

Prediction of stress-related conditions in students and their prevention through health-enhancing recreational physical activity

NATALIIA BYSHEVETS¹, OLENA ANDRIEIEVA², NATALIIA GONCHAROVA³, ANNA HAKMAN⁴,
IEVGENIIA ZAKHARINA⁵, IHOR SYNIHOVETS⁶, VOLODYMYR ZAITSEV⁷

^{1,2,3} National University of Ukraine on Physical Education and Sport, Kyiv, UKRAINE

⁴ Yuriy Fedkovych Chernivtsi National University, Chernivtsi, UKRAINE

⁵ National University «Zaporizhzhia Polytechnic», Zaporozhye, UKRAINE

^{6,7} Chernihiv Polytechnic National University, Chernihiv, UKRAINE

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Abstract.

Introduction. Persistent negative mental-emotional experiences and the body's responses to stress may have a negative impact on physical condition and mental-emotional status of students and provoke behavioral disorders. Health-enhancing recreational physical activity helps to cope with the negative influence of stress factors. The study was focused on the prediction of stress-related conditions in students and their prevention through health-enhancing recreational physical activity (HRPA). *The aim of the study* was to develop predictive models for assessing stress-related conditions among students and to identify the opportunities for their prevention through engagement in health-enhancing recreational physical activity based on the assessment of the relationship between physical activity and emotional status. **Material & methods.** The study involved 573 higher education students from various regions of Ukraine. The following methods were applied: surveying, statistical analysis using non-linear estimation methods and statistical classification methods based on data mining and machine learning methods, such as neural networks. **Results.** Statistically significant ($p < 0.05$) logistic binary models were developed and scientifically substantiated, which can be used to predict stress-related conditions among higher education students based on data about their HRPA and behavioral characteristics in a long-term stressful situation. According to the survey data, the military conflict on the territory of Ukraine has provoked the emergence of emotional distress in 80.8% of respondents. It was found that regular engagement in HRPA and an active lifestyle allows predicting the maintenance of emotional well-being among students with a probability of 78.0%. **Conclusions.** The behavioral disorders in higher education students combined with lack of HRPA during the period of armed conflict on the territory of Ukraine significantly increase their risk of anxiety, aggressiveness, depressive states, and mood swings as well as lead to deterioration in physical condition and mental-emotional status. An active lifestyle, regular engagement in health-enhancing recreational physical activity, and cessation of bad habits increase students' adaptability to the impact of stress factors.

Keywords: physical activity, stress, status, disorders, behavior, correction, well-being, logit models

Introduction

Today, the population of Ukraine is going through difficult challenges such as quarantine restrictions due to COVID-19, hostilities on the territory of the country, which can trigger stress development. According to the report of the WHO representative in Ukraine, up to 10 million citizens are at risk of mental disorders as a result of the war in the country. During distance learning, higher education students experience significant mental and emotional stress, which can cause them anxiety, threaten sleep and appetite, and increase the risk of using psychoactive substances (Pascoe, 2020). Furthermore, among the consequences of stress, researchers have mentioned a decrease in attention, memory, and thinking ability, which leads to difficulties learning, in particular, and to a decrease in the success of educational activities, in general (Dubchak, 2019). This prompted scientists to study stress issues in higher education students (Filipovych, 2017). Until recently, exam sessions, which lead to a significant increase in mental stress, were considered among the most threatening factors provoking stress in students. According to G. Dubchak (2019), the average level of exam stress among students was 7.25 points on a 10-point scale. The author suggests that this result significantly exceeds the data reported in earlier studies and notes the increase in exam stress among higher education students over the last decade. In recent years, the influence of stressogenic factors has increased significantly, which has diversified the spectrum of persistent negative mental-emotional experiences and body responses to adverse environmental changes among students. These changes include the transformation of the way of life, threats to health and life of a person, caused by actual challenges: crisis situations and circumstances that cannot be influenced, and the solution of which lies beyond our competence (Kovshova et al, 2021; Byshevets et al, 2021, 2022). Quarantine restrictions due to COVID-19 pandemic and armed confrontation on the territory of Ukraine made it impossible

for students to attend classes in educational institutions. Distance learning was introduced in higher education institutions. This was accompanied by the disruption of social ties and the limitation of opportunities to fully engage in physical activity, which became a difficult challenge, thus contributing to a significantly increase of stress in higher education students. Therefore, students may develop stress-related disorders, which may have negative consequences for their health and well-being (Anikhovskaya et al, 2015; Sklyannaya et al, 2017). Modern scientists do not doubt the extraordinary role of health-enhancing recreational physical activity (HRPA) in addressing the issue of coping with stress and mitigating its consequences (Nguyen-Michel, 2006; Andrieieva et al, 2020, 2021). Regular physical activity during leisure causes positive emotions and allows to use physical activity as an effective means of resisting stress in them (Andrieieva et al, 2018; Hakman et al, 2019). Furthermore, scientists draw attention to the fact that stress prevents physical activity and provokes behavioral disorders, such as smoking, drinking alcohol, and using sedatives.

Taking into account the harmful effects of stress and a sedentary lifestyle on the health of students, an important direction of research is the development of programs for the prevention of behavioral, physical, and emotional disorders in higher education students through engagement in health-enhancing recreational physical activity. It is known that physical activity not only contributes to the achievement of emotional well-being, increases the quality of life of a person, allows to maintain and strengthen health, but is also an effective means of overcoming stress, reducing the level of anxiety (Galan et al, 2020, Kashuba et al, 2021) This requires an assessment of the relationship between engagement in physical activity and stress-related disorders in students.

Material & methods

Study participants

The study involved 573 higher education students from various regions of Ukraine. The average age of the subjects was 19.7 ± 2.7 years. Among them, 41.0 % were young males. At the time of the survey, 64.2% of students were on the territory of Ukraine, and 45.5% of them were at the epicenter of hostilities (36.8% were civilians, 7.8% were volunteers, and the remaining 0.9% were servicemen). All respondents were informed about the aim and objectives of the study as well as about how to find the results of the survey, and gave voluntary consent to participate in the study.

Organization of the study

The study was conducted from April 20 to June 20, 2022. To address the objectives set out in this study, the questionnaire "Response of Ukrainian students to hostilities in the country" was developed using Google Forms on the basis of the methods of personality psychodiagnostic testing in crisis situations (Zlyvko, 2016) and distributed through the most popular messenger apps (Viber and Telegram) among high education students. The questionnaire contained 19 questions about age, gender, educational institution, place of stay, characteristics of mental-emotional status and physical condition, behavior, and physical activity. The questions of the questionnaire assumed that the respondents would indicate all the signs of emotional distress they identified from the proposed list. In addition, they rated the level of their usual mental-emotional status and physical condition from 1 to 5 before and after the start of hostilities, where mental-emotional status scores ranged from (1) apathetic and depressed to (5) aggressive and irritated. Physical condition was assessed in the same scoring range, where (1) was very lethargic, frail, and getting tired quickly; and (5) was too active, restless. Based on the analysis of the obtained data, binary variables were defined as: (1) Yes (the signs of emotional distress are identified; deterioration in mental-emotional status and/or physical condition is recorded), or (0) No (no stress-related disorders are observed). The answers to questions about the peculiarities of HRPA and the behavior of students under the conditions of hostilities in Ukraine were coded as follows: (5) Yes; (4) rather Yes; (3) rather No; and (2) No. The answers to questions about the life way were coded in a similar way: (5) active; (4) moderately active; (3) passive; and (2) not conducive to preservation and promotion of health.

Statistical analysis

Reliability and internal consistency of the developed questionnaire were measured using Cronbach's alpha, which was 0.785, and spline reliability, which value was 0.814. Statistical classification methods based on data mining and machine learning methods, such as neural networks, were used to test the hypothesis about the positive effect of HRPA on students' stress tolerance under conditions of hostilities on the territory of Ukraine, in particular, on their emotional well-being (Maroco, 2011; Radakovich, 2020). Based on the Quasi-Newton method and taking into account asymptotic standard errors, a logistic regression was developed, where the binary response variable was assumed to take two possible values: (0) if the student has no signs of emotional distress and (1) if the signs are present. In addition, logit regressions were developed with the following binary variables: the value (0), if the student's mental-emotional status and/or physical condition did not deteriorate during the period of martial law, and (1) in the opposite case. The Pearson's chi-square test was used to test the hypothesis that the obtained regression coefficients were different from zero. The assessment of the accuracy of developed models was carried out using the ROC analysis with the calculation of the area under the ROC curve (AUC). ROC-analysis was performed using Data Mining in the Neural Networks module. Furthermore, the sensitivity and specificity of the models were assessed. The significance level was set to $\alpha = 0.05$ ($p < 0.05$). When p was

less than $1.0 \cdot 10^{-5}$, its value was shown as “ $p < 0.05$ ”, and in other cases it was shown in the standard form. Statistica 10.0 software was used to analyze the raw data.

Results

As a result of the study, we identified stress-related conditions that may be inherent in students due to the impact of hostilities on the territory of Ukraine. These includes the appearance of signs of emotional distress and deterioration in mental-emotional status and/or physical condition. Logistic regressions were developed, the application of which allowed predicting the appearance of stress-related conditions in students depending on the participation in HRP, lifestyle, and addictive behaviors.

The development of logit regressions was preceded by a survey focused on establishing the features of adaptation of higher education students to emotional and informational stress during the period of hostilities on the territory of Ukraine.

The study showed that 37.6% of respondents systematically engaged in physical activity and continued to lead an active lifestyle, 58.6% did not use sedatives, and 58.3% did not develop or increase bad habits. It was found that 80.8% of the respondents recognized signs of emotional distress, 41.5% of them were characterized by deterioration in mental-emotional status, and 51.7% showed deterioration in physical condition. Therefore, the respondents were unevenly distributed by the presence of signs of emotional distress, then, in order to balance them, the sample of students with signs of emotional distress was reduced by constructing a periodic sample with a sampling period of 4. This made it possible to prepare data for logistic analysis (Rumyantsev, 2014; Luchinin, 2022). Logit models were developed that allowed determining the probability of stress-related conditions being detected in students depending on engagement in physical activity under the conditions of hostilities. The parameters of the logit models and assessment of their statistical significance are presented in Table 1.

The developed models and determined coefficients were statistically significant ($p < 0.05$).

Table 1. Parameters of the regression models and assessment of accuracy

Binary variable	Parameters and standard errors of logit regression		Evaluation of model significance (χ^2 ; p -level)	Correct prediction, %	Area under the ROC curve (AUC)
	$b_0 \pm m_{b_0}$; p -level	$b \pm m_b$; p -level			
Deterioration in physical condition ($n_1=304$; $n_2=269$)	-2.034 ± 0.364 ; <0.05	0.484 ± 0.089 ; <0.05	31.431; <0.05	60.56	0.62
Deterioration in mental-emotional status ($n_1=238$; $n_2=335$)	1.079 ± 0.347 ; $1.9 \cdot 10^{-3}$	-0.364 ± 0.087 ; $3.0 \cdot 10^{-5}$	18.157; $2.0 \cdot 10^{-5}$	60.38	0.61
Signs of emotional distress ($n_1=115$; $n_2=110$)	-2.029 ± 0.635 ; $1.6 \cdot 10^{-3}$	0.481 ± 0.150 ; $1.48 \cdot 10^{-3}$	10.981; $9.2 \cdot 10^{-4}$	67.8	0.61

Note: n_1 – the number of students with stress-related conditions; n_2 – the number of students without disorders, which were taken into account in the logit regression

When calculating the corresponding probabilities, p indicates the prediction that corresponds to a smaller number of observations. The analysis of logit models indicates the probability of a decrease in the negative impact of stressful situations on the physical condition and emotional well-being of subjects when engaging in physical activity, but there is a possibility that their mental-emotional status will deteriorate (Table 2).

Table 2. The influence of health-enhancing recreational physical activity on stress-related conditions in students (n=573)

No	Binary variable	Equation of logistic regression	Logit transformation	Δ , %
1	Adaptation of physical condition to stress	$y = -2.034 + 0.484 \cdot X$	$p = \frac{1}{1 + e^{-(-2.034 + 0.484 \cdot X)}}$	33.9
2	Stress-related deterioration in mental-emotional status	$y = 1.079 - 0.365 \cdot X$	$p = \frac{1}{1 + e^{-(-1.079 - 0.365 \cdot X)}}$	26.4
3	Emotional well-being	$y = -2.029 + 0.481 \cdot X$	$p = \frac{1}{1 + e^{-(-2.029 + 0.481 \cdot X)}}$	33.7

Note: y – standard regression equation; $X = \{2, 3, 4, 5\}$ – level of students' engagement in HRP; p – the probability of the predicted event; e – the base of the natural logarithm ($e \approx 2.71$); Δ – a decrease in the probability of the stress-related deterioration in the student's condition for dependent variable 2 and an increase in the probability of adaptation to a stress under the condition of regular engagement in HRP compared to the lack of PA for variables 1, 3

When making a prediction regarding a stress-associated deterioration in student's mental-emotional status, the score of the answer to the question "Do you engage in health-recreational physical activity?" was included in the developed model. If student chooses the answer "Yes", which will correspond to a score of 5, then the appropriate calculations ($p = \frac{1}{1+e^{-(1.079-0.365 \cdot 5)}} \approx 0.322$) with a probability of 32.2% allow us to draw conclusions that the student will have a stress-related deterioration of mental-emotional status. However, when student chooses a negative answer ($p = \frac{1}{1+e^{-(1.079-0.365 \cdot 2)}} \approx 0.586$), the risk of deterioration increases by 26.4% to 58.6%. On the other hand, in contrast to the lack of HRP, regular engagement in HRP increase their chances of not experiencing stress-related disorders and adapting to a stressful situation by 33.9% to 59.5%. Therefore, regular engagement in HRP results in an increase in the probability of maintaining student's emotional well-being from 25.6 to 59.3%. The analysis carried out in a similar way made it possible to develop and prove the statistical significance of both multiple logit regressions and their coefficients ($p < 0.05$). Furthermore, the addition of variables characterizing students' lifestyles and/or signs of destructive behaviors to the model significantly improved the accuracy of the developed models (Fig. 1).

For instance, the value of AUC, which characterizes the accuracy of the model for predicting the adaptation of physical condition among higher education students under the conditions of hostilities, increased by 0.08 and amounted to 0.70. The sensitivity of the model increased by 7.3 to 68.1%, which indicates the possibility of using the developed model to identify 68.1% of students who have physically adapted to the conditions of the armed conflict and who did not show a deterioration in their physical condition. The specificity of the model increased by 2.3% and amounted to 63.0%. This means that 27.0% of students with a stress-related deterioration in physical condition will be classified as adapted. The model for predicting stress-related deterioration in mental-emotional status was improved with the inclusion of additional indicators as evidenced by an increase in its accuracy: AUC increased by 0.08 to 0.69, sensitivity by 5.45, and specificity by 0.51%. Furthermore, the indicators of the accuracy of the model for predicting students' emotional well-being increased as follows: AUC increased by 0.16 to 0.77, sensitivity and specificity increased by 11.2 and 5.9%, respectively. Note that the accuracy of the developed models for predicting the dynamics of the physical condition and mental-emotional status among higher education students under stress improved from average to good, when, in addition to the HRP, the students' lifestyle and behaviors under conditions of hostilities were taken into account.

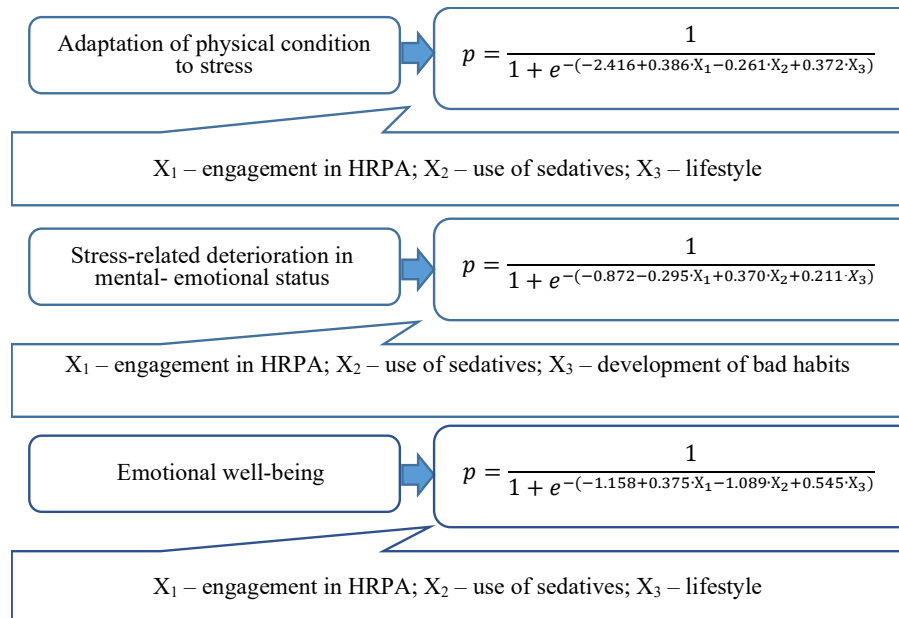


Figure 1. Logit models for predicting stress-related conditions among higher education students (n=573)

According to the developed models, regular engagement in HRP, an active lifestyle and cessation of sedatives increased the probability that the student's physical condition will not deteriorate under conditions of hostilities by 60.2% up to 70.1% (from 9.9% in the absence of HRP, the use of sedatives, and adoption of a lifestyle that is not conducive to preservation and promotion of health). Moreover, engagement in HRP together with cessation of sedatives and bad habits reduced the probability of deterioration in students' mental-emotional status by 57.5% to 23.4% (compared to 80.9% in the opposite case). Finally, the probability that the student will not show signs of emotional distress increased by 77.1% (from 0.9 to 78.0%) under the conditions of regular engagement in HRP, an active lifestyle, and cessation of sedatives. Thus, one can argue that the

behavioral disorders in higher education students combined with the lack of HRPAs significantly increase their risk of anxiety, aggressiveness, depressive states, and mood swings during the period of armed conflict on the territory of Ukraine.

Discussion

A significant part of the population of Ukraine experience stress, which causes various mental-emotional disorders and dysfunctions of the body organs and systems, when adaptation to stress is manifested by achieving a balance between the stress impact and protective responses (Naugolnyk, 2015). In this study we considered as stress-related conditions of higher education students the spectrum of persistent mental-emotional experiences and body responses to adverse environmental changes (Kioseva, 2016). Obviously, at present, research aimed at the development of preventive measures that contribute to reducing the severity of stress factors impact on the state of higher education students is extremely relevant and requires an urgent solution (Hakman et al, 2020; Kuswahyudi et al, 2022).

There are conflicting evidences in the literature regarding the influence of HRPAs on the development of stress among students. In particular, A. Hubbs, E. Doyle and others (2012) indicate that despite the statistically significant correlations revealed between the level of physical activity and self-esteem of students, no such correlations were found between the level of stress and PA. However, the vast majority of scientists, through experimental studies, have believed in the positive impact of HRPAs on stress tolerance among students (Nguyen-Michel, 2006; Hamer, 2012; Bland, 2014). As a result of the study, we confirmed the effectiveness of the use of HRPAs to cope with stress by higher education students which has been demonstrated previously (Kim, 2014; Pascoe, 2020; Sluhenska, 2021). The main result was the development of statistically significant ($p < 0.05$) logistic models, which can be used to predict stress-related deterioration in mental and physical condition among higher education students depending on the engagement in HRPAs. The created models have good accuracy and can be used to predict stress-related conditions among higher education students. In particular, if a student regularly engages in HRPAs, the probability of deterioration in his mental-emotional status under conditions of hostilities decreases. The lack of HRPAs increases the risk of mental-emotional disorders in students by more than 25% compared to those who regularly engage in HRPAs (Yamada, Tsuchiya, 2022). Furthermore, the developed prognostic statistically significant ($p < 0.05$) logit models allowed to extend the knowledge about the strengthening of stress affects in higher education students with behavioral disorders (Stults-Kolehmainen, 2014). For instance, regular engagement in HRPAs, an active lifestyle, and cessation of sedatives increase the probability of adaptation of students' physical condition under the influence of hostilities to 70.1%, whereas under similar conditions, the use of sedatives reduces the probability of stress-related deterioration in students' physical condition by 18.4%. Moreover, regular engagement in HRPAs and cessation of bad habits and sedatives reduce the probability of stress-related deterioration in mental-emotional status from 80.9 to 23.4%, whereas the behavioral disorders increase the risk of such deterioration to 63.6% even in students who regularly engaged in HRPAs. Engagement in HRPAs, an active lifestyle, and cessation of sedatives allowed to predict the maintenance of emotional well-being during hostilities with a probability of 78.0%, whereas the regular use of sedatives reduced this probability to 11.8%. Note that the use of sedatives, neglecting the principles of a healthy lifestyle, and HRPAs almost certainly (the probability of maintaining emotional well-being is 0.8%) resulted in the development of anxiety, depressive states, aggressiveness, and mood swings among students. The application of the developed logit models allowed to provide predictions of stress-related deteriorations in the state of students depending on their behavioral strategies under the conditions of hostilities. It should be noted that the improved models had higher accuracy compared to the models that take into account only engagement in HRPAs. However, in contrast to other models which had good accuracy, the model developed to predict mental-emotional disorders had a moderate accuracy (AUC of 0.69). Therefore, this model needs further improvement. Furthermore, there is untapped potential for improving other models, by increasing their sensitivity, specificity, and accuracy.

It is also worth pointing out that at the stage of modeling, a variable was included in the logit model that characterized the level of students' personal responsibility for own health, but its effect on the stress-related conditions among higher education students was not statistically significant ($p > 0.05$), so it was excluded from further analysis. Thus, the proposed models should be considered as pilot, and their further improvement is planned to be carried out on a test sample, which will allow obtaining the models with the accuracy of predictions closest to real data.

Conclusions

Studying at a higher education institution is typically accompanied by excessive mental and emotional stress, and Ukrainian students have had to study under extremely difficult conditions in recent years. Against the background of the transition to online and remote forms of education and under the conditions of military conflict in Ukraine, a significant number of higher education students had no or limited opportunities for health-enhancing recreational physical activity. The negative impact of stress on human health is a well-recognized fact.

Persistent negative mental-emotional experiences and the body's responses to stress not only have a negative impact on physical condition and mental-emotional status of students, but can also provoke behavioral

disorders. Physical activity helps to cope with the negative influence of stress factors, which necessitates the development of measures aimed at the prevention and correction of stress-related conditions among students through engagement in health-enhancing recreational physical activity. Prognostic statistically significant ($p < 0.05$) logit models were developed, which allow to establish the probability of stress-related conditions among higher education students based on information about their engagement in physical activity. The models were improved by including variables that characterize the lifestyle of students, the use of sedatives, and the presence of bad habits. The mental-emotional status and physical condition of higher education students and their emotional well-being were found to be directly dependent on the level of physical activity and lifestyle of students. It has been proven that physical exercise, an active lifestyle, and cessation of sedatives make it possible to predict the maintenance of emotional well-being in higher education students during hostilities in Ukraine with a probability of 78.0%. Furthermore, systematic health-enhancing recreational physical activity and cessation of bad habits and sedatives reduce the probability of stress-related mental and emotional health disorders under the conditions of armed confrontation in Ukraine from 80.9 to 23.4%. The study demonstrated that systematic health-enhancing recreational physical activity, an active lifestyle, and cessation of sedatives increase the probability of adaptation of the physical condition of students to difficult living conditions to 70.1%. Thus, it can be concluded that a high level of physical activity and an active lifestyle have a beneficial effect on the mental, emotional, and physical health of higher education students and their emotional well-being in stressogenic situations. The lack or insufficient level of physical activity increase the risk of stress-related conditions in students. Likewise, behavioral disorders increase the stress impact.

Conflict of interest

Authors state no conflict of interest.

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