; 76.2]	61.9 [47.6; 76.2]	0.463
Seeking social support	50.0 [36.1; 66.7]	50.0 [27.8; 72.2]	0.697	50.0 [27.8; 66.7]	50.0 [38.9; 32.2]	0.507
Taking responsibility	50.0 [33.3; 66.7]	66.7 [50.0; 83.3]	0.009	50.0 [41.7; 83.3]	50.0 [41.7; 75.0]	0.974
Escape-avoidance	39.6 [25.0; 58.3]	58.3 [41.7; 79.2]	< 0.001	41.7 [29.2; 62.5]	50.0 [37.5; 75.0]	0.034
Problem solving planning	72.2 [61.1; 77.8]	66.7 [55.6; 77.8]	0.270	66.7 [61.1; 77.8]	66.7 [55.6; 77.8]	0.659
Positive revaluation	61.9 [52.4; 78.6]	57.1 [33.3; 81.0]	0.327	71.4 [47.6; 85.7]	57.1 [42.9; 71.4]	0.151
Coping Strategy Indicator Questionnaire (CSI). Number of points on the scale (Me [LQ; UQ])						
Problem solving	25.0 [24.0; 30.0]	24.0 [21.0; 28.0]	0.028	27.0 [24.0; 31.0]	24.0 [22.0; 28.0]	0.052
Seeking social support	21.0 [18.0;23.0]	21.0 [16.0; 24.0]	0.687	21.0 [18.0; 25.0]	21.0 [17.0; 23.0]	0.575
Avoidance	19.0 [17.0; 22.0]	22.0 [20.0; 24.0]	0.001	21.0 [18.0; 23.0]	21.0 [19.0; 22.0]	0.957

Note: *ME [LQ; UQ] – median with upper and lower quartile* parameters: increased HR and shortening of R-R intervals ($p < 0.001$), increased NNBc (in individuals without depression – $p = 0.006$; in individuals with depression, as well as in individuals with and without personality type D – $p < 0.001$) against the background of exposure to mild stressors (performance of test tasks); as well as an increase in skin conductivity ($p < 0.001$). In addition, PPG amplitude changed reliably during stress testing: in individuals with personality type D, it slightly increased from the baseline during the mental arithmetic test, then significantly decreased during the Stroop test ($p = 0.003$), and in individuals without it, it de-creased from the baseline already during the mental arithmetic test ($p = 0.008$). Peripheral vasospasm can also be considered a marker of sympathetic activation under the influence of stress factors (Tables 3–5). In addition, the SI in the entire cohort of subjects significantly decreased during the

Table 3. Dynamics of cardiovascular system functioning indicators during mental stress tests in groups with/without type D personality and depression

	Personality type / Depression	Rest Session #1	Mental arithmetic test	Stroop-test	p
R-R intervals, ms	Type D	712.62 [646.29; 795.45]	655.64 [646.30; 733.26]	654.01 [590.98; 728.53]	< 0.001
	Type not D	725.20 [686.74; 793.53]	679.63 [609.52; 706.14]	650.61 [610.07; 692.53]	< 0.001
	p	0.384	0.519	0.910	
	Depressed	731.50 [690.72; 862.98]	675.11 [618.51; 747.21]	655.41 [606.06; 728.53]	< 0.001
	Not depressed	710.61 [650.86; 767.78]	660.62 [604.50; 705.76]	652.28 [597.03; 696.91]	< 0.001
	p	0,150	0,463	0,583	
HR, beats/min	Type D	85.0 [75.8; 93.2]	91.6 [82.2; 99.7]	93.4 [82.4; 101.8]	< 0.001
	Type not D	83.5 [75.9; 88.0]	88.4 [85.1; 98.6]	92.7 [86.8; 100.5]	< 0.001
	p	0.357	0.513	0.910	
	Depressed	82.9 [70.2; 87.8]	89.1 [80.5; 97.1]	91.9 [82.4; 99.6]	< 0.001
	Not depressed	84.5 [78.3; 92.6]	91.1 [85.2; 99.3]	92.4 [86.2; 101.3]	< 0.001
	p	0,159	0,456	0,561	
LF/HF	Type D	1.09 [0.45; 2.14]	1.54 [0.79; 3.67]	1.18 [0.78; 2.39]	0.071
	Type not D	1.33 [0.61; 2.39]	1.78 [1.01; 2.53]	1.78 [1.01; 2.53]	0.091
	p	0.669	0.749	0.410	
	Depressed	1.28 [0.55; 2.14]	1.63 [1.15; 2.87]	1.33 [0.85; 2.43]	0.014
	Not depressed	1.21 [0.62; 2.08]	1.61 [0.93; 2.41]	1.34 [0.82; 2.50]	0.102
	p	0,944	0,450	0,910	
RSA, ms.	Type D	79.60 [53.54; 121.37]	110.95 [71.99; 139.12]	89.24 [65.78; 153.06]	0.097
	Type not D	92.22 [72.42; 138.27]	96.98 [76.85; 135.89]	96.69 [80.55; 143.91]	0.336
	p	0.301	0.690	0.486	
	Depressed	80.33 [52.38; 123.55]	100.44 [77.33; 127.76]	89.24 [60.07; 143.30]	0.027
	Not depressed	93.59 [63.39; 118.40]	103.10 [76.19; 138.41]	104.44 [86.54; 142.79]	0.519
	p	0,205	0,832	0,129	
SI	Type D	102.04 [62.64; 189.16]	62.82 [42.71; 100.61]	79.67 [45.33; 140.71]	< 0.001
	Type not D	93.03 [53.89; 150.77]	59.95 [34.58; 102.12]	69.37 [45.38; 91.59]	0.002
	p	0.475	0.605	0.247	
	Depressed	106.56 [52.24; 193.78]	62.82 [34.81; 95.04]	84.67 [48.18; 144.07]	< 0.001
	Not depressed	95.02 [67.41; 124.20]	69.77 [45.59; 105.40]	52.87 [45.33; 91.16]	0.012
	p	0,613	0,497	0,069	
IARP	Type D	57.90 [42.93; 69.28]	56.90 [45.59; 69.54]	57.82 [44.66; 70.76]	0.811
	Type not D	50.39 [41.96; 58.42]	45.73 [35.33; 59.09]	49.50 [39.91; 59.38]	0.121
	p	0.226	0.026	0.031	
	Depressed	58.17 [42.02; 69.28]	53.47 [38.53; 64.78]	53.44 [41.90; 70.76]	0.081
	Not depressed	48.99 [43.47; 58.67]	53.33 [41.43; 63.17]	52.26 [40.40; 60.75]	0.227
	p	0,396	0,782	0,213	
PWPT, ms	Type D	182.62 [141.03; 224.44]	177.28 [142.13; 237.15]	180.48 [150.25; 228.12]	0.704
	Type not D	203.00 [141.37; 277.73]	185.99 [147.92; 227.67]	199.24 [145.20; 281.19]	0.250
	p	0,703	0,663	0,338	
	Depressed	197.80 [153.34; 249.89]	190.94 [151.27; 246.48]	201.51 [163.72; 256.44]	0.590
	Not depressed	158.15 [138.66; 225.11]	172.62 [144.94; 228.49]	164.17 [143.85; 242.47]	0.898
	p	0.148	0.458	0.240	

Note: *HR – heart rate; IARP – indicator of the adequacy of regulatory processes; LF/HF – low-to-high frequency ratio; PWPT – pulse wave propagation time; R-R intervals – R-R interval duration; RSA – respiratory sinus arrhythmia; SI – Baevsky`s strain index.*

performance of stressful tasks compared to the initial level (for individuals with personality type D – p < 0.001, without it – p = 0.002; for individuals with depression – p < 0.001, without it – p = 0.012). The interpretation of this phenomenon is difficult, perhaps the very fact of the study made the students experience anxiety, from which they were distracted during the performance of cognitive tasks. As for the IARP, this index, on the contrary, demonstrated a logically explainable greater sympathetic activation. It was higher in representatives of personality type D relative to individuals without it during the performance of stressful tasks – mental arithmetic (p = 0.026) and the Stroop test (p = 0.031). However, no reliable increase or decrease was recorded in the dynamics of sessions in any of the groups (Table 3, Figures 2–5).

Controversial data were obtained on the indices of respiratory system functioning. Thus, during stress testing, the duration of the respiratory cycle increased in all subjects (p ≤ 0.001). The frequency of respiratory movements and the breathing mode de-creased in those with type D (p = 0.005 and 0.003, respectively), as well as in individuals with depression (p = 0.007 and 0.023, respectively). In individuals without type D personality these indices did not change under the influence of mild stressors, in individuals without depression the breathing rate increased during the mental arithmetic test (p = 0.010), and the frequency of the breathing mode decreased during the Stroop test (p = 0.003). The Rio ratio in type D and non-depressed individuals increased slightly during the arithmetic mental arithmetic test, then significantly decreased during the Stroop test (p < 0.001 and 0.002, respectively); in non-D and non-depressed individuals, it consistently decreased during both cognitive tasks (p = 0.031 and 0.015, respectively) (Table 4).

Table 4. Dynamics of respiratory system functioning indicators during mental stress tests in groups with/without type D personality and depression

	Personality type / Depression	Rest Session #1	Mental arithmetic test	Stroop-test	p
RespRate, breaths/min	Type D	18.7 [15.6; 20.8]	17.9 [14.5; 20.3]	16.1 [14.2; 18.3]	0.005
	Type not D	16.9 [14.6; 18.3]	19.6 [16.6; 22.0]	16.8 [15.2; 19.6]	0.131
	p	0.221	0.035	0.198	
	Depressed	18.6 [16.0; 21.2]	18.0 [15.0; 20.3]	16.7 [15.0; 18.3]	0.007
	Not depressed	16.9 [14.3; 18.7]	19.0 [15.2; 21.7]	16.0 [13.5; 19.9]	0.010
	p	0,046	0,381	0,790	
BMF, Hz	Type D	0.27 [0.22; 0.32]	0.25 [0.15; 0.30]	0.18 [0.13; 0.22]	0.003
	Type not D	0.27 [0.22; 0.32]	0.26 [0.19; 0.33]	0.20 [0.17; 0.23]	0.080
	p	0.972	0.151	0.255	
	Depressed	0.28 [0.24; 0.32]	0.25 [0.17; 0.32]	0.20 [0.17; 0.27]	0.023
	Not depressed	0.25 [0.22; 0.28]	0.25 [0.18; 0.32]	0.18 [0.13; 0.20]	0.003
	p	0,089	0,521	0,026	
RCD, sec.	Type D	3.44 [3.20; 4.06]	4.07 [3.38; 4.94]	4.52 [3.95; 5.05]	< 0.001
	Type not D	3.70 [3.34; 4.77]	3.51 [3.12; 4.50]	4.10 [3.68; 5.01]	0.001
	p	0.306	0.059	0.201	
	Depressed	3.42 [3.07; 4.02]	4.03 [3.27; 4.88]	4.45 [3.94; 4.80]	< 0.001
	Not depressed	3.86 [3.41; 4.98]	3.63 [3.21; 4.80]	4.28 [3.57; 5.50]	< 0.001
	p	0,037	0,532	0,965	
Rio	Type D	0.76 [0.64; 0.87]	0.78 [0.51; 1.13]	0.56 [0.43; 0.71]	< 0.001
	Type not D	0.67 [0.61; 0.81]	0.65 [0.55; 1.06]	0.60 [0.47; 0.90]	0.031
	p	0.123	0.633	0.375	
	Depressed	0.71 [0.61; 0.87]	0.65 [0.51; 1.07]	0.58 [0.40; 0.91]	0.015
	Not depressed	0.71 [0.61; 0.84]	0.76 [0.58; 1.13]	0.58 [0.50; 0.72]	0.002
	p	0,879	0,289	0,579	
NNbc	Type D	4.63 [4.22; 5.71]	6.10 [5.17; 7.81]	6.55 [5.56; 7.57]	< 0.001
	Type not D	4.77 [3.85; 6.23]	5.60 [4.68; 6.86]	6.04 [5.15; 7.62]	< 0.001
	p	0.977	0,122	0.290	
	Depressed	4.43 [3.85; 5.17]	5.82 [4.68; 7.56]	6.31 [5.44; 7.11]	< 0.001
	Not depressed	5.06 [4.46; 6.23]	5.69 [4.90; 7.45]	6.76 [5.33; 7.88]	0.006
	p	0,022	0.687	0.441	

Note: *BMF – breathing mode frequency; iEMG – integrated electromyography; NNbc – number of R-R intervals in one respiratory cycle; PPG amplitude – systolic wave amplitude during photoplethysmography; RCD – respiratory cycle duration; RespRate – respiratory rate; Rio – ratio of inhalation time to exhalation time; SC – skin conductance; Temp. – temperature.*

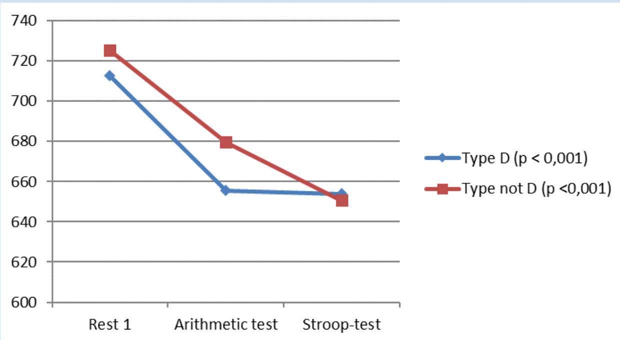

Figure 2. Dynamics of R-R intervals (ms) during mental stress tests in groups with/without type D personality

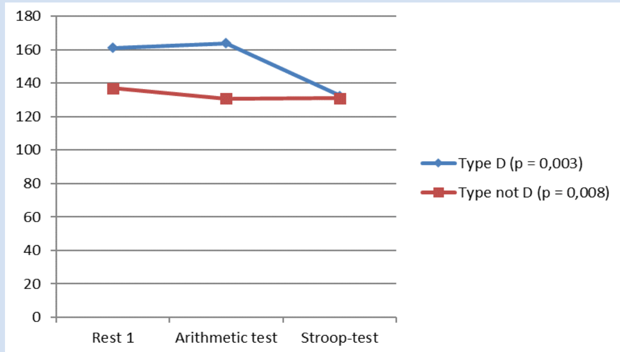

Figure 4. Comparison of IAPR values during mental stress tests in groups with/without type D personality

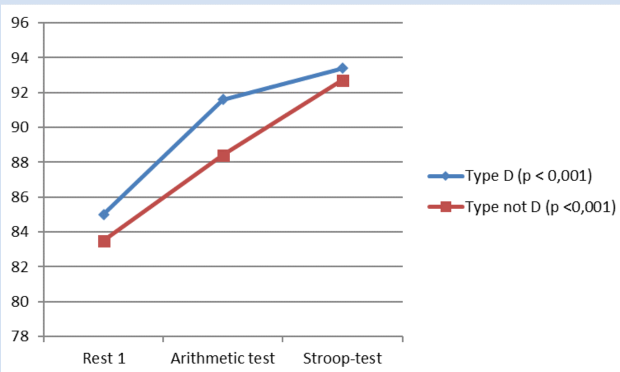

Figure 3. Dynamics of HR (beats/min) during mental stress tests in groups with/without type D personality

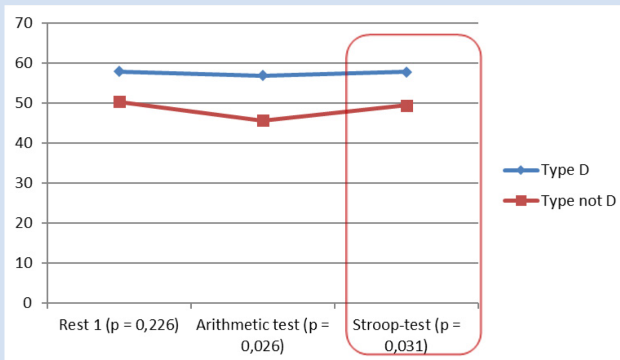

Figure 5. Dynamics of PPG amplitude during mental stress tests in groups with/without type D personality

Table 5. Dynamics of other functional indicators during mental stress tests in groups with/without type D personality and depression

	Personality type / Depression	Rest Session #1	Mental arithmetic test	Stroop-test	p
PPG amplitude	Type D	161.2 [99.1; 212.1]	163.8 [101.9; 280.2]	132.5 [97.1; 189.4]	0.003
	Type not D	136.9 [104.3;226.9]	130.7 [105.5; 178.2]	131.0 [110.4; 161.4]	0.008
	p	0,879	0.332	0.840	
	Depressed	169.2 [101.9; 218.4]	168.0 [109.5; 235.7]	142.5 [114.0; 197.0]	0.097
	Not depressed	129.2 [106.5; 226.9]	122.1 [99.9; 171.0]	123.4 [101.3; 155.6]	0.066
	p	0.770	0.147	0.225	
iEMG, mcV	Type D	12.7 [10.3; 18.3]	14.5 [10.6; 21.1]	14.3 [10.6; 19.1]	0.242
	Type not D	11.5 [8.6; 17.0]	11.9 [9.6; 16.6]	12.0 [9.3; 15.3]	0.256
	p	0.332	0.182	0.071	
	Depressed	12.2 [10.4; 16.5]	14.5 [10.6; 18.3]	13.5 [10.6; 17.9]	0.281
	Not depressed	12.5 [8.4; 17.3]	11.7 [9.7; 15.2]	12.7 [10.3; 15.9]	0.131
	p	0.511	0.194	0.716	
SC, mcS	Type D	6.0 [2.9; 8.7]	8.1 [5.3; 11.6]	9.3 [5.5; 14.4]	< 0.001
	Type not D	6.6 [4.2; 11.1]	8.5 [4.8; 13.8]	9.3 [5.7; 16.2]	< 0.001
	p	0.451	0.598	0.654	
	Depressed	6.9 [3.8; 8.9]	8.3 [5.3; 13.5]	10.8 [5.7; 15.9]	< 0.001
	Not depressed	5.5 [4.2; 10.9]	7.3 [4.8; 13.0]	8.2 [5.9; 14.0]	< 0.001
	p	0.628	0.691	0.463	
Temp, F	Type D	79.4 [76.1; 89.7]	79.4 [75.8; 89.5]	80.7 [75.1; 91.1]	0.320
	Type not D	79.0 [75.6; 88.6]	78.8 [75.0; 88.4]	80.8 [74.6; 89.2]	0.009
	p	0.506	0.500	0.794	
	Depressed	84.2 [76.6; 90.9]	83.9 [76.3; 90.4]	84.4 [76.2; 91.8]	0.094
	Not depressed	78.3 [75.7; 81.9]	77.7 [75.5; 86.6]	77.7 [75.0; 87.4]	0.207
	p	0,047	0,052	0,047	

***Note:** iEMG – integrated electromyography; PPG amplitude – systolic wave amplitude during photoplethysmography; SC – skin conductance; Temp. – temperature.*

At the same time, there were differences in respiratory indices between the patient groups: initially, depressed individuals had higher RR and lower RCD than non-depressed subjects (p = 0.046 and 0.037, respectively), while non-D individuals had higher RR than their non-depressed counterparts during the mental arithmetic task (p = 0.035). The frequency of the respiratory mode was higher in individuals with de-pression during the Stroop test (p = 0.026), the NNbc index was initially higher in individuals without depression (p = 0.022), but during stress testing, reliable differences in this indicator ceased to be observed (Table 5).

Psychophysiological indices during mental stress tests associated with psychological factors

To identify psychophysiological parameters during mental stress that were independently associated with psychological factors, we used binary logistic regression. The model included all studied parameters in the stress sessions, as well as age and gender. The results of this analysis are presented in Table 6.

Notable differences in the binary logistic regression data for individual psychological factors were noted. An independent significant relationship with personality type D was observed only for the following indicators: heart rate (p = 0.022), Baevsky's SI index (p = 0.004), respiratory rate (p = 0.020), and IARP (p < 0.001) in the mental arithmetic test. The only indicator associated with the presence of depression was temperature in the Stroop test (p = 0.028).

Significant differences in psychophysiological indicators were noted with different severity of

Table 6. Results of binary logistic regression (forward LR method): association of psychophysiological indices during mental stress tests with the psychological factors

	B	S.E.	Wald	df	Sig.	Exp(B)	95% CI for EXP(B)	
							Lower	Upper
Association of type D personality with psychophysiological indices during mental stress tests								
HR (MAT)	–0.084	0.037	5.246	1	0.022	0.919	0.855	0.988
SI (MAT)	–0.032	0.011	8.266	1	0.004	0.969	0.948	0.990
RespRate (MAT)	–0.203	0.087	5.413	1	0.020	0.816	0.687	0.968
IARP (MAT)	0.151	0.042	13.113	1	0.000	1.163	1.072	1.263
Constant	5.824	2.657	4.805	1	0.028	338.3		
Association of depression with psychophysiological indices during mental stress tests								
Temp (ST)	0.071	0.032	4.835	1	0.028	1.074	1.008	1.144
Constant	–5.698	2.686	4.502	1	0.034	0.003		
Association of GR_WSQ_1 with psychophysiological indices during mental stress tests								
PWPT (MAT)	–0.004	0.002	4.007	1	0.045	0.996	0.993	1.000
Temp (MAT)	0.081	0.037	4.757	1	0.029	1.084	1.008	1.166
RCD (ST)	–0.159	0.082	3.742	1	0.053	0.853	0.726	1.002
Constant	–4.403	3.014	2.133	1	0.144	0.012		
Association of GR_WSQ_2 with psychophysiological indices during mental stress tests								
RespRate (MAT)	0.153	0.064	5.667	1	0.017	1.166	1.027	1.323
PWPT (ST)	–0.005	0.003	3.705	1	0.054	0.995	0.990	1.000
LF/HF (ST)	–0.632	0.258	5.980	1	0.014	0.532	0.320	0.882
iEMG (ST)	0.019	0.015	1.618	1	0.203	1,.020	0.990	1.050
Constant	–0.757	1.263	0.359	1	0.549	0.469		
Association of GR_WSQ_5 with psychophysiological indices during mental stress tests								
RespRate (MAT)	0.131	0.059	4,.976	1	0.026	1.140	1.016	1.280
SC (MAT)	–0.080	0.040	3.937	1	0.047	0.923	0.853	0.999
Constant	–1.539	1.119	1.891	1	0.169	0.215		
Association of GR_WSQ_8 with psychophysiological indices during mental stress tests								
RRate (MAT)	0.154	0.061	6.306	1	0.012	1.167	1.034	1.316
Constant	–2.530	1.121	5.096	1	0.024	0.080		
Association of GR_A2 with psychophysiological indices during mental stress tests								
Age	0.271	0.125	4.725	1	0.030	1.311	1.027	1.674
Constant	–5.316	2.549	4.349	1	0.037	0.005		

Note: *CI – confidence interval; HR - heart rate; IARP – indicator of the adequacy of regulatory processes; iEMG – integrated electromyography; LF/HF – low-to-high frequency ratio; MAT – mental arithmetic test; PPG amplitude – systolic wave amplitude during photoplethysmography; PWPT – pulse wave propagation time; RCD – respiratory cycle duration; RespRate – respiratory rate; SC – skin conductance; SI – Baevsky`s strain index; ST – Stroop test; Temp. – temperature.*

coping strategies. When comparing with coping strategies according to the WCQ data, the following independent associations were revealed according to the binary logistic regression data. In individuals with a predominance of the "Confrontation" coping strategy, a significant association was noted with the following indicators: PWPT (p = 0.045) and Temp (p = 0.029) during the mental arithmetic test. For individuals with a predominance of the "Distancing" coping strategy, an association was noted with the RespRate (p = 0.017) indicators in the mental arithmetic test and LF/HF (p = 0.014) in the Stroop test. For individuals with a predominance of the "Taking responsibility" coping strategy, an association with the RespRate (p = 0.026) and SC (p = 0.047) indicators was noted in the mental arithmetic test. For individuals with a predominance of the "Positive revaluation" coping strategy, an association was found only with the RRate indicator in the mental arithmetic test (p = 0.012). When comparing the data of other coping strategies according to the WCQ, as well as according to the SCI questionnaire, no significant associations with psychophysiological indicators were found during stress tests.

Discussion

Received data

Thus, based on the obtained indicators, it is clear that representatives of personality type D had a greater severity of anxiety and depressive symptoms compared to individuals without personality type D, based on the data of the HADS scale, and patients with depression also tended to have personality type D, scoring higher on the negative affectivity scale.

This study also shows that different psychological factors have different effects on the dynamics of psychophysiological parameters during mental stress tests. All subjects showed markers of sympathetic activation during stress testing against the back-ground of moderate stressors according to the following parameters: increased heart rate and shortening of R-R intervals, increased NNBc against the background of expo-sure; as well as increased skin conductivity. In addition, the presence of both type D and depression predisposed to the choice of maladaptive coping strategies, however, the influence of personality type D in this regard was more significant and extended to a wider range of coping strategies. More pronounced independent associations of personality type D with psychophysiological parameters during mental stress tests were noted compared to depression.

Also, the severity of individual coping strategies influenced the reaction of psychophysiological parameters during stress tests.

History of the study of the issue

In previous studies, the hemodynamic reaction to stress factors was primarily studied in individuals with personality type D. Early studies on this issue showed that type D has an increased hemodynamic response to various stresses (taxing mental arithmetic task or cold pressor test) [38, 39]. However, in further studies using tests with moderate psychoemotional stress, on the contrary, the hemodynamic response to stress in type D turned out to be smoothed out [40–42]. Manifestations of such reduced stress reactivity in type D have been noted for different studied cohorts. For example, young female students have been shown to have a less pronounced SBP response to a mental test [42], and patients with CHF have been shown to have a lesser increase in HR in response to acute social stress [40]. Several hypotheses have been made about precisely these (smoothed) maladaptive hemodynamic responses to stress in type D [43]. On the one hand, conducting tests in laboratory conditions may not cause sufficient motivation in type D, which leads to a less pronounced hemodynamic response. On the other hand, difficulties in social interactions in type D led to greater problems in tests simulating such situations (for example, in public speaking). It is in such cases that it is possible to record increased hemodynamic stress reactivity [44], but not in the performance of individual tasks in laboratory conditions. However, when modeling social isolation, participants exhibited significant increases in cardiovascular and affective reactivity to the socially evaluative stressor [45]. It should also be taken into account that in stressful situations the body reacts not only with changes in hemodynamics, which is also evident in individuals with personality type D. This has been shown in patients with cardiovascular pathology. Thus, in arterial hypertension in type D, a more pronounced decrease in the vasodilator response under stress was noted [46]. In patients with coronary heart dis-ease in type D, the presence of endothelial dysfunction was revealed [47], and in acute coronary events – dysfunction of the hypothalamic-pituitary-adrenal axis and higher daily secretion of cortisol [48]. In personality type D, more pronounced sympathetic activity is noted after public speaking, which reflects the presence of dysautonomia in them [49]. The data of the present study also confirm more pronounced sympathetic activation in individuals with personality type D according to the studied psychophysiological parameters.

The present study revealed a number of unexpected and contradictory results. First, although people with personality type D have increased sympathetic nervous system activity (e.g. elevated IARP) during stress, the Baevsky's stress index (SI) paradoxically decreases. It can be assumed that the phenomenon of a paradoxical decrease in SI during stress (against the background of a parallel increase in IARP and an in-crease in RR, typical of stress) can be explained by the difference in the formulas for calculating these indicators. SI is calculated using the formula AMo / (2X × Mo), and

IAPR is calculated using the formula AMo / Mo. Mo is the mode (in milliseconds) – the most frequently occurring value of RR intervals. AMo is the mode amplitude (in milli-seconds) – the proportion of cardio intervals corresponding to the mode value (these parameters reflect the influence of the central mechanisms of heart rate regulation: through neural (AMo) and humoral (Mo) channels). X is the difference between the duration of the longest and shortest R-R intervals (in milliseconds), this indicator is entirely related to respiratory fluctuations in vagal tone [50]. Thus, SI takes into account additional parameters that are not taken into account by IAPR (the influence of the peripheral link, the indicator of which is reflected in the denominator). And if SI decreases against the background of stress, then the denominator in the formula increases, i.e. the difference between the maximum and minimum R-R values in-creases. Perhaps this is explained by the fact that stress is acute, i.e. it acts quickly, and the heart rate increases quickly (and R-R, accordingly, decreases) – and the difference between the duration of the largest and smallest R-R intervals – also, accordingly, manifests itself quickly and is pronounced. This phenomenon occurs during the stress test, which lasts a maximum of 3 minutes. Perhaps, in situations of chronic stress load, including that caused by disease, such rapid changes in heart rate do not occur (since the stress load is constant, and does not appear quickly and over short time intervals). Consequently, in this case, a persistent increase in SI is determined primarily by the values of Mo and AMo, i.e. parameters that reflect the central mechanisms of regulation of the heart rhythm.

The decrease in respiratory rate under stress in individuals with personality type D also requires possible explanations. Personality type D carriers, in accordance with the characteristics of this personality type, are more susceptible to chronic stress, and they also have an increased incidence of depression. With chronic stress, as with depression, hyperactivity of the hypothalamic-pituitary-adrenal axis develops (the process is triggered by the amygdala, which transmits a signal to the hypothalamus, where the production of corticotropin-releasing factor is triggered, and, as a result, the release of cortisol and adrenaline by the adrenal glands), which contributes to the development of a state of persistent sympathicotonia. With prolonged exposure to a stressful situation, depletion of the hypothalamic-pituitary-adrenal axis and a decrease in the sensitivity of cortisol receptors in the brain occur [51]. Next, a compensatory increase in the tone of the parasympathetic nervous system probably occurs, and its predominance develops, so reactions to stress may be not sympathicotonic, but parasympathicotonic in nature (such as, for example, compensatory vagal modulation). Apparently, a similar mechanism is responsible for smoothed hemodynamic reactions to stress in individuals with personality type D.

Until now, stress reactivity of individual psychophysiological parameters has been studied not in personality type D, but in other cohorts. in personality type D has been poorly studied. To date, these parameters have been studied in other cohorts of healthy individuals and patients [52–54]. For example, assessing skin conductivity during a mental stress test has been proposed to predict the future development of depression [52]. When continuously performing a task of varying complexity, it has been pro-posed to use the skin conductivity index to assess the level of psychoemotional stress [54].

The study of EMG parameters during stress expands the possibilities for assessing maladaptive reactions. For example, facial muscle activity can be assessed to identify differences in self-esteem during stress [55]. EMG registration allows one to assess the effect of breathing exercises during the Stroop test [56]. Finally, EMG can be used for biofeedback training as part of a rehabilitation program for psychosomatic problems [57]. Accordingly, a com-prehensive assessment of several physiological parameters during stress can expand the possibilities for studying stress reactivity. One example of such an approach was the development of a stress resistance index based on changes in a number of indica-tors, including EMG, heart rate, respiratory rate, temperature, and skin conductivity. As in our case, the authors of this study used a biofeedback device, which emphasizes the potential of this approach [25, 26].

Rationale and novelty of the study

As the results of this study showed, the presence of personality type D can be ac-companied by deviations in other psychological parameters – with the presence of anxiety and depression, the predominance of maladaptive coping strategies. As shown earlier, these psychological characteristics themselves can affect stress reactivity indicators. For example, the use of reappraisal coping strategies has been associated with weakened cardiovascular responses to stress [11]. Previous chronic stress exposure and the use of maladaptive coping strategies have been shown to have a negative impact on cardiovascular reactivity. At the same time, the use of adaptive coping styles can mitigate these effects and improve cardiovascular reactivity [13]. Patients with depressive symptoms immediately after myocardial infarction have a smoothed diurnal serum cortisol profile. This is especially pronounced in patients with longer-term symptoms [8]. Interesting data were obtained when examining the links between cardiovascular reactivity to social stress and manifestations of psychological distress in patients after acute coronary syndrome. Multiple linear regression analysis showed an association between type D personality and lower heart rate during social stress test periods. Depressive symptoms were associated with higher systolic blood pressure during baseline and test [9]. Similar differences in stress reactivity between individuals with type D and depression were noted in our study.

This study is a pilot one in this direction. The problem of optimal influences for correcting maladaptive reactions to stress in personality type D is far from being resolved [58, 59]. In our opinion, one of the promising areas is to increase stress resistance in such individuals. In our opinion, one of the promising areas is to increase stress resistance in such individuals. It has recently been shown that individuals who reported a greater tendency toward religious and spiritual coping demonstrated significantly lower SBP, DBP, and SBP responses to acute mental stress [60]. However, such a method of reducing stress reactivity cannot, of course, be widely used. Interestingly, visualization ability predicted lower perceived stress intensity and perceived physiological arousal intensity, suggesting that greater visualization ability may help people perceive stress responses as more conducive to performance and thus be an effective stress coping strategy [61]. Behavioral intervention programs for this purpose deserve attention, but they are difficult to include in everyday clinical practice. It is quite possible that devices using biofeedback will be more convenient in such programs. The data of this study allow us to take the first step in developing biofeedback methods in stress-limiting therapy for individuals with personality type D. The next stage of research requires an assessment of the response of psychophysiological parameters to various biofeedback options. Ultimately, it will be necessary to evaluate biofeedback training programs to increase stress resistance in individuals with personality type D. In particular, relaxation training of various modalities using biofeedback technologies looks promising. The limitations of the study should be taken into account when analyzing its results. First of all, the study included a limited number of subjects, which could affect the significance of the data. In addition, young individuals without the diseases were examined, so the results obtained cannot be used in other cohorts (older age, presence of cardio-vascular pathology). Also, in this study, personality type D was studied as a dichotomous indicator, which could affect the significance of the associations obtained (as was shown earlier in the analysis of the prognostic value of type D [62]). We recognize the limitations of the personality type D construct we used, but in the design, we used with the assessment of many additional indicators, this approach appears optimal.

Conclusion

There is a high prevalence of personality type D and depression among the examined cohort of young healthy individuals. The presence of personality type D (to a greater extent), like the presence of depression, predisposes to the choice of maladaptive coping strategies in the examined cohort. In addition, representatives of personality type D have higher activation rates of the sympathoadrenal system against the background of stress exposure relative to the rest of the population of young healthy individuals. That was shown by the intergroup differences in IAPR (which is a calculated index related to heart rate variability indices, reflecting the degree of sympathetic influence on heart rhythm in relation to the leading function of the sinus node) which demonstrated significantly greater increase when performing the mental arithmetic test (p = 0,026) and the Stroop test (p = 0,031) in individuals with personality type D. Various psychological factors have different effects on the dynamics of psychophysiological indicators in mental stress tests, which must be additionally taken into account when developing stress-limiting effects. The possibility of using a set of psychophysiological parameters in biofeedback programs for individuals with personality type D requires further study.

Conflict of interest

A.N. Sumin is the scientific editor of the journal "Complex Issues of Cardiovascular Diseases". N.N. Zagorskaya declares no conflict of interest. A.V. Shcheglova declares no conflict of interest. I.Y. Prokashko declares no conflict of interest.

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Author Contribution Statement

SAN – contribution to the concept and design of the study, data analysis, manuscript writing, editing, approval of the final version, fully responsible for the content

ZNN – contribution to the concept of the study, data analysis, editing, approval of the final version, fully responsible for the content

ShAV – contribution to the concept and design of the study, data collection and interpretation, editing, approval of the final version, fully responsible for the content

PIYu – contribution to the concept and design of the study, data collection and interpretation, editing, approval of the final version, fully responsible for the content

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