

## MEDICAL PSYCHOLOGY / МЕДИЧНА ПСИХОЛОГІЯ

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**Peculiarities of relationships between the characteristics of psychophysiological adaptation of organism and criterion indicators of motor activity of modern students****Koval Nataliia, Drezhenkova Inna, Ocheredko Oleksandr, Serheta Ihor, Belov Oleksandr, Redchits Mykola**

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**Annotation:** one of the priority components of the implementation of modern physiological and hygienic research is a prognostic assessment of the features of the leading characteristics formation of the adaptive resources state of the student's organism based on the use of modern methods of statistical analysis in accordance with the conditions of stay, which differ in the features of the influence of health-creating factors, among which it is necessary to include level of motor activity. The purpose of the study was to determine the peculiarities of the relationships between the characteristics of psychophysiological adaptation and criterion indicators of motor activity of modern students based on the application of cluster and factor analysis procedures. In the course of the scientific work 285 students (150 young women and 135 young men) were supervised, who were divided into 3 comparison groups according to the level of motor activity. Individuals with high motor activity (group 1 of motor activity: 50 young women and 45 young men), medium motor activity (group 2 of motor activity: 50 young women and 45 young men) and low motor activity (group 3 of motor activity: 50 young women and 45 young men) levels were involved in their composition. As criterion indicators of motor activity, it was necessary to note the indicators of daily energy expenditure, which were estimated according to the timing-table method - up to 9000 kJ (low level of motor activity), 9000-11000 kJ (medium level of motor activity), more than 11000 kJ (high level of motor activity) among girls, and indicators of motor activity - up to 11,000 kJ (low motor activity level), 11,000-13,500 kJ (medium motor activity level), over 13,500 kJ (high motor activity level) among young men. Medical-sociological, epidemiological, psychophysiological, psychological-pedagogical and statistical methods were used in the scientific work. In the course of the conducted research, based on the application of cluster and factor analysis procedures, the features of the relationships between the characteristics of the functional state and the level of development of psychophysiological functions and, therefore, the leading characteristics of psychophysiological adaptation and criterion indicators of motor activity of modern students were determined. Data of cluster analysis procedures usage determined that the leading characteristics of the state of health and academic success were most significantly influenced by 3 leading clusters of characteristics of the psychophysiological adaptation of the students' organism, namely: visual-motor speed, visual-sensory and integrative-coordination clusters. At the same time, based on the results of the application of factor analysis procedures, it was established that the most positive effect on the functional state of the organism of young women and young men was exerted by the movement regime characteristic of students, the values of daily energy expenditure of which vary between 9000-11000 kJ and between 11000-13500 kJ.

**Keywords:** [cluster analysis](#), [learning](#), [motor activity](#), [health](#), [students](#).

## Introduction

Due to determining the features of adaptive transformations that occur in the organism of student youth during the performance of various types of everyday usual and unusual activities performing a comprehensive assessment of the state of health, it is customary to pay special attention to the patterns of psychophysiological adaptation of young women and young men who learn (Aherne et al., 2016; Мороз та ін., 2021). In this regard, it should be noted that it is psychophysiological adaptation that contributes to ensuring a completely adequate organization of psychophysiological relationships, which determine the optimal patterns of the processes of preserving and strengthening health, in many aspects it assures a favorable course of adaptive processes that occur and are determined by the specific content of psychophysiological relationships, i.e. the role played by individual psychophysiological functions in the set of established psychophysiological connections (Сергета и др., 2020; Мороз та ін., 2021; Voloshyna et al., 2022). That is why identifying of the regularities of the formation processes of certain criterion psychophysiological functions in specific conditions of being is an essential component of any physiological and hygienic research (Сергета та ін., 2016, 2022; Hrynzovskyi et al. 2022). However, an equally significant component of them is a prognostic assessment of formation features of the leading characteristics of adaptive resources state of the students' organism based on the use of modern methods of multidimensional statistical analysis and, in particular, procedures of cluster and factor analysis, in accordance with the conditions of stay, which differ, first of all, by the features of the influence of health-creating factors that include the level of motor activity (MA) (Arnetz & Blomkvist, 2007; Сергета та ін., 2020; Kalashchenko et al., 2021).

### Aim

The aim of scientific work is to determining peculiarities of relationships between the characteristics of psychophysiological adaptation of organism and criterion indicators of motor activity of modern students based on the application of cluster and factor analysis procedures.

### Materials and methods

During the scientific research, 285 students (150 young women and 135 young men) were under

supervision, who were divided into 3 comparison groups according to the MA level. They included individuals with high (group 1 of MA: 50 young women and 45 young men), medium (group 2 of MA: 50 young women and 45 young men) and low (group 3 of MA: 50 young women and 45 young men) levels of MA. As criterion indicators of MA, it was necessary to note the indicators of daily energy expenditure, estimated according to the time-table method, within the range of up to 9,000 kJ (low level of MA), from 9,000 to 11,000 kJ (average level of MA) and over 11,000 kJ (high level of MA) – among young women, and indicators of MA within the range of up to 11,000 kJ (low level of MA), from 11,000 to 13,500 kJ (medium level of MA) and over 13,500 kJ (high level of MA) – among young men.

The work is a fragment of the research work of the National Pirogov Memorial Medical University, Vinnytsya: «Physiological and hygienic assessment of the peculiarities of adaptation of children, adolescents and young people to the conditions of learning in modern educational institutions and the scientific basis of university hygiene: career guidance aspects, problems of introducing health-preserving technologies and creation of a preventive educational environment» (state registration No 0116U000038). The conducted research fully complies with the basic bioethical norms of the Helsinki Declaration, the Council of Europe Convention on Human Rights and Biomedicine, the relevant provisions of the WHO and the Ministry of Health of Ukraine, as well as the ethical standards established by the Bioethics Committee of the National Pirogov Memorial Medical University, Vinnytsia (protocol No. 10, 26.11.2020).

The leading functional features of higher nervous activity (HNA) were established on the basis of the values determining of latent periods of simple (LPSVMR) and differentiated (LPDVMR) visual-motor reaction, indicators of mobility (MNPr) and balance (BNPr) of nervous processes using the technique of chronoreflexometry, functional characteristics of the visual sensory system (VSS) and the somatosensory analyzer were studied, respectively, by evaluating the values of the critical frequency of light flashes fusion (CFLFF) on the basis of the «Light test» technique and coordination of movements (CM) using tremometry, stability of attention and features of mental performance were

studied with the help of Schulte's tables and on based on the usage of proofreading tests. Indicators of morbidity with temporary loss of working capacity and chronic morbidity were used as criterion indicators of health status. Academic performance indicators, primarily for a whole group of professionally oriented disciplines, were established on the basis of copying the results of intermediate and annual success rate of student youth. The obtained data were subjected to a thorough statistical processing based on the application of the package of applied statistical analysis programs «Statistica 6.1» (license number BXXR901E245722FA) using the procedures of (1) descriptive statistics, (2) cluster analysis and (3) factor analysis.

### Results

Application for the purpose of prognostic assessment of cluster analysis procedures determines the carrying out of a statistically defined generalized grouping of both specific research objects and their most significant features into separate clusters, which constitute a certain grouping of data based on the formation of completely homogeneous groups of them in the multi-vector space of manifestations, that are to be investigated. It should also be noted that the basis of the article is mainly the previously unpublished data obtained in the research (Дреженкова, 2016), which require mandatory further in-depth interdisciplinary and, above all, interdisciplinary professional interpretation and versatile interpretation by specialists of various directions in the context of prospects for their further widespread use in the medical field.

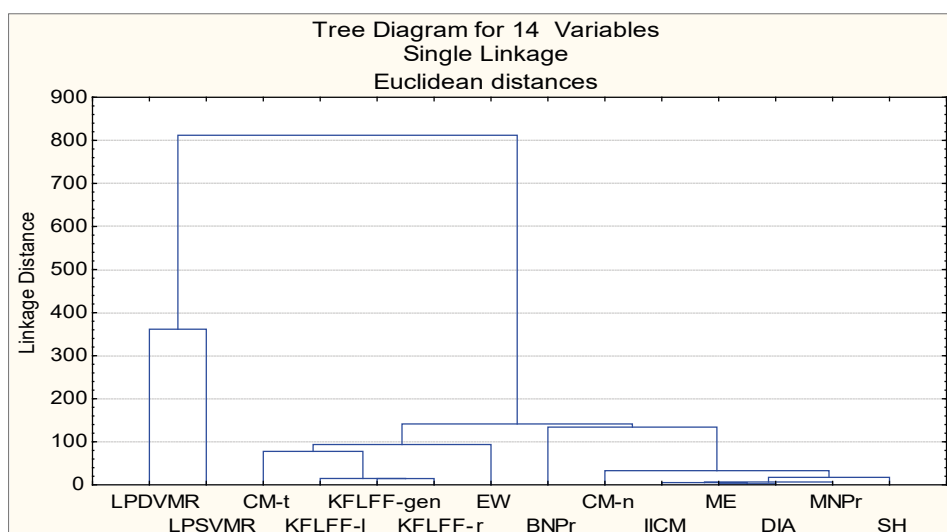
In particular, the application of the agglomeration-hierarchical method of cluster analysis made it possible, based on the determination of the minimum distance between the studied indicators, to identify 3 priority clusters, which are characterized by the presence of the most favorable influence on the leading characteristics formation of the of both the state of health and the characteristics of academic success, primarily according to a whole group of professionally oriented disciplines.

So, both for young women and for young men who belonged to group 1 of MA (the level of daily energy expenditure, respectively, up to 9000 kJ and up to 11000 kJ) and in the case of determining the leading indicators of the state of health, and in the case of performing a prognostic assessment of

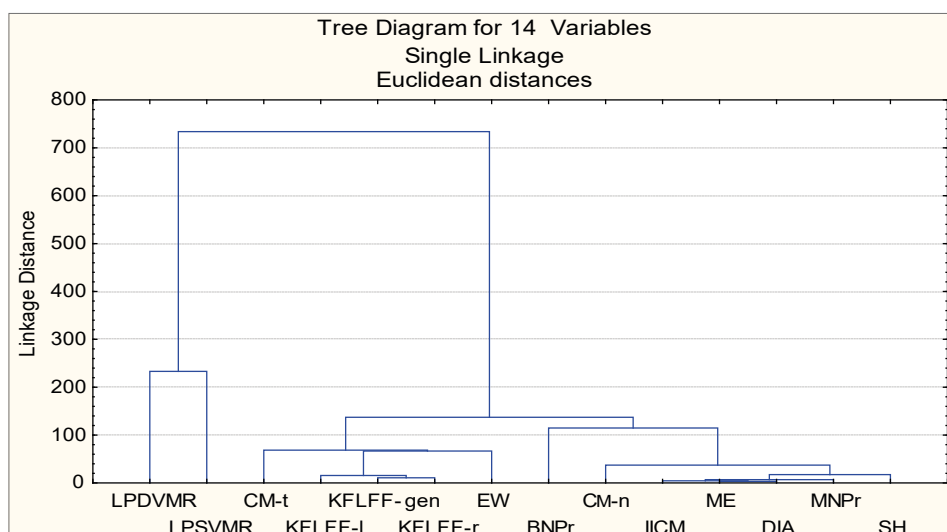
educational success according to the group of professional-oriented disciplines, 3 clusters should be considered characteristic: visual-motor speed cluster (cluster No. 1), visual-sensory cluster (cluster No. 2), integrative-coordination cluster (cluster No. 3). The composition of the visual-motor speed cluster should have included the indicators of LPSVMR and LPDVMR, the composition of the visual-sensory cluster – indicators of KFLFF and the efficiency of the work performed, the composition of the integrative-coordination cluster – a number of indicators that marked the properties of the main nervous processes, the value of the integral index of CM, as well as a number of characteristics of attention functions (degree of involvement in the activity being performed, mental endurance, etc.). Moreover, it was the last cluster that was the closest to the characteristics of the state of health and educational success that were studied in the multidimensional space of the indicators that were measured (Fig. 1-2).

It should be noted that the following conventional symbols are used in the figures below: SH – criterion indicator of the state of health (health group); LPDVMR – the latent period of a differentiated visual-motor reaction in the conditions of choice; LPSVMR – the latent period of a simple visual-motor reaction under standard conditions; BNPr – balance of nervous processes; MNPr – mobility of nervous processes; EW – efficiency of work performed; ME – mental endurance; DIA – the degree of involvement in the activity being performed; KFLFF-gen – the generalized average value of the data regarding the critical frequency of the fusion of light flashes; KFLFF-l – data on the critical frequency of the fusion of light flashes, characteristic for the left eye; KFLFF-r – data on the critical frequency of the fusion of light flashes, characteristic for the right eye; CM-n – data on the number of touches during tremometry; CM-t – data on the speed of execution of the test task during tremometry; IICM – integral index of coordination of movement.

The situation was similar for young women students and young men students who belonged to 2 groups of MA (the level of daily energy expenditure 9000-11000 kJ and 11000-13500 kJ, respectively). Both during the determination of the leading characteristics of the state of health,



**Fig. 1** Peculiarities of unification of clusters of studied indicators among young women of the group 1 of motor activity in the case of prognostic assessment of criterion characteristics of the state of health

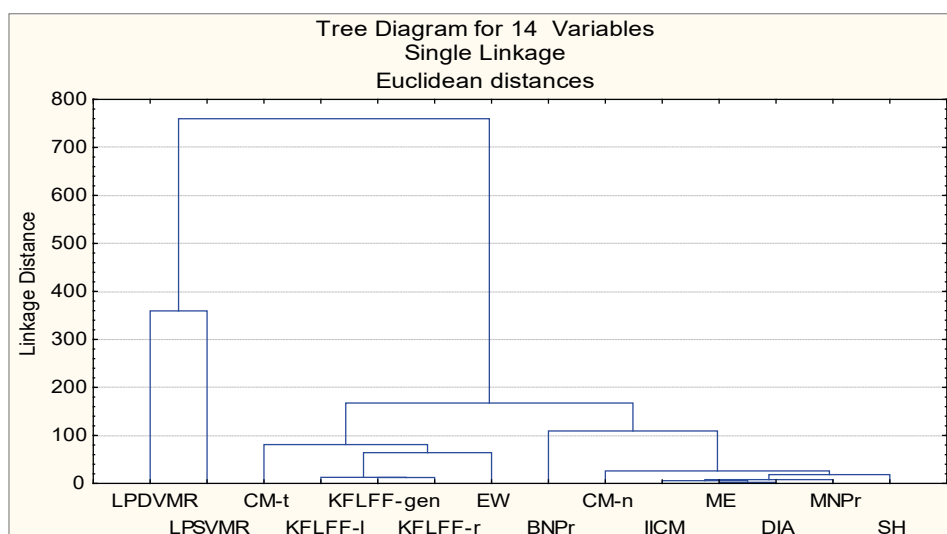


**Fig. 2.** Peculiarities of unification of clusters of studied indicators among young men of the group 1 of motor activity in the case of prognostic assessment of criterion characteristics of the state of health

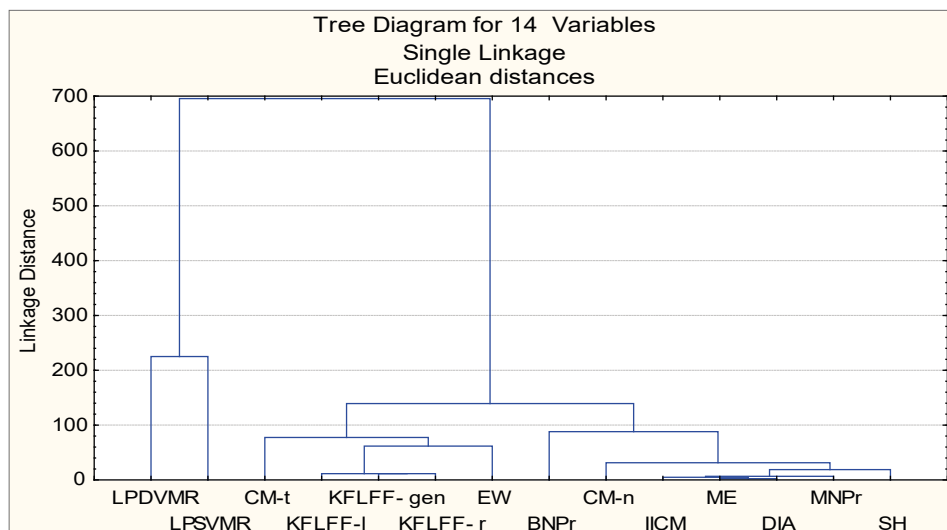
and during the prognostic assessment of educational success by a group of professionally oriented disciplines, the following clusters should also be considered priority: visual-motor speed cluster (cluster No. 1), visual-sensory cluster (cluster No. 2), integrative and coordination cluster (cluster No. 3). Their composition included, respectively, the indicators of the LPSVMR and LPDVMR (cluster No. 1), indicators of KFLFF and the efficiency of the work performed (cluster No. 2), a number of indicators that noted the properties of the main nervous processes, leading characteristics of the CM, first of all, the num-

ber of touches during tremometry and indicators of the integral index of CM, as well as characteristics of attention functions (degree of involvement in the activity being performed, mental endurance, etc.) (cluster No. 3). Moreover, as in the previous case, it was the last cluster that was the closest to the characteristics of the state of health and educational success in the multidimensional space of the measured indicators (Fig. 3-4).

In the end, the content is quite similar to the previous two cases, there were relationships between the leading characteristics of the state of health and the characteristics of academic per-



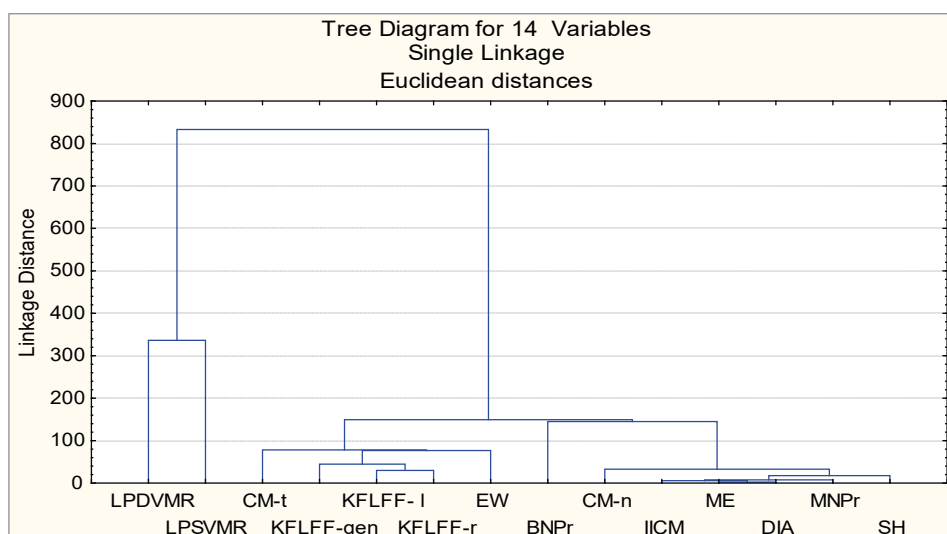
**Fig. 3.** Peculiarities of unification of clusters of studied indicators among young women of group 2 of motor activity in the case of prognostic assessment of criterion characteristics of the state of health



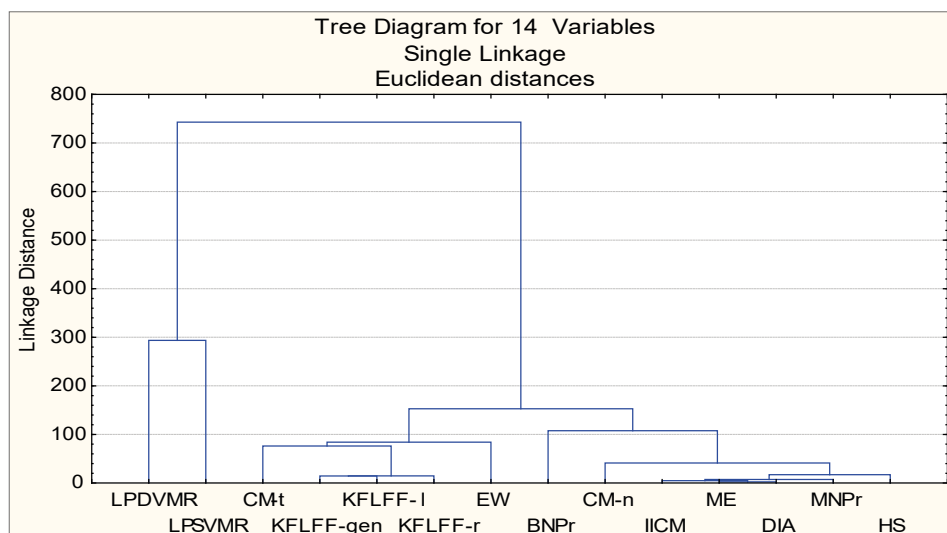
**Fig. 4.** Peculiarities of unification of clusters of studied indicators among young men of group 2 of motor activity in the case of prognostic assessment of criterion characteristics of the state of health

formance by the group of professionally oriented disciplines and psychophysiological functions of students belonging to group 3 of MA (the level of daily energy expenditure, respectively, more than 11,000 kJ and more than 13500 kJ). And in this case, the visual-motor speed cluster (cluster No. 1), visual-sensory cluster (cluster No. 2), integrative-coordination cluster (cluster No. 3) should have been considered the most significant. The components of the visual-motor speed cluster included the indicators of LPVZMR and LPDVMR, the composition of the visual-sensory cluster included indicators of KFLFF and the efficiency of

the work being performed, the composition of the integrative-coordination cluster included a number of indicators that noted the properties of the main nervous processes, characteristics of the CM, first of all the number of touches during tremometry and indicators of the integral index of CM, as well as characteristics of attention functions (degree of involvement in the activity being performed, mental endurance, etc.). In this case, the last cluster was the closest to the characteristics of the state of health and academic success that were studied in the multidimensional space of the indicators that were measured (Fig. 5-6).



**Fig. 5.** Peculiarities of unification of clusters of studied indicators among young women group 3 of motor activity in the case of prognostic assessment of criterion characteristics of the state of health



**Fig. 6.** Peculiarities of unification of clusters of studied indicators among young men of group 3 of motor activity in the case of prognostic assessment of criterion characteristics of health

Another method of establishing the interdependence of indicators that determine the peculiarities of the functional state and adaptation capabilities of the organism of young women and young men, which are characterized by different approaches to the organization of MA and, therefore, different values of MA in the context of their influence on the state of the studied characteristics, it is a factor analysis. Its main procedures allow to carry out a quantitative analysis of directly unmeasurable indicators that can be evaluated by studying certain signs, and, therefore, they provide an opportunity to carry out a correct description of multidimensional objects based on the definition of in-depth,

systematic in their content, processes of formation of their indicators. Thus, among students of group 1 of MA the peculiarities of the interdependence of the characteristics of academic performance by the group of professionally oriented disciplines (y) and indicators of psychophysiological functions of young women and young men should be determined and formalized as a relationship (1-2):

– in young women who belonged to group 1 of MA:

$$y = 0,391f_1 + 0,135f_2 + 0,438f_3; \quad (1)$$

where the factor  $f_1$  should have been defined as the «functional state of the VSS» (the share of the

variance is 32.68%) and it was associated with the characteristics of KFLFF, factor  $f_2$  should have been defined as the «functional state of CM» (the share of variance is 21.71%) and, above all, it included in its structure such characteristics of the coordination abilities of the young women under study, as data on the number of touches during tremometry and the value of the integral index of CM; factor  $f_3$  should have been defined as the «functional state of HNA» (the share of variance is 22.38%) and, above all, it combined in its structure indicators of LPDVMR and BNPr of young women;

– in young men who belonged to group 1 of MA:

$$y = 0,3121f_1 + 0,194f_2 + 0,505f_3; \quad (2)$$

where the factor  $f_1$  should have been defined as the «functional state of the VSS» (the share of variance is 33.59%) and it was related to the indicators of KFLFF; factor  $f_2$  should have been defined as the «functional state of the CM» (the share of variance is 26.95%) and it combined in its structure the characteristics of the organism's coordination abilities, namely, data on the number of touches during tremometry, the speed of performing the test task, and the values of the integral CM index; factor  $f_3$  should have been defined as the «functional state of the HNA» (the share of variance is 24.50%) and, above all, it included in its structure the indicators of LPSVMR and LPDVMR of young men.

Peculiarities of the interdependence between the academic performance characteristics in the professionally oriented disciplines group (y) and the indicators of psychophysiological functions development of the students of the group 2 of MA had to be presented and formalized as a relationship (3-4):

– in young women who belonged to group 2 of MA:

$$y = 0.324f_1 + 0.212f_2 + 0.428f_3; \quad (3)$$

where the factor  $f_1$  should have been defined as the «functional state of the HNA» (the share of variance is 32.20%) and, above all, it combined the indicators of the LPSVMR and LPDVMR of young women; factor  $f_2$  should have been defined as the «functional state of the VSS» (the share of variance is 25.87%) and it was related to the indicators of the young women students' KFLFF; factor  $f_3$  should

have been defined as the «functional state of CM» (the share of variance is 22.89%) and, first of all, it caused the inclusion in its structure of indicators that provide information about the peculiarities of such leading characteristics of the coordination abilities of the girls under study, as the number of touches during tremometry and values of the integral index of the CM;

– in young men who belonged to group 2 of MA:

$$y = 0.388f_1 + 0.395f_2 + 0.237f_3; \quad (4)$$

where factor  $f_1$  should have been defined as «functional state of HNA» (the share of variance is 31.83%) and, first of all, it determined the presence in its structure of the indicators of LPSVMR and LPDVMR of young men, factor  $f_2$  should have been defined as «functional state of VSS» (the share of the variance is 23.87%) and it was related to the indicators of students' KFLFF; factor  $f_3$  should have been defined as «functional state of the CM» (the share of variance is 27.02%) and it combines in its structure the characteristics of coordination abilities, namely: indicators of the number of touches during tremometry;

Peculiarities of the interdependence between the academic success characteristics in the professionally oriented disciplines group (y) and indicators of the development of psychophysiological functions of the body of students of the 3 group of MA had to be determined and formalized in the form of relationships (5-6):

– in young women who belonged to group 3 of MA:

$$y = 0.190f_1 + 0.352f_2 + 0.348f_3; \quad (5)$$

where the factor  $f_1$  should have been defined as the «functional state of the CM» (the share of variance is 28.08%) and, first of all, it includes in its structure indicators that provide information on the peculiarities of such coordination abilities characteristics of the young women under study, as indicators of the number of touches during carrying out tremometry and the value of the integral index of CM; factor  $f_2$  should have been defined as the «functional state of the VSS» (the share of variance is 27.49%) and it is related to the indicators of the young women students' KFLFF; factor  $f_3$  should have been defined as «functional state of HNA»

(the share of variance is 22.01%) and, first of all, it combined in its structure the indicators of young women' LPDVMR;

– in young men who belonged to group 3 of MA:

$$y = 0.373f_1 + 0.240f_2 + 0.338f_3; \quad (6)$$

where the factor  $f_1$  should have been defined as the «functional state of the CM» (the share of the variance is 31.00%), which was determined by the data on the number of touches during tremometry; factor  $f_2$  should have been defined as the «functional state of the VSS» (the share of variance is 28.67%) and it was related to the indicators of the students' KFLFF; factor  $f_3$  should have been defined as the «functional state of the HNA» (the share of variance is 21.59%) and, first of all, it combined in its structure the indicators of LPSVMR and LPDVMR of young men.

### Discussion

The use of the most common procedures of cluster analysis, both during the prognostic assessment of the leading health indicators and during the determination of the academic success characteristics in a group of professionally oriented disciplines, made it possible to determine 3 priority clusters of the studied characteristics of the psychophysiological adaptation of the students' organism, which make a significant difference influence on their criterion values: visual-motor speed cluster (its composition should have included the characteristics of the LPSVMR and LPDVMR), the visual-sensory cluster (its composition should have included the characteristics of the KFLFF and the efficiency of the work being performed), as well as the integrative coordination cluster (its composition should have included a number of indicators reflecting the properties of leading nervous processes, more accurate in their content of the CV characteristics, as well as a number of characteristics of the functions of attention, first of all, the degree of involvement in the activity being performed and mental endurance), which actually was the most painful approximating the characteristics of the state of health and academic success in the multidimensional space of the indicators that were measured. Such results confirmed a number of data obtained in the course of research conducted in recent years (Mopoz та ін., 2020; Ceprepa та ін., 2022; Hrynzovskyi, 2022) and they determined the leading ways of developing and fur-

ther introducing effective health-preserving measures, creating a preventive educational environment in a medical institution of higher education, which, according to the data presented in a number of works (Дреженкова, 2016; Aherne et al., 2016; Ceprepa та ін., 2020; Kalashchenko et al., 2021), is the most effective basis for the formation of a comprehensively developed, healthy personality.

The application of the leading procedures of factor analysis made it possible to establish that the following factors most favorably affect the academic success characteristics in the group of professionally oriented disciplines in young women and young men: «functional state of the HNA», «functional state of the VSS», «functional state of the CV». However, the share of their variance in the structure of factor loads, which was determined, is significantly different: among students, the level of daily energy expenditure is up to 9,000 kJ (young women) and up to 11,000 kJ (young men), the most significant contribution is characteristic of the factor «functional state of the VSS», which is related to the indicators of the students' KFLFF (among young women the share of variance is 32.68%, young men – it is 33.59%), among students whose daily energy expenditure varies between 9000-11000 kJ (young women) and 11000-13500 kJ (young men), – the most significant contribution is characteristic of the factor «functional state of HNA» (among young women the share of variance is 32.20%, among young men – it is 31.83%), among students, the level of daily energy expenditure is 11,000 kJ (young women) and 13,500 kJ (young men), – the most important contribution is characteristic of the factor «functional state of the CM» (among young women, the share of variance is 32.20%, among young men – it is 31.83%). Taking into account the peculiarities of the processes of professional formation of future specialists in the medical field, which is associated with the need to learn rather large volumes and theoretically, mainly, practically significant information, this situation indicates in favor of the presence of clearly expressed signs of the positive influence of the motor regime, characteristic of young women and young men, whose daily energy consumption is 9000-11000 kJ and 11000-13500 kJ, respectively, which contributes to the predominant development of the



leading functional characteristics of the HNA of students engaging in the process of studying.

### Conclusions

In the course of the conducted research, based on the use of such procedures of multidimensional statistical analysis as cluster and factor analysis, the priority features of the relationships between the characteristics of the degree of development of psychophysiological functions and, therefore, the leading characteristics of psychophysiological adaptation and criterion indicators of motor activity of modern students were established.

The identified features of the relationship between the characteristics of the functional state and the indicators of the motor activity of student youth should be used in the future for the development of modern, effective and fully adequate to the requirements of today's health-preserving technologies and the creation, which is extremely important, based on today's positions and the main trends in the development of university hygiene, preventive educational space in medical institutions of higher education today.

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### Conflict of interest

All authors have read the text of the manuscript and have given their consent for its publication.

### Consent to publication

Author read and approved the final version of the manuscript. All authors agreed to publish this manuscript.

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A – Research concept and design, B – Collection and/or assembly of data, C – Data analysis and interpretation, D – Writing the article, E – Critical revision of the article, F – Final approval

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## Особливості взаємозв'язків характеристик психофізіологічної адаптації організму та критеріальних показників рухової активності сучасних студентів

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**Анотація:** одним із пріоритетних компонентів здійснення сучасних фізіолого-гігієнічних досліджень є прогностична оцінка особливостей становлення провідних характеристик стану адаптаційних ресурсів організму студентів на підставі використання сучасних методів статистичного аналізу відповідно до умов перебування, що відрізняються особливостями впливу здоров'ятвірних чинників, до числа яких необхідно віднести рівень рухової активності. Метою дослідження було визначення особливостей взаємозв'язків між характеристиками психофізіологічної адаптації та критеріальними показниками рухової активності сучасних студентів на підставі застосування процедур кластерного і факторного аналізу. В ході виконання наукової роботи під наглядом перебували 285 студентів (150 дівчат та 135 юнаків), які згідно із рівнем рухової активності були розподілені на 3 групи порівняння. До їх складу відповідно були залучені особи з високим (1 група рухової активності: 50 дівчат та 45 юнаків), середнім (2 група рухової активності: 50 дівчат та 45 юнаків) та низьким (3 група рухової активності: 50 дівчат та 45 юнаків) рівнем рухової активності. Як критеріальні показники рухової активності слід було відзначити показники добових енерговитрат, що оцінювались згідно із хронометражно-табличним методом – до 9000 кДж (рівень рухової активності низький), 9000-11000 кДж (рівень рухової активності середній), понад 11000 кДж (рівень рухової активності високий) серед дівчат, та показники рухової активності – до 11000 кДж (рівень рухової активності низький), 11000-13500 кДж (рівень рухової активності середній), понад 13500 кДж (рівень рухової активності високий) серед юнаків. У науковій роботі використовувались медико-соціологічні, епідеміологічні, психофізіологічні, психолого-педагогічні та статистичні методи. В ході проведених досліджень на підставі застосування процедур кластерного і факторного аналізу визначені особливості взаємозв'язків між характеристиками функціонального стану та рівня розвитку психофізіологічних функцій і, отже, провідними характеристиками психофізіологічної адаптації та критеріальними показниками рухової активності сучасних студентів. Дані використання процедур кластерного аналізу визначали, що на провідні характеристики стану здоров'я та навчальної успішності найбільш суттєвий вплив справляли 3 провідних кластери характеристик психофізіологічної адаптації організму студентів, а саме: зорово-моторний швидкісний, зорово-сенсорний та інтегративно-координаційний кластери. Разом з тим за результатами застосування процедур факторного аналізу встановлено, що найбільш позитивний вплив на функціональний стан організму дівчат і юнаків справляв руховий режим, властивий для студенток і студентів, значення добових енерговитрат яких коливаються у межах від 9000-11000 кДж та у межах 11000-13500 кДж.

**Ключові слова:** взаємозв'язки, кластерний аналіз, навчання, прогностичне значення, психофізіологічна адаптація, рухова активність, стан здоров'я, студенти, факторний статистичний аналіз.



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