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### **A STUDY OF INFLUENCE OF MENTAL AND PHYSICAL LOAD ON THE INDICATORS OF HEART RATE VARIABILITY IN STUDENTS WITH DIFFERENT DOMINANT TYPES OF AUTONOMIC REGULATION**

**Abstract.** Modern education in universities causes significant stress in students and strains the functional systems of their bodies.

Analysis of scientific literature over the last few years convincingly shows that here has been a trend of worsening health among youth in many countries around the world. The issue of the health of students in higher education institutions in Ukraine is particularly acute. Firstly, this is directly related to the learning process itself, which is an extremely responsible and stressful period in the lives of modern young people, for the successful realization of which good somatic (physical) health is necessary. Secondly, this problem is related to deteriorating political, ecological, and economic conditions in Ukraine, as well as with unhealthy eating habits and a sedentary lifestyle. The causes of the worsening health of students can also be attributed to a low level of motivation for a healthy lifestyle and health culture among young people, which is associated with a lack of parental upbringing, namely, a lack of understanding from early childhood of the importance of a healthy lifestyle and the formation of a stable motivation for sports activities.

It should be noted that an important role in the adaptation process during stressful situations is played by a personality trait such as resilience. In case of insufficient vitality in young people, apathy, reduced efficiency or a state of high tension can be observed.

In particular, during teaching, it is necessary to take into account the individual characteristics of each student, as well as the peculiarities of their mental

processes and states. Individuals with different individual typological properties of higher nervous activity (HNA) differ not only in the reactivity of the cardiovascular system, formation of the initial psychological background, but also in the activation of mechanisms for regulating heart rhythm.

**Keywords:** health, adaptation, students, cardiovascular system, central and autonomic regulation.

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## ДОСЛІДЖЕННЯ ВПЛИВУ РОЗУМОВОГО ТА ФІЗИЧНОГО НАВАНТАЖЕННЯ НА ПОКАЗНИКИ ВАРІАБЕЛЬНОСТІ СЕРЦЕВОГО РИТМУ У СТУДЕНТІВ З РІЗНИМИ ДОМІНАНТНИМИ ТИПАМИ ВЕГЕТАТИВНОЇ РЕГУЛЯЦІЇ

**Анотація.** Сучасне навчання в університетах зумовлює значний стрес у студентів та напруження роботи функціональних систем їхнього організму.

Аналіз наукової літератури за останні роки переконливо свідчить, що протягом останніх років у багатьох країнах світу спостерігається тенденція погіршення стану здоров'я серед молоді. У закладах вищої освіти України питання стану здоров'я студентів постає особливо гостро. Це пов'язано, по-перше, безпосередньо із процесом навчання, який є надзвичайно напруженим періодом життя сучасних молодих людей, для успішної реалізації якого потрібно мати гарне соматичне здоров'я. По-друге, дана проблема пов'язана з умовами погіршення політичної, економічної та екологічної ситуації в Україні, а також через малорухливий спосіб життя та нераціональне харчування. До причин погіршення стану здоров'я студентів також можна віднести недостатній рівень мотивації здорового способу життя та культури здоров'я молоді, що пов'язано з браком батьківського виховання, а саме, відсутністю розуміння з раннього дитинства значення здорового способу життя та формування стійкої мотивації до занять спортом.

Слід зазначити, що важливу роль у процесі адаптації під час стресових ситуацій відіграє така якість особистості, як стійкість. При недостатній життєдіяльності у молодих людей спостерігається апатія, зниження працездатності або стан високої напруженості.

Зокрема, під час навчання необхідно враховувати індивідуальні особливості кожного студента, а також особливості його розумових процесів та станів. Особи із різними індивідуально-типологічними властивостями вищої нервової діяльності мають відмінності не тільки в реактивності серцево-судинної системи, формуванні вихідного психологічного фону, але й активації механізмів регуляції серцевого ритму.

**Ключові слова:** здоров'я, адаптація, студенти, серцево-судинна система, центральна та автономна регуляція.

**Defining the problem and argumentation of the topicality of its consideration.** Student age, according to Ananiev B. G., is a sensitive period for the development of the main sociogenic potentials of a person [1, 2], and the period of ontogenesis from 17 to 25 years is the final stage of the formation of a student's personality and the main phase of professional development. Therefore, young people try to find their place in society, trying to understand themselves [3]. It should be noted that the student period of life is characterized by the highest plasticity in the functioning of the cerebral cortex, which determines the high flexibility in the formation of complex psychomotor and other skills [4, 5].

Currently, university students experience various pressures, such as adapting to changes in their social status academic and life pressure, emotional pressure, economic pressure, employment pressure and interpersonal pressure, which seriously affect their physical and mental health. Students with "low levels" of psychological tolerance may develop psychological disorders, and in serious cases even mental illness. Research results have shown that 17%-20.23% of students have psychological disorders. Excessive and prolonged stress can cause psychological, depressive and anxiety states, physical fatigue and discomfort, which can lead to various diseases and even death. Therefore, studying the state of mental health and stress among university students, as well as developing countermeasures to improve their mental health, is of great importance [6]. This has led to increasing concerns about the mental health of students in the university education sector. Improving students' literacy in the field of mental health is one of the strategies that educational institutions invest in to support students in developing their ability to be healthy [7].

In particular, there is a critical situation in Ukraine regarding the physical health of young people. Almost 90% of children, pupils and students have health problems, more than 50% have unsatisfactory physical fitness, and 61% of young people aged 16-19 have below average or low physical health, 67.2% of young people aged 20-29. Over the past five years alone, the number of students classified as needing medical attention due to their health has increased by 41% [8]. These physical health issues among modern Ukrainian youth undoubtedly affect the overall trends regarding their mental health as well [9]. According to the WHO, mental illnesses affect about 25% of the population of Europe every year, and depression is currently one of the most common illnesses in the population (WHO, 2015) [10].

It should be noted that the incidence of illnesses among students is increasing every year. Among the nosological forms, diseases of the cardiovascular, nervous systems and the musculoskeletal systems prevail [11]. In particular, as the authors note, cardiovascular diseases are the main cause of death and disability worldwide [12]. However, by increasing the intensity of training, the functioning of the cardiovascular system can be improved, although the time spent on training should be taken into account. Thus, the intensity of physical exercises can be considered as a valuable tool or measure for weight loss and reducing cardiovascular diseases among sedentary individuals [13].

In particular, heart rate variability (HRV) has become a useful tool for analyzing the cardiovascular system in both research and clinical fields [14]. The assessment of stress and the sympathetic/parasympathetic balance is the best prognostic indicator of HRV regarding internal load [15].

Heart rate variability indexes neurocardial function and is generated by the cardiac-brain interaction and dynamic nonlinear processes of the autonomic nervous system (ANS). HRV is the property of interdependent regulatory systems working in different time scales to help us adapt to different environmental changes. The fluctuations of a healthy heart rhythms are complex and constantly changing, allowing the cardiovascular system to quickly adapt to sudden physical and psychological homeostatic challenges [16].

It is known that the tone of the autonomic nervous system (ANS) reflects the physiological and homeostatic state of the student's body, as well as a mechanism for its stabilization. Vegetative tone disturbances can be caused by various factors and reasons: stress, chemical and physical influences, infections, hormonal disorders, genetic factors, physical exertion [17]. The ability to use one's own internal resources and develop skills to access external resources contributes to expanding the range of understanding and mastering the appropriate behavior necessary for successful adaptation in higher education institutions [18].

**Previous Research in the Area.** A wide range of scientists dealt with the problem of this issue and ways to solve it: Oleg Kokun, Georgiy Korobeynikov, Bogdan Mytskan, Wojciech J. Cynarski, Lesia Korobeinikova, Maksymova, K. V. et al. Thus, applied aspects of improving the adaptive capabilities of students [19, 20], the importance of diet and the level of physical activity in maintaining health [21, 22], monitoring of students' health, comprehensive assessment of risk factors and trends in health promotion [20, 23], study of factors affecting the health of residents of different countries [24], assessment of the impact of academic life on the state of health of university students [25], monitoring of the state of physical health of students of the 1st course of higher educational institutions [26].

**The purpose:** determination of the features of changes heart rate variability indices in students under the influence of cognitive and physical load, taking into account the type of autonomic regulation.

**Material & methods.** The study involved 128 students, including 65 males and 63 females aged 17-25 years, studying at the I, III and V courses of the Petro Mohyla Black Sea National University. To determine heart rate variability indicators before and after loads (mental and physical), a multi-functional instrument «MPFI rhythmograph-1» by «ASTER-AYTI» (Kharkiv, Ukraine) was used. The mental load was carried out using the Krivonosov M.V. and others method, which consisted in searching for and highlighting the specified letter in test tables. The physical load was aerobic and consisted of covering a distance of 2000 meters on a Concept-2 rowing machine. The Shlyk N.I. method of express assessment of the functional state of regulatory systems was used to divide students into groups according to the types of autonomic regulation that predominate.

**Results.** In the studies, men (n=65) and women (n=63) participated in a state of rest and after mental stress, and men (n=45) and women (n=45) after physical work.

Table 1 presents the statistical and temporal indicators of the four types of vegetative regulation in students, obtained before and after the load.

*Table 1*

**Values of statistical and temporal indicators of vegetative regulation in students before and after the load (Me; 25%, 75%)**

| Indicators        | Groups                  |                          |                          |                           |
|-------------------|-------------------------|--------------------------|--------------------------|---------------------------|
|                   | type I (n=47)           | type II (n=16)           | type III (n=57)          | type IV (n=8)             |
| At rest           |                         |                          |                          |                           |
| HR, beat/min      | 94,11 (86,78; 101,0)    | 105,04 (87,76; 124,73)   | 81,06 (74,75; 86,66)     | 68,44 (60,17; 78,32)      |
| RRNN, ms          | 637,60 (594,00; 691,40) | 575,05 (480,98; 683,75)  | 740,20 (692,35; 802,65)  | 876,95 (767,38; 1000,38)  |
| SDNN, ms          | 42,62 (35,77; 47,61)    | 33,26 (24,94; 52,26)     | 59,88 (53,26; 68,69)     | 110,10 (94,20; 132,45)    |
| RMSSD, ms         | 22,05 (15,89; 25,43)    | 24,14 (12,03; 39,66)     | 36,90 (30,20; 46,27)     | 94,68 (83,94; 113,73)     |
| pNN50, %          | 3,21 (0,59; 5,21)       | 3,72 (0; 14,26)          | 13,77 (7,41; 26,03)      | 43,81 (41,21; 56,01)      |
| Mode, ms          | 625,00 (575,00; 675,00) | 575,00 (475,00; 675,00)  | 725,00 (675,00; 825,00)  | 875,00 (787,50; 1050,00;) |
| AM0, %            | 45,83 (39,31; 50,23)    | 54,08 (43,02; 67,24)     | 32,52 (28,17; 36,63)     | 21,21 (17,81; 24,46)      |
| deltaX, ms        | 200,00 (200,00; 250,00) | 200,00 (150,00; 250,00)  | 350,00 (300,00; 350,00)  | 525,00 (500,00; 650,00)   |
| After mental load |                         |                          |                          |                           |
| HR, beat/min      | 92,74 (85,32; 102,30)   | 89,38 (85,33; 92,69)*    | 83,79 (74,89; 92,67)     | 77,06 (68,59; 81,20)      |
| RRNN, ms          | 647,00 (586,70; 703,30) | 671,35 (647,45; 703,23)* | 716,10 (647,50; 801,20)* | 779,00 (738,95; 876,68)   |

|                     |                             |                             |                             |                             |
|---------------------|-----------------------------|-----------------------------|-----------------------------|-----------------------------|
| SDNN, ms            | 41,97 (31,10;<br>55,76)     | 47,58 (37,80;<br>58,49)     | 57,68 (44,99;<br>66,08)*    | 76,49 (60,62;<br>98,12)*    |
| RMSSD,<br>ms        | 22,80 (14,48;<br>31,92)     | 29,11 (17,10;<br>37,89)     | 30,69 (21,77;<br>41,54)*    | 56,13 (32,77;<br>63,73)*    |
| pNN50, %            | 2,80 (0,50; 10,26)          | 6,79 (1,12; 15,66)          | 8,59 (2,97; 18,34)*         | 28,99 (11,10;<br>36,34)*    |
| Mode, ms            | 625,00 (575,00;<br>675,00)  | 675,00 (625,00;<br>675,00)* | 725,00 (625,00;<br>800,00)  | 725,00 (725,00;<br>887,50)* |
| AM0, %              | 43,56 (34,21;<br>52,56)     | 43,33 (34,41;<br>49,66)*    | 35,40 (29,62;<br>42,69)*    | 29,88 (21,57;<br>36,45)*    |
| deltaX, ms          | 250,00 (200,00;<br>300,00)  | 275,00 (250,00;<br>300,00)* | 300,00 (250,00;<br>350,00)* | 350,00 (312,50;<br>450,00)* |
| After physical load |                             |                             |                             |                             |
|                     | type I (n=32)               | type II (n=11)              | type III (n=42)             | type IV (n=5)               |
| HR,<br>beat/min     | 124,75 (111,13;<br>139,10)* | 115,20 (94,92;<br>131,90)   | 118,85 (100,34;<br>126,78)* | 117,80 (110,65;<br>132,35)* |
| RRNN, ms            | 481,10 (431,50;<br>539,98)* | 521,00 (454,80;<br>632,10)  | 504,80 (473,48;<br>598,20)* | 509,20 (453,45;<br>542,65)* |
| SDNN, ms            | 14,66 (8,80;<br>21,90)*     | 15,56 (10,56;<br>58,81)     | 18,87 (9,72; 31,04)*        | 13,06 (9,81;<br>38,83)*     |
| RMSSD,<br>ms        | 5,11 (2,83; 9,71)*          | 9,35 (3,73; 38,56)*         | 4,62 (3,05; 16,00)*         | 5,00 (3,48; 8,86)*          |
| pNN50, %            | 0 (0; 0,29)*                | 0 (0; 13,71)                | 0 (0; 1,52)*                | 0 (0; 0,76)*                |
| Mode, ms            | 475,00 (425,00;<br>525,00)* | 525,00 (475,00;<br>625,00)  | 525,00 (475,00;<br>587,50)* | 475,00 (475,00;<br>550,00)* |
| AM0, %              | 79,42 (63,09;<br>96,85)*    | 72,24 (33,71;<br>93,12)     | 60,19 (50,94;<br>86,77)*    | 58,27 (48,31;<br>72,51)*    |
| deltaX, ms          | 100,00 (100,00;<br>150,00)* | 100,00 (100,00;<br>300,00)  | 150,00 (100,00;<br>200,00)* | 100,00 (100,00;<br>225,00)* |

Notes: \* - differences in the values of the indicator obtained before and after the loads are reliable according to the Wilcoxon criterion ( $p < 0,05$ )

According to Table 1, it can be noted that in students with type I autonomic regulation, the mental load used for students did not cause significant changes in the indicators. This can be explained by the fact that mental activity is a common activity for university students in this group, and they already have a stereotype of response to it. Students with type II autonomic regulation showed a significant decrease in HR, AM0 and an increase in RRNN, Mode and deltaX. These results indicate an increased influence of the autonomic circuit and the parasympathetic nervous system, which indicates high adaptation-compensatory mechanisms. In particular, students with type III autonomic regulation showed a significant decrease in RRNN and a significant increase in heart rate indicators, and students with type IV autonomic regulation showed a significant decrease in the value of Mode. Thus, in students with types III and IV of autonomic regulation, SDNN, RMSSD, pNN50 and deltaX significantly decreased, indicating a decrease in the role of the

autonomous regulation circuit, a decrease in heart rate variability, and accordingly, an increase in the tension of adaptation-compensatory capabilities of the students' bodies. However, the value of AMO increased in representatives of these groups after mental load, confirming an increase in the mobilizing effect of the sympathetic division of the nervous system.

However, a different reaction of students is observed after physical load. In all groups, except for group II, which is characterized by a pronounced predominance of central regulation, the indicators of RRNN, SDNN, pNN50, Mode and deltaX decreased significantly. In particular, the values of heart rate and AMO significantly increased in all groups, except for group II. It should be noted that the RMSSD index values significantly decreased in all groups. The obtained results indicate a decrease in heart rate variability, which is a sign of an increase in the influence of the central circuit and the sympathetic nervous system, and this is a manifestation of the state of stress of adaptation-compensatory mechanisms. However, it should be emphasized that the smallest impact of physical activity was observed in representatives of group II, which was confirmed by the absence of significant changes, except for RMSSD.

Table 2 presents the average values of the integral indicators characterizing the peculiarities of regulation of the cardiovascular system in students of four groups before and after mental and physical loads.

Table 2

**Values of integral indicators of the cardiovascular system regulation of students before and after loads (Me; 25%, 75%)**

| Indicators            | Groups                  |                          |                         |                        |
|-----------------------|-------------------------|--------------------------|-------------------------|------------------------|
|                       | type I (n=47)           | type II (n=16)           | type III (n=57)         | type IV (n=8)          |
| At rest               |                         |                          |                         |                        |
| IVR, %/s              | 196,50 (156,20; 250,00) | 270,35 (146,78; 443,93)  | 100,60 (80,55; 124,65)  | 41,05 (29,50;47,80)    |
| VPR, 1/s <sup>2</sup> | 6,96 (5,52; 8,00)       | 8,6 (5,62; 12,60)        | 4,04 (3,69; 4,60)       | 1,99 (1,67; 2,27)      |
| RPAI, %/s             | 70,90 (62,20; 80,60)    | 85,90 (73,25; 137,73)    | 43,20 (38,50; 52,35)    | 21,65 (18,80;30,90)    |
| SI, %/s <sup>2</sup>  | 169,50 (117,50;192,00)  | 208,05 (129,13; 348,48)  | 66,30 (52,25; 83,25)    | 21,65 (15,58; 27,95)   |
| After mental load     |                         |                          |                         |                        |
| IVR, %/s              | 196,70 (115,30; 254,50) | 153,20 (113,03; 217,85)* | 118,40 (86,60; 188,30)* | 75,25 (51,78; 117,58)* |
| VPR, 1/s <sup>2</sup> | 6,45 (4,94; 8,70)       | 5,44 (4,31; 6,39)*       | 4,60 (3,54; 6,38)*      | 3,62 (2,84; 4,44)*     |
| RPAI, %/s             | 69,70 (48,80; 91,40)    | 68,10 (49,90; 80,18)*    | 48,40 (39,30; 65,15)*   | 34,60 (30,73; 48,53)*  |
| SI, %/s <sup>2</sup>  | 157,40 (81,40; 216,20)  | 122,45 (76,45; 161,35)*  | 82,00 (58,70; 130,50)*  | 49,40 (34,15; 78,68)*  |

| After physical load   |                              |                            |                             |                             |
|-----------------------|------------------------------|----------------------------|-----------------------------|-----------------------------|
|                       | type I (n=32)                | type II (n=11)             | type III (n=42)             | type IV (n=5)               |
| IVR, %/s              | 660,30 (394,30;<br>968,53)*  | 568,60 (112,40;<br>931,20) | 499,95 (282,50;<br>827,48)* | 582,70 (213,35;<br>725,10)* |
| VPR, 1/s <sup>2</sup> | 20,05 (12,00;<br>23,53)*     | 17,39 (5,33;<br>21,05)     | 14,04 (8,00;<br>21,67)*     | 19,05 (8,75; 21,05)*        |
| RPAI, %/s             | 158,70 (122,20;<br>210,50)*  | 152,10 (53,90;<br>196,00)  | 121,80 (90,43;<br>182,18)*  | 122,70 (91,40;<br>145,05)*  |
| SI, %/s <sup>2</sup>  | 671,95 (365,53;<br>1092,50)* | 541,50 (89,90;<br>980,20)  | 491,25 (226,03;<br>913,40)* | 613,40 (204,00;<br>725,30)* |

Notes: \* - differences in the values of the indicator obtained before and after the loads are reliable according to the Wilcoxon criterion ( $p < 0,05$ )

Comparison of the integral indicators of the functional state of the body of students with different types of autonomic regulation before and after mental load allows us to note that in all groups, except for the 1st, the values of all indicators have changed significantly. Students with a significant predominance of central regulation (type II) showed a significant decrease in all studied indicators - IVR, VPR, RPAI and SI, which indicates an increase in the activity of the parasympathetic division and the autonomic circuit after mental activity. Thus, students with a moderate predominance of autonomous regulation (type III) and with a pronounced predominance of autonomic regulation (type IV) showed a significant increase in all indicator values, which indicates an increase in the activity of the sympathetic division and the degree of centralization of heart rhythm control.

In particular, after physical load, representatives of all types of autonomic regulation, except for type II, showed a significant increase in all HRV indicators. That is, in students with moderate predominance of the central regulation (type I), with a moderate predominance of autonomous regulation (type III) and pronounced predominance of autonomic regulation (type IV), a significant increase in all HRV indicators indicates an increase in the activity of the sympathetic division of the autonomic nervous system (ANS) and an increase in the role of the central link in controlling the work of the sinoatrial node. It should be noted that in representatives with a significant predominance of central regulation (type II), significant changes were absent after the influence of the load, but there was a tendency towards an increase in all indicators, which also indicates an increase in sympathetic activity of the vegetative nervous system.

Table 3 presents spectral indicators of HRV, which provide important information about the cardiovascular system of the four groups before and after mental and physical loads.

Table 3

**The values of spectral indices of HRV in students before and after loads  
(Me; 25%, 75%)**

| Indicators           | Groups                          |                              |                               |                                |
|----------------------|---------------------------------|------------------------------|-------------------------------|--------------------------------|
|                      | type I (n=47)                   | type II (n=16)               | type III (n=57)               | type IV (n=8)                  |
| At rest              |                                 |                              |                               |                                |
| TP, ms <sup>2</sup>  | 1355,00<br>(844,00;<br>1684,00) | 829,00 (529,50;<br>1166,00)  | 2263,00 (1692,50;<br>2878,50) | 6005,50 (4305,75;<br>9703,25)  |
| VLF, ms <sup>2</sup> | 510,00 (346,00;<br>729,00)      | 177,50 (119,25;<br>225,25)   | 776,00 (458,50;<br>1094,50)   | 2246,50 (1113,75;<br>3438,00)  |
| LF, ms <sup>2</sup>  | 528,00 (343,00;<br>725,00)      | 352,00 (173,75;<br>752,00)   | 959,00 (700,00;<br>1404,50)   | 1996,50 (1409,75;<br>2904,00)  |
| HF, ms <sup>2</sup>  | 170,00 (102,00;<br>283,00)      | 172,00 (70,00;<br>495,25)    | 398,00 (260,50;<br>610,00)    | 2116,50 (895,25;<br>3325,25)   |
| LF/HF                | 2,91 (2,06;<br>4,70)            | 2,42 (1,02; 3,38)            | 2,56 (1,22; 4,09)             | 0,95 (0,78; 2,06)              |
| After mental load    |                                 |                              |                               |                                |
| TP, ms <sup>2</sup>  | 1253,00<br>(824,00;<br>2192,00) | 1561,00(958,50;<br>2338,75)* | 2140,00 (1340,00;<br>2779,50) | 3483,00 (2190,25;<br>6080,75)* |
| VLF, ms <sup>2</sup> | 421,00 (252,00;<br>722,00)      | 627,00 (365,25;<br>967,25)*  | 577,00<br>(360,00;1016,50)    | 911,50 (589,50;<br>2040,50)    |
| LF, ms <sup>2</sup>  | 668,00 (319,00;<br>980,00)      | 616,00 (323,50;<br>1141,00)  | 872,00 (480,50;<br>1365,50)   | 1492,50 (920,25;<br>1814,75)*  |
| HF, ms <sup>2</sup>  | 194,00 (93,00;<br>361,00)       | 264,50 (120,75;<br>465,75)   | 264,00 (145,50;<br>516,00)    | 651,50 (304,75;<br>1144,25)*   |
| LF/HF                | 3,36 (2,00;<br>5,32)            | 0,73 (0,55; 0,84)            | 2,91 (1,89; 5,52)             | 1,84 (1,09; 3,16)*             |
| After physical load  |                                 |                              |                               |                                |
|                      | type I (n=32)                   | type II (n=11)               | type III (n=42)               | type IV (n=5)                  |
| TP, ms <sup>2</sup>  | 201,50 (78,50;<br>409,50)*      | 232,00 (114,00;<br>2412,00)  | 340,00 (94,25;<br>745,50)*    | 161,00 (104,50;<br>1377,50)*   |
| VLF, ms <sup>2</sup> | 122,00 (46,50;<br>224,00)*      | 175,00 (47,00;<br>1196,00)   | 176,50 (58,75;<br>486,50)*    | 87,00 (52,50;<br>1072,50)*     |
| LF, ms <sup>2</sup>  | 33,00 (23,25;<br>173,00)*       | 68,00 (44,00;<br>415,00)     | 86,00 (45,25;<br>362,25)*     | 80,00 (35,50;<br>266,50)*      |
| HF, ms <sup>2</sup>  | 7,00 (4,00;<br>60,75)*          | 15,00 (3,00;<br>305,00)*     | 11,50 (6,00;<br>125,50)*      | 15,00 (6,50; 38,50)*           |
| LF/HF                | 5,28 (3,41;<br>8,04)*           | 4,08 (1,71; 9,13)*           | 5,35 (2,88; 8,58)*            | 6,92 (3,01; 12,89)*            |

Notes: \* - differences in the values of the indicator obtained before and after the load are reliable according to the Wilcoxon criterion ( $p < 0,05$ )

After mental exertion, significant changes in spectral indicators compared to the initial state were not observed in students with moderate predominance of central regulation (type I) and with moderate predominance of autonomic regulation (type

III), as mental activity is habitual for representatives of these groups, and they have developed a stereotype of response, which is confirmed by minor changes in the indicator values. In particular, students with a significant dominance of central regulation (type II) showed a significant increase in TP and VLF, which indicates an increase in the adaptive capacity of the cardiovascular system and a hyperadaptive response of the body. After the load, the VLF value was significantly higher than normal, which can be interpreted as a hyperadaptive state. Thus, students with a significant dominance of autonomic regulation (type IV) showed a significant decrease in TP, LF, HF and an increase in the value of LF/HF. After load, the LF value was significantly higher than normal. The results obtained indicate a shift in the autonomic balance towards the predominance of the central regulation of the heart, a decrease in the role of autonomous regulation and a decrease in the adaptive capabilities of the cardiovascular system.

In particular, after the loads, representatives of all types of autonomic regulation, except for the second, showed a significant decrease in the values of all HRV indicators, with the exception of LF/HF (the value increased). Thus, a decrease in the values of TP, VLF, LF, HF and an increase in LF/HF indicates a decrease in the level of activity of the vasomotor center, an increase in the activity of the central control circuit, a decrease in the adaptive capabilities of the cardiovascular system, and post-exercise energy deficiency. It should also be noted that in all groups of students, the VLF values were above the norm, which can be interpreted as a hyperadaptive state. Thus, in groups of students with II and III types of autonomic regulation, LF values were within the normal range, with type I regulation it was less than normal, and in representatives of type IV it was higher than normal. In particular, the results of HF in all groups were significantly lower. This confirms a significant advantage of sympathetic activity in regulating the cardiovascular system.

### **Conclusions.**

1. After a mental load, the statistical, temporal, integral and spectral indicators did not change significantly in students with moderate predominance of the central regulation (type I), indicating the formation of adaptation mechanisms to such a volume of mental activity. Representatives with moderate predominance of autonomous regulation (type III), showed significant changes in statistical, temporal and integral indicators, which indicates an increase in the activity of the sympathetic division, degree of centralization of heart rate control and tension of adaptive-compensatory capabilities of students' bodies. Students with a significant predominance of central regulation (type II) and significant predominance of autonomic regulation (type IV) showed significant changes in statistical, temporal, integral and spectral parameters. This indicates an increase in the influence of the autonomous circuit, high adaptive-compensatory mechanisms, an increase in the adaptive capabilities of the cardiovascular system and a hyperadaptive response of the body in the type II group of students. In particular, the results of the

representatives of the IV group indicate a decrease in the role of the autonomous regulation circuit, a decrease in heart rate variability, a decrease in the adaptive capabilities of the cardiovascular system and, accordingly, tension of the adaptive-compensatory capabilities of students' bodies.

2. After exercise, representatives of all groups, except for students with a significant predominance of central regulation (type II), showed significant changes in indicators indicating an increase in the influence of the central circuit, sympathetic nervous system, the presence of manifestations of tension in adaptive-compensatory mechanisms and post-exercise energy deficiency. Thus, in the representatives of group II, significant changes were observed in the RMSSD, HF, LF/HF indicators, which indicates an increase in the activity of the central control loop.

3. The obtained results can be used in the distribution of students into sections (within physical education classes in universities), which will correspond to individual physical and psychological needs of students.

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