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Orlov O.I.[1,2], Serhiienko Yu.P.[1], Danylevych M.V.[3], Lohvynenko O.B.[4], Nekrasov H.H.[5]

Reducing high school students' stress indicators in the process of physical exercises

[1] State Tax University, Irpin, Ukraine
[2] Dragomanov Ukrainian State University, Kyiv, Ukraine
[3] Ivan Boberskyi Lviv State University of Physical Culture, Lviv, Ukraine
[4] Drohobych Ivan Franko State Pedagogical University, Drohobych, Ukraine
[5] Berdyansk State Pedagogical University, Zaporizhzhia, Ukraine

Орлов О.І.[1,2], Сергієнко Ю.П.[1], Данилевич С.В.[3], Логвиненко О.Б.[4], Некрасов Г.Г.[5]

Зниження показників стресу в учнів старших класів у процесі занять фізичними вправами

[1] Державний податковий університет, м. Ірпінь, Україна
[2] Український державний університет імені Михайла Драгоманова, м. Київ, Україна
[3] Львівський державний університет фізичної культури імені Івана Боберського, м. Львів, Україна
[4] Дрогобицький державний педагогічний університет імені Івана Франка, м. Дрогобич, Україна
5 Бердянський державний педагогічний університет, м. Запоріжжя, Україна

alexalians007@gmail.com

Introduction

The vast majority of Ukraine's population experiences increased psycho-emotional stress and is in a permanent state of stress, including due to long-term pandemic restrictions and a full-scale war. Children and adolescents, as a special group of people under 18, as the social group is particularly sensitive to the impact of stressors today. Among the child population, schoolchildren, especially high school students, require the most attention, as general stressors of modern life are compounded by stresses associated with the crisis of adolescence, graduation from school, and the need to plan for the future beyond school [1]. For example, according to the study [2], 75% of high school students in Ukraine experience various manifestations of stress.

The high pace and tension of modern life increase the burden on the psyche of high school students, causing increased anxiety, emotional fluctuations, behavioral reactions, and even physiological manifestations, which justifies the importance of stress resistance as an individual trait for maintaining mental and somatic health. Given this, one of the tasks of current school-based education is to increase students' stress resistance as an integral quality of a personality [3]. The modern understanding of stress resistance theory includes biological and psychological aspects and is interdisciplinary. Researchers are increasingly attracted to the issues of the influence of psyche and physical skills on stress resistance, the interrelation of stress resistance with physical activity, and the possibilities of its formation in physical exercises [4–7].

Scientific studies [8] confirmed the influence of physical activity on reducing students' psycho-emotional stress. Scientists [9; 10] considered the possibilities of improving the psycho-emotional state of children and youth in the process of physical education and revealed the connection of stress resistance with physical and mental qualities, with indicators of the volitional sphere of high school students.

The analysis of studies [11–13] showed that among various kinds of sports and physical activity, physical exercises of a situational nature, in particular different types of martial arts, including boxing, have a high potential for developing physical qualities and the education of volitional characteristics of a personality. Boxing training involves overcoming fatigue and pain, restraining emotions, maintaining working capacity and variability of actions during the performance of physical loads in conditions of psycho-emotional tension due to the need to anticipate the opponent's plans and quickly restructure movements in attack and defense [14]. Therefore, the question of using boxing to overcome stress and form resistance to its influence requires scientific research, which determines the relevance of developing a methodology for reducing high school students' stress indicators as well as improving the motor indicators through boxing in the process of physical education.

The aim of the study is to investigate the dynamics of stress and motor indicators of high school students in the process of physical exercises (using the example of boxing).

Object, materials and research methods

Participants. The research involved 64 high school students (boys) who studied in the 11th grades (17 years old) of Lyceum № 3 (Irpin, Ukraine). A pedagogical experiment

was conducted, for which two groups were formed: control (CG, n = 31) and experimental (EG, n = 33). The main criteria for inclusion of high school students in the study were: their personal desire to engage in boxing according to the author's methodology; mandatory absence of health abnormalities and contraindications to physical exercises (belonging to the main medical group). The exclusion criterion was the high school students' desire to stop classes and withdraw from the experiment at any time during the study. At the same time, high school students were assigned to groups by their own choice. High school students who were part of the EG were engaged in physical education in lessons according to the methodology we proposed, which included boxing, and the CG high school students were trained according to the current physical education curriculum. Before the experiment, it was established that there were no statistically significant differences between the studied indicators of EG and CG high school students. Also, high school students of both groups had no previous experience of boxing.

Research methods: analysis and synthesis of literary sources, psycho-diagnostic testing, testing of physical qualities, pedagogical experiment, statistical methods. The analysis and generalization of literary sources allowed us to study the theoretical basis of the problem. The researcher processed 30 literary sources from various international scientometric databases. Psychodiagnostic testing included assessing the level of anxiety, stress tolerance, and signs of stress in high school students of both study groups. In the process of testing physical qualities, the level of coordination and strength endurance, as well as the speed and strength endurance of high school students, was determined. Before the commencement of the pedagogical experiment, it was established that there were no statistically significant differences between the values of the investigated indicators in the representatives of the experimental and control groups. The duration of the experiment was one year.

The Spielberger–Khanin anxiety self-assessment scale was used to determine the level of anxiety of high school students [15]. Diagnosing individual levels of high school students' stress resistance involved using the Boston Method of Self-Assessment of Personality Stress Resistance [16]. The level of stress was determined by the V. Yu. Shcherbatykh test [16], which makes it possible to study various signs of stress, including intellectual, behavioral, emotional, and physiological signs. A functional and dynamic exercise was used for a comprehensive assessment of coordination and strength endurance – the Burpee test (10 s). In the evaluation of speed and strength endurance, the test of jumping rope for 1 min, the number of times was used.

Mathematical and statistical methods. At the beginning of the experiment, the homogeneity of all the EG and the CG indicators was determined ($p > 0.05$). The compliance of the sample data distribution with the Gauss' law was assessed using the Shapiro–Wilk W-test and it was found that the distributions of the EG and the CG were normal. This allowed us to assess the reliability of the results using the Student's t-test. The reliability of the difference was set at $p < 0.05$. All indicators are presented as M ± m, where "M" is the arithmetic mean, and "m" is the standard error of the mean. To study the relationship between the level of development of physical qualities of high school students and the stress level as well as stress resistance, we used the Pearson correlation coefficient. All statistical analyses were performed using SPSS software, version 10.0, adapted for medical and biological research.

Ethical approval. The research implementation process was built following the requirements of scientific ethics. The research was approved by the Academic Ethics Commission of Mykhailo Drahomanov Ukrainian State University. Also, this research followed the regulations of the World Medical Association Declaration of Helsinki. The pedagogical experiment was open; its participants were informed about the aim of the research and voluntarily participated in it.

Research Results

To determine the content of the boxing training methodology for reducing stress levels in high school students, a correlation analysis was used, which showed the existence of relationships of varying degrees of basic physical qualities manifested in boxing with the stress level and stress resistance (Table 1).

The methodology for reducing high school students' stress indicators as well as improving the motor indicators through boxing in the process of physical education has been developed. The general and special physical training was planned in obligatory combination with technical and volitional training. The means of increasing the resistance to psycho-emotional stress of high school students of the EG in the process of boxing training include general developmental, especially developmental and competitive exercises, breathing and relaxation exercises, methods – methods of teaching physical exercises, development of physical qualities, methods of combined influence, methods of educational influence. The key idea of the methodology is a positive transfer of the purposeful development of physical qualities and volitional indicators to reduce

Table 1

The relationship between the level of development of physical qualities of high school students and the stress level and stress resistance (n = 64)

Physical qualities	Stress level (test by V. Yu. Shcherbatykh)	Stress resistance (Boston test)
Coordination and strength endurance (Burpee test, 10 s)	–0.32	0.41
Speed and strength endurance (jumping rope, 1 min)	–0.54	0.33

high school students' stress indicators and increase their stress resistance in boxing training sessions. The idea's implementation is based on the scientifically confirmed prognostic significance of certain indicators of physical development, volitional sphere, physiological mechanisms of formation of functional systems, dynamic stereotypes, and volitional behavior regulation in their interconnection. The content of physical loads in boxing is characterized by special requirements for the simultaneous manifestation of strength, speed, and coordination, the ability to perform short-term and long-term physical work in conditions of fatigue and psycho-emotional tension; it is characterized by the acyclic structure of exercises, variability of situations, unpredictability, which necessitates the manifestation of will and resilience in response to the actions of the opponent.

To test the effectiveness of the developed methodology for reducing high school students' stress indicators as well as improving the motor indicators through boxing in the process of physical education, a pedagogical experiment was conducted to determine the dynamics of the level of manifestation of the stress and motor indicators of high school students. The selection of high school students to the groups was carried out arbitrarily in compliance with the sample's homogeneity and representativeness requirements. Before the experiment, it was established that there were no statistically significant differences between the studied indicators of the EG and the CG high school students.

Introducing the methodology for reducing high school students' stress indicators through boxing into the physical education process resulted in positive changes in the manifestation of physical stress and motor indicators. The influence of boxing training on separate indicators of physical qualities and characterization of the level of manifestation of special types of endurance has been investigated (Table 2).

During the pedagogical experiment, the positive dynamics of the manifestation of special types of endurance were established: there were positive changes in high school students of both groups, but a significant increase was observed only among the EG high school students. Thus, the results in the Burpee test in the EG increased by 0.8 times ($p \leq 0.05$) and in the CG by 0.2 times ($p > 0.05$), in jumping rope in the EG by 9.2 times ($p \leq 0.05$) and in the CG by 1.8 times ($p > 0.05$). After the experiment in EG the results in Burpee test and in jumping rope were significantly ($p \leq 0.05$) better than in CG by 0.7 and 7.2 times, respectively. This indicates a positive effect of the developed methodology on the development of coordination and strength endurance as well as speed and strength endurance in EG high school students.

The dynamics of high school students' stress indicators during the pedagogical experiment showed the following tendency (Table 3).

The dynamics of changes in the stress indicators of high school students under the influence of boxing training was positive in both groups, but the improvement of stress indicators is statistically significant ($p \leq 0.05$) only in the EG high school students. It was found that personal anxiety indicators in the EG decreased by 5.6 points, and in the CG by 0.6 points, reactive anxiety indicators

Table 2

Effect of implementation of the methodology for reducing high school students' stress indicators through boxing training sessions on the development of physical qualities of 17-year-old young men of the EG (n = 31) compared to the CG (n = 33), times

Physical qualities	Research stages	EG	CG	Δ	t / p
Coordination and strength endurance (Burpee test, 10 s)	Before the experiment	5.6 ± 0.21	5.5 ± 0.19	0.1	0.35 / > 0.05
	After the experiment	6.4 ± 0.22*	5.7 ± 0.21	0.7	2.30 / ≤ 0.05
Speed and strength endurance (jumping rope, 1 min)	Before the experiment	88.9 ± 2.20	89.1 ± 2.16	0.2	0.06 / > 0.05
	After the experiment	98.1 ± 2.15*	90.9 ± 2.19	7.2	2.35 / ≤ 0.05

Legend: Δ – difference between the studied indicators; t – value of Student's t-test; p – level of statistical significance of differences; * – statistically significant differences between the indicators of groups before and after the experiment at the levels of $p \leq 0.05$.

Table 3

Effect of implementation of the developed methodology on the stress indicators of 17-year-old young men of the EG (n = 31) compared to the CG (n = 33), points

Stress indicators	Research stages	EG	CG	Δ	t / p
Personal anxiety (Spielberger–Khanin scale)	Before the experiment	43.7 ± 1.58	43.5 ± 1.61	0.2	0.09 / > 0.05
	After the experiment	38.1 ± 1.51*	42.9 ± 1.59	4.8	2.19 / ≤ 0.05
Reactive anxiety (Spielberger–Khanin scale)	Before the experiment	44.2 ± 1.52	43.8 ± 1.49	0.4	0.19 / > 0.05
	After the experiment	38.3 ± 1.47*	43.2 ± 1.46	4.9	2.37 / ≤ 0.05
Stress level (test by V. Yu. Shcherbatykh)	Before the experiment	9.5 ± 0.32	9.4 ± 0.29	0.1	0.23 / > 0.05
	After the experiment	8.3 ± 0.29*	9.2 ± 0.28	0.9	2.23 / ≤ 0.05
Stress resistance (Boston test)	Before the experiment	33.2 ± 1.13	33.0 ± 1.09	0.2	0.13 / > 0.05
	After the experiment	29.3 ± 1.07*	32.6 ± 1.08	3.3	2.17 / ≤ 0.05

Legend: Δ – difference between the studied indicators; t – value of Student's t-test; p – level of statistical significance of differences; * – statistically significant differences between the indicators of groups before and after the experiment at the levels of $p \leq 0.05$.

in the EG decreased by 5.9 points, and in the CG by 0.6 points, stress level in the EG decreased by 1.2 points, and in the CG by 0.2 points, stress resistance level in the EG improved by 3.9 points, and in the CG by 0.4 points. After the experiment, personal and reactive anxiety indicators in the EG turned out to be lower than in the CG by 4.8 and 4.9 points, respectively, stress level lower by 0.9 points, and stress resistance level better by 3.3 points. Thus, the purposeful influence in boxing training in 17-year-old high school students' increases stress resistance, decreases anxiety and stress levels, and improves the manifestation of physical qualities.

Discussion of the Research Results

Currently, many methods and techniques of physical activity are successfully used to improve physical and mental well-being, teach emotion management, develop the volitional sphere, increase psycho-emotional stability, and reduce mental manifestations of stress in children and youth. However, most scientific research and methodological developments identify the features of physical exercises as a means of psychological recovery, relaxation, and harmonization of the physical and psycho-emotional state through physical exercises, breathing techniques, and concentration of attention [17–20].

Currently, the problem of educating the volitional qualities of schoolchildren in the process of various sports and physical activity has been sufficiently studied, in particular from the standpoint of forming readiness for volitional stress in adolescents in physical exercises; confidence in older adolescents through judo; development of mental functions of students through boxing, volitional training of students in physical exercises; education of moral and volitional qualities of children and youth through various types of martial arts; development of emotional stability in physical exercises [21].

In sports science, special studies of the manifestation of volitional qualities of athletes of various specializations have shown that in gymnastics, perseverance, courage, and determination are most manifested; in game sports – independence, determination, and initiative; in sports requiring a high level of strength and endurance, will, patience, firmness, and perseverance are manifested. For example, a complication of physical tasks during physical exercises stimulates the development of purposefulness; exercises that involve overcoming fear develop courage; exercises requiring quick, independent, and responsible decision-making, involving suddenness and risk, are aimed at developing determination and initiative; physical tasks aimed at overcoming obstacles, fatigue, and significant muscle effort successfully develop fullness, purposefulness, and perseverance. Studies [22] have established the dependence of the manifestation of volitional qualities on the nature of physical exercises and the level of physical fitness of high school students and proposed a separate approach to the volitional training of high school students, which consists of coordination with the development of specific physical qualities through exercises that require the manifestation of will, self-control, and resilience in risky and non-standard situations. Scientists [23; 24] have noticed a direct link between the level of muscle tension and the degree of volitional effort. Therefore, developing resilience to difficulties, the ability to selectively, accurately, and flexibly overcome them, involves using technically complex exercises, exercises that require significant effort, variable exercises, the choice of which depends on the situation, etc. At the same time, researchers believe that the most radical means of developing volitional qualities is using such physical loads, the level of which is regulated by the nature of the exercise. Researchers [25] have identified the features and nature of physical loads in various sports and physical activities following the manifestation of the properties of the nervous system that determine psycho-emotional stability. In particular, the authors have shown that physical tasks based on the mobilization of cognitive functions, including attention, short-term memory, and perception, can be used to overcome stressful situations.

Given this, some sports and physical activities that involve overcoming difficulties, demonstrating volitional efforts, and maintaining self-control and resilience, as well as those that include overcoming fatigue, pain, restraining emotions, and maintaining performance during training sessions, in particular strength-based physical exercises and various types of martial arts, have wide opportunities for modeling conditions and situations that involve overcoming difficulties, demonstrating volitional efforts, and maintaining composure and resilience. The nature of such physical exercises included in the content allows the regulation of the level of physical loads and the degree of volitional efforts with the active participation of cognitive functions in their performance. Different types of martial arts are characterized by a unique manifestation and combination of strength, speed, coordination, and endurance, as well as a significant level of functional and adaptive capabilities and sufficient recovery speed in a short period, and are characterized by a situational nature. Non-standard movements during the performance of physical loads do not allow the formation of a dynamic stereotype, which serves as a prerequisite for the development of extrapolation abilities – to instantly assess the situation, suddenly react, make informed decisions, and apply rational actions in response, predict the development of events and the behavior of the opponent. In addition, physical tasks in martial arts are characterized by significant mental stress, which contributes to the formation of resistance to this type of physical activity in the conditions of systematic training.

According to scientists [26; 27], fights in martial arts are determined not only by the physical potential but also by the neuropsychological capabilities of those who train, the ability to perceive the situation subtly, accurately calculate time, effort, and distance, the ability to restrain emotions, as well as heuristic abilities, in particular the ability to guess the opponent's plans, predict the course of the fight, and think through the outcome.

The conclusions of studies of the psychophysiological characteristics of the development of the boxers' body are interesting. For example, researchers [14] have confirmed that an attack in boxing is accompanied by high performance, reduced anxiety, and increased information processing speed. It has also been proven that the functional mobility of nervous processes in boxers directly correlates with stress resistance. A high level of stress resistance corresponds to an optimal manifestation of impulsivity and emotional stability. Researchers have noted that boxing helps reduce stress levels, improves the overall psycho-emotional state of those who train, and effectively promotes physical qualities development. During boxing, concentration, and accumulation of physical and mental strength allow you to distract from worries, promote emotional relief, cultivate various manifestations of will, reduce anxiety, etc. [28–30].

The content of the methodology developed by the authors for reducing high school students' stress indicators in the process of boxing is based on the use of tools and methods aimed at forming high school students' special theoretical knowledge of boxing techniques and tactics, safety rules during training sessions, the peculiarities of stress on the body, the formation of motor experience, the development of various manifestations of students' will in the process of boxing in different organizational forms of physical education based on compliance with its principles and focus on individual developmental characteristics. It is important to create conditions for the formation of stress resistance of high school students in the process of boxing by solving a set of pedagogical tasks: educational (formation of knowledge and relevant motor experience), health (reducing stress level and improving psycho-emotional state, development of general and special physical skills) and awareness-raising (individual mental characteristics of the personality and education of volitional qualities).

Prospects for further research

Prospects for further research are seen in introducing a methodology for increasing stress resistance in boxing training sessions in the educational process of students of higher educational institutions.

Conclusions

The methodology for reducing high school students' stress indicators in the process of boxing training has been developed. The effectiveness of the implementation of the developed methodology in the process of physical education is proved by statistically significant positive dynamics of the level of manifestation of physical qualities (speed and strength endurance, coordination and strength endurance), a substantial decrease in personal and reactive anxiety, stress level in the EG high school students. In addition, at the end of the experiment, significantly better results were found in the EG high school students than in the CG regarding the studied indicators of motor and stress indicators.

The high level of physical qualities developed in boxing training, the reduction of anxiety and stress levels in high school students, and the increase of their stress resistance will strengthen their physical and mental health, improve their academic performance, and achieve self-realization in the future.

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The purpose of the work is to investigate the dynamics of stress and motor indicators of high school students in the process of physical exercises (using the example of boxing).

Materials and methods. The research involved 64 high school students (boys) (17 years old). A pedagogical experiment was conducted, for which two groups were formed: control (CG, n = 31) and experimental (EG, n = 33). The CG high school students were trained according to the current physical education curriculum, and the EG high school students were trained according to the methodology we proposed, which involved boxing. The following indicators were studied: stress indicators (anxiety, stress resistance, stress level); motor indicators (coordination and strength endurance, speed and strength endurance).

Results. A methodology for reducing high school students' stress indicators as well as improving the motor indicators through boxing in the process of physical education has been developed. Testing the methodology's effectiveness has shown significantly better results in the EG high school students than in the CG in all stress and motor indicators. Thus, from boxing training, the EG high school students showed statistically significant reduction the stress and anxiety level, and improvement in stress resistance and speed and strength endurance, as well as coordination and strength endurance level.

Conclusions. A high level of development of physical qualities in the dynamics of boxing training sessions, a decrease in the level of anxiety and stress in high school students, as well as an increase in stress resistance, will contribute to strengthening the physical and mental health of high school students, improving their academic performance, and achieving self-realization in the future.

Key words: high school students, physical exercises, stress, stress resistance, physical qualities, motor activity indicators.

Мета роботи – дослідити динаміку показників стресу та рухових показників учнів старших класів у процесі занять фізичними вправами (на прикладі боксу).

Матеріали та методи. У дослідженні взяли участь 64 учні старших класів (хлопці) віком 17 років. Був проведений педагогічний експеримент, для якого було сформовано дві групи: контрольну (КГ, n = 31) та експериментальну (ЕГ, n = 33). Основними критеріями включення учнів старших класів до дослідження були: їх особисте бажання займатися боксом за авторською методикою; обов'язкова відсутність відхилень у стані здоров'я та протипоказань до фізичних вправ (належність до основної медичної групи). Критерієм виключення було бажання учнів старших класів припинити заняття та вийти з експерименту в будь-який момент протягом дослідження. Учні старших класів КГ тренувалися за чинною програмою з фізичного виховання, а учні старших класів ЕГ – за запропонованою нами методикою, яка передбачала заняття боксом. Відбір учнів до груп відбувався з дотриманням вимог до однорідності та репрезентативності вибірки. Перед початком експерименту встановлено відсутність статистично достовірних розбіжностей між досліджуваними показниками учнів ЕГ і КГ. Також в учнів обох груп був відсутнім попередній досвід занять боксом. Вивчалися такі показники: показники стресу (тривожність, стресостійкість, рівень стресу); рухові показники (координаційно-силова витривалість, швидкісно-силова витривалість). Для визначення рівня тривожності використовувалися шкала самооцінки рівня тривожності Спілбергера – Ханіна. Діагностика індивідуального рівня стресостійкості передбачала застосування Бостонської методики самооцінки стресостійкості особистості. Визначення рівня стресу здійснювалося за тестом В. Ю. Щербатих, який дає можливість дослідити різні ознаки стресу – інтелектуальні, поведінкові, емоційні та фізіологічні. Для комплексного оцінювання координаційно-силової витривалості використовували функціональну й динамічну вправу – тест Берпі (за 10 с). Для оцінювання швидкісно-силової витривалості застосовували тест стрибки на скакалці за 1 хв за кількістю разів. Педагогічний експеримент передбачав упровадження авторської методики в освітній процес із фізичного виховання школярів ЕГ та перевірку її ефективності. Тривалість експерименту – 1 рік.

Результати. Розроблено методику зниження показників стресу в учнів старших класів, а також покращення рухових показників за допомогою занять боксом у процесі фізичного виховання. Перевірка ефективності методики показала значно кращі результати в учнів старших класів ЕГ, ніж у КГ, за всіма показниками стресу та руховими показниками. Виявлено, що показники особистісної тривожності в ЕГ знизилися на 5,6 бала, а в КГ – на 0,6 бала, показники реактивної тривожності в ЕГ знизилися на 5,9 бала, а в КГ – на 0,6 бала, рівень стресу в ЕГ знизився на 1,2 бала, а в КГ – на 0,2 бала, рівень стресостійкості в ЕГ покращився на 3,9 бала, а в КГ – на 0,4 бала. Після експерименту показники особистісної та реактивної тривожності в ЕГ виявилися нижчими, ніж у КГ, на 4,8 та 4,9 бала відповідно, рівень стресу нижчий на 0,9 бала, а рівень стресостійкості кращий на 3,3 бала. Результати у тесті Берпі в ЕГ збільшилися в 0,8 раза ($p \leq 0,05$), в КГ – у 0,2 раза ($p > 0,05$), у стрибках зі скакалкою в ЕГ – у 9,2 раза ($p \leq 0,05$), в КГ – в 1,8 раза ($p > 0,05$). Після експерименту в ЕГ результати тесту Берпі та у стрибках зі скакалкою були значно ($p \leq 0,05$) кращими, ніж у КГ: у 0,7 та 7,2 раза відповідно. Таким чином, у старшокласників, які займаються боксом, спостерігається статистично значуще зниження рівня стресу та тривожності, покращення стійкості до стресу та швидкісно-силової витривалості, а також координації та рівня силової витривалості.

Висновки. Високий рівень розвитку фізичних якостей у динаміці тренувальних занять з боксу, зниження рівня тривожності та вираженості стресу в старшокласників, а також підвищення стійкості до стресу сприятимуть зміцненню фізичного та психічного здоров'я старшокласників, покращенню їхньої успішності та досягненню самореалізації в майбутньому.

Ключові слова: старшокласники, фізичні вправи, стрес, стресостійкість, фізичні якості, показники рухової активності.

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Information about the authors

Orlov Oleksandr Ivanovych – Honored Coach of Ukraine, Candidate of Pedagogical Sciences, Associate Professor, Associate Professor at the Department of Health Technologies and Physical Culture and Sports Rehabilitation of the State Tax University; Universytetska Str., 31, Irpin, Ukraine, 08200; Doctoral Student of the Dragomanov Ukrainian State University; Pyrohova Str., 9, Kyiv, Ukraine, 01601.
alexalians007@gmail.com, ORCID ID: 0009-0003-3965-2620 [A, B, E, F]

Serhiienko Yurii Petrovych – Candidate of Pedagogical Sciences, Associate Professor, Associate Professor at the Department of Rehabilitation Technologies and Physical Culture and Sports Rehabilitation of the State Tax University; Universytetska Str., 31, Irpin, Ukraine, 08200.
sergienkofpm@gmail.com, ORCID ID: 0000-0003-1019-6513 [B, D]

Danylevych Myroslava Vasylivna – Doctor of Pedagogical Sciences, Professor, Head of the Tourism Department of the Ivan Boberskyi Lviv State University of Physical Culture; Kostyushka Str., 11, Lviv, Ukraine, 79007.
myrdanylevych@gmail.com, ORCID ID: 0000-0002-1285-392X [C, D]

Lohvynenko Oleksandr Borysovych – Candidate of Pedagogical Sciences, Associate Professor, Associate Professor at the Department of Theory and Methods of Physical Education and Sport of the Drohobych Ivan Franko State Pedagogical University; Ivana Franka Str., 24, Drohobych, Ukraine, 82100.
logvynenko_oleksandr@dspu.edu.ua, ORCID ID: 0000-0001-6417-7006 [C, E]

Nekrasov Hryhoriy Hryhorovych – Senior Lecturer at the Department of Physical Education, Sports and Teaching Methods of the Berdyansk State Pedagogical University; Universytetska Str., 55 A, Zaporizhzhia, Ukraine, 69011.
gplayer03082017@gmail.com, ORCID ID: 0000-0002-2399-6133 [B]

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