Journal of Physical Education and Sport ® (JPES), Vol. 24 (issue 9), Art 239, pp. 1147 - 1158, September 2024
online ISSN: 2247 - 806X; p-ISSN: 2247 – 8051; ISSN - L = 2247 - 8051 © JPES

Original Article

General regression modeling of the impact of physical activity on stress-related states in higher education students during military conflict

NATALIIA BYSHEVETS[1], OLENA ANDRIEIEVA[2], NATALIIA GONCHAROVA[3], OKSANA SHYNKARUK[4], ANNA HAKMAN[5], VITALII USUCHENKO[6], IHOR SYNIHOVETS[7]
[1,2,3,4,6,] National University of Ukraine on Physical Education and Sport, Kyiv, UKRAINE
[5] Yuriy Fedkovych Chernivtsi National University, Chernivtsi, UKRAINE
[7] Chernihiv Polytechnic National University, Chernihiv, UKRAINE

Published online: September 30, 2024
Accepted for publication: September 15, 2024
DOI:10.7752/jpes.2024.09239

Abstract
Understanding the factors influencing stress-related states in higher education students during military conflict is crucial for developing interventions to mitigate stress in young people. Purpose: This study aimed to identify significant factors related to the impact of physical activity on stress-related states in Ukrainian university students and to analyze the relationships between these factors. Materials and methods: Sociological and psychodiagnostic approaches, along with statistical analysis, were applied. The study included 1,901 students from Ukraine. Results: Using general regression modeling (GRM), the study identified relationships between stress-related states, psychophysiological indicators, and various factors such as gender, lifestyle, physical activity (PA), bad habits, and the use of sedatives. Statistically significant ($p<0.05$) models were built that can predict the number of stress-associated conditions based on mood and well-being scores (Model 1) and on the presence of bad habits, use of sedatives, PA, and active lifestyle depending on gender (Model 4); the total score of students' psychophysiological indicators based on the presence of stress-related states (Model 2) and on the basis of data on gender, bad habits, use of sedatives, PA, and active lifestyle (Model 3). It was proved that an active lifestyle and systematic PA partially affect the psychophysiological indicators of students. According to Model 3, a sedentary lifestyle leads to a decrease in the total score of the indicators by 5.8% from 21.16 to 19.94 points. Moreover, a sedentary lifestyle combined with the absence of regular PA causes a decrease in this parameter by 8.5% to 19.36 points. And, according to Model 4, the predicted number of stress-related states increases by 7.8% due to a sedentary lifestyle. Furthermore, students with bad habits can be predicted to have the highest number of stress-related states, especially in the absence of regular physical activity. Conclusions. The developed GRM-models can predict: the number of stress-related states based on the assessment of well-being and mood; the total score of psychophysiological indicators based on the presence of stress-related states and taking into account the gender of students; the probability of stress-related states in this population group. Furthermore, we obtained new information about the factors that affect the stress-related states in higher education students under military conflict conditions.
Keywords: lifestyle, physical exercise, model, stress, young people

Introduction.

In recent years, Ukraine has faced unprecedented challenges related to the armed conflict on its territory. This conflict has had significant negative consequences for all layers of the population, including higher education students. Ukrainian students find themselves in a particularly difficult situation. On the one hand, they continue their studies, acquiring the knowledge and skills they need for their future lives. On the other hand, they are constantly faced with the impact of stressful events related to the armed conflict. Against the backdrop of prolonged exposure to military stressor, which is one of the most powerful stressors, researchers have initiated a broad discussion of issues related to the study of factors that exacerbate stress-related states or contribute to their prevention in the studied population. A number of published data (Kozina et al, 2024; Herbert et al, 2020; Hartmann et al, 2023; Liu et al, 2022; Petrachkov et al, 2023) and our previous studies (Andrieieva et al, 2022, 2024; Byshevets et al, 2023, 2024b; Hakman et al, 2019, 2020) suggest that an active lifestyle and systematic physical activity (PA) are factors that can mitigate the impact of this factor. However, preliminary results of our research show that bad habits and the use of sedatives can be not only behavioral consequences of stressful events (loss of relatives or friends, injury, forced emigration, etc.), but also the factors that can exacerbate their influence (Ketata et al, 2021).

The study showed (Liu et al, 2022; Lou et al, 2023; Herbert et al, 2020; Volken et al, 2021) that the mental health of higher education students remains in the focus of attention of the global scientific community. The data presented in the literature indicate a significant spread of stress-related states such as depression, anxiety, and stress among students in response to the impact of increased stressors. The identification of

Corresponding Author: OLENA ANDRIEIEVA E-mail: olena.andreeva@gmail.com

psychologically vulnerable groups of students opens the prospects for the development and implementation of preventive measures aimed at preventing stress-related states in them. Therefore, researchers are faced with questions about the determinants of depression, anxiety, and stress and the way to quickly identify students at risk of developing these states based on general assessment data (Bichler et al, 2022; Lindegård et al, 2019). By studying the impact of stressful events that occur in US university students during postgraduate education, N. Ketata et al (2021) recorded severe or extremely severe depression, anxiety, and stress in 29.1%, 43.7%, and 18.2% of study participants, respectively. The authors demonstrated that bad habits (smoking) are a factor that exacerbates depression and anxiety, while chronic diseases increase the risk of developing stress, depression, and anxiety. During the COVID-19 outbreak, the prevalence of stress-related states among university students increased. For example, 32.1%, 27.4%, and 26.0 % of university students in Bangladesh showed high and very high levels of depression, anxiety, and stress, respectively (Rahman et al, 2022). Using linear regression models, M. M. Rahman et al (2022) investigated the relationships among demographic profile, academic profile, socio-academic status, university support, and students' scores of depression, anxiety, and stress and concluded that social satisfaction, mental health problems, and safety of the place of residence affect students' stress-related states.

Without questioning the negative impact of such stressors as higher education, exams, defending qualification works, etc. faced by university students, or quarantine restrictions and fears for their health and the health of their relatives during the pandemic, it is worth pointing out that military stressor can be considered one of the most threatening (Luo et al, 2022). Its detrimental impact on the mental health of the general population and students in particular is difficult to overestimate. According to I.C.Z.Y. Lim et al (2021), the pooled prevalence of depression and anxiety during active hostilities in the country was 38.7% and 43.4%, respectively.

Even the fear of war, which has been exacerbated in the world due to the Russian-Ukrainian conflict and the escalation of the conflict in the Middle East, affects the mental health of young people in communities that are not directly involved in the war. G.M. Regnoli et al (2024) provides evidence that fear of war increases levels of fear of the future and the unknown, which increases stress, anxiety, and depression among Italian young adults aged 18-30 years. To predict anxiety and depression on the basis of such predictors as age, gender, Fear of War Scale (FOWARS), Dark Future Scale (DFS), and Intolerance of Uncertainty scale (IUS-12), the researcher built multiple regressions that explain 31% to 38% of the variance in the data. Moreover, the fear of war proved to be the most significant predictor for anxiety and depression among Italian young adults.

The results of scientific research reported by A. Abudayya et al (2023) were useful for our study. Through the study of the effects of traumatic reactions related to the war, the determinants of traumatic stress in young people living in the Gaza Strip were identified: exposure to violence and destruction, loss of family members and friends aggravate mental health problems, while stress resilience and the use of constructive ways to cope with stress help mitigate the negative impact. Studying the impact of the Russian-Ukrainian war on the populations of Poland, Ukraine and Taiwan, A. Chudzicka-Czupała et al (2022) found that female gender, Ukrainian and Polish citizenship, self-assessment of health status, a psychiatric history, and avoidance of difficulties are the risk factors for increased stress, anxiety, and depression, as well as post-traumatic stress disorder.

According to O. Kokun, O. Bezverkhyi (2024), the factors that mitigate the impact of military stressor on the mental health of Ukrainian higher education students are emotional stability and stress resistance. Furthermore, based on regression modelling data, M. Palace et al (2023) developed a model that explains 20.4% of the variance in the data and found that the strongest predictors of depression among young civilian Ukrainians are loneliness, stress resistance, and female gender. However, despite his assumption, social and family support did not prove to be a significant factor in reducing the likelihood of developing post-traumatic stress and depression, which may be due to the exchange of negative experiences of the ongoing war. In addition, the author provides evidence of the negative impact of stressful situations experienced during the war on the mental health of young people. Despite the existence of some studies that examine the impact of military stressor on Ukrainian students (Kokun et al, 2024; Pavlova et al, 2023), modelling the factors influencing the stress-related states in Ukrainian higher education students under military conflict conditions remains an unexplored issue that needs to be addressed.

Materials and methods

Study participants

The sample used to test the hypotheses regarding the peculiarities of the impact of military stressor on higher education students depending on their PA included students from different regions of Ukraine (Kyiv, Chernihiv, Uzhhorod, Kryvyi Rih, and Zaporizhzhia). It should be noted that students from the southern and eastern regions were involved in the study to a limited extent due to objective reasons, such as active hostilities in the region or occupation of the region. On the other hand, Kryvyi Rih and Zaporizhzhia are located in the eastern region closer to its western part, so they can be considered as the transition zone between the east and the center. The inclusion criteria were studying at a Ukrainian higher education institution, being in Ukraine at the beginning of the armed conflict on its territory, and agreeing to participate in the study. Thus, the statistical sample contained data on 1901 higher education students of age 21 (18; 21) years (where age is represented as the

median Me and 25 and 75 quartiles) from the western and central regions of Ukraine. According to the State Statistics Service of Ukraine (https://www.ukrstat.gov.ua), as of the beginning of the academic year 2023-2024, the total number of students in these regions was 799726, while the overall number of students in Ukraine was 1148658. Of these, 47.8% were female students. The calculations showed that the minimum sample size for male and female students with an accuracy of 95% and a margin of error of 3.5% is 783 students in each group. Our study involved 824 male and 1077 female students from different forms of education. Thus, the results of this study are representative for students from different forms of education at universities in the central and western regions of Ukraine, depending on their gender. The sampling error did not exceed 3.5%.

Organization of the study

The study used the questionnaire "Reaction of Ukrainian students to the hostilities in the country" that was developed using Google Forms at the National University of Ukraine on Physical Education and Sport. The answers to three blocks of questions were analyzed as follows: psychophysiological indicators (activity, mood, sleep, appetite, working capacity, and well-being; measured using 5-point Likert scale from 1 (very poor) to 5 (very good)); stress-related state (mood fluctuations, anxiety, depression, and aggressiveness; measured using categorical scale: 1 – Yes, 0 – No); factors that can enhance or mitigate the impact of military stressor (gender, measured using categorical scale: 1 – male, 0 – female; bad habits, use of sedatives, PA, and active lifestyle, measured using categorical scale: 1 – Yes, 0 – No). In this study, a general assessment of psychophysiological indicators was used and its Cronbach's alpha was 0.822.

Statistical analysis

In this study, the General Regression Model (GRM) was used to analyze the influence of factors coded as binary and quantitative variables on the total score of students' psychophysiological indicators. This method was chosen because of its ability to handle different types of data and to account for complex interactions between predictors. GRM allows to accurately assess the influence of each factor, which is key to identifying significant determinants of students' psychophysiological states. In addition, this method enables to adjust for covariates, which ensures more accurate and reliable analysis results. The best subset method was used for the development of GRM models, as it allows identifying and including only those predictors that make a significant contribution to the explanation of the dependent variable. This improves the interpretability and predictive accuracy of the model and reduces the risk of overfitting. The use of information criteria such as AIC and BIC ensures a balance between complexity and quality of fit of models. Furthermore, importantly, models with fewer predictors are easier to implement in practice, which saves resources and increases their use in solving real-world and practice-oriented problems. The model parameters were calculated using the sigma-restricted parameterization method, which allows for categorical predictors to be included in the model and provides correct statistical conclusions. In the case when not all predictors in the model were binary variables (a special case of categorical predictors with two possible values) or predictors were measured on different scales, in addition to unweighted regression coefficients, the paper presents standardized regression coefficients that allow to interpret the relative influence of each predictor in the model on the dependent variable. They show how many standard deviations the dependent variable will change for a one standard deviation change of predictor. In the case of binary predictors, the use of non-standardized coefficients is reasonable and preferable. At different stages, a dataset of 1901 observations was used to build the models. GRM models were built to analyze the relationship between the dependent and independent variables and to identify the variables that have the greatest impact on it. Model 1: the dependent variable was the number of stress-related states (mood swings, anxiety, depression, and aggressiveness) ranged from 0 to 4 points; ordinal scale was used for measurement; and data type was integer); the independent variable were psychophysiological indicators (activity, mood, sleep, appetite, working capacity, and well-being); ordinal scale was used for measurement; and data type was integer. Model 2: the dependent variable was total score of psychophysiological indicators ranged from 6 to 30 points, measured with continuous scale, and data type was integer; the independent variables were mood fluctuations, anxiety, depression, and aggressiveness coded as: 1 – Yes and 0 – No; and gender was coded as: 1 – male and 0 – female. Model 3: the dependent variable was the total score of psychophysiological indicators ranged from 6 to 30 points; independent variables included categorical variables such as gender, use of sedatives; bad habits, PA, and active lifestyle coded as: 1 – Yes; 0 – No; and gender coded as: 1 – male and 0 – female; and ordinal variables such as the number of stress-related states ranged from 0 to 4. Model 4: the dependent variable was the number of stress-related states (mood swings, anxiety, depression, and aggression) ranged from 0 to 4, measured with ordinal scale, and data type was integer; the independent variables were gender, use of sedatives, bad habits, PA, and active lifestyle coded as: 1 – Yes and 0 – No; and gender was coded as: 1 – male and 0 – female. For a comprehensive assessment of the quality of the models, the residuals were analyzed using Mean Absolute Error (MAE) (shows how much the forecasts deviate from the actual data on average; the lower the MAE value, the better the model) and Root Mean Squared Error (RMSE) (shows how large the model errors are on average; the lower the RMSE value, the better the model). Coefficient of Determination (R^2) was calculated, which shows how much of the total variance in the data is explained by the model (ranged from 0 to 1; the higher the R^2 value, the better the model explains the data). F-statistic was used to test the statistical significance of the model and p-value was calculated to assess the probability that the calculated F-statistic value could have occurred by chance.

Results

Under war conditions, a significant proportion of students are characterized by stress-related states such as anxiety (56.5%), mood swings (53.3%), depression (38.9%), and aggression (22.7%). Nevertheless, only 22.5% of respondents stated that they did not have any stress-related states, while 54.2% of students had a combination of at least two stress-related states. The number of stress-related states among Ukrainian students is statistically significantly ($p<0.05$) related to their well-being and mood. The Pareto chart of the absolute t-values for the regression coefficients allowed us to create a visual representation of the most significant regression coefficients and assess their statistical significance at the level of 0.05, where the vertical line represents the specified threshold.

In the course of model development, its parameters were estimated, and the results of the estimation are presented in the table (Table 1).

Table 1 – Estimation of the parameters of the model of influence of psychophysiological indicators on stress-related states in students

Regression indicators	Regression coefficients and their estimates (Model 1)					
	α	S(α)	t	p	CI	
					-95%	+95%
Intercept	3.78	0.11	33.250	<0.05	3.56	4.01
Activity	0.02	0.03	0.539	0.5897	-0.04	0.07
Sleep	-0.03	0.03	-1.165	0.2442	-0.08	0.02
Mood	-0.28	0.04	-7.680	<0.05	-0.36	-0.21
Appetite	0.03	0.03	1.020	0.3078	-0.03	0.08
Working capacity	-0.04	0.03	-1.320	0.1869	-0.10	0.02
Well-being	-0.33	0.04	-9.460	<0.05	-0.40	-0.27

Note: S(α) is the standard deviation of the regression coefficients and its standardized coefficients; t is a Student's test score; p-value is the achieved significance level; 95% CI is the confidence interval at the significance level of 0.05

To simplify the perception of the model, we omitted variables whose coefficients were not statistically significant ($p>0.05$). A model was obtained ($R^2 = 0.221$; $F=90.935$; $p<0.05$) that demonstrates the relationship between the number of stress-related states and their psychophysiological indicators in students:

$$y = 3.78 - 0.28 \cdot Mood - 0.33 \cdot Well - being \quad (1),$$

where y is the number of stress-related states

Negative values of the model parameters indicate an increase in the number of stress-related states in students along with a decrease in the scores of their psychophysiological indicators. The coefficient of -0.28 for mood indicates that a decrease in mood score by 1 point is accompanied with a decrease in the number of stress-related states by 0.28.

The coefficient of -0.33 for well-being indicates that a decrease in well-being score by 1 point is accompanied with a decrease in the number of stress-related states by 0.33. According to the modelling results, in the worst case, when a student's well-being and mood are rated at 1 point, he or she is likely to have a combination of three stress-related states ($y = 3.78 - 0.28 - 0.33 = 3.15 \approx 3$). Improvement of well-being and mood up to 3 points allows us to predict that student will have from 1 to 2 stress-related states ($y = 3.76 - 0.28 \cdot 3 - 0.33 \cdot 3 = 1.96 \approx 2$), and in case of excellent health and mood the student will have from 0 to 1 stress-related states ($y = 3.76 - 0.28 \cdot 5 - 0.33 \cdot 5 = 0.71 \approx 1$). Thus, it should be noted that the frequency of the combination of stress-related states and psychophysiological indicators of students are interdependent: an increase in the number of stress-related states is accompanied by a decrease in the total score of psychophysiological indicators.

The decrease in the psychophysiological indicators was found to be caused by depression and anxiety. A statistically significant ($p<0.05$) GRM model of the impact of stress-related states on the total score of psychophysiological indicators of higher education students was developed. In the developed model, all the studied stress-related states, as well as the combination of mood fluctuations, anxiety, and gender, were found to be statistically significant ($p<0.05$) parameters. The most significant predictor for predicting the total score of psychophysiological indicators of higher education students is depression: its absence leads to an increase in the indicator by 1.20 points (Table 2).

Table 2 – Estimation of the parameters of the model of the impact of stress-related states on the total score of psychophysiological indicators in students

Regression indicators	Regression coefficients and their estimates (Model 2)					
	α	S(α)	t	p	CI	
					-95%	+95%
Intercept	19.71	0.12	158.351	<0.05	19.46	19.95
Mood swings (MS)	0.73	0.11	6.440	<0.05	0.51	0.96
Depression (D)	1.20	0.11	10.486	<0.05	0.98	1.43
Anxiety (Anx)	0.78	0.11	7.066	<0.05	0.56	1.00
Aggressiveness (Aggr)	0.47	0.13	3.692	<0.05	0.22	0.72
Gender (G)						
1*3*5	0.28	0.11	2.615	0.009	0.07	0.50

Note: S(α) is the standard deviation of the regression coefficients and its standardized coefficients; t is a Student's test score to assess the significance of the coefficient; p-value is the achieved significance level; 95% CI is the confidence interval

Using the developed model, the total score of students' psychophysiological indicators (y) can be calculated using the analytical expression:

$$y = 19.71 + 0.73 \cdot MS(0) + 1.20 \cdot D(0) + 0.78 \cdot Anx(0) + 0.47 \cdot Aggr(0) + +0.28 \cdot 1 * 3 * 5(1) \quad (2)$$

It should be noted that the numbers in brackets in the analytical expression refer to the presence (1) or absence (0) of a stress-related state or their combination. For example, the coefficient of 0.73 refers to the case when "Mood swings" is 0 (this stress-related state is absent), and 0.28 indicate the case when the listed factors such as mood swings, anxiety, and male gender are present. Interpretation of the obtained equation shows that the average score of psychophysiological indicators of higher education students is 19.71 points. The maximum positive impact on the total score of these indicators is made by the absence of depression: in this case, the score will increase by 1.20 points, i.e. by 6.1% and will be 20.91 points. According to the model, in the absence of stress-related states, the total score of a student's psychophysiological indicators can be expected to increase by 16.1% to 22.89 points (from 22 to 23 points). In the case of a male student, even with a combination of mood swings and anxiety, his score is expected to increase from the average by 1.4% (to 19.99 points).

An in-depth analysis of the interaction of factors influencing the total score of psychophysiological indicators showed that the highest score was demonstrated by students who do not have mood swings and anxiety, and the lowest score was found for students with these stress-related states. Moreover, regardless of gender, the absence of mood swings has a positive effect on the total score of psychophysiological indicators in higher education students. Anxiety has a more significant effect on female students, while mood swings have a greater impact on male students (Fig. 1).

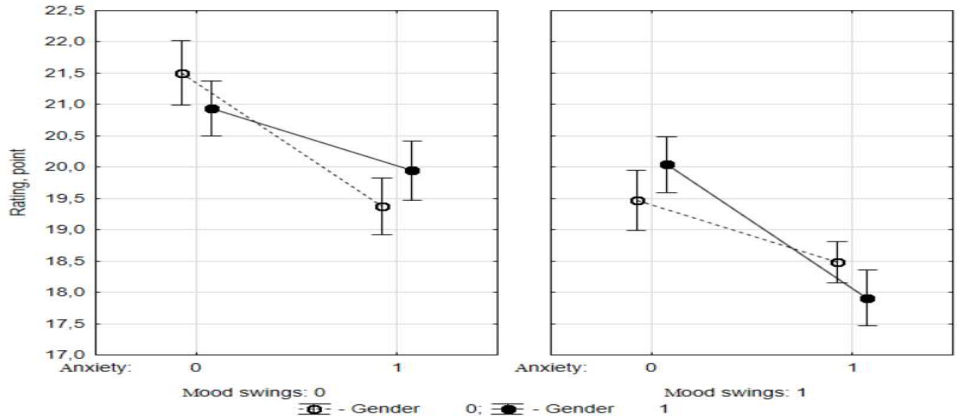

Figure 1 – Analysis of the interaction of the factors Mood swings*Anxiety*Gender (F(1, 1895)=6.838, p=0.0090; n=1901), where vertical columns are equal to 0.95 confidence intervals

When developing a model with predictors that determine positive ("Physical activity" and "Active lifestyle") and negative ("Number of stress-relates states", "Bad habits", "Use of sedatives") factors of influence on students' psychophysiological indicators, it was found that the rating of the most significant factors is headed

by the number of stress-related states. Next in descending order are such factors as active lifestyle, use of sedatives, systematic PA, bad habits, and the interaction of the factors Gender*Bad habits*Physical activity*Active lifestyle.

According to Model 3, the expected average score of psychophysiological indicators of higher education students was found to be 21.16 points. The coefficient -1.22, which refers to the factor "Active lifestyle", shows that a sedentary lifestyle has an adverse effect on the total score of students' psychophysiological indicators, which in this case is predicted to be 19.94 points. However, the most threatening factor is the number of stress-related states: an increase in the index by 1 results in a decrease in the total score of students' psychophysiological indicators by 1.03 points. A comparison of the standardized regression coefficients demonstrate that the number of stress-related states reduces the score by 0.28, while a sedentary lifestyle decrease it by 0.25 standardized units. In contrast, the positive factors that lead to an increase in the indicator are the absence of bad habits and cessation of sedatives: in these cases, the total score of students' psychophysiological indicators increases by 0.79 and 0.55 points, respectively (Table 3).

Table 3 – Estimation of the parameters of the model of the impact of different factors on the total score of students' psychophysiological indicators

Regression indicators	Regression coefficients and their estimates (Model 3)						Standardized coefficients			
	α	S(α)	t	p	CI		β	S(β)	CI	
					-95%	+95%			-95%	+95%
Intercept	21.16	0.21	101.620	<0.05	20.75	21.57				
Number of stressful conditions (NS)	-1.03	0.08	-12.762	<0.05	-1.19	-0.87	-0.28	0.02	-0.32	-0.23
Gender (G)										
Use of sedatives (Sed)	0.79	0.11	6.901	<0.05	0.57	1.02	0.14	0.02	0.10	0.18
Bad habits (Bh)	0.55	0.11	4.883	<0.05	0.33	0.76	0.10	0.02	0.06	0.14
Physical activity (PA)	-0.58	0.10	-5.688	<0.05	-0.79	-0.38	-0.11	0.02	-0.15	-0.08
Active lifestyle (AcL)	-1.22	0.10	-12.210	<0.05	-1.41	-1.02	-0.25	0.02	-0.29	-0.21
1*3*4*5	-0.22	0.09	-2.397	0.0166	-0.40	-0.04	-0.05	0.02	-0.08	-0.01

Note: S(α) is regression coefficients, S(α) is the standard deviation of the regression coefficients and its standardized coefficients; t is a Student's test score to assess the significance of the coefficient; p-value is the achieved significance level; 95% CI is the confidence interval

$$y = 21.16 - 1.03 \cdot NS + 0.79 \cdot Sed(0) + 0.55 \cdot Bh(0) - 0.58 \cdot PA(0) - 1.22 \cdot AcL(0) - 0.22 \cdot 1 * 3 * 4 * 5(1) \quad (3)$$

Gender affects the total score of students' psychophysiological indicators only in interaction with other factors. According to the model, even in the presence of bad habits, physical activity, an active lifestyle, and male gender increase the average score to 21.38 points (by only 0.22 points). With a sedentary lifestyle and the absence of systematic PA, the scores of male and female students are equally low (from 16.5 to 17.5 points). However, this situation has a more pronounced negative impact on students. Conversely, if higher education students lead an active lifestyle and systematically engage in PA, they, especially male students, demonstrate the highest scores of psychophysiological indicators. In contrast, the absence of systematic PA combined with active lifestyle is accompanied by a decrease in psychophysiological indicators, mostly among female students (Fig. 2).

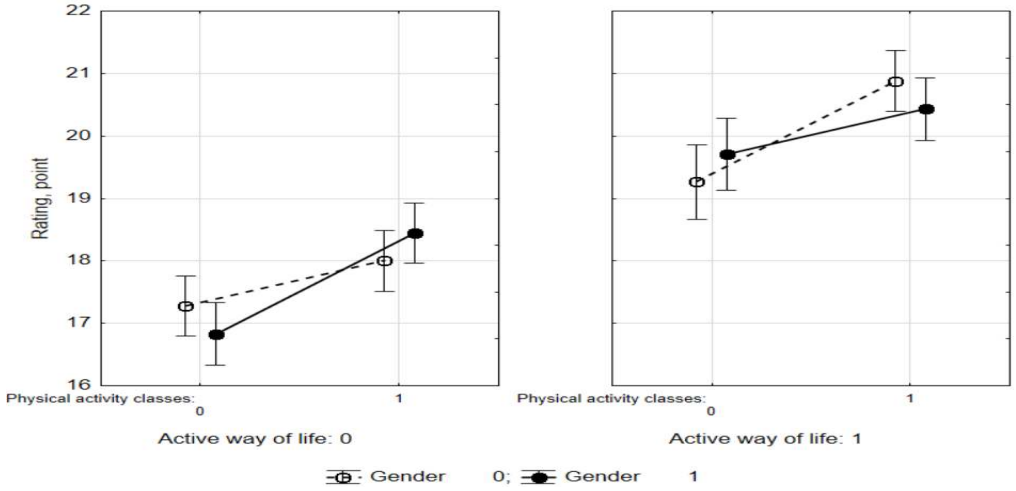

Figure 2 – Influence of active lifestyle and regular PA on the total score of students' psychophysiological indicators depending on gender, where the current effect F(1, 1894) = 5.745; p = 0.0166

Further analysis of the relationships between the factors showed that higher education students of both genders, who lead an active lifestyle, have a significantly higher score of psychophysiological indicators.

Moreover, with a sedentary lifestyle, the presence of bad habits is especially threatened for female students (their average score is 18 points against 18.5 for male students), while with an active lifestyle, it is threatened for male students (20.5 points for male students against 21 points for female students) (Fig. 3).

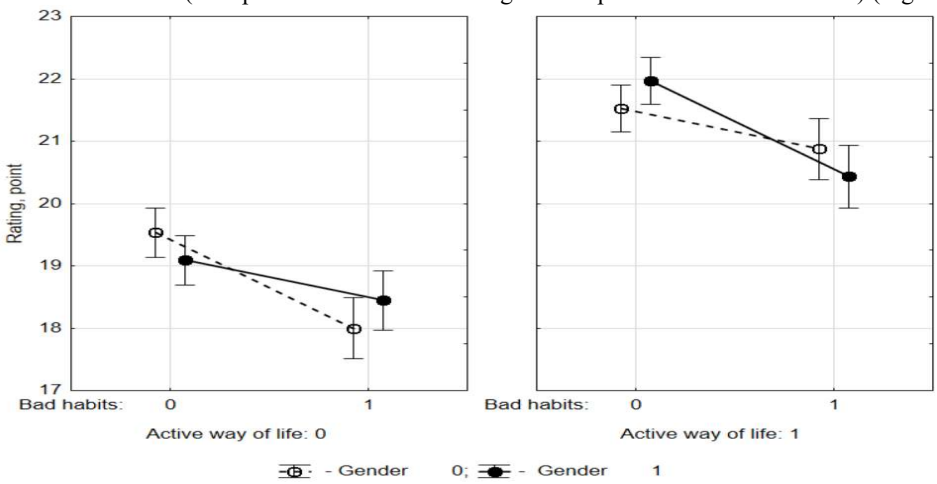

Figure 3 – Influence of active lifestyle and bad habits on the total score of students' psychophysiological indicators depending on gender, where the current effect F(1, 1894) = 5.745; p = 0.0166

It should be noted that the factor "PA" interacts with the factors "Bad habits" and "Gender" and has an impact on the total score of psychophysiological indicators in higher education students similar to the factor "Active lifestyle". In particular, the maximum score was achieved by students without bad habits who were systematically engaged in PA (22 points for males versus 21.5 points for females), and the minimum score was demonstrated by students who had bad habits and did not engage in PA (19.3 points for females versus 19.7 points for males) (Fig. 4).

Regarding the relationship between the factors "PA" and "Active lifestyle", bad habits increase the negative factors expressed by their absence (Fig. 5).

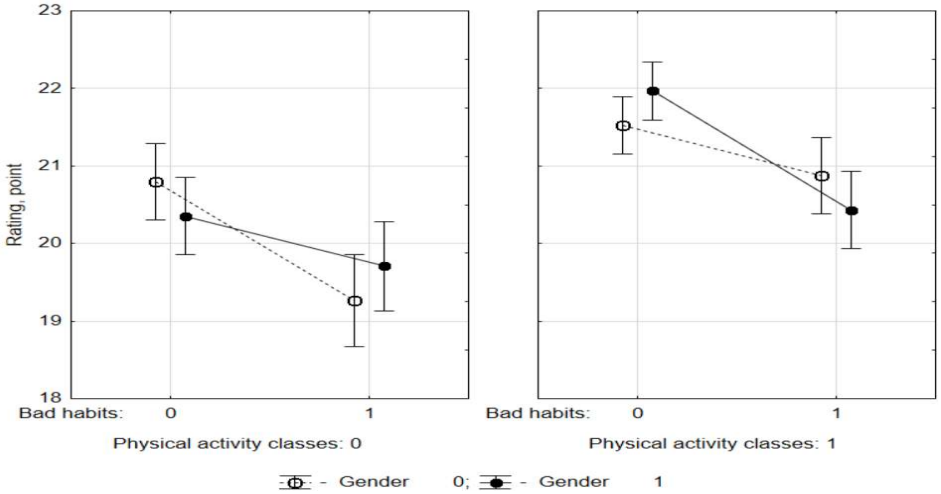

Figure 4 – Influence of regular PA and bad habits on the total score of students' psychophysiological indicators depending on gender, where the current effect F(1, 1894) = 5.745; p = 0.0166

On the other hand, an active lifestyle compensates for bad habits to a certain extent: the total score of psychophysiological indicators of higher education students with active lifestyle is higher than that of those with a sedentary lifestyle. It should be emphasized that giving up bad habits has the maximum effect on students who are systematically engaged in PA and have an active lifestyle.

Based on the Pareto map of absolute t-values for the regression coefficients, it can be argued that Model 4 allows predicting the number of stress-related states depending on the identified factors, primarily using the factor "Gender". The analysis of the parameters of the model of the influence of different factors on the number of stress-related states in students showed that gender, use of sedatives and bad habits are the most significant ones in predicting the number of stress-related states.

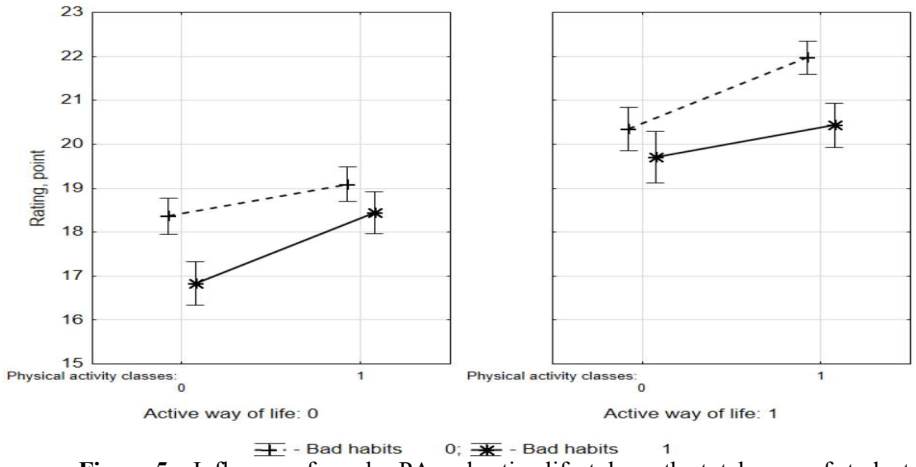

Figure 5 – Influence of regular PA and active lifestyle on the total score of students' psychophysiological indicators depending on bad habits, where the current effect F(1, 1894) = 5.745; p = 0.0166

Furthermore, the factor of regular PA affects this indicator only in interaction with other factors, such as gender and bad habits (Table 4).

Table 4 – Analysis of the parameters of the model of the influence of different factors on the number of stress-related states in students

Regression indicators	Regression coefficients and their estimates (Model 4)					
	α	S(α)	t	p	CI	
					-95%	+95%
Intercept	1.98	0.03	60.472	<0.05	1.92	2.05
Gender (G)	0.37	0.03	13.735	<0.05	0.32	0.43
Use of sedatives (Sed)	-0.35	0.03	-11.176	<0.05	-0.41	-0.28
Bad habits (Bh)	-0.34	0.03	-11.597	<0.05	-0.40	-0.29
Physical activity (PA)						
Active lifestyle (AcL)	0.15	0.03	5.895	<0.05	0.10	0.20
1*3*4	0.10	0.03	3.983	0.0001	0.05	0.15

Model 4 is described by the following analytical expression:

$$y = 1.98 + 0.37 \cdot G(0) - 0.35 \cdot Sed(0) - 0.34 \cdot Bh(0) + 0.15 \cdot AcL(0) + 0.10 \cdot 1*3*4(1) \quad (4)$$

The interpretation of the model shows that on average, higher education students have two stress-related states (1.98≈2); and female gender and a sedentary lifestyle increase the risk of combining stress-related states by 0.52. In contrast, cessation of bad habits and taking sedatives predictably reduces the number of stress-related states by 0.69. In other words, at best, a male student who does not use sedatives and gives up bad habits is expected to have one $(1.98 - 0.35 - 0.34 = 1.29 \approx 1)$ stress-related state, and at worst, a female student who uses sedatives, has bad habits and leads a sedentary lifestyle will have 2 to 3 stress-related states $(1.98 + 0.37 + 0.15 = 2.5)$. A visual analysis of the interacting factors showed that, regardless of regular PA, the number of simultaneously manifested stress-related states in female students is higher than in male students. The absence of bad habits reduces this indicator, especially among male students. However, female students with bad habits can be predicted to have the highest number of stress-related states, especially in the absence of PA (Fig. 6).

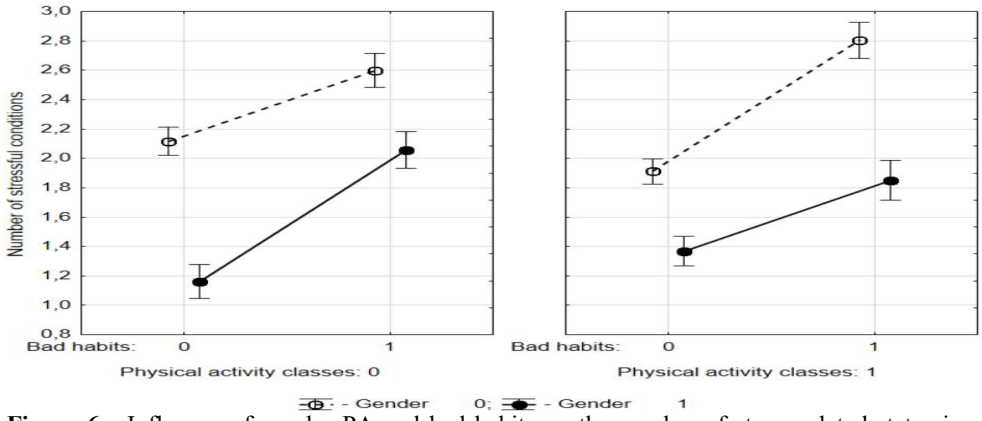

Figure 6 - Influence of regular PA and bad habits on the number of stress-related states in students, where the current effect is F(1, 1895) = 15.866, p = 0.0001

A comprehensive analysis of the quality of the models showed that, according to the F-statistic, all the developed models are statistically significant ($p<0.05$). However, higher proportions of the data variance indicate that models 3 and 4 are better than others (Table 5). It can be argued that Model 4 has better performance than Model 3. Although the coefficients of determination show that Model 3 explains 30.5% and Model 4 27.7% of the variance in the data, the difference is not significant. In contrast, the MAE for Model 3 shows that it deviates from the actual values by 3.157 units on average, while Model 4 deviates only by 0.916 units. Therefore, Model 4 has a significantly lower MAE, meaning that its forecasts are more accurate. The comparison of RMSE also confirmed the initial findings: Model 3 has a mean error of 4.014 and Model 4 has a mean error of 1.097 units, which means that it provides more accurate forecasts.

Table 5 – Comprehensive quality analysis of models

Models	Indicators of model quality			Residuals analysis	
	R^2	F	p	MAE	RMSE
Model 1	0.224	90.935	<0.05	0.938	1.138
Model 2	0.187	86.930	<0.05	3.480	4.344
Model 3	0.305	138.775	<0.05	3.157	4.014
Model 4	0.277	144.956	<0.05	0.916	1.097

It is important to note that the developed models in each case explain small proportion of variance in the dependent variable. Nevertheless, even if our models explain only 18.7-30.5% of the variance, they can still be useful for identifying and explaining the relationships between the characteristics under study and understanding how these relationships affect the dependent variable.

Discussion

The war in Ukraine has posed new challenges to the scientific community dealing with students. How does the war affect the mental and physical state of students? What kind of help do they need from educators? Can regular PA help prevent or mitigate stress-related conditions?

According to numerous researchers (Limone et al, 2022; Liu et al, 2023; Rahman et al, 2022), the impact of stressors causes a significant spread of stress-related states such as anxiety, depression, stress, etc. among students (Donofry et al, 2021). The military stressor is one of the most threatening to the mental health of the population. Furthermore, the negative impact of the armed conflict in Ukraine has gone beyond geographical boundaries and led to an increased fear of war among the population of other countries (Regnoli et al, 2024). The prevalence of anxiety among students in different countries during COVID-19 and the Russian-Ukrainian conflict has been ranging from 13.6% to 88.9%, and prevalence of depression has been ranging from 28.1% to 56.0%. Studies of the dynamics of the prevalence of general depression, anxiety, and stress among higher education students in Ukraine and the European Union during the war show a tendency for depression and anxiety to increase and for stress to stabilize. According to our data, 53.3%, 38.9%, 56.5%, and 22.7 % of Ukrainian university students suffer from mood swings, depression, anxiety, and aggression, respectively. In addition, the authors show that under the influence of military stressor, there is an increase in the use of psychoactive substances (e.g., tobacco, alcohol, painkillers, and sedatives) among higher education students (Kurapov et al, 2023). Our data show that 25.1% and 25.7% of respondents reported using sedatives and increased bad habits. Thus, our results do not contradict the literature data.

In this article, we investigated relationships among stress-related states, psychophysiological indicators, and different factors such as gender, lifestyle, physical activity, bad habits, and sedative use. GRM modelling allowed us to develop statistically significant ($p<0.05$) models that can predict the number of stress-related states based on mood and well-being scores (Model 1) and on the presence of bad habits, sedative use, physical activity, and active lifestyle depending on gender (Model 4); to check the effect of stress-related states (Model 2) and to assess the impact of gender, bad habits, sedative use, physical activity and active lifestyle on psychophysiological indicators in higher education students (Model 3).

The relationships between the factors that influence the psychophysiological indicators of higher education students were investigated. It was found that the most significant predictor for predicting the total score of psychophysiological indicators of higher education students is depression and anxiety. It was found that the key factors influencing the number of stress-related states in higher education students are, on the one hand, gender, use of sedatives, bad habits, and active lifestyle and, on the other hand, mood and well-being. Instead, the number of stress-related states and active lifestyle primarily determine the total score of students' psychophysiological indicators. Model 3 was found to have the highest quality, showing that an active lifestyle has a positive impact on the psychophysiological indicators of higher education students regardless of gender. This indicates that optimal PA can be an effective way to improve the psychophysiological state of both male and female students. It is important to note that the degree of this impact may vary depending on individual characteristics and other factors. In addition, Model 3 demonstrates that bad habits have a negative impact on the psychophysiological indicators of higher education students, especially female students. This indicates that the impact of bad habits can have a different impact on higher education students depending on their gender, and

giving them up helps to improve their psychophysiological state, especially for female students. The established interaction between lifestyle and bad habits is complex. A sedentary lifestyle is associated with a more pronounced negative impact of bad habits on psychophysiological indicators, especially among female students. In contrast, an active lifestyle is associated with a less pronounced negative impact of bad habits and reduced difference in psychophysiological indicators between male and female students. Based on the results of Model 3, it is possible to recommend that higher education students lead an active lifestyle and give up bad habits. This can help them improve their psychophysiological state and reduce the risk of developing stress-related states.

It is important to note that the results presented in this article are consistent with the results of our previous studies and findings of other researchers, according to which female gender and bad habits can increase stress, depression, and anxiety in higher education students, whereas an active lifestyle and systematic physical exercise can counteract the military stressor (Andrieieva et al, 2024; Byshevets et al, 2023, 2024a; Chudzicka-Czupala et al, 2023; Drozdovska et al, 2020; Ketata et al, 2021; Stults-Kolehmainen et al, 2014).

This article has a number of limitations. Firstly, for objective reasons (military conflict in the country, distance learning, etc.), the input data was generated on the basis of self-reports, which can lead to a decrease in data quality. This is because people may have inaccurate memories or try to suppress negative experiences. However, the impact of self-report bias was minimized by ensuring the anonymity of the survey and informing participants that there was no intention to disclose individual data. Secondly, under military conflict conditions, it was not possible to involve students from all regions in the study. Nevertheless, the clustering of the sample of higher education students in our previous studies showed no statistically significant ($p>0.05$) differences between respondents depending on their region of residence (Andrieieva et al, 2024, Byshevets et al, 2023, 2024a). Therefore, the results of this study are representative of higher education students from different forms of education at universities in the central and western regions of Ukraine, depending on their gender. Nowadays, researchers from all over the world use online surveys for studying the state of mental health in students during critical periods (prolonged lockdown, quarantine, socio-economic shocks, fear of uncertainty, or adaptation to new living conditions), which allows us to compare our results with the reported data.

Despite the fact that these limitations may affect the generalization of the results of this study to other groups of students from other regions of Ukraine, it can be argued that the data obtained are of practical value and allow us to outline the prospects for further research.

Conclusions

GRM models were developed that allow predicting: the number of stress-related states based on the assessment of well-being and mood; the total score of psychophysiological indicators based on the presence of stress-related states, taking into account the gender of students; the probability of stress-related states in this population group. Furthermore, we obtained new information about the factors that affect the number of stress-related states in higher education students under military conflict conditions.

It was proved that an active lifestyle and systematic physical activity partially affect the psychophysiological indicators of students. For example, according to Model 3, a sedentary lifestyle leads to a decrease in the total score of the indicators by 5.8% from 21.16 to 19.94 points. Moreover, a sedentary lifestyle combined with the absence of regular PA causes a decrease in the indicator by 8.5% to 19.36 points. And according to Model 4, the predicted number of stress-related states due to a sedentary lifestyle increases by 7.8%. Furthermore, students with bad habits can be predicted to have the highest number of stress-related states, especially in the absence of regular PA.

Prospects for further research. Since the total score of psychophysiological indicators was found to depend on the number of stress-related states in students, as well as on their PA, which in turn partially depends on an active lifestyle, it can be assumed that psychophysiological indicators mediate the impact of PA on the number of stress-related states in higher education students. To investigate the above relationship and to make final conclusions, we plan to conduct a mediator analysis using the Structural Equation Modeling (SEM) module, which provides tools for estimating mediator effects.

Conflict of interest Authors state no conflict of interest.

Funding. The study was carried out in accordance with the applied research carried out of the expenses of the general fund of the state budget of the Ministry of Education and Culture of Ukraine "Reducing stress-related risks in military personnel and youth of Ukraine by means of health-recreational physical activity" (state registration number 0124U000705).

References

Abudayya, A., Geir Tarje Fugleberg Bruaset, Hedda Bøe Nyhus, Aburukba, R, Tofthagen, R. (2023). Consequences of war-related traumatic stress among Palestinian young people in the Gaza Strip: A scoping review. *Mental Health & Prevention*, Vol. 32, December 2023, 200305. https://doi.org/10.1016/j.mhp.2023.200305.

Andrieieva, O., Byshevets, N., Kashuba, V. et al. (2024). Application of mental fitness tools in the prevention of stress-associated conditions of female students of higher education establishments. *Physical rehabilitation and recreational health technologies*, 9, 98–112. https://doi.org/10.15391/prrht.2024-9(3).01.

Andrieieva, O., Maltsev, D., Kashuba, V. et al. (2022). Relationship between quality of life and level of physical activity and family well-being. *Physical Education Theory and Methodology*, 2022, 22(4), c. 569–575

Bichler, C. S., Niedermeier, M., Hüfner, K., Gálffy, M., Sperner-Unterweger, B., & Kopp, M. (2022). Affective Responses to Both Climbing and Nordic Walking Exercise Are Associated With Intermediate-Term Increases in Physical Activity in Patients With Anxiety and Posttraumatic Stress Disorder - A Randomized Longitudinal Controlled Clinical Pilot Trial. *Frontiers in psychiatry*, *13*, 856730. https://doi.org/10.3389/fpsyt.2022.856730

Byshevets, N., Andrieieva, O., Dutchak, M. et al. (2024a). The Influence of Physical Activity on Stress-associated Conditions in Higher Education Students. *Physical Education Theory and Methodology*, 24(2), 245–253. https://doi.org/10.17309/tmfv.2024.2.08

Byshevets, N., Andrieieva, O., Goncharova, N. et al. (2023). Prediction of stress-related conditions in students and their prevention through health-enhancing recreational physical activity. *Journal of Physical Education and Sport*, 23(4), 937–943. https://doi.org/10.7752/jpes.2023.11339.

Byshevets, N., Andrieieva, O., Pasichniak, L. et al. (2024b). Evaluation of emotional disorder risk in students with low physical activity levels under stressful conditions. *Journal of Physical Education and Sport*, 24(4), 894–904. URL: https://doi.org/10.7752/-jpes.2024.04102.

Chudzicka-Czupała, A., Hapon, N., Chiang, S.K. et al. (2023). Depression, anxiety and post-traumatic stress during the 2022 Russo-Ukrainian war, a comparison between populations in Poland, Ukraine, and Taiwan. *Sci Rep*, 3, 13(1), 3602. https://doi.org/10.1038/s41598-023-28729-3.

Donofry, S. D., Stillman, C. M., Hanson, J. L., Sheridan, M., Sun, S., Loucks, E. B., & Erickson, K. I. (2021). Promoting brain health through physical activity among adults exposed to early life adversity: Potential mechanisms and theoretical framework. *Neuroscience and biobehavioral reviews*, *131*, 688–703. https://doi.org/10.1016/j.neubiorev.2021.09.051

Drozdovska, S., Andrieieva, O., Yarmak, O., & Blagii, O. (2020). Personalization of health-promoting fitness programs for young women based on genetic factors. *Journal of Physical Education and Sport*, 20, 331–337. https://doi.org/10.7752/jpes.2020.s1046

Hakman, A., Andrieieva, O., Kashuba, V. et al. (2019). Technology of planning and management of leisure activities for working elderly people with a low level of physical activity. *Journal of Physical Education and Sport*, 19, 2159–2166. https://doi.org/10.7752/jpes.2019.s6324

Hakman, A., Andrieieva, O., Bezverkhnia, H. et al. (2020). Dynamics of the physical fitness and circumference sizes of body parts as a motivation for self-improvement and self-control in students. *Journal of Physical Education and Sport*, 20(1), 116–122. https://doi.org/10.7752/jpes.2020.01015

Hartmann, U., Kleinert, J., Wegner, M., & Pels F. (2023). Presentation and evaluation of the stress lab - A tool to prepare physical education students to handle stressful teaching situations *Journal of Physical Education and Sport*, 23(11), 2903–2916. https://doi.org/ *Journal of Physical Education and Sport*, 23(4), 937–943. https://doi.org/10.7752/jpes.2023.11331.

Herbert, C., Meixner, F., Wiebking, C., & Gilg, V. (2020). Regular Physical Activity, Short-Term Exercise, Mental Health, and Well-Being Among University Students: The Results of an Online and a Laboratory Study. *Frontiers in psychology*, *11*, 509. https://doi.org/10.3389/fpsyg.2020.00509

Ketata, N., Ben Ayed, H, Maamri, H., Yaich, S., Baklouti, M., Feki, H., Damak, J. (2021). What are the determinants of stress, anxiety and depression among university students? *European Journal of Public Health*, Vol. 31(3), October 2021, ckab165.591, https://doi.org/10.1093/eurpub/ckab165.591.

Kokun, O., Bezverkhyi, O. (2024). Ukrainian students' Personal Resources and Resistance to War Stress: A Cross-Sectional Survey. *Journal of Loss and Trauma*, 1–18. https://doi.org/10.1080/15325024.2024.2325084.

Kozina, Z., Berezhna, Y., Boychuk, Y. et al. (2024). Assessment of reaction speed and nervous system characteristics: implications for physical exercise selection in humanities students' physical education. *Journal of Physical Education and Sport*, 24(3), 513–520. https://doi.org/ *Journal of Physical Education and Sport*, 23(4), 937–943. https://doi.org/ 10.7752/jpes.2024.03062.

Kurapov, A., Pavlenko, V., Drozdov et al. (2023) Toward an Understanding of the Russian-Ukrainian War Impact on University Students and Personnel. *Journal of Loss and Trauma*, 28, 2, 167–174, https://doi.org/10.1080/15325024.2022.2084838.

Lim, I.C.Z..Y, Tam, W.W.S., Chudzicka-Czupała, A. et al. (2022). Prevalence of depression, anxiety and post-traumatic stress in war- and conflict-afflicted areas: A meta-analysis. *Front Psychiatry*. 2022 Sep 16, 13, 978703. https://doi.org/10.3389/fpsyt.2022.978703.

Limone, P., Toto, G.A., Messina, G. (2022). Impact of the COVID-19 pandemic and the Russia-Ukraine war on stress and anxiety in students: A systematic review. *Front Psychiatry*. 25, 13, 1081013. https://doi.org/10.3389/fpsyt.2022.1081013.

Lindegård, A., Wastensson, G., Hadzibajramovic, E., & Grimby-Ekman, A. (2019). Longitudinal associations between cardiorespiratory fitness and stress-related exhaustion, depression, anxiety and sleep disturbances. *BMC public health*, *19*(1), 1726. https://doi.org/10.1186/s12889-019-8081-6

Liu, R., Menhas, R., Dai, J., Saqib, Z. A., & Peng, X. (2022). Fitness Apps, Live Streaming Workout Classes, and Virtual Reality Fitness for Physical Activity During the COVID-19 Lockdown: An Empirical Study. *Frontiers in public health*, *10*, 852311. https://doi.org/10.3389/fpubh.2022.852311

Liu, Y., Feng, Q., & Guo, K. (2023). Physical activity and depression of Chinese college students: chain mediating role of rumination and anxiety. *Frontiers in psychology*, *14*, 1190836. https://doi.org/10.3389/fpsyg.2023.1190836

Lou, H., Liu, X., & Liu, P. (2023). Mechanism and implications of pro-nature physical activity in antagonizing psychological stress: the key role of microbial-gut-brain axis. *Frontiers in psychology*, *14*, 1143827. https://doi.org/10.3389/fpsyg.2023.1143827

Luo, Q., Zhang, P., Liu, Y., Ma, X., & Jennings, G. (2022). Intervention of Physical Activity for University Students with Anxiety and Depression during the COVID-19 Pandemic Prevention and Control Period: A Systematic Review and Meta-Analysis. *International journal of environmental research and public health*, *19*(22), 15338. https://doi.org/10.3390/ijerph192215338

Palace, M., Zamazii, O., Terbeck, S. et al. (2023). Mapping the factors behind ongoing war stress in Ukraine-based young civilian adults. *Health and Well-Being*, 20 September 2023, https://doi.org/10.1111/aphw.12493.

Pavlova, Iu., Rogowska, A.M. (2023). Exposure to war, war nightmares, insomnia, and war-related posttraumatic stress disorder: A network analysis among university students during the war in Ukraine. *Journal of Affective Disorders*, 342, 148–156. https://doi.org/10.1016/j.jad.2023.09.003.

Petrachkov, O., Yarmak, O., Shostak, R. et al. (2023). The effect of stress factors on cognitive and management functions of cadets of higher military educational institutions. *Journal of Physical Education and Sport*, 23:162-169, https://doi.org/10.7752/jpes.2023.01020

Rahman, M.M., Asikunnaby, Khan S.J., Arony, A. et al. (2022). Mental Health Condition among University Students of Bangladesh during the Critical COVID-19 Period. *J Clin Med*., 11(15), 4617. https://doi.org/10.3390/jcm11154617.

Regnoli, G.M., Tiano, G., De Rosa, B. (2024). How Is the Fear of War Impacting Italian Young Adults' Mental Health? The Mediating Role of Future Anxiety and Intolerance of Uncertainty. *Eur J Investig Health Psychol Educ*, 26, 14(4), 838–855. https://doi.org/10.3390/ejihpe14040054.

State Statistics Service of Ukraine. URL: https://www.ukrstat.gov.ua.

Stults-Kolehmainen, M.A., Sinha, R. (2014). The effects of stress on physical activity and exercise. *Sports Med*. 44(1), 81–121. https://doi.org/10.1007/s40279-013-0090-5.

Volken, T., Zysset, A., Amendola, S. et al. (2021). Depressive Symptoms in Swiss University Students during the COVID-19 Pandemic and Its Correlates. *International journal of environmental research and public health*, *18*(4), 1458. https://doi.org/10.3390/ijerph18041458