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Refutation

We inform you that in issue 3/2024 Acta Balneologica the names of the authors of the article were published incorrectly
The effect of thermotherapy on functions of the circulatory system. Review literature.
The authors of the above-mentioned article are: Jakub Szewczyk, Krzysztof Szczepan Krajewski, Jarosław Śmieszek.

We apologize to the authors and readers for the current situation.
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EDITORIAL ARTICLE

Evaluation of the efficacy of cryotherapy in painful shoulder syndrome

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ABSTRACT

Aim: The aim of this study was to evaluate the use of cryotherapy in painful shoulder syndrome.

Materials and Methods: The study involved 30 patients with painful shoulder syndrome. The patients were treated with 10 cryotherapy procedures followed by kinesiotherapy. Pain intensity according to the Laitinen scale and ranges of motion in the shoulder joint were evaluated before and after treatment.

Results: After treatment, 60% of study patients showed complete elimination of shoulder pain and 33% experienced occasional pain only. 56% of study patients showed full shoulder mobility and 43% showed partial improvements.

Conclusions: 1. Painful shoulder syndrome is a difficult diagnostic and therapeutic problem. 2. The use of cryotherapy helped eliminate or reduce the symptoms. 3. Study patients showed increased ranges of motion in all planes in the joint. 4. The quality of life and functioning in study patients improved. 5. Treatment of this disorder is based on physical therapy.

KEY WORDS: painful shoulder syndrome, treatment, cryotherapy

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INTRODUCTION

Painful shoulder syndrome is characterised by pain and partial or complete limitation of the range of mobility in the shoulder and sometimes also in the clavicular joints. "Pain is the first symptom, which forces the patient to limit their own movements". Shoulder pain in the area of the rotator cuff tendons may be caused by impingement syndrome, injury, adhesive capsulitis in the shoulder joint, rheumatoid arthritis or hemiparesis. Similar symptoms may result from degenerative changes of the cervical spine. Regardless of the aetiology, patients may develop the clinical presentation of so-called frozen shoulder, where the pain usually radiates along the upper limb towards the arm and below the elbow joint, to the hand. Patients often position their arm in adduction and internal rotation, and the shoulder is elevated and pushed forward, which causes the development of adhesions in the capsule and ligaments [1-9].

Due to the complex structure of the shoulder joint, there is a wide variety of pathological changes that can occur in this area, and the interconnected functional mechanisms may be altered in ways that are difficult to predict. This is one of the main challenges faced in everyday practice by physicians: orthopaedists, rheumatologists, and physiotherapists [10-12].

Several forms of painful shoulder syndrome may be described based on the aetiology [10-12]:

- rotator cuff damage;
- calcium deposits building up in the tendons of muscles responsible for shoulder joint mobility;
- shoulder bursitis (bursa is a structure that reduces friction);
- inflammation of the synovial sheath;
- tendon disruption;
- frozen shoulder.

"This disorder usually affects women aged 45-55 years. Shoulder joint pain is the main symptom and is sometimes accompanied by swelling". Patients also experience increased muscle tone in the supraspinatus; however, there are no sensory disturbances and no impairment of the reflexes. These symptoms are typical of all forms of painful shoulder syndrome [11-15].

The treatment of this disorder is based on physical therapy and rehabilitation. The introduction of cryotherapy into the physical therapy regimens considerably improved the therapeutic options [16-20].

Using a stream of liquid nitrogen vapor provides very strong cryostimulation (temperature ranging from -15 to -170°C). The stream is directed onto the treated area of the body, and the circular movements of the nozzle throughout the session help avoid frostbite. The procedure can be repeated multiple times but no sooner than 3 hours after the end of the first session. This intense stimulus reduces local perfusion and then increases the temperature of the tissues, with the increase being the more pronounced the colder the area became earlier. "Immediately after the procedure, pain and swelling decrease and the ability to perform a wider range of passive movements increases. Intensive kinesiotherapy is recommended following the

application of liquid nitrogen vapor" [10,16-20]. Maintaining homeostasis in a situation where the body is being subjected to extreme cold depends mostly on adequate cardiovascular and endocrine system function and metabolic processes. When the body undergoes cryotherapy, both the somatic and autonomic nervous system is stimulated. An increase in the activity of the sympathoadrenal part of the autonomic nervous system leads to increased release of catecholamines and stimulates beta-adrenergic receptors. The metabolism rate during a cryotherapy session was found to decrease by approximately 50%, resulting in a reduced oxygen demand. The opposite effects were found after the cryotherapy session had been completed; internal organ perfusion was increased, which accelerated the elimination of harmful metabolism waste products and contributed to faster tissue regeneration.

Optimum intermediate reactions and processes in cells, mainly enzymatic reactions, require the body to be able to maintain a stable temperature. The activity of these processes depends on the temperature on the cellular level. The enzymes acting within a cell are interdependent, and the chemical reactions occur sequentially and are catalysed by a series of enzymes that are connected to multiple process chains [10,16,17].

Short cold therapy sessions cause increased excitability of peripheral sensory and motor nerves as well as increased muscle tone. In contrast, long cold therapy sessions with extremely low temperatures raise the pain threshold, decrease the excitability of nerve fibres, reduce nerve conduction velocity, and decrease muscle tone. "The pain reduction or elimination as well as the reduced muscle tone seen after these procedures are very important in patient management, especially in musculoskeletal disorders. The anti-inflammatory and anti-oedema effects are important therapeutic effects of cold therapy" [16-18].

AIM

The aim of this study was to evaluate the use of cryotherapy in painful shoulder syndrome.

MATERIALS AND METHODS

The study was conducted in the Sul-Med Rehabilitation Clinic in Sulejów in patients with painful shoulder syndrome (PSS) who were found eligible for conservative treatment (physical therapy) based on the results of clinical and radiographic examinations. Study patients underwent local cryotherapy procedures.

The study included 30 patients with PSS: 15 women and 15 men. All study patients had unilateral pathological changes; the changes affected the right shoulder joint in 17 patients and the left shoulder joint in 13 patients Table 1.

The study group consisted of patients aged 35 to 60 years. All patients were evaluated twice: before the treatment and once they had undergone 10 procedures, all performed in the same setting.

The assessments included the following:

a) history taking with subjective assessment of pain during movement according to the 5-point Laitinen scale;
b) measurements of the ranges of motion in the shoulder joint using a goniometer with an accuracy of 2º; the results were recorded according to the SFTR method.

The measurements performed in all patients were as follows:

- they included flexion and extension of the arm;
- the patient was in a sitting position when the ranges of arm abduction and adduction were measured;
- the starting position for the measurement of the range of external and internal rotation of the arm was the supine position with the arm in adduction to the chest and with 90-degree forearm flexion.

Treatment of PSS patients consisted of 10 procedures performed on 10 consecutive working days and included the following:

- local cryotherapy procedures of the shoulder joint area;
- kinesiotherapy.

PHYSICAL THERAPY

Study patients underwent cryotherapy procedures, which directly prepared them for the exercises. The procedures were performed using the Kriopol R26 device. Each study patient underwent 10 procedures; the duration of a single procedure was 3 minutes. Each cryotherapy procedure involved circular movements of the nozzle around the shoulder joint at a distance of approximately 10 centimetres from the surface of the skin. The temperature reached at the nozzle was -170ºC. No study patients showed poor tolerability of the low temperature. Kinesiotherapy was started on the second or third day of treatment. Initially, the kinesiotherapy sessions lasted 15-20 minutes; their duration changed to 25-35 minutes at the end of the rehabilitation period. In the first days of treatment, when study patients experienced considerable pain, only active

Table 1. Diagnosis in study patients

Diagnosis	Number of patients (%)	
Impingement syndrome (rotator cuff disorder)	9	30%
Shoulder joint instability	7	23.3%
Damaged tendon of the long head of the biceps brachii	4	13.3%
Neck and shoulder pain	8	26.6%
Frozen shoulder	2	6.6%

exercises with no weight-bearing on the affected joint were used.

The patient moved the affected upper limb slowly and without assistance while the limb was in axial suspension in a UGUL cage. The movements were only performed until the point of pain. Near the end of the first week, as the pain decreased, self-assisted exercises were introduced. Local relaxation exercises and breathing exercises were performed between the exercises in each plane. Throughout the treatment period, study patients also performed isometric exercises of the muscles of the affected shoulder girdle. Once the pain had been eliminated, patients performed autoredressive exercises with the use of the same equipment as for the self-assisted exercises. Half-way through the second week, resistance exercises with weight cuffs were introduced.

RESULTS

Patients with painful shoulder syndrome mostly complained of pain, which disturbed their sleep, considerably limited their ability to perform household chores, and reduced their work productivity. The majority of study patients used analgesic and anti-inflammatory medication. The frequency and intensity of pain in study patients varied considerably (Table 2).

Before treatment, all study patients had mobility limitations in all planes as compared to the physiological values.

The nonparametric Wilcoxon signed-rank significance test was performed in order to verify whether the differences in results seen in patients after vs. before the procedures were statistically significant or not. This test was used for two dependent samples, for paired samples, to determine significant differences after vs. before treatment. Four tests were performed for the following variables: pain intensity, pain frequency, analgesic and anti-inflammatory medication use, and motor activity limitation. Motor activity limitation is significantly less common in patients after the procedures.

As shown in Table 3, the results of all four tests turned out to be statistically significant. The results obtained in patients after treatment are significantly better than those seen before treatment. The responses provided by study patients suggest that pain intensity (Z=-4.939, p<0.001)

Table 2. Pain assessment according to Laitinen scale

Pain index	Pain assessment	Score	Number of people before treatment	Number of people after treatment
I	pain intensity			
	without pain	0		17
	mild	1		13
	strong	2	8	
	very strong	3	18	
	not sustainable	4	4	
II	pain frequency			
	does not occur	0		17
	periodical	1		13
	frequent	2	12	
	very frequent	3	9	
	continuous	4	9	
III	analgesic and anti-inflammatory medication use			
	without analgesic medication	0	2	
	periodically	1	10	20
	permanently – small doses	2	9	7
	permanently – big doses	3	8	3
	permanently – very big doses	4	1	
IV	motor activity limitation			
	none	0		17
	partial	1	7	13
	making work difficult	2	14	
	making work impossible	3	9	
	preventing self-sufficiency	4		

Table 3. Wilcoxon signed-rank significance test based on positive ranks

	Pain intensity	Pain frequency	Medication use	Motor activity limitation
Z	-4.939	-4.932	-3.153	-4.964
Asymptotic significance (two-sided)	<0.001	<0.001	0.002	<0.001

Table 4. Range of motion (average) for each type of movement

	Physiological	Mean range before the procedures in degrees	Mean range after the procedures in degrees
Abduction	180	107.3	160.4
Adduction	0	0	0
Flexion	180	90.25	158.2
Extension	60	35.85	48.9
External rotation	60	27.45	41.9
Internal rotation	80	46.3	60.5

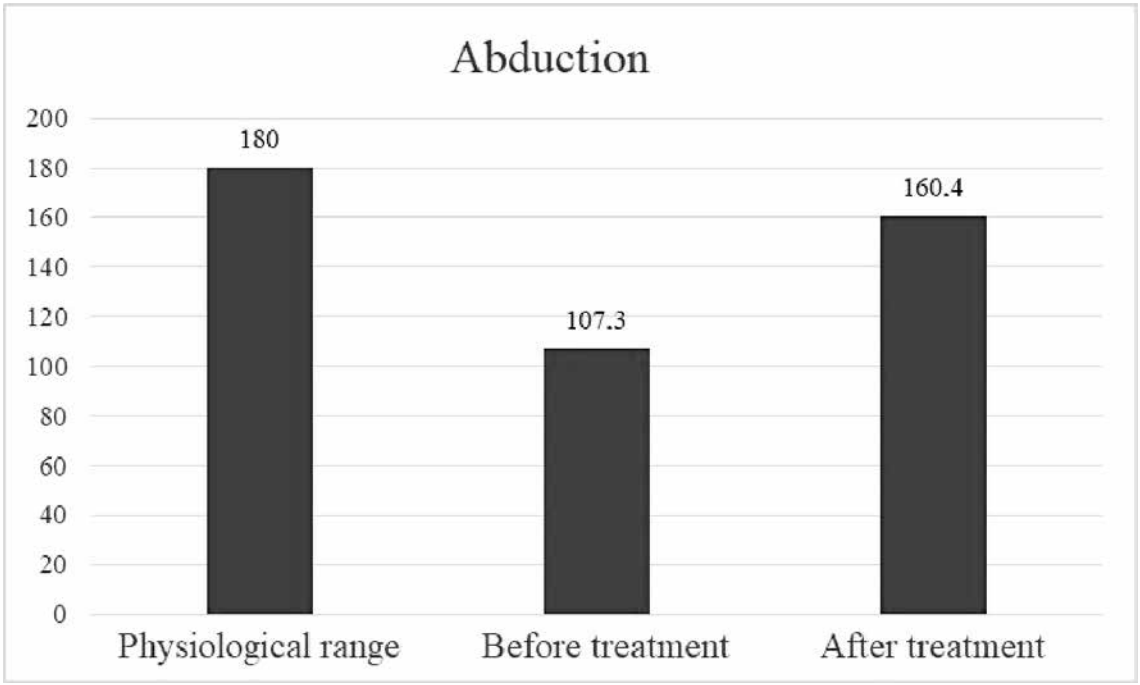

Fig. 1. Range of motion (average) for abduction.

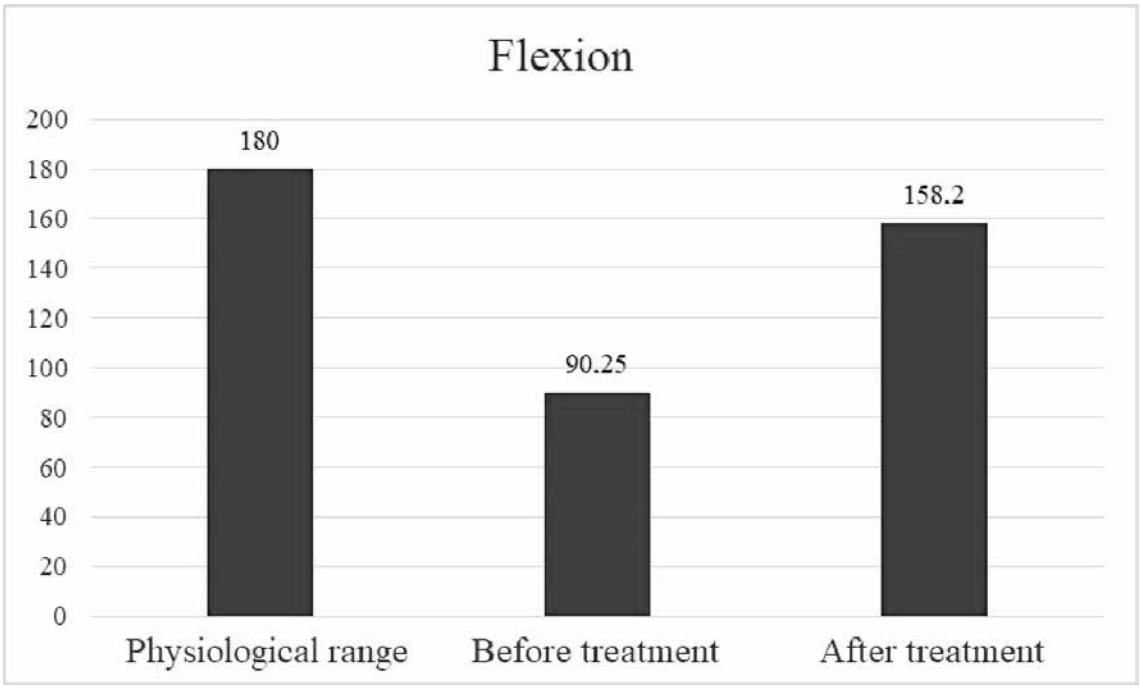

Fig. 2. Range of motion (average) for flexion.

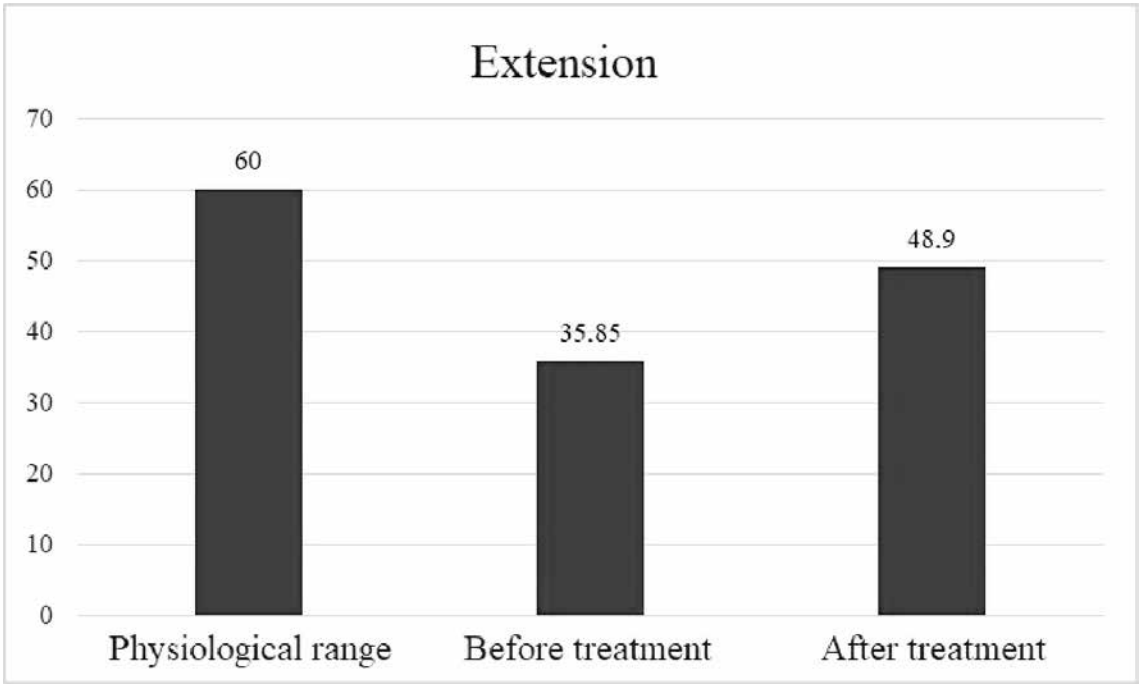

Fig. 3. Range of motion (average) for extension.

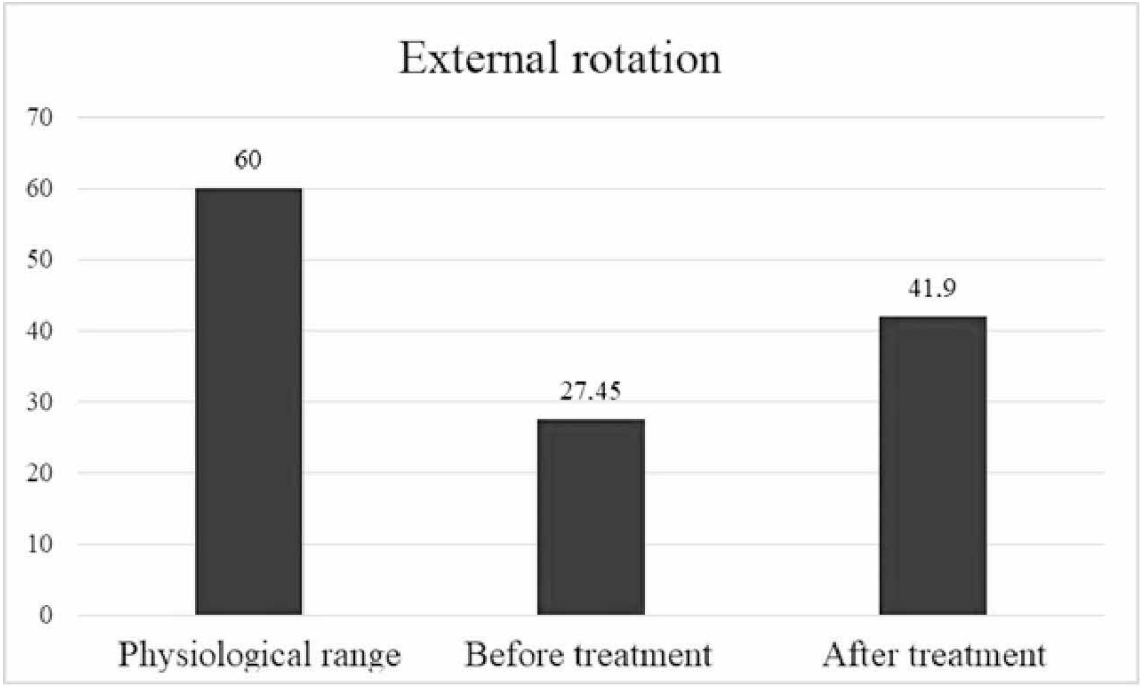

Fig. 4. Range of motion (average) for external rotation.

and pain frequency (Z=-4.932, p<0.001) were reduced. After the procedures, study patients reported significantly lower use of analgesic and anti-inflammatory medication (Z=-3.153, p=0.002). After treatment, the respondents reported a significantly lower level of motor activity limitation as compared with the results recorded before the procedures (Z=-4.964, p<0.001).

The range of motion for each type of motion is presented in Table 4 and Figures 1-5.

DISCUSSION

The results of baseline range of motion measurements in the study group show mobility limitations in all planes in the affected joint as compared to the physiological values. Pain described as severe or not sustainable in the Laitinen scale was reported by 22 patients (73%). The pain intensified at night, making it difficult or impossible to fall asleep. The pain experienced by study patients made it difficult and sometimes impossible to work and perform the activities

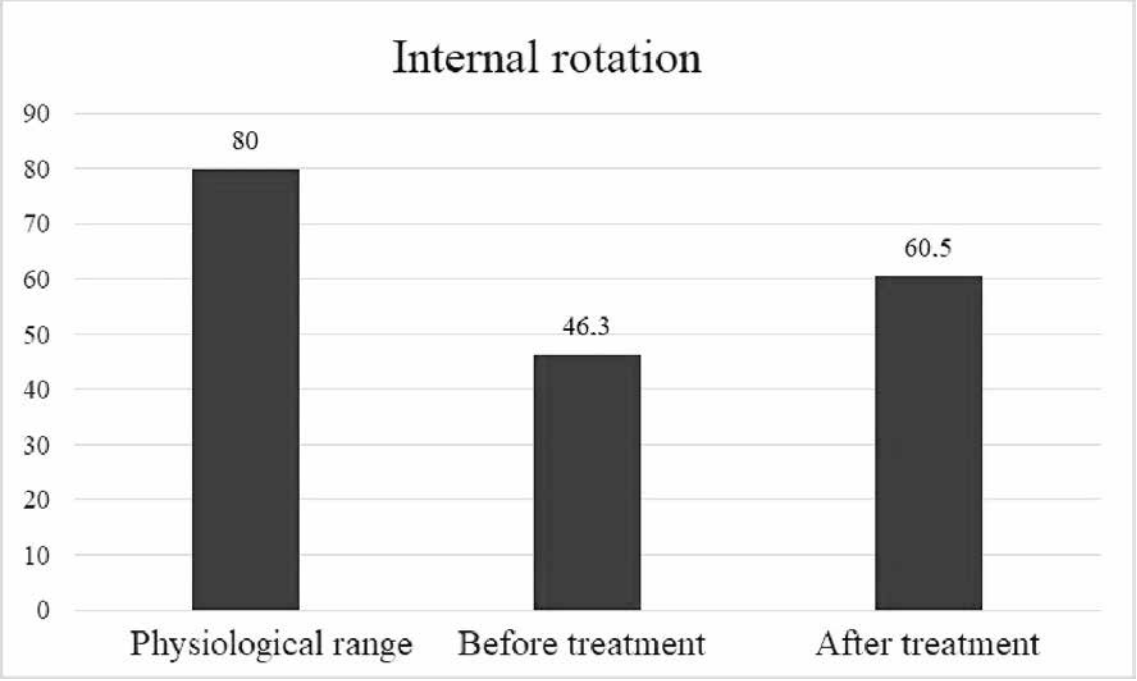

Fig. 5. Range of motion (average) for internal rotation.

of daily life. This situation forced study patients to take analgesic and anti-inflammatory medication; at baseline, 9 patients (30%) used this form of treatment. Apart from pain, limited ranges of mobility in all planes as compared to the physiological values were found using functional tests and measurements of the range of motion in the shoulder joint according to the SFTR method. The most pronounced joint mobility limitation concerned external rotation of the arm (up to 35 degrees on average).

After treatment, the range of motion in all the planes examined in the study increased on average by over ten degrees, with the final results being much closer to the physiological values. The improvement achieved in the range of motion in these planes seems satisfactory. Based on pain assessment criteria, it was also found that all patients showed a very clear reduction in pain due to the treatment they had received, with 20 patients (66%) being pain-free and 10 patients (33%) experiencing occasional pain. After treatment, 17 patients did not have any motor activity limitation (56%) and 13 patients showed only partial limitation (43%).

All baseline and post-treatment ranges of motion are within the range of functionally useful movements. Functionally useful ranges of motion for the upper limb are ranges that allow the patient to perform unassisted activities such as eating, preparing meals, turning a page in a book while holding the upper and lower corner of the page, writing, dressing, brushing hair etc.

The baseline and post-treatment ranges of motion without pain were enough for study patients to efficiently perform the activities of daily living without help, which reflects a considerable improvement as a result of local cryotherapy and kinesiotherapy in the treatment of patients with painful shoulder syndrome. This method of assessment seems justified.

Local cryotherapy is one of the better forms of treatment for patients with painful shoulder syndrome. Cryotherapy is a valuable physical therapy method and helps perform kinesiotherapy, allows for early introduction of motor exercises and, consequently, for increasing the range of motion and functionality of the joint. Local application of cryotherapy at a temperature of approximately -170°C for up to three minutes has analgesic effects and relaxes the muscles, ligaments, and capsule, which makes it possible to apply and modify the kinesiotherapy programme and decrease or increase weight-bearing on the shoulder joint depending on the patient's functional capability. No study patients reported poor tolerability of the procedure during shoulder joint cryotherapy sessions. Moreover, there were no side effects during and after the procedures. The therapy was seen as beneficial, which was mostly due to the reduction or elimination of pain. Although the ranges of motion achieved after treatment were close to the physiological values, the kinesiotherapy programme should be continued at home.

The positive effects of local cryotherapy encourage a wider use of this form of treatment.

CONCLUSIONS

1. Painful shoulder syndrome is a difficult diagnostic and therapeutic problem.
2. The use of cryotherapy helped eliminate or reduce the pain.
3. Study patients showed increased ranges of motion in all planes in the joint.
4. The quality of life and functioning in study patients improved.
5. Treatment of this disorder is based on physical therapy.

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CONFLICT OF INTEREST

The Authors declare no conflict of interest

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ORIGINAL ARTICLE

Peculiarities of population compliance with the rules of dietary nutrition for health promotion

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ABSTRACT

Aim: To study the attitude of the population of Ukraine to the rules of dietary nutrition to improve their health.

Materials and Methods: The research which involved 214 respondents (38 men and 176 women) of different ages. Research methods: bibliosemantic, medical and sociological (survey), statistical. The survey was anonymous and it was conducted according to the author's questionnaire.

Results: It has been found that the 79.0 % of the respondents are unaware of the importance of dietary nutrition and its significance in promoting health, and incorrectly define the term "dietary nutrition". It has been found that 44.0 % of the respondents are overweight, 11.0 % are obese of varying degrees; 78.0 % of the respondents consume excessive amounts of sour and pickled food, 71.5 % eat sugar and sweets, 52.8 % – fatty, smoked, and fried food, 45.3 % – bakery products, 22.9 % – fast food; only 26.0 % know about the norm of the ratio of nutrients in food and try to adhere to it. This indicates that the vast majority of the respondents have an unbalanced and chaotic diet, and do not follow dietary rules.

Conclusions: Nutrition is one of the factors influencing public health. An optimal healthy diet can improve human health and prevent most non-communicable diseases. The results of the research can be used in the course of outreach and awareness-raising activities by public health professionals to prevent chronic non-communicable diseases among the population.

KEY WORDS: nutrition, diet, health, healthy lifestyle

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INTRODUCTION

High-quality, healthy nutrition is the key to maintaining and improving the health of the population of any country. According to experts [1], a healthy diet helps prevent multifactorial non-communicable diseases and treats existing diseases. In contrast, inadequate and irrational nutrition provokes a weakening of the immune system, increased susceptibility to disease, impaired physical and mental development, and reduced productivity and learning. The consequences of improper (irrational) nutrition are most often diseases of the gastrointestinal tract, cardiovascular, excretory, hepatobiliary, and endocrine systems [2].

There is a need for dietary nutrition that will help to correct metabolic processes, promote health, and prevent diseases in the population. According to experts [3], an imbalance in the chemical composition of diets, namely an insufficient amount of some components and an excessive amount of others, is a major risk factor for the development of chronic non-communicable diseases. Food in the diet of a modern person is a supplier of energy, and if there is a disproportion of nutrients, the amount of energy can be excessive. Therefore, the task of dietetics is to balance the nutrients of food and thus achieve its optimal value. With this in mind, studying the impact of dietary nutrition on promoting the health of Ukrainian citizens and developing promising areas for the dissemination and implementation of healthy eating is an important public health task.

AIM

The aim is to study the attitude of the population of Ukraine to the rules of dietary nutrition to improve their health.

MATERIALS AND METHODS

The research was conducted in 2022-2024 at Zhytomyr Medical Institute of Zhytomyr Regional Council and Zhytomyr Ivan Franko State University. The research involved 214 respondents (38 men and 176 women) of different ages

(18 to 70 years and older). The ratio of the respondents by age is as follows: 18-29 years old – 17.0 %, 30-39 years old – 19.0 %, 40-49 years old – 28.0 %, 50-59 years old – 15.0 %, 60-69 years old – 18.0 %, over 70 years old – 3.0 %. All respondents were patients of outpatient clinics in Zhytomyr city.

Research methods: bibliosemantic – to study the existing world and national practices of dietary nutrition and its impact on the state of health of the population; medical and sociological (survey) – to determine the awareness of the population about the features of dietary menus, their importance for the treatment and prevention of chronic non-communicable diseases, as well as to study the impact of dietary nutrition on the health of the population of different ages; statistical – to analyze the results of medical and sociological research. The survey was conducted using the author's questionnaire. The questionnaire has a standard structure and contains the following components: addressing the respondent, obtaining the respondent's consent to participate in the study, and the main section with targeted questions (35 questions). The questionnaire was anonymous without any references to the authors of the article in the answers. The results were used for scientific purposes only. Questionnaire was assessed by the experts in this field (3 professors and 3 associate professors) and was approved by the Academic Council of Zhytomyr Ivan Franko State University (Protocol No. 2 dated 12.09.2022).

Data calculation, processing, and analysis of the research results were performed on a personal computer using a software package that allows the use of statistical data processing methods – MS Excel. Consent to voluntary participation in the survey was obtained from all the respondents involved in the study. This research followed the regulations of the World Medical Association Declaration of Helsinki – ethical principles for medical research involving human subjects.

RESULTS

It has been found that 83.0 % of the respondents live in a city, and the rest – 17.0 % – in a village or town. Only 9.0 % of the respondents have a medical degree. The study of the respondents' answers about their body weight and height allowed us to determine their body mass index, which is calculated as the ratio of body weight in kilograms to height in meters squared. The results allowed us to divide the respondents into the categories of "less than normal", "normal", "overweight" and "obese", as shown in Fig. 1. The distribution of the calculated indicators shows that the vast majority of the respondents are overweight (44.0 %), and 11.0 % are obese to varying degrees. As it is well known, an increase in body mass index indicates a risk of stroke in men and women, development of gastrointestinal pathologies, etc.

Research shows that the impact of certain dietary factors has a significant impact on public health. For example, excessive salt intake, insufficient whole grains and fruits in the diet, high consumption of red meat and sweetened beverages, and trans fats can cause more than 50 % of deaths related to nutrition. The results of answers to the question "Which of the following foods do you consume in excess?" show that 78.0 % of the respondents consume sour and pickled foods, canned foods, and preserves in excess; 71.5 % consume sugar and sweets. Half of the respondents (52.8 %) abuse fatty, smoked, and fried foods. Slightly less than half of the respondents (45.3 %) consume a lot of bakery products. A fifth of the respondents abuse fast food and excessive salt – 22.9 % and 18.0 %, respectively.

Food is the most important factor affecting blood sugar levels. Blood sugar levels are important for human health. Optimal blood sugar levels help ensure normal body function, while high or low blood sugar levels can lead to health problems. Carbohydrates, such as sugar and white flour, are quickly broken down into glucose and absorbed into the bloodstream, causing a rapid rise in blood sugar levels. Glucose levels can increase after eating, so people with diabetes should carefully follow dietary recommendations and closely monitor their sugar levels. It has been found that more than half of the respondents (53.3 %) "systematically" take blood tests to monitor glucose levels; more than a third of the respondents (36.0 %) said they check their glucose levels only when directed or recommended by their doctors.

Nutritionists note that a snack is the consumption of food or drink between meals. Snacks include tea or coffee breaks, cookies, chips or popcorn, etc. The main purpose of any snack is to satisfy hunger. The analysis of the answers to the question about the availability of snacks between main meals shows that a significant number of the respondents – 71.0 % answered the question about snacks in the affirmative. Only 29.0 % of the respondents do not have snacks between meals. It has been found that the largest share of snacks was made up of pastries (buns, pies, cookies, muffins, cakes, pancakes) and sweets (candies, chocolate, chocolate bars, waffles) – 24.3 % and 17.1 %, respectively; tea or coffee – 16.4 %, sandwiches with cheese or sausage – 16.4 %; seasonal fruits (apple, pear, strawberry, cherry, orange, banana) – 13.8 %; fruit juices or compote – 5.9 %; potato chips, crackers, dry noodles – 3.3 %; energy drinks – 2.6 %; sweet carbonated drinks – 1.3 %.

The following results were obtained when asked "What influences the choice of food you eat the most?" 45.0 % of the respondents choose food according to their financial capabilities; 21.0 % consider the "healthiness of food"; 18.0 % listen to advertising and the media (television, radio, Internet, street advertising); 16.0 % follow family traditions.

The results of answers to the question "Do you think it is important and appropriate to follow a diet?" show that one-third of the respondents do not consider it necessary to follow the principles of dietary nutrition. The share of such answers was 31.0 %. The majority of the respondents know little about dietary nutrition and primarily associate it with starvation and compliance with "beauty standards."

According to nutritionists, the basis of a healthy diet is a balanced meal (three or four times a day), with a

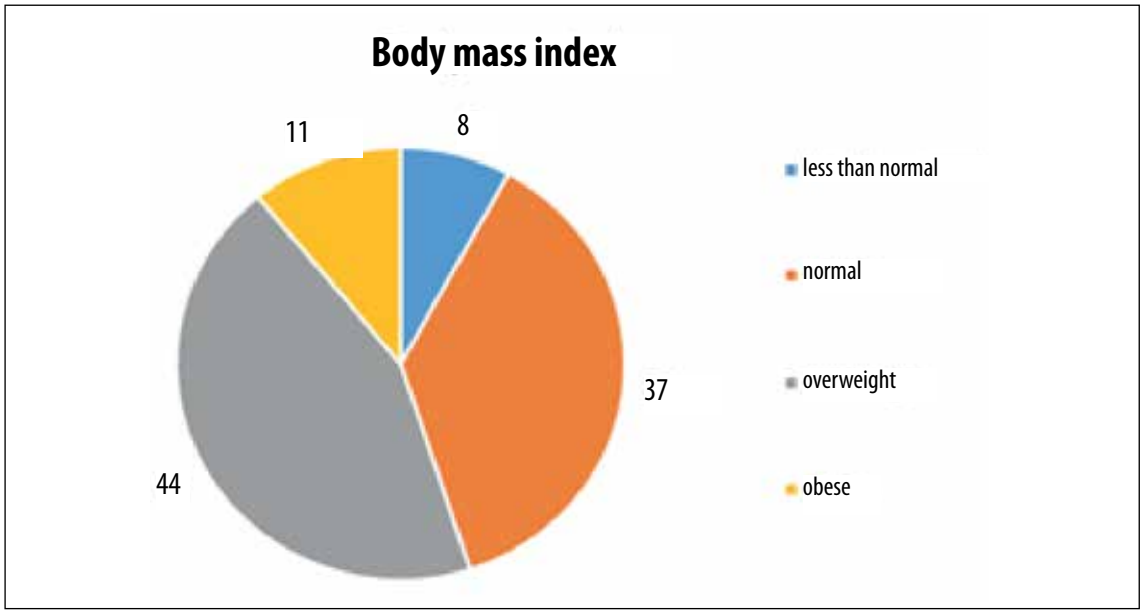

Fig. 1. Ratio of the respondents by body mass index (n = 214, %).

redistribution of calories: breakfast should account for 20-25 % of calories, lunch – 50-55 %, and dinner – 20-30 %. In addition, the ratio of proteins, carbohydrates, and fats should also be balanced and should be 1:4:1. It has been found that only a quarter of the respondents (26.0 %) are aware of the norm of the ratio of nutrients in food and try to adhere to it. The vast majority – 67.0 % – do not know about this distribution and, accordingly, do not adhere to it, stating that the choice of food depends on the desire, financial capabilities, and availability of food in a certain period. Similar answers were given to the question "Do you observe the ratio of the amount of food for breakfast/lunch/dinner in your daily diet?". From there, 74.0 % of the respondents answered "no". Some of these respondents do not adhere to this ratio because they eat only 2 meals a day.

The results of the next question "Do you have sufficient knowledge about dietary nutrition and its importance for health promotion?" have shown that the vast majority of the respondents (79.0 %) are unaware of the meaning of dietary nutrition and its importance for health promotion. The distribution of answers to the question "Does a person's diet affect their health?" confirms that the respondents have insufficient knowledge about the impact of dietary nutrition on health promotion. One-third of the respondents (32.0 %) mistakenly believe that diets harm health rather than promote it.

To promote health, nutritionists recommend following a "healthy" diet, which regulates nutrient content, reduces the risk of cancer, helps to overcome depression, and improves well-being. After all, a healthy diet improves human health. Dietary nutrition is the introduction of a lifelong way of eating. However, when asked the question "If your weight starts to increase, do you eat less than usual?" 25.0 % of the respondents answered "sometimes"; 21.0 % – "never"; 17.0 % – "very rarely". This distribution indicates that a significant number of the respondents do not associate weight gain with their diet and do not care about their health. At the same time, one-third of the respondents stated that they do not monitor the amount of food they consume. When asked about the respondents' opinions on refusing food and drinks to maintain weight, the following distribution of answers was obtained: 14.0 % answered "very often", 21.0 % answered "often", and 20.0 % answered "sometimes".

Nutritionists note that to lose weight, one should consult a doctor, increase physical activity, review their eating habits, and change them to more rational ones. The analysis of answers to the question "Do you choose food on purpose to lose weight?" showed that a significant cohort of the respondents "often" or "very often" deliberately choose food for weight loss – 27.0 % and 22.0 %, respectively. It has been also found that 26.0 % of the respondents "very often" eat breakfast, lunch, and dinner at the same time, 26.0 % "often", 23.0 % "sometimes", 17.0 % "very rarely", and 8.0 % "never". When asked about the respondents' opinion on the healthiness of the food they eat, it was found that 25.0 % of the respondents do so "very often," 24.0 % – "often," 24.0 % – "sometimes," 18.0 % – "very rarely," and 9.0 % – "never." This distribution indicates that half of the respondents try to keep track of the healthiness of the food they prefer. At the same time, the respondents do not always monitor the ratio of proteins, fats, and carbohydrates in their daily diet, in the vast majority, do not adhere to it. The largest share of the respondents answered "never" (33.0 %) and "very rarely" (23.0 %). The following distribution of responses was revealed when asking the respondents about vitamins in the food they consume: "very often" – 9.0 %, "often" – 14.0 %, "sometimes" – 16.0 %, "very rarely" – 32.0 %, "never" – 29.0 %.

The distribution of answers to the question "How often do you try not to eat in the evening because you are watching your weight?" was as follows: "very often" – 19.0 %, "often" – 27.0 %, "sometimes" – 17.0 %, "very rarely" – 17.0 %, "never" – 20.0 %. This trend is negative, as it has been found that evening meals worsen sleep and lead to fat storage. At the same time, 32.0 % of the respondents "very often" overeat for the night, 27.0 % – "often", 18.0 % – "sometimes", 15.0 % – "very rarely", and 8.0 % – "never". Analyzing the results of the survey, we can conclude that the majority of the respondents have an extremely unbalanced and chaotic daily diet. 32.0 % of the respondents "very often" overeat, 25.0 % – "often", 21.0 % – "sometimes", 15.0 % – "very rarely", 7.0 % – "never".

DISCUSSION

The problem of preserving human health is always relevant, especially for the population of Ukraine today. According to the researchers [4], health is one of the most important resources necessary for the development and realization of the personal potential of each person. It is a multidimensional phenomenon, complex and heterogeneous in its structure. As scientists point out [5], studying the factors that influence health, as well as understanding the significant role of the individual in health protection and health promotion, will increase the effectiveness of influencing this process. Scientists [6, 7] divide the factors that shape the level of health into the following groups: 1) socio-economic – determine the conditions and lifestyle of the population. The share of such factors is 50-55 %. These include working conditions, material well-being and living conditions, quality and level of nutrition, recreation, etc.; 2) socio-biological factors – determined by heredity. They account for 15-20 %. This group includes such factors as age, gender, predisposition to hereditary diseases, etc.; 3) environmental and natural-climatic factors – environmental pollution, average annual temperature, extreme natural-climatic events, etc. They account for 20-25 %; 4) organizational or medical factors – determined by the level of medical care. They account for 10-15 %. These factors include the provision of medical and social assistance to the population, its quality and accessibility, etc. According to researchers [8], lifestyle, in particular the level and quality of nutrition, has the greatest impact on human health. Thus, healthy nutrition is one of the most important factors that ensures and guarantees human health, the ability to work, determines the quality and duration of life, and the ability to withstand external adverse influences [9]. Rational and balanced nutrition combined with regular physical loads form the basis of a high level of health. Incorrect and unbalanced (irrational) nutrition leads to a weakening of the immune system, a decrease in human productivity, an increase in morbidity, and a violation of the physical and mental state [2].

In Ukraine, nutritionists advise adhering to the following nutrition model – "Ukrainian plate of healthy food", which is divided into five sectors, each of which is represented by the most useful food products that should be consumed daily [10]. The first and largest sector is traditional Ukrainian vegetables and legumes (beets, carrots, onions, garlic, pumpkin, cabbage and zucchini, cucumbers and tomatoes, peas, beans, chickpeas, lentils, soybeans, and others). The second segment includes fruits and berries (apples, pears, apricots, plums, bananas and oranges, strawberries, blueberries, raspberries, currants, blackberries, and others). The list of fruits and berries according to the Ukrainian healthy food plate should be in a person's daily diet. The next sector is milk, dairy, and fermented milk products. The fourth sector is represented by whole grain products, nuts, and seeds (various cereals, bread and bread rolls, durum pasta). The last, fifth segment includes meat and meat products, eggs, and fish. Scientists [11] claim that diet is one of the most important methods of treatment for many diseases. For diseases such as mild diabetes or alimentary obesity, it is the only method of treatment. The main principles of therapeutic nutrition are the correct selection of products and compliance with the technological rules of culinary processing, the temperature of the food, as well as the frequency, time, and number of meals. Experts [12] are convinced that exacerbations of many diseases are associated with various nutritional disorders. The consumption of sugary foods in diabetes mellitus leads to a sharp rise in blood sugar, dry mouth, and increased thirst. The progression of fatty infiltration of the liver and pancreas and chronic pancreatitis is observed after eating fatty foods, alcoholic beverages, fried foods, etc. A large amount of salt in food provokes an increase in blood pressure in people with hypertension [3].

According to scientists [13], medical nutrition (diet therapy) is used for therapeutic or preventive purposes using specially formulated food rations and dietary regimens. Dietary therapy is an integral and essential aspect of the overall treatment plan for all diseases, which aims to restore metabolic disorders and correct the state of human health by excluding foods that hurt diseased organs. The dietary regimen depends on the nature of the disease, its stage, the patient's condition, and individual characteristics. The vast majority of diets should contain the physiological norm of all nutrients. This is especially true for diets prescribed for a long time. If there is an increased need for certain nutrients due to the disease (increased consumption of protein, vitamins, iron, fluid loss, mineral salts), the content of individual components can be increased. The basis of medical nutrition is compliance with its regimen, which should take into account the following rules [1, 6, 14, 15]:

1. Adhere to dietary prescriptions (tables), quantitative and qualitative distribution of the daily ration, and intervals between individual meals. The optimal interval between meals is 4 hours. A second breakfast is organized for five meals a day, and an afternoon snack for six meals a day.
2. Eat meals at the same time and with a certain frequency. The night break should be 10-11 hours, and it is not recommended to eat two hours before bedtime.
3. Take into account the qualitative composition of food (increase or decrease in proteins, fats, carbohydrates,

etc.) and its quantity. Portion size, taste, and physical properties of food are important. The temperature of hot dishes should be about 60°C, and cold dishes 10-15°C.
4. Adhere to the approaches to culinary processing of food (degree of grinding, heat treatment, steaming or boiling in water, baking, etc.).
5. Do not forget about the importance of appetite and everything that contributes to it. The aesthetic design of dishes, table setting, and the creation of a calm atmosphere during meals are important. Tables in the dining room should be designed for 2-4 people. Only patients who are on the same diet should be brought together at the tables.

CONCLUSIONS

The research has shown that the vast majority of the respondents (79.0 %) are unaware of the meaning of dietary nutrition and its importance in promoting health, incorrectly define the term "dietary nutrition", and mistakenly associate diet with weight loss. At the same time, succumbing to general trends and beauty standards, they do not take into account that rapid weight loss can occur due to deprivation of energy, vitamins, and nutrients. All food mistakes affect human health. It has been found that 44.0 % of the respondents are overweight, 11.0 % are obese of varying degrees; 78.0 % of the respondents consume excessive amounts of sour and pickled food, 71.5 % – sugar and sweets, 52.8 % – fatty, smoked, and fried food, 45.3 % – bakery products, 22.9 % – fast food; only 26.0 % know about the norm of the ratio of nutrients in food and try to adhere to it; 32.0 % of the respondents overeat "very often", 25.0 % – "often", and 21.0 % – "sometimes". This shows that the vast majority of the respondents have an unbalanced and chaotic diet.

It has been shown that the consequence of improper and unbalanced nutrition and abuse of the amount of food consumed or complete rejection of it is the deterioration of health and the development of chronic diseases. The survey results have also shown the desire of the Ukrainian population to increase their knowledge of dietary nutrition, and indicated areas of outreach and awareness-raising activities by public health professionals on healthy eating and healthy lifestyles. Thus, nutrition is one of the factors influencing public health. An optimal healthy diet can improve human health and prevent most non-communicable diseases. Dietary nutrition is a means of normalizing health, preventing and treating chronic diseases, and maintaining high working capacity.

Prospects for further research are in assessing the quality of nutrition and compliance with dietary rules by students of higher educational institutions in Ukraine.

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ORIGINAL ARTICLE

The effects of whole-body cryotherapy on the mental and physical condition of patients with degenerative changes of the spine following the COVID-19 pandemic

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ABSTRACT

Aim: To assess the therapeutic effects of ten whole-body cryotherapy treatments on mental and physical condition in patients with degenerative spine changes post-COVID-19 pandemic.

Materials and Methods: 65 patients underwent whole-body cryotherapy at a rehabilitation center in Lodz. Well-being, fatigue, physical fitness, and pain severity were evaluated using Modified Fatigue Impact Scale, Short Physical Performance Battery, and Visual Analogue Scale. Impacts of demographic factors and COVID-19 infection were assessed.

Results: 72% of patients showed improved physical fitness. Fatigue index demonstrated the lowest increase and highest variability. 77% reported decreased pain post-treatment.

Conclusions: Ten whole-body cryotherapy treatments improved mental and physical condition, including pain reduction, in patients with degenerative spine changes, regardless of demographic factors or previous COVID-19 infection. The therapy enhanced lower limb strength, balance, and walking speed, potentially mitigating pandemic-related functional decline.

KEY WORDS: whole-body cryotherapy, degenerative changes of the spine, COVID-19

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INTRODUCTION

Despite being one of the oldest fields of medicine, physical medicine continues to develop dynamically [1]. Cryotherapy, a form of physical therapy, uses cold to achieve therapeutic effects. While various methods of cryotherapy exist, whole-body cryotherapy (WBC) has gained particular attention in recent years [2].

WBC involves exposing the entire body to extremely low temperatures, typically between -100°C and -140°C, in special cryogenic chambers for short durations (2-3 minutes). The proposed mechanisms of action for WBC are complex and multifaceted. Initially, the extreme cold causes vasoconstriction, followed by rapid vasodilation upon rewarming, which may contribute to reducing inflammation and pain. The analgesic effects are thought to occur through the slowing of nerve conduction velocity and the release of endorphins. WBC is also believed to have an anti-inflammatory action by decreasing the production of pro-inflammatory cytokines. Furthermore, the treatment stimulates the autonomic nervous system, potentially improving cardiovascular function. There is also evidence suggesting that WBC influences antioxidant parameters in the body, possibly reducing oxidative stress.

These mechanisms collectively contribute to pain relief, reduction of inflammation, and improvement in musculoskeletal function [3]. WBC is being studied as a potential treatment for various conditions, including rheumatic diseases, inflammatory disorders, and sports injuries [4]. However, the full range of benefits and potential risks associated with WBC are still subjects of ongoing research [5].

Recent health challenges, including the COVID-19 pandemic, have highlighted the need to seek effective and innovative methods to improve mental [6] and physical health [7] in patients with degenerative spine disease [8]. Therefore, it is worth verifying whether whole body cryotherapy may not only be an effective form of therapy, but also a treatment that supports their adaptation to the changing post-pandemic environment and health situation [9].

AIM

The aim of the study is to evaluate the therapeutic effects of a series of 10 WBC treatments on the mental and physical condition of patients with degenerative spinal changes, after the end of the COVID-19 pandemic. Its findings can contribute to the development of new therapeutic perspectives for this group of patients.

MATERIALS AND METHODS

The study included 65 people: 48 women and 16 men. The youngest and oldest participants were women, aged 24

and 78 years old, respectively. All participants were patients of the Creator Centre for Prevention and Rehabilitation Ltd. NZOZ in Lodz (Teaching and Research of the Medical University of Lodz).

The inclusion criterion comprised a diagnosed degenerative spine disease of varying severity, confirmed by imaging examinations (X-ray/MRI/CT). The exclusion criteria comprised coexisting diseases with similar clinical symptoms (rheumatoid diseases, neurological diseases), the use of whole-body cryotherapy procedures within three months preceding the study, the use of other physiological treatments during observation, the use of any pharmacotherapy before or during therapy, age less than 18 years.

The participants were examined as part of their initial and final physiotherapeutic visits. During the initial visit, the patient recorded their sex, work mode (remote, hybrid, stationary), COVID-19 infection status and possible hospitalization due to this disease, in a questionnaire. The remaining information, namely age, comorbidities, mobility mode, parameters related to range of motion, and muscle strength, were recorded in the medical records by the person who conducted the initial and final physiotherapeutic visits.

The following tests and scales were used to assess the mental and physical condition of the patients:

- Modified Fatigue Impact Scale (MFIS) – a test consisting of 21 questions regarding the level of fatigue experienced by the patient in various areas of daily life [10],
- Short Physical Performance Battery (SPPB) – a test that checks lower limb function using tasks that mimic everyday activities, i.e. getting up from a chair, balance test, 3-meter walk test [11].
- Visual analogue scale (VAS), a scale for assessing the severity of pain using a 10-centimeter section, on which the participant places markers determining the subjective intensity of pain [12].

Each patient underwent a full series of ten whole-body cryotherapy procedures. They also used general physical fitness exercises and instrument-based exercises every day, being part of combined therapy.

The final part of the analysis was the final physiotherapeutic visit, during which the qualified participants again underwent the MFIS and SPPB tests and the VAS scale. The results were entered into the participant's study card.

The initial and final visits took place on the first and last days of the treatment cycle. All statistical calculations were performed using Statistica 13.1 software. The statistical significance of the results was considered at $p<0.05$.

RESULTS

During the research, participants were asked about the nature of their professional work (i.e. currently or before retirement), COVID-19 infection status, and possible hospitalization for this reason. The results are presented in Table 1.

The results of the MFIS scale showed that only 66% of the subjects achieved better parameters after cryo-chamber treatment. The responses also demonstrated considerable variation, indicated by the standard deviation. The mean MFIS values differed between the sexes: both before the treatment (women 21.43 points vs men 8.33 points) and afterwards (women 7.31 points vs. men 2.63 points) (Fig. 1). Regarding age, surprisingly, the smallest decrease in mean MFIS value was noted in the 21-40 age group (by seven points); this was followed by the 61-80 age group (by 8.66 points), and then the 41-60 age group (by 16.04 points). The mean MFIS values for people who had previously caught COVID-19 and those who had not are given in Fig. 2. The majority of respondents showed improved MFIS test parameters after the use of whole-body cryotherapy (Fig. 3).

Table 2 and Figure 4 present the results of the SPPB test, comparing participants who have had COVID-19 with those who have not. The test evaluates three aspects of physical performance: balance, lower limb muscle strength, and gait. For balance, both groups showed improvement after cryotherapy. The mean score for those with previous COVID-19 infection increased from 3.08 to 3.75, while for those without infection, it increased from 3.34 to 3.83. The standard deviation decreased in both groups, indicating more consistent performance post-treatment. Lower limb muscle strength also improved in both groups. Participants with COVID-19 history saw their mean score increase from 2.46 to 2.92, while those without increased from 2.93 to 3.22. Notably, the standard deviation for the COVID-19 group decreased substantially from 2.46 to 1.21, suggesting more uniform improvement. Gait performance improved as well. The COVID-19 group's mean score increased from 3.04 to 3.67, and the non-COVID group from 3.39 to 3.73. The standard deviation for the non-COVID group decreased, while it increased slightly for the COVID-19 group. The total test score, which combines all three components, showed overall improvement in both groups. The COVID-19

Table 1. Division of subjects according to work mode and COVID-19 infection

	Women	Men	Total subjects
Stationary work	43	14	57
Remote work	1	0	1
Hybrid work	5	2	7
COVID-19 infection	23	3	26
Hospitalization	0	0	0

Table 2. SPPB test results with regard to prior COVID-19 status

		People who have had COVID-19	People who have not had COVID-19
Balance	M - before cryotherapy	3.08	3.34
	M - after cryotherapy	3.75	3.83
	SD - before cryotherapy	0.83	0.88
	SD - after cryotherapy	0.61	0.54
Lower limb muscle strength	M - before cryotherapy	2.46	2.93
	M - after cryotherapy	2.92	3.22
	SD - before cryotherapy	2.46	1.17
	SD - after cryotherapy	1.21	0.96
Gait	M - before cryotherapy	3.04	3.39
	M - after cryotherapy	3.67	3.73
	SD - before cryotherapy	1.04	0.77
	SD - after cryotherapy	1.21	0.55
Total test score	M - before cryotherapy	8.58	9.66
	M - after cryotherapy	10.33	10.78
	SD - before cryotherapy	2.60	2.17
	SD - after cryotherapy	1.90	1.51

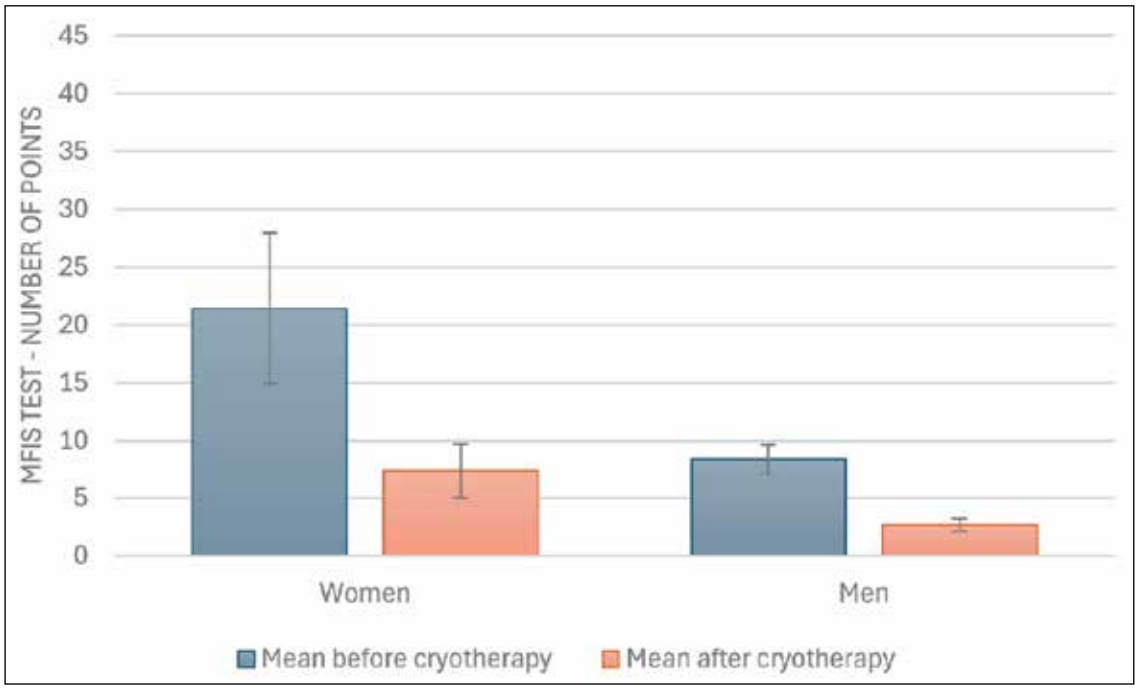

Fig. 1. MFIS test results for women and men.

group's mean total score increased from 8.58 to 10.33, while the non-COVID group improved from 9.66 to 10.78. Standard deviations decreased in both groups, indicating more consistent overall performance after cryotherapy.

The results of the VAS scale were much less diverse than the results of the previous tests. The vast majority of mean scored decreased during WBC. The percentage of people who showed improvement after the procedure in the cryochamber is presented in Figure 5.

Table 3 presents the statistical analysis of the three assessment tools used in this study: MFIS, VAS, and SPPB test. The MFIS test showed a statistically significant result ($p=0.00738$) with a Pearson's correlation coefficient of $r=0.33$. This indicates a weak positive correlation between the treatment and fatigue impact reduction. The VAS scale also demonstrated statistical significance ($p=0.01617$) with a correlation coefficient of $r=0.30$, suggesting a weak positive correlation between the treatment and pain reduction.

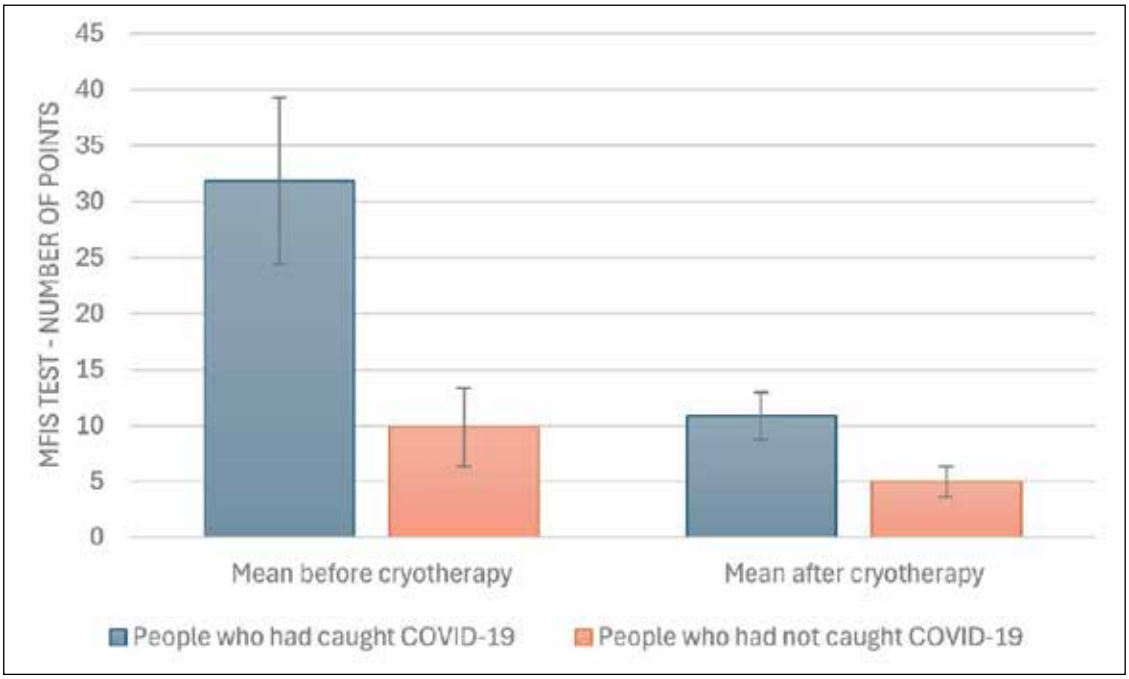

Fig. 2. MFIS test results according to previous COVID-19 status.

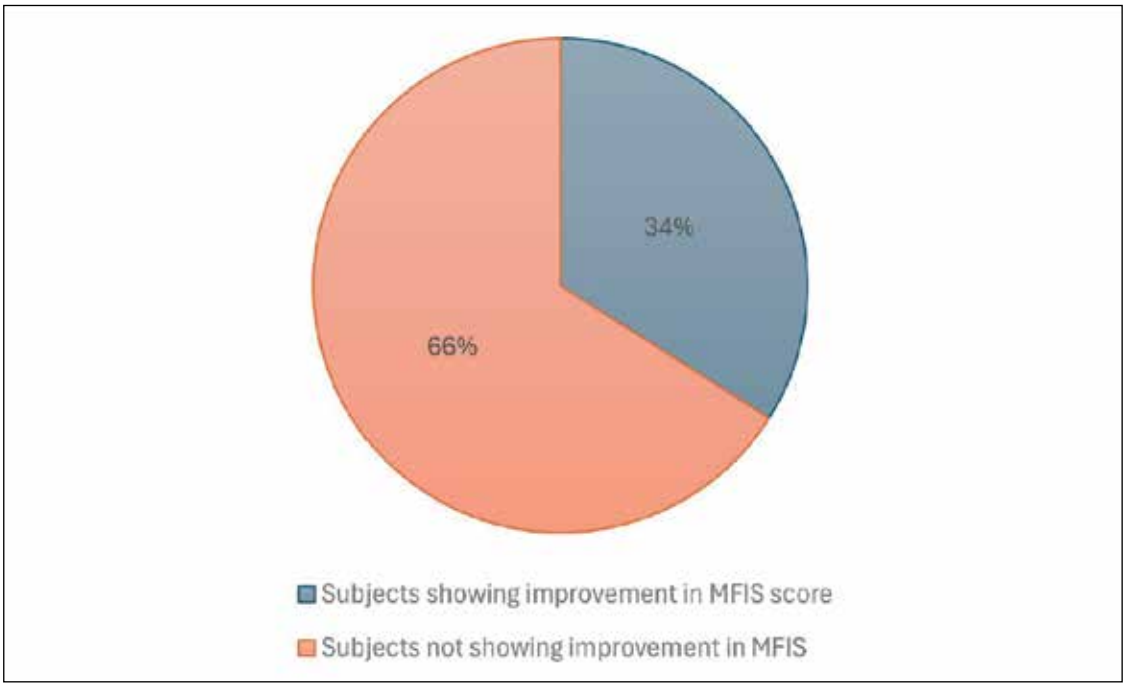

Fig. 3. Percentage share of subjects showing improvement in the MFIS Test.

The SPPB test yielded highly significant results (p=0.00001) with a strong positive correlation (r=0.90) between the treatment and improved physical performance.

These findings suggest that while whole-body cryotherapy had a statistically significant impact on all measured parameters, its effect was particularly pronounced in improving physical performance as measured by the SPPB test. The treatment showed weaker, though still significant, correlations with fatigue reduction and pain alleviation.

DISCUSSION

WBC has emerged as a promising therapeutic approach for various musculoskeletal disorders, including degenerative spine disease. Our study aimed to evaluate the efficacy of WBC in improving physical and mental conditions of patients with spinal degenerative changes, particularly in the context of the post-COVID-19 pandemic era. The results obtained from this investigation provide valuable insights into the potential benefits of WBC and its role in rehabilitation programs.

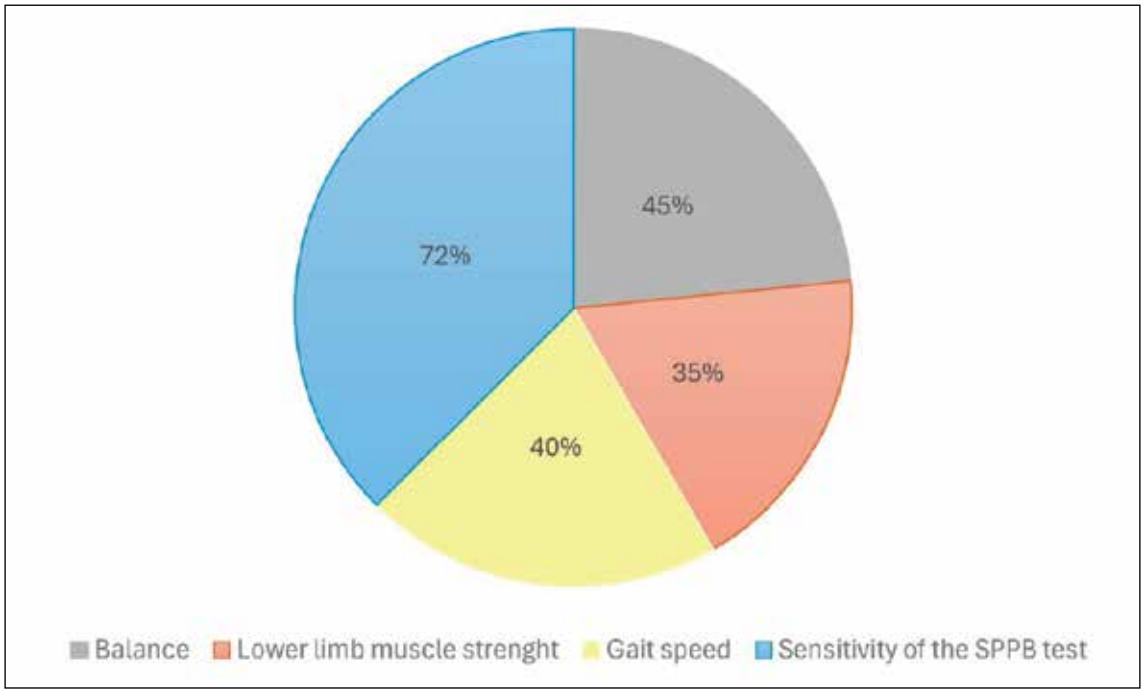

Fig. 4. Percentage distribution of subjects showing improvement in the SPPB test results and its individual components.

Table 3. Pearson's correlation - the effect of whole-body cryotherapy on individual tests

	Statistical significance	Pearson's correlation coefficient	r coefficient range	Type of correlation
MFIS Test	p=0.00738	r=0.3294	0<r<0.5	weak
VAS Scale	p=0.01617	r=0.2973	0<r<0.5	weak
SPPB Test	p=0.00001	r=0.8696	0.5<r<1	strong

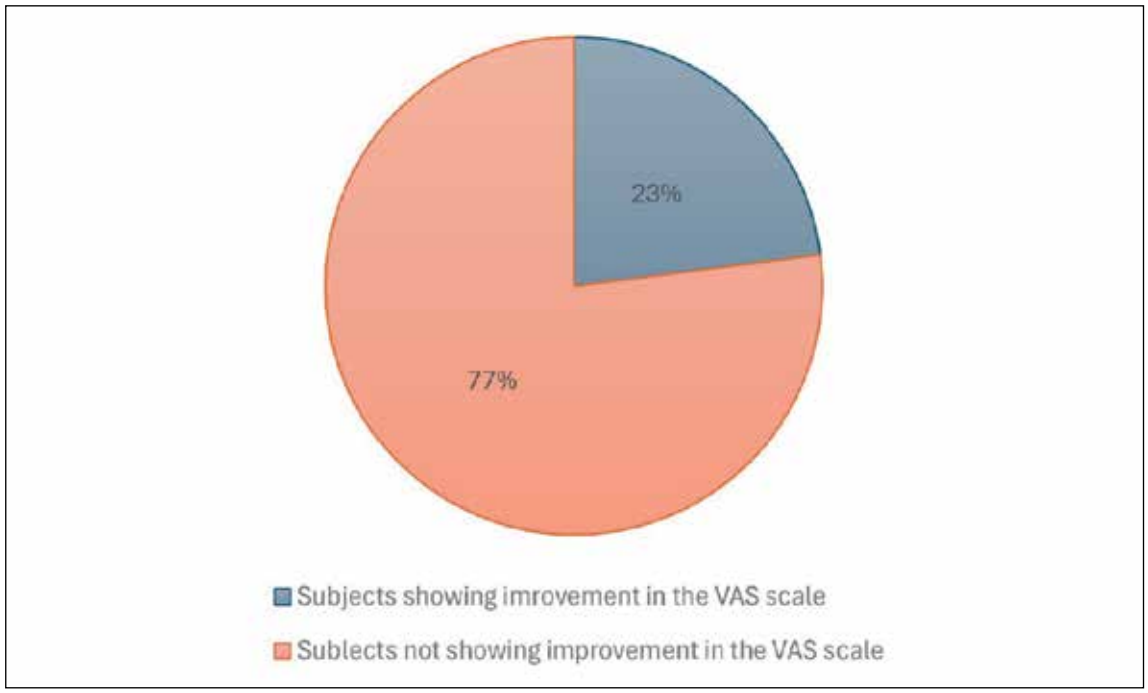

Fig. 5. Percentage distribution of subjects showing improvement in the VAS Scale.

Our study yielded several significant findings regarding the effects of WBC on patients with degenerative spinal changes. Primarily, we observed a substantial reduction in pain perception, with 77% of patients reporting decreased pain levels after the WBC treatment series. Furthermore, 72% of participants demonstrated marked improvements in physical fitness parameters, as measured by the SPPB test. However, the effect on fatigue was less pronounced, with only 66% of patients reporting improvements in the MFIS. Interestingly, our results also indicated that patients with a history of COVID-19 infection generally showed poorer outcomes across all measured parameters compared to those without prior infection. These findings provide a comprehensive overview of WBC's impact on pain, physical function, and fatigue in the context of degenerative spinal conditions and post-COVID-19 recovery.

Our study corroborates and extends previous findings on the efficacy of WBC in pain management for patients with degenerative spinal conditions. The applied series of 10 WBC treatments significantly reduced the subjective sensation of pain in 77% of our patients with degenerative changes in the spine. This result aligns with the observations of Pietrzak et al. [13], who reported a significant reduction in pain perception after a 10-day treatment series, specifically noting a 33% reduction in pain for patients with discopathy. Similarly, Banfi et al. [14] observed an approximate 30% decrease in pain severity among osteoarthritis patients following 10 cryogenic chamber treatments. All these studies, including ours, utilized the Visual Analogue Scale (VAS) to evaluate subjective pain, providing a consistent measure across investigations [13,14]. Beyond pain relief, WBC has been found to improve general well-being in patients [15] and demonstrate beneficial effects on the respiratory and cardiovascular systems [16]. These multifaceted benefits suggest that WBC can be an effective treatment modality for alleviating spinal pain of various etiologies while potentially offering broader health improvements.

One significant observation is that 72% of patients demonstrated a marked improvement in physical fitness parameters, measured by the SPPB test, after 10 treatments. Similar results, such as increased muscle strength and balance, have also been noted in patients with motor system diseases following a cycle of treatments in a cryochamber [17]. Again, this effect can be attributed to the lower inflammation, edema and muscle tension associated with treatment as well as the increased range of motion in joints when combined with kinesiotherapy. The results of the SPPB test indicate that cryotherapy can improve limb function and thus increase physical fitness in patients with spinal disorders.

However, only 66% of the patients reported an improvement in the fatigue index (MFIS) after the cryogenic chamber treatments. This value is significantly lower than the observed decrease in pain severity or the increase in functional fitness, suggesting that whole-body cryotherapy has a weaker effect on reducing fatigue associated with degenerative spinal changes. A similar relationship has been observed in other studies, i.e. that WBC is more effective in relieving pain symptoms than in reducing feelings of fatigue in patients [18]. It is possible that a greater number or frequency of treatments is required to achieve a clear anti-fatigue effect.

An interesting observation was that patients who had recovered from COVID-19 obtained worse results in both the MFIS and SPPB tests, as well as a greater severity of pain (VAS), than those who had not been infected. This may indicate that the past infection had a long-term negative impact on the functioning and well-being of patients with spinal disorders. Similar conclusions were drawn by Vélez-Santamara et al. [19], who showed that reduced physical fitness, increased fatigue, and poorer quality of life persist after recovery from COVID-19. This may be explained by post-COVID syndrome, which includes breathing disorders, changes in the central nervous system, anxiety and depressive disorders, among others [20]. It is believed that WBC can beneficially modulate some immune parameters [21], so regular treatments in a cryochamber, after SARS-CoV-2 infection, can help improve immune system regeneration of convalescents, and thus their general well-being. Further research is needed on the use of extremely low temperatures as part of post-COVID rehabilitation.

The present study assessed the impact of WBC on the mental and physical condition of patients with degenerative spinal changes using the MFIS and SPPB questionnaires and the VAS scale. The MFIS test indicated only a moderate improvement in subjectively-evaluated fatigue, while beneficial effects were noted for pain (VAS) and physical fitness (SPPB). Other studies have used the Oswestry Disability Index (ODI) and the Laitinen questionnaire to assess the effect of WBC on the quality of life of patients with degenerative changes [22, 23].

The use of varied research tools allows for a more complete assessment of the health status and well-being of patients as a result of the therapy. An assessment of the efficacy of WBC in osteoarthritis showed a significant improvement in functional fitness based on the ODI test [22], while another study found WBC to decrease mean pain score in degenerative spine disease based on the Laitinen questionnaire [23]. This indicates that WBC brings tangible effects in the form of pain reduction and improvement of motor functions.

The present study has some limitations that should be considered when interpreting its results. First, the relatively small group of 65 patients does not allow the conclusions to be reliably generalized to the entire population of patients with degenerative spinal changes; therefore, further randomized studies with a larger group of participants would be advisable. Additionally, no long-term observation was performed, only single assessments of the condition before and immediately after 10 treatments; therefore, it is suggested to extend the measurements to six- and 12-month periods after the end of treatment, in order to determine whether any positive effects are maintained.

Nevertheless, despite these methodological limitations, our findings provide promising evidence for the efficacy of whole-body cryotherapy in alleviating symptoms

of degenerative spinal disease. They indicate that it is worth considering including this method in the standard physiotherapeutic procedure for the treatment of spinal disorders, especially in combination with kinesiotherapy. However, medical personnel, and the patients themselves, require more training on the possible benefits and safety of WBC before it can become an effective part of clinical practice. Developing comprehensive algorithms for the rehabilitation of patients with degenerative spinal changes, including a series of regular treatments in a cryochamber, can bring even better therapeutic effects.

CONCLUSIONS

A series of ten whole-body cryotherapy treatments improves mental and physical condition, including pain reduction, in patients with degenerative spinal changes, regardless of sex, age, prior COVID-19 infection, and work mode (remote, hybrid, stationary).

The treatment significantly improves physical parameters, such as lower limb muscle strength, balance, and walking speed, in people with degenerative spine disease. Whole-body cryotherapy can be useful in combating the emotional and functional effects caused by the COVID-19 pandemic.

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ORIGINAL ARTICLE

Comparative analysis of the levels of cadets' physical activity at different stages of their professional training

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ABSTRACT

Aim: To investigate cadets' physical activity levels at different stages of their professional training.

Materials and Methods: The study involved the 3rd training year cadets (n = 61). To determine the level of physical activity and daily energy expenditure of cadets, the Framingham method was used. The research was conducted in two stages: the first was during cadets' training in a higher educational institution, and the second was during their practical training (work experience internship) in practical police units.

Results: A significant difference in the index of physical activity ($p < 0.01$) and daily energy expenditure ($p < 0.01$) in cadets during their training and work experience internships in practical units has been found. It has been established that during the day for academic activity, cadets spent 2565.4 ± 32.4 kcal, the physical activity index was 32.96 ± 0.43 points; and in the conditions of work experience internship, 2708.6 ± 33.2 kcal of daily energy expenditure has been recorded, the physical activity index – 34.92 ± 0.47 points.

Conclusions: The difference in the levels of physical activity of cadets during their academic activity and work experience internship is due to the specifics of performing tasks in practical police units in modern conditions, which is characterized by extremity, novelty, change of the usual daily routine, accompanied by nervous and emotional strain, stress and requires additional energy expenditure. In contrast to the work experience internship stage, cadets engage in insufficient physical activity during their academic activities.

KEY WORDS: physical activity, daily energy expenditure, health, cadets, professional training, physical training

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INTRODUCTION

Physical activity is a biological need of the human body, which is caused by muscle activity and contributes to adaptation to environmental conditions [1, 2]. Muscle activity stimulates the functional activity of almost all organs and tissues and causes positive changes in the body. An appropriate amount of physical activity is an important component of human health, which contributes to the body's optimal functioning and prevents diseases of the cardiovascular and musculoskeletal systems [3, 4]. Physical activity is the main indicator of a person's physical development, forms the necessary conditions for manifesting physical abilities, and promotes faster mastering of motor skills [5, 6]. The importance of physical activity is growing in modern conditions of functioning of society, as computerization of most spheres of human activity leads to hypodynamia and hypokinesia and, as a result, to deterioration of health and decrease of physical fitness of youth [7].

In the scientific literature, the concept of "physical activity" is interpreted as the volume of movements that a person performs in the course of life [8]; as any movement of the human body that is carried out through the work of skeletal muscles, is accompanied by additional energy expenditure and is characterized by several indicators, including the physical activity index and daily energy expenditure [9]. Scientists argue that with a low level of physical activity, everyday morphological and functional changes in the body are hardly noticeable. Still, the cumulative effect of hypokinesia leads to negative consequences, which is manifested in a decrease in the functional activity of organs and systems, disruption of nervous and humoral regulation, the appearance of trophic and degenerative changes in the musculoskeletal system, in particular its neuromuscular and bone components, metabolic disorders, an increase in adipose tissue, etc. [10, 11]. This is especially acute for higher educational institutions (HEIs) that train police officers, as intensive mental work with minimal

physical effort is accompanied by a decrease in physical activity, which, combined with other unfavorable factors, significantly worsens the health of future officers [12, 13].

The study of regulatory documents gives grounds to state that the training of future law enforcement officers combines several stages of their professional development, which differ in types of activities and, accordingly, levels of physical activity and energy expenditure [14, 15]. An important stage of professional development is practical training, which involves consolidating and improving theoretical knowledge and acquiring useful skills and competencies by cadets. Practical training is conducted in both basic and additional types of practice. The main types of practical training include introductory practice, academic practice, work experience internship, and pedagogical (research) practice. Additional types include participation in ensuring public safety and order, work of operational (investigative) groups of police units, and service as part of daily details to ensure the activities of the HEI. A key stage in the professional development of future officers is a work experience internship, which is conducted after the completion of the theoretical part before the certification. The work experience internship aims to familiarize cadets with specific work areas in real conditions and to test the theoretical part of the training in the activities of central executive bodies. During the work experience internship, cadets' daily physical activity changes. This necessitates the identification and analysis of indicators of physical activity of future law enforcement officers at different stages of their professional training to develop and implement scientifically based forms and means of special physical training in the educational process, which would improve the level of health of future specialists, form personal responsibility, proper attitude to their health, promote awareness of the importance of its preservation, and ensure the future effectiveness of the tasks of professional activity.

AIM

The aim is to investigate cadets' physical activity levels at different stages of their professional training.

MATERIALS AND METHODS

The study conducted in 2023-2024 involved the 3rd training year cadets (male) studying in the specialty referred to as "Law Enforcement" (n = 61). To determine the level of physical activity and daily energy expenditure of cadets, the Framingham method was used. The research was conducted in two stages: the first was during cadets' training in a higher educational institution, and the second was during their practical training (work experience internship) in practical police units.

To achieve the research aim, a set of modern general scientific methods was used, including theoretical, empirical, and methods of mathematical statistics. Theoretical methods were used to systematize and summarize information about the object and subject under study and to compare existing theoretical approaches and methods for determining the level of daily physical activity and energy expenditure. To establish the index of cadets' physical activity and daily energy expenditure, we used the Framingham method, which is based on registering activities during the day [16]. This method provides complete information about the duration of a particular activity and rest, the combination of physical loads of different intensities, the total duration of various types of activity, and the amount of energy expenditure. The numerical value is represented as a physical activity index (PAI). According to this method, a person's physical activity is divided into five levels: basic, sedentary, small, average, and high. Each level is determined by certain types of physical activity and, accordingly, has an energy value depending on the kcal expended, which makes it possible to calculate the daily energy expenditure of each cadet and develop an average model of physical activity and daily energy expenditure. To determine the amount of time spent on each type of physical activity, the daily timekeeping of activities lasting more than 5 minutes was performed. All types of physical activity were recorded in a special form.

The methods of mathematical statistics were used for correct processing of the data obtained. The compliance of the sample data distribution with the Gauss' law was assessed using the Shapiro-Wilk W test. The reliability of the difference between the indicators was determined using the Student's t-test. The reliability of the difference was set at $p<0.05$. All statistical analyses were performed using SPSS software, version 10.0, adapted for medical and biological research. This research was carried out in accordance with the requirements of the Regulations on academic integrity at the National Academy of Internal Affairs and the regulations of the World Medical Association Declaration of Helsinki. Prior consent to participate in the study was obtained from all respondents.

RESULTS

Processing of the obtained results gave grounds to state a significant ($p < 0.01$) difference in the PAI and daily energy expenditure of cadets during different stages of their professional development (Table 1). In particular, during the academic activity in the HEI, cadets spent 2565.4 ± 32.4 kcal per day. At the same time, the PAI was 32.96 ± 0.43 points. In the work experience internship, daily energy expenditure increased by 142.6 kcal, totaling 2708.0 ± 33.2 kcal, and the PAI reached 34.92 ± 0.47 points.

The analysis of physical activity levels showed that during their academic activity for the day, cadets spent 611.4 ± 19.2 min on the basic level of physical activity (sleep, lying down rest). The PAI at this level was 10.1 ± 0.33 points, and daily energy expenditure – 764.3 ± 25.2 kcal. The processing of the physical activity forms gave grounds to state that future law enforcement officers spent an average of 479 minutes sleeping and the rest of the time lying down rest (watching TV programs, videos, using gadgets, etc.). During the work experience internship, the volume of the basic level of physical activity decreased to 477.6 ± 19.1 minutes, the PAI reached 7.96 ± 0.32 points, and daily energy expenditure decreased by 167.3 kcal

Table 1. Comparative analysis of cadets' physical activity at different stages of their professional development (Mean±m, n=61)

Levels of physical activity	Daily time spent on physical activity, min	PAI, points	Energy expenditure, kcal
Indicators of daily physical activity of cadets during academic activities			
Basic	611.4±19.2	10.1±0.33	764.3±25.2
Sedentary	246.1±17.8	4.51±0.34	344.5±26.5
Small	460.3±21.8	11.51±0.54	943.7±44.6
Average	77.2±8.6	3.09±0.32	231.6±26.0
High	45.0±6.9	3.75±0.52	281.25±39.8
Total	1440	32.96±0.43	2565.4±32.4
Indicators of daily physical activity of cadets during work experience internship			
Basic	477.6±19.1	7.96±0.32	597.0±24.7
Sedentary	275.3±19.3	5.05±0.36	385.4±25.1
Small	472.7±20.9	11.82±0.56	969.0±44.3
Average	179.5±8.2	7.18±0.31	538.5±24.9
High	34.9±6.2	2.91±0.53	218.1±39.2
Total	1440	34.92±0.47	2708.0±33.2
$t; p\ PAI_{\text{academic activities–work experience internship}}$		3.08; <0.01	
$t; p\ E_{\text{academic activities–work experience internship}}$			3.07; <0.01

Legend: Mean – arithmetic mean; m – standard deviation error; n – number of cadets; t – Student's t-test value; p – confidence interval;
$t; p\ PAI_{\text{academic activities–work experience internship}}$ – the reliability of the difference between the indicators of cadets' PAI during their academic activities and work experience internship;
$t; p\ E_{\text{academic activities–work experience internship}}$ – the reliability of the difference between the indicators of cadets' energy expenditure during their academic activities and work experience internship.

and amounted to 597.0 ± 24.7 kcal. The results of the study revealed a significant decrease in the time spent lying down rest.

The sedentary level of physical activity, which includes traveling in transport, reading, watching TV, playing computer games, and eating during academic activities, covers 246.1 ± 18.9 minutes. The PAI at this level is 4.51 ± 0.35 points, and daily energy expenditure is 344.5 ± 26.5 kcal. Among the types of physical activity of the sedentary level, the largest proportion was reading (studying educational literature, regulatory documents, etc.) and preparation for training sessions – 116 minutes; eating – 54 minutes; watching TV, video, working at the computer – 48 minutes, traveling in transport – 28 minutes. During the work experience internship, the cadets' sedentary level of physical activity increased by almost 30 minutes and reached 275.3 ± 19.3 minutes, the PAI – 5.05 ± 0.36 points, and daily energy expenditure was 385.4 ± 25.1 kcal per day. The distribution of time by types of physical activity in the conditions of work experience internship changed. In particular, a significant decrease in the time allocated for preparation for training sessions was found; cadets were mostly engaged in processing the necessary regulatory documents (20 min); the time of movement in transport averaged 90 min, work at the computer – 110 min.

During the day, low-level physical activity in the conditions of academic activities accounted for an average of 460.3 ± 21.8 min. This amount is due to the specifics of academic activities, as this level involves studying (except for physical training), walking (to training sessions, a public transport stop, etc.), and personal hygiene. Accordingly, the PAI is also the highest – 11.51 ± 0.54 points, and daily energy expenditure – 943.7 ± 44.6 kcal. Among the main types of physical activity of this level, the largest percentage is accounted for by training sessions – 300 minutes; walking – 60 minutes; hygiene procedures – 55 minutes; 45 minutes – other types of physical activity, which are low in energy expenditure (moving around the dormitory, lining up, some types of household work, etc.). During the work experience internship, the amount of physical activity that belongs to the low level did not vary significantly – 472.7 ± 20.9 min. The PAI and daily energy expenditure were 11.82 ± 0.56 points and 969.0 ± 44.3 kcal, respectively. The largest period is spent at the workplace in practical units and performing tasks provided for by the individual work experience internship plan (paperwork, delivery of documents to various institutions and organizations, etc.).

In the conditions of academic activity, much less time was recorded for physical activity of average activity level (morning gymnastics, homework, walking, mass sports of low and medium intensity) – 77.2 ± 8.6 minutes. Among the activities that belong to this level, the largest proportion is occupied by low-intensity mass sports (30 min) and

walking (30 min). The PAI is 3.09 ± 0.32 points, respectively, and the daily energy expenditure is 231.6 ± 26.0 kcal. In the conditions of work experience internship, a significant increase in the volume of the average level of physical activity was revealed – 179.5 ± 8.2 min. The PAI and daily energy expenditure were 7.18 ± 0.31 points and 538.5 ± 24.9 kcal, respectively. Such indicators are due to an increase in the share of homework and the performance of other tasks of the internship supervisor, which involved a higher intensity of activity.

A high level of physical activity includes specially organized physical exercises and active recreation (intensive games, running, cycling, etc.). During academic activity in the studied category of persons, the high activity level accounts for only 45.0 ± 6.9 minutes, which, according to scientists, is insufficient for the full development of persons of this age. The PAI of future law enforcement officers at this level is 3.75 ± 0.52 points, and daily energy expenditure is 281.25 ± 39.8 kcal. It is possible to increase the level of physical activity by encouraging cadets to engage in independent physical exercises and involve them in sporting and mass participation as well as fitness and health recreation events. During the work experience internship, this indicator decreased by an average of 8 minutes and amounted to 34.9 ± 6.2 minutes. The PAI is 2.91 ± 0.53 points, daily energy expenditure – 218.1 ± 39.2 kcal. The absence of practical training sessions on special physical training causes such results. An increase in the amount of time allocated for independent exercise was found.

DISCUSSION

Scientists are convinced that understanding the norm of physical activity occurs through the prism of a person's natural need for movement, which ranges from 14-19,000 steps per day and is equivalent to energy expenditure of approximately 600-800 kcal [17]. According to research by scientists [18], higher education students spend a significant part of the day in an almost stationary position. As a result, some organs and systems lose their ability to function properly. That is, hypokinesia causes a set of negative changes in the body's functioning. All the life support systems that accompany physical activity gradually deteriorate the degree of realization of their potential.

Researchers have identified two key causes of hypokinesia, including household – getting used to a sedentary lifestyle, reduced physical initiative, household comfort, dismissive attitude to physical fitness; and academic – irrational organization of the educational process, overloading with training sessions, ignoring physical training, lack of free time [19]. In general, the hypodynamic effects of hypokinesia cause gradual atrophy of muscle and bone tissue, impair the adaptation of the cardiovascular system to habitual physical loads, decrease lung capacity and back strength, and increase blood cholesterol levels [20]. Scientists say that the daily energy expenditure of higher education students averages 2550-2800 kcal. At the same time, the optimal limit that ensures the proper functioning of young men aged 17-19 years is considered 3020-3100 kcal, and girls – 2200-2340 kcal [7].

The results obtained confirm the findings of many scientists [21, 22] and expand them, in particular in the direction of a rational combination of mental and physical labor during the academic activities of higher education students; the need to introduce physical exercises as part of extracurricular activities and increase the level of motivation to exercise and a conscious attitude to maintaining their health at the proper level. Implementing physical activity through various means of physical culture contributes to the prevention of diseases, increases working capacity, ensures active, creative longevity, organization of full leisure, combats bad habits, and creates prerequisites for cognition of one's psychophysiological capabilities [23, 24].

CONCLUSIONS

A comparative analysis of the physical activity index and daily energy expenditure has been carried out, and the levels of physical activity of future law enforcement officers at different stages of their professional training have been characterized. A significant difference in the index of physical activity ($p < 0.01$) and daily energy expenditure ($p < 0.01$) in cadets during their training and work experience internships in practical units has been found. It has been established that during the day for academic activity, cadets spent 2565.4 ± 32.4 kcal, the physical activity index was 32.96 ± 0.43 points; and in the conditions of work experience internship, 2708.6 ± 33.2 kcal of daily energy expenditure has been recorded, the physical activity index – 34.92 ± 0.47 points.

The difference in the levels of physical activity of cadets during their academic activity and work experience internship is due to the specifics of performing tasks in practical police units in modern conditions, which is characterized by extremity, novelty, change of the usual daily routine, accompanied by nervous and emotional strain, stress and requires additional energy expenditure. In contrast to the work experience internship stage, cadets engage in insufficient physical activity during their academic activities. The obtained results should be considered when substantiating special physical training of senior training year cadets during their studies at a higher educational institution to improve their health and ensure the effectiveness of future professional activities.

Prospects for further research are to determine and conduct a comparative analysis of the levels of physical activity indicators of cadets in distance and full-time education.

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ORIGINAL ARTICLE

Methodological approaches to expert assessment of the level of training of basketball players at the stage of preliminary basic training

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ABSTRACT

Aim: 1. Conducting an analysis of the survey of experts (basketball coaches) to determine the state of the control system of basketball players at the stage of preliminary basic training. 2. Using clustering with the help of self-organizing Kohonen maps, conduct a study of the characteristics of the groups into which experts can be divided, to identify the difference in the conceptual approaches followed by experts for correcting the educational and training process of basketball players at the stage of preliminary basic training.

Materials and Methods: At the stage of the ascertainment experiment, we conducted a questionnaire with the coaches of SCAYSSOOR (Specialized Children's and Youth Sports School of Olympic Reserve) № 5. 20 basketball experts (experienced coaches) from Dnipro city, who have a special higher education and various coaching experience, took part in the survey.

Key aspects of preparation, components and indicators of preparation of basketball players at the stage of preliminary basic training were divided into 7 main components, which included technical (X1), integral (X2), general physical (X3), special physical (X4), tactical (X5), psychological training (X6) and competitive training (X7).

Results: Thus, after conducting an analysis of the questionnaire of coaches, the overwhelming number of which, namely, 11 experts, gave preference to technical training (X1) (first priority), the second priority given by these experts to tactical training (X5). Five experts gave preference to tactical training (X5) (first priority), while these experts gave second priority to technical training (X1). Cluster "1" included 4 experts, who give the first two priorities either to technical training (X1) or integral training (X2). From this, in our opinion, it follows that experts follow two main approaches. More than half of the experts consider technical training to be the main one, followed by tactical training. The second main group of experts, on the contrary, considers tactical training to be the most important, and only then is technical training the priority.

Conclusions: Therefore, conducting an analysis of a questionnaire of experts (basketball coaches), made it possible to determine the state of the control system of basketball players at the stage of preliminary basic training, and using clustering with the help of self-organizing Kohonen maps, they conducted a study of the characteristics of groups into which it is possible to allocate experts, and were able to identify the difference in conceptual approaches followed by experts, which makes it possible to correct the educational and training process of basketball players at the stage of preliminary basic training.

KEY WORDS: Basketball players, the stage of preliminary basic training, questionnaires, control of the readiness of basketball players, clustering, correction of the educational and training process

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INTRODUCTION

The problem of monitoring the readiness of young basketball players remains one of the most urgent in the modern conditions of sports training of children's and youth teams, and its solution will prevent the forcing of the educational and training process, when the coach, under certain requirements, tries to win with his students to the detriment of their rational formation and preservation physical and mental health, purposeful solving of the tasks of the stage of preliminary basic training, rational distribution of training loads during the year, taking into account the nature of the team game and individual characteristics of the players [1, 2, 3].

The programs and training plans that operate in the system of domestic sports don't fully reflect the body of knowledge and practical experience accumulated in the field of rational construction of multi-year training and a control system focused on the full disclosure of the individual capabilities of each athlete in the optimal age zone [4, 5, 6].

Theoretical and methodological approaches to control in team sports games are disclosed in the works of Kostyukevich, O.O. Mitova, V.O. [7, 8].

At the same time, there is not enough information about the organization and measures of the system of monitoring the readiness of basketball players who are at the stage of preliminary basic training, taking into account the latest achievements of sports science and, in particular, modern trends in competitive activity and the peculiarities of the construction and content of the training process of young athletes during the annual training cycle.

The above determines the relevance of research aimed at comprehensive control of the readiness of basketball players at the stage of preliminary basic training [9, 10, 11, 12].

AIM

1. Conducting an analysis of the survey of experts (basketball coaches) to determine the state of the control system of basketball players at the stage of preliminary basic training.
2. Using clustering with the help of self-organizing Kohonen maps, conduct a study of the characteristics of the groups into which experts can be divided, to identify the difference in the conceptual approaches followed by experts for correcting the educational and training process of basketball players at the stage of preliminary basic training.

MATERIALS AND METHODS

At the stage of the ascertainment experiment, we conducted a questionnaire with the coaches of SCAYSSOOR (Specialized Children's and Youth Sports School of Olympic Reserve) № 5. 20 basketball experts (experienced coaches) from Dnipro city who have a special higher education and various coaching experience, took part in the survey.

Key aspects of preparation, components and indicators of preparation of basketball players at the stage of preliminary basic training were divided into 7 main components, which included technical (X1), integral (X2), general physical (X3), special physical (X4), tactical (X5), psychological training (X6) and competitive training (X7). The results of the questionnaire made it possible to determine the state of the control system of basketball players at the stage of preliminary basic training. By examining the characteristics of the groups into which experts can be divided, it is possible to reveal differences in the conceptual approaches followed by experts. This, in our opinion, can be done using a tool such as clustering, in particular, clustering using self-organizing Kohonen maps. The analytical platform Deductor Academic version 5.0 of the company BaseGroup_Lab was used as a software environment for conducting research, which allows obtaining relevant simulation results. To analyze the clustering results, not only the input vector maps X1, X2, X3, X4, X5, X6, and X7, but also the distance matrix, the quantization error matrix, and the hit density matrix were used. A cluster is a nominal particle in the atlas of Kohonen maps and includes one or more identical information items. The analysis of the "Distance matrix" map made it possible to identify four clusters, which are marked with the numbers "0", "1", "2" and "3" (Fig. 2, c).

RESULTS

The questionnaire was compiled with the aim of revealing the opinions of coaches regarding the methodical support of the system of control of various aspects of basketball players' readiness at the stage of preliminary basic training and its practical application in practice in the educational and training process. The questionnaire included questions focused mainly on the possibility of obtaining information about what coaches are guided by when exercising control in the process of training basketball players at the stage of preliminary basic training, their content, types, deadlines, shortcomings, etc. It was important, in our opinion, to study the importance of aspects, components and indicators of the readiness of basketball players at the stage of preliminary basic training. 20 basketball experts (experienced coaches) from Dnipro city who have a special higher education and various coaching experience, took part in the survey.

All aspects of preparation, components and indicators of preparation of basketball players at the stage of preliminary basic training were divided into 7 main components, which included technical (X1), integral (X2), general physical (X3), special physical (X4), tactical (X5), psychological training (X6) and competitive training (X7).

Technical training (X1) of basketball players at the stage of preliminary basic training is recognized as indicators of technical training of basketball players during testing, namely when performing a combined exercise, alternating running of 98 m, free throws, throwing the ball into the basket [13-15].

Integral training (X2) of basketball players is a system of training exercises that contribute to the manifestation of the maximum training effects of physical, technical, tactical and all other types of training in continuous game and competitive activities of basketball players [16].

The results of the questionnaire are given in the Table 1, visualized survey results are presented in Fig. 1. The results of the questionnaire made it possible to determine the state of the control system of basketball players at the stage of preliminary basic training.

According to a preliminary review of the Table 1 and Fig. 2, we can note the following features of the distribution of priorities regarding the location of types of training. All experts put technical training (X1) as the first or second priority. Moreover, the number of experts who tend to give the first priority to the above-mentioned level of training to those who tend to give the second priority is 13:7.

The second priority for most experts (for 11 out of 20 experts) is tactical training (X5), it is also the first priority for 5 experts. The third and fourth priority for all experts is physical training (X3 and X4). General physical training (X3) was given the third priority by 8 experts, 12 experts gave it the 4th priority. Special physical training (X4) was given the third priority by 12 experts, 8 experts gave it the 4th priority. The fifth priority for the majority of all experts is psychological training (X6), it is preferred by 15 out of 20 experts, the rest of the experts put psychological training as the penultimate (6th) or last (7th) priority.

Competitive training (X7) is given either 5th, 6th, or 7th priority in the ratio 3:4:13. As you can see, most experts prioritize competitive training for the last, 7th place. Integral training (X2) is mainly given the 6th priority (12 out of 20 experts) or close to the 6th 7th priority (4 experts out of 20), i.e. in a ratio of 3:1. It should be noted that the rest of the experts (4 experts out of 20), on the contrary, give integral training (X2) the 1st or 2nd priority. In addition to the preliminary conclusions according to the Table 1 and Table 2, it is important to study the characteristics of the groups into which it is possible to allocate experts. We imagine that in this way it is possible to reveal the difference in the conceptual approaches followed by the experts. This, in our opinion, can be done using a tool such as clustering, in particular, clustering using self-organizing Kohonen maps. The analytical platform Deductor Academic version 5.0 of the company BaseGroup_Lab was used as a software environment for conducting research. The Kohonen map learning parameters are presented in Table 2.

The simulation results can be seen in Fig. 2. To analyze the clustering results, not only the input vector maps X1, X2, X3, X4, X5, X6, and X7 were used, but also the distance matrix, the quantization error matrix, and the hit density matrix.

A cluster is a nominal particle in the atlas of Kohonen maps and includes one or more identical information items. The analysis of the "Distance Matrix" map made it possible to identify four clusters, which are marked with the numbers "0", "1", "2" and "3" (Fig. 2, c).

The distribution of experts by clusters based on the work of Kohonen's map is presented in the Table 3.

Table 1. Significance of aspects of preparation, components and indicators of preparation of basketball players at the stage of preliminary basic training (according to the survey of 20 specialists)

№	Technical training	Integrated training	General physical training	Special physical training	Tactical training	Psychologic al preparation	Competitve training
	X1	X2	X3	X4	X5	X6	X7
1	1	2	3	4	5	6	7
2	2	1	3	4	6	5	7
3	1	6	4	3	2	5	7
4	1	6	4	3	2	5	7
5	1	6	4	3	2	5	7
6	1	6	4	3	2	5	7
7	1	6	4	3	2	7	5
8	1	6	3	4	2	7	5
9	2	6	3	4	1	7	5
10	1	2	3	4	5	6	7
11	2	1	3	4	6	5	7
12	1	7	3	4	2	5	6
13	1	7	3	4	2	5	6
14	1	7	4	3	2	5	6
15	1	7	4	3	2	5	6
16	1	6	4	3	2	5	7
17	2	6	4	3	1	5	7
18	2	6	4	3	1	5	7
19	2	6	4	3	1	5	7
20	2	6	4	3	1	5	7

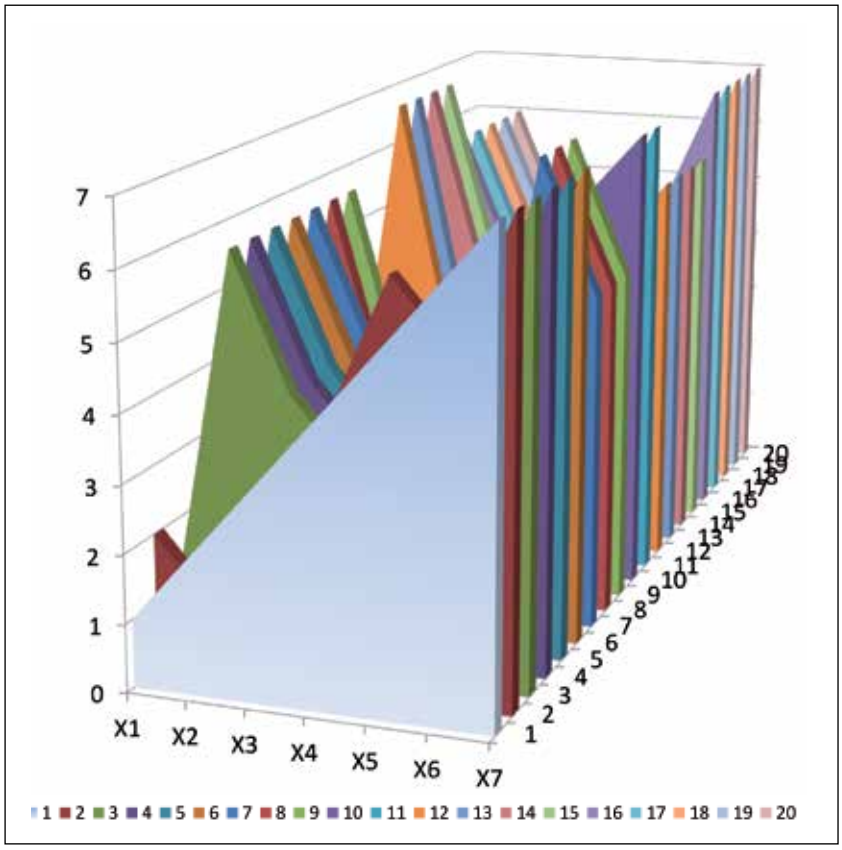

Fig. 1. Visualized results of a questionnaire survey of 20 basketball experts (coaches): technical training (X1), integral training (X2), general physical training (X3), special physical training (X4), tactical training (X5), psychological training (X6), competitive training (X7).

Table 2. Kohonen map learning parameters

Parameters	Parameter values
Kohonen map size	16×12
The shape of cells	Cell
The number of epochs (cycles) with approximate setting	500
The number of epochs (cycles) during fine setting	500
Learning speed with approximate setting	0,3
Learning speed with fine setting	0,006
Initialization of weights	normally distributed random variables
Study time	5 minutes
Data partition error	0,12
Typographical error	0,21

Analysis of table data 3 allows all experts to be divided into four clusters (groups).

Cluster "3", the largest in terms of the number of experts, contains seven experts. For them, the priority chain contains the following sequence X1-X5-X4-X3-X6-X2-X7 (for 5 experts) and X1-X5-X4-X3-X6-X7-X2 (for 2 experts). Thus, both types of chains differ only in the sequence of the last two links. Chains differ in the sequence of the last two links.

The second cluster by the number of experts (cluster "0") contains 5 experts. For them, the chains of priorities do not have any repetition, but some fragments of the links coincide. Yes, all 5 experts in this cluster gave the first two priorities to either technical (X1) or tactical training (X5). Also, the last three priorities are given to two types of links, namely the X7-X2-X6 link (three experts) and the X6-X7-X2 link (two experts).

Clusters "1" and "2" contain the same number of experts - 4 experts each.

All four chains of cluster "2" are identical and have the sequence X5-X1-X4-X3-X6-X2-X7. All experts of this cluster

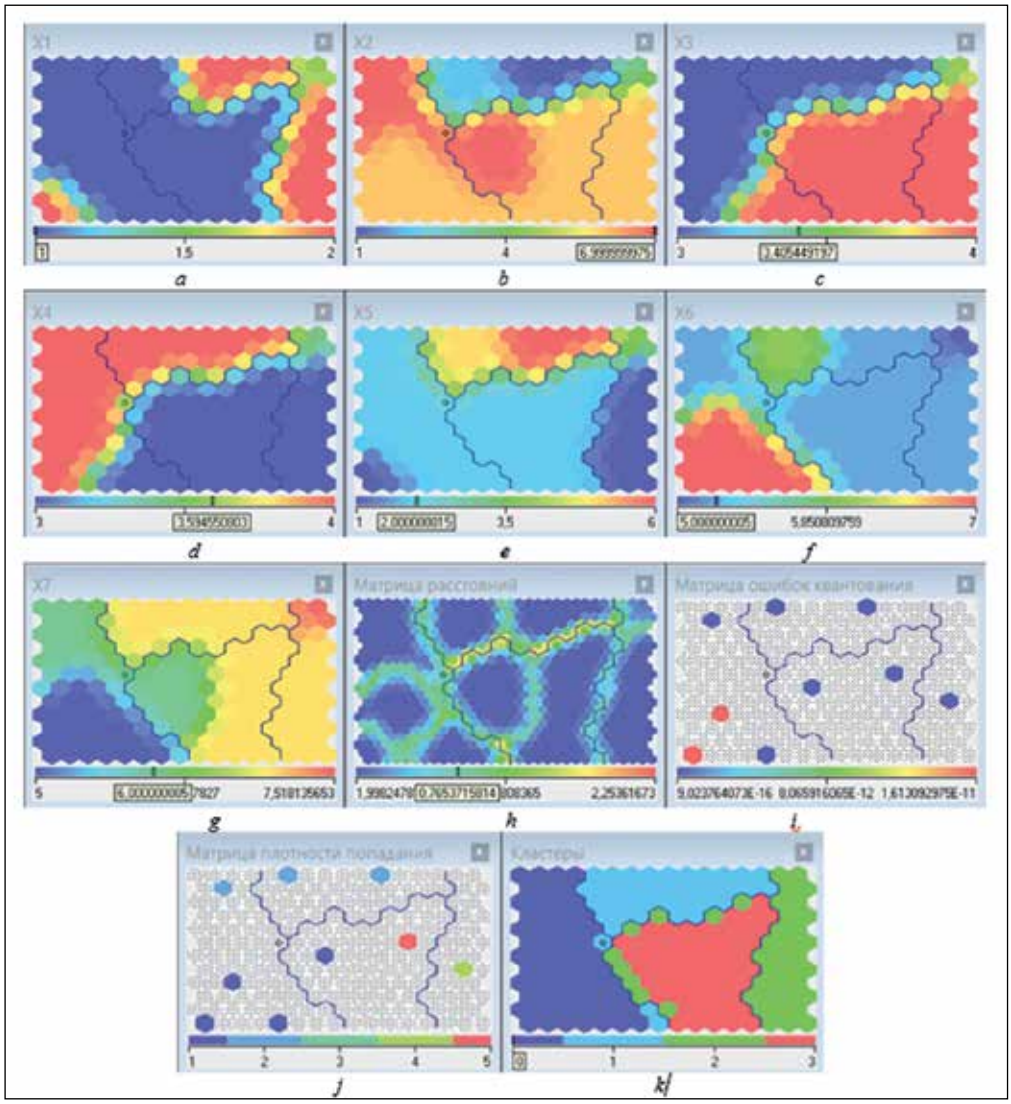

Fig. 2. Atlas of Kohonen maps with distribution by clusters of basketball players' training: a) technical training (X1); b) integrated training (X2); c) general physical training (X3); d) special physical training (X4); e) tactical training (X5); f) psychological training (X6); g) competitive training (X7); characteristics of the model in the form of matrices: h) matrix of distances; i) quantization error matrix; j) hit density matrix and k) clusters of input values.

put tactical training (X5) as the first priority, and technical training (X1) as the second priority. Experts give third and fourth priority to special physical training (X4) and general physical training (X3), respectively.

All four chains of cluster "1" as the first two priorities have either technical (X1) or integral training (X2). Experts give the third and fourth priority to general physical training (X3) and special physical training (X4), respectively. The last three priorities are given to two types of links, namely the X5-X6-X7 link (two experts) and the X6-X5-X7 link (two experts).

The characteristics of the clusters obtained by the results of neural processing of input information are presented in the Table. 4.

DISCUSSION

It is known that the general physical training (X3) of basketball players is primarily a pedagogical process, which is mostly aimed at comprehensive and special physical development of athletes, as well as improvement of vital motor qualities, increase of functional opportunities and general health improvement. Indeed, the speed and quality of mastering the technique and tactics of the game and, as a consequence, sports achievements depend on the level of physical fitness of basketball players at the stage of preliminary basic training [17-21]. Accordingly, the physical training of basketball players at the stage of preliminary basic training should also be divided into general and special physical training. General and special physical training in the process of educational and training activities should be harmoniously divided into two sides of the same process, organically connected with each other in an effective educational and training process.

Also, special physical training (X4) of basketball players consists in the process of purposeful development of physical and functional abilities of basketball players, which ensure

Table 3. Distribution of experts by clusters based on the Kohonen map

An experts conditional number	Cluster number	The distance from the center of the cell	Distance from the center of the cluster
1	1	1,808E-15	0,57613
2	1	1,808E-15	0,57373
3	3	1,808E-15	0,40259
4	3	1,808E-15	0,40259
5	3	1,808E-15	0,40259
6	3	1,808E-15	0,40259
7	0	1,808E-15	1,23804
8	0	1,808E-156	0,67171
9	0	1,808E-15	1,14390
10	1	1,808E-15	0,57613
11	1	1,808E-15	0,57373
12	0	1,808E-15	0,90771
13	0	1,808E-15	0,90771
14	3	1,808E-15	0,61122
15	3	1,808E-15	0,61122
16	3	1,808E-15	0,40259
17	2	1,808E-15	0,17299
18	2	1,808E-15	0,17299
19	2	1,808E-15	0,17299
20	2	1,808E-15	0,17299

Table 4. Characteristics of clusters obtained by the results of neural processing of input Information

Conventional cluster number	The number of experts	Conventional numbers of experts	Cluster parameters
"0"	5	7, 8, 9, 12, 13	The second cluster by the number of experts (cluster "0") contains 5 experts. For them, the chains of priorities do not have any repetition, some fragments of the links coincide. Yes, all 5 experts in this cluster gave the first two priorities to either technical (X1) or tactical training (X5). The last three priorities are given to two types of links, namely the X7-X2-X6 link (three experts) and the X6-X7-X2 link (two experts).
"1"	4	1, 2, 10, 11, 12	The cluster includes four experts, all four chains of cluster "1" as the first two priorities have either technical (X1) or integral training (X2). Experts give the third and fourth priority to general physical training (X3) and special physical training (X4), respectively. The last three priorities are given to two types of links, namely the X5-X6-X7 link (two experts) and the X6-X5-X7 link (two experts).
"2"	4	17, 18, 19, 20	Cluster "2" includes experts who indicated the same chains. Each of the four chains of this cluster "2" is the same and has the sequence X5-X1-X4-X3-X6-X2-X7. All experts of this cluster put tactical training (X5) as the first priority, and technical training (X1) as the second priority.
"3"	7	3, 4, 5, 6, 14, 15, 16	Cluster "3" includes experts who preferred the following two chains of priorities: the first chain contains the sequence X1-X5-X4-X3-X6-X2-X7 (for 5 experts), the second chain contains the sequence X1-X5-X4-X3-X6-X7-X2 (for 2 experts). Chains differ in the sequence of the last two links.

the achievement of high sports results. Regarding the tactical training of basketball players at the stage of preliminary basic training, which is no less important and consists of theoretical and practical knowledge, where appropriate methods and forms of sports fighting are studied, as well as their application against a specific opponent in various circumstances of the competition in order to achieve victory. Tactics in sports games and, in particular, in basketball, are divided into offensive and defensive tactics. These sections are mutually opposite in purpose. Their confrontation is the source of development of the entire game. By their nature, all actions of attack and defense are divided into individual, group and team. Properly coordinated individual actions grow into the interaction of several players, which, in turn, make up the elements of the entire game system.

The psychological training (X6) of basketball players should include the formation, development and improvement of mental properties that are necessary for the successful performance of each individual athlete, the development of group and team relationships, as well as the ability not to fall under the psychological pressure of changing circumstances and to be stable no matter what.

The aim of competitive training (X7) of basketball players at the stage of preliminary basic training is the realization of accumulated training effects and skills, which consist of technical, tactical, physical and other aspects of training in the integral game and competitive activity of basketball players 13-14 years old. The main tasks of competitive training include making connections between all types of training, achieving stability of playing skills in difficult competition conditions, etc. Thus, the overwhelming number of experts (11 experts) gave preference to technical training (X1) (first priority), these experts gave second priority to tactical training (X5). Five experts preferred tactical training (X5) (first priority), while these experts gave second priority to technical training (X1). Cluster "1" included 4 experts who give the first two priorities either to technical training (X1) or integral training (X2). From this, in our opinion, it follows that experts follow two main approaches. More than half of the experts consider technical training to be the main one, followed by tactical training. The second main group of experts, on the contrary, considers tactical training to be the most important, and only then is technical training the priority.

CONCLUSIONS

1. The overwhelming number of experts (11 experts) preferred technical training (X1) (first priority), at the same time, these experts gave second priority to tactical training (X5).
2. Five experts preferred tactical training (X5) (first priority), while these experts gave second priority to technical training (X1).
3. Cluster "1" included 4 experts who give the first two priorities either to technical training (X1) or integral training (X2).
4. General physical training (X3) or special physical training (X4) is preferred by all experts without exception as either the third or fourth priority.
5. All experts put psychological training (X6) only as the 5th, 6th, or 7th (last) priority.
6. Thus, experts follow two main approaches. More than half of the experts consider basic, technical training, then the next priority is tactical training. The second main group of experts, on the contrary, considers tactical training to be the main one, and only then the second priority is technical training. Physical training - either general or special - is either the third or the fourth priority in the opinion of all experts.
7. As a wish, we can recommend basketball specialists to take into account the results of the analysis of the expert survey in order to improve the readiness of basketball players at the stage of preliminary basic training.

Therefore, conducting an analysis of a questionnaire of experts (basketball coaches), made it possible to determine the state of the control system of basketball players at the stage of preliminary basic training, and using clustering with the help of self-organizing Kohonen maps, they conducted a study of the characteristics of groups into which it is possible to allocate experts, and were able to identify the difference in conceptual approaches followed by experts, which makes it possible to correct the educational and training process of basketball players at the stage of preliminary basic training.

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ORIGINAL ARTICLE

Dynamics of students' health indicators during studying under stress

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ABSTRACT

Aim: To investigate the dynamics of mental and physical health indicators of students during studying under stress.

Materials and Methods: The research, conducted in the 2023/2024 academic year, involved 161 students (75 boys and 86 girls). Two groups were formed (experimental (EG, n = 63) and control (CG, n = 98)): the EG included students (34 boys and 29 girls) who additionally attended university sports club training sessions; the CG included students (41 boys and 57 girls) who attended only scheduled physical education training sessions. Physical health was assessed by body weight, heart rate, and breath-holding time; mental health was evaluated by stress resistance, reactive anxiety, and a tendency to develop stress.

Results: The positive influence of physical exercises during sports club training sessions (regardless of the sport) on students' physical and mental health indicators has been revealed. In the EG, the studied indicators tend to improve during studying under stress, and in the CG – to deteriorate. At the end of the research, all indicators of physical and mental health in the EG were significantly better than in the CG.

Conclusions: It has been found that motor activity effectively prevents stress in students, reduces the manifestation of intellectual, behavioral, and emotional symptoms of stress, and improves their mental and physical health during stressful learning. In turn, this will positively influence the results of their academic performance and further professional activities.

KEY WORDS: health, stress, stress resistance, motor activity, exercise, students

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INTRODUCTION

The full-scale invasion of Ukraine by the russian aggressor has changed the lives of Ukrainians, bringing a lot of stress and anxiety about the future of both their families and the country as a whole. Ukrainians have found themselves in extremely difficult conditions, whether they are living in frontline cities, occupied settlements, or relatively safe cities in Ukraine. However, every Ukrainian today is experiencing stress due to the constant threat to life and health, frequent sirens of missile danger and air raids, power outages and water supply interruptions, mobile phone disconnections, the need to work or study remotely, etc.

Stress manifests itself in different forms and causes many other symptoms on the mental (emotional, intellectual) and physiological (behavioral) levels [1]. Psychological symptoms range from irritability, anxiety, anger, and hostility to feelings of fear, panic, and insomnia, as well as cognitive impairment [2]. Psychological stress can also lead to the development of physical symptoms. This is because of inherent muscle tension, which provokes a headache or neck and back pain. Typical physical symptoms of stress include rapid breathing, heart rate, digestive problems, and others [3]. Experts [4] note that the physiological reaction to stress can be so strong that it causes additional mental stress, closing the circle of "cause and effect." Among the means of coping with stress, scientists [5, 6] identify communication with family and friends, doing what you love (hobby), various games, developing creative potential, spending time with pets, mental self-regulation (introspection, relaxation), yoga, meditation, self-massage, and motor activity (exercise).

The issues of organizing rational motor activity in modern society have become especially relevant [7]. This is especially true for student youth. Motor activity is the best medicine for relieving psycho-emotional stress, overcoming stress, preventing students' diseases, and promoting their health. Physical exercises help to improve mood, gain confidence, bring the body's functional state to an optimal level, and improve the results of educational activities [8]. Conversely, a decrease in motor activity among students during the war leads to disorders of the musculoskeletal system, reduced functional capacity and efficiency of the heart, and an increased risk of cardiovascular disease [9]. Suppose we add that the lack of systematic motor activity is associated with changes in brain activity. In that case, it becomes clear why the body's overall defenses decrease and why there is increased fatigue, sleep disturbance, and a reduced ability to maintain mental and physical performance.

AIM

The aim is to investigate the dynamics of mental and physical health indicators of students during studying under stress.

MATERIALS AND METHODS

The research involved 161 students (75 boys and 86 girls) in the 1st instructional year of the National Technical University of Ukraine "Igor Sikorsky Kyiv Polytechnic Institute" (Kyiv, Ukraine). The research was conducted in the 2023/2024 academic year.

Based on the experience of stress prevention among university students during the war, in the 2022/2023 academic year, we introduced the coaches' positions in the Department of Health and Sports Technologies. We opened sports clubs in 10 sports (futsal, volleyball, basketball, table tennis, swimming, aerobics, modern dance, boxing (kickboxing), powerlifting (strength fitness), athletics). We have also developed practical recommendations for students to build stress resistance during exercise in the proposed sports clubs, as well as suggestions for increasing knowledge about stress and ways to overcome it, relieving emotional strain, correcting negative attitudes and reducing anxiety, preventing stress, and strengthening students' physical and mental health through motor activity during the war. To test the effectiveness of the proposed recommendations, we formed two groups of students (experimental (EG, n = 63) and control (CG, n = 98)) who entered the National Technical University of Ukraine "Igor Sikorsky Kyiv Polytechnic Institute" in 2023 at the Faculty of Radio Engineering and Faculty of Electric Power Engineering and Automatics. The EG included students (34 boys and 29 girls) who, in addition to scheduled physical education training sessions at the university (2 times a week for 2 hours), additionally attended sports clubs created by us at the department during the extracurricular time (3 times a week for 2 hours). The CG included students (41 boys and 57 girls) who attended only scheduled physical education training sessions. Scheduled physical education training sessions were held offline and online throughout the research period, and club training sessions were held offline. The selection of students in the EG and the CG was carried out after the introductory briefing at the beginning of the 1st semester exclusively at the students' request.

Research methods: theoretical (analysis and generalization of literary sources), empirical (survey, testing), and methods of mathematical statistics. 18 sources on the article's topic from the scientometric databases Web of Science, PubMed, Scopus, and others were analyzed. The survey was conducted based on the methodology for determining the stress level by V. Shcherbatykh, which contains 21 questions to determine the intellectual, behavioral, and emotional symptoms (signs) of stress. The students had to determine the degree of stress symptoms on a five-point scale (from 1 (low) to 5 (high)). The testing involved determining the indicators of physical health (body mass (M), heart rate (HR), duration of breath holding (DBH)) and mental health (stress tolerance (S), anxiety (A), and tendency to stress development (TSD)). The physical health indicators were determined by the instructors of the Department of Health and Sports Technologies using standard medical equipment, and the mental health indicators were determined using psycho-diagnostic methods: "Self-Assessment of Stress Tolerance" (S. Cowan and G. Willianson) – to assess stress resistance; "Reactive (Situational) Anxiety" (C. Spielberger and Yu. Khanina); "Tendency to Stress Development" (T. A. Nemchyn and Taylor) [10]. The survey and testing were conducted twice: at the research's beginning (September 2023) and end (June 2024).

Statistical processing of the obtained results was carried out by methods of variation statistics using the STATISTICA 6.1 software package (number AGAR909E415822FA). The compliance of the data distribution with the normal law (Gauss' law) was assessed using the Shapiro-Wilk W-test. The results were presented as ($M \pm m$), where M is the arithmetic mean, and m is the error of the arithmetic mean. The authenticity of the difference between the indicators of students of studied groups was determined by the Student's t-test. The level of statistical significance of the research results was chosen as $p < 0.05$.

This research complies with the ethical standards of the Act of Ukraine "On Higher Education" No. 1556-VII dated 01.07.2014 and the Letter from the Ministry of Education and Science of Ukraine "On the Academic Plagiarism Prevention" No. 1/11-8681 dated 15.08.2018. Also, this research followed the regulations of the World Medical Association Declaration of Helsinki – ethical principles for medical research involving human subjects. Informed consent was received from all individuals who took part in this research.

RESULTS

The results of the assessment of the dynamics of intellectual, behavioral, and emotional symptoms of the stress of the EG and the CG students in the course of their studies during the war are presented in Table 1. It has been found that at the beginning of the academic year (in September 2023), the indicators of the EG and the CG students were practically the same for the vast majority of stress symptoms. At the same time, almost half of the surveyed students of both groups manifested some symptoms of stress: prevalence of negative thoughts, difficulty concentrating, memory impairment, voice tremors, low productivity, sleep disturbances, gloomy mood, feelings of loneliness, and dissatisfaction with themselves and their work. This shows that half of the students experience stress and anxiety during the war.

It has been found that for the year of study during the war in Ukraine, the students who were systematically engaged in motor activity (additionally attended university sports clubs) had virtually no change in intellectual symptoms of stress; some even improved, especially mental cognitive processes (memory, thinking, attention). In general, the difference between the 2023 and 2024 indicators ranged from –4.8 to +3.1 %. Instead, in the CG, there is a negative dynamics of all intellectual symptoms of stress (deterioration ranges from +9.2 to +20.4 %). Comparing the indicators of the EG and the CG students in June 2024, it has been found that in terms of certain intellectual signs of stress (passivity, logic disorder, confused thinking, impulsive thinking), the indicators of the CG are twice, and sometimes three times, worse than in the EG.

Table 1. Dynamics of intellectual, behavioral, and emotional symptoms of stress in the EG (n = 63) and the CG (n = 98) students in the course of their studies during the war (2023-2024), %

Symptoms of stress	EG (n = 63)		CG (n = 98)		Dynamics	
	September 2023	June 2024	September 2023	June 2024	EG	CG
Intellectual symptoms of stress						
Prevalence of negative thoughts	42.9	46.0	44.9	54.1	+3.1	+9.2
Difficulty concentrating	50.8	47.6	48.9	59.2	–3.2	+10.3
Deterioration of memory performance	38.1	33.3	41.8	53.1	–4.8	+11.3
Increased distraction	44.4	46.0	39.8	60.2	+1.6	+20.4
Passivity, a desire to shift responsibility to someone else	19.1	20.6	22.4	39.8	+1.5	+17.4
Violation of logic, confused thinking	12.7	9.5	14.3	29.6	–3.2	+15.3
Impulsive thinking, hasty and unreasonable decisions	11.1	9.5	9.2	25.5	–1.6	+16.3
Behavioral symptoms of stress						
Increase in errors in habitual actions	9.5	10.2	7.9	21.4	–1.6	+11.2
Voice trembling	41.2	36.7	34.9	48.9	–6.3	+12.2
Increase in conflict situations with people around you	11.1	12.2	12.7	20.4	+1.6	+8.2
Less time to spend with family and friends	31.7	29.6	36.5	39.8	+4.8	+10.2
Loss of attention to your appearance	22.2	18.4	6.3	27.6	–15.9	+9.2
Low productivity of activities	39.7	41.8	28.6	62.2	–11.1	+20.4
Sleep disturbance or insomnia	30.1	32.7	17.4	52.0	–12.7	+19.3
Emotional symptoms of stress						
Suspicion	19.1	17.4	21.4	26.5	–1.7	+5.1
Gloomy mood	46.0	34.9	44.9	56.1	–11.1	+11.2
Feeling of constant longing, depression	30.2	19.1	28.6	61.2	–11.1	+32.6
Irritability, bouts of anger	33.3	25.4	35.7	68.3	–7.9	+32.6
Decreased life satisfaction	38.1	30.2	38.7	60.2	–7.9	+21.5
Feelings of alienation, loneliness	42.9	31.7	40.8	55.1	–11.2	+14.3
Decreased self-esteem, dissatisfaction with oneself and one's work	41.3	22.2	39.8	58.2	–19.1	+18.4

A comparison of behavioral symptoms of stress at the end of the research shows that the EG students also have significantly lower indicators than the CG students. The biggest difference between the EG and the CG has been found in symptoms such as increased errors in habitual actions, voice tremors, loss of attention to one's appearance, low productivity, and sleep disturbances or insomnia. It has also been found that the EG showed an improvement in stress resistance for most symptoms, which confirms the positive impact of motor activity on reducing the negative effects of stress during the war. The difference between the indicators at the beginning and end of the research ranged from –12.7 to +4.8 %. In the CG, all behavioral symptoms worsened, with the most pronounced negative changes in the following symptoms: low productivity (+20.4 %), sleep disturbance (19.3 %), and voice tremor (12.2 %). The negative dynamics of stress symptoms in the CG indicate the physiological response of the students' body to constant and uncontrolled anxiety.

The analysis of the dynamics of emotional symptoms of stress shows that during the research period, certain changes for the better occurred in the EG for all symptoms (from –19.1 to –1.7 %), in contrast to the CG, where for some symptoms (a feeling of constant longing, depression; irritability, bouts of anger; decreased life satisfaction) negative changes are in the range of 21.5 to 32.6 %. The greatest differences in emotional symptoms of stress in the EG and the CG at the end of the research are observed in the following symptoms: gloomy mood; feeling of constant longing, depression; irritability, bouts of anger; decreased life satisfaction; decreased self-esteem, dissatisfaction with oneself or one's work, with the EG indicators being significantly lower than in the CG. All this testifies to the effectiveness of additional physical activity training sessions in the university sports clubs in reducing the symptoms of stress in students during their studies in war conditions.

The results of assessing the dynamics of physical health indicators of the EG and the CG students during their studies

Table 2. Dynamics of physical health indicators of the EG (n = 63) and the CG (n = 98) students in the course of their studies under stress (2023-2024)

Physical health indicators	EG (n = 63)		CG (n = 98)		Reliability of the difference between the EG and the CG (t; p)	
	September 2023	June 2024	September 2023	June 2024	September 2023	June 2024
			Boys (n = 75)			
M, kg	73.6±0.87	72.9±0.82	74.1±0.81	77.3±0.85	0.42; >0.05	3.75; <0.01
HR, bpm	70.6±0.69	70.1±0.65	70.9±0.61	72.1±0.67	0.33; >0.05	2.14; <0.05
DBH, s	43.1±1.21	45.9±1.29	42.5±1.18	41.7±1.25	0.36; >0.05	4.50; <0.001
			Girls (n = 86)			
M, kg	59.2±0.79	58.7±0.75	58.5±0.68	61.1±0.72	0.67; >0.05	2.31; <0.05
HR, bpm	68.5±0.62	68.3±0.59	68.8±0.55	70.3±0.58	0.36; >0.05	2.42; <0.05
DBH, s	40.6±1.07	43.8±1.02	39.8±0.98	38.5±1.04	0.55; >0.05	3.64; <0.01

Legend: M – body mass, HR – heart rate, DBH – duration of breath holding, t – Student's t-test value; p – confidence interval.

under stress are presented in Table 2. It was found that at the beginning of the research, all indicators, both in boys and girls, did not differ significantly ($p > 0.05$).

At the end of the research, students of the EG showed significantly ($p < 0.05$-0.001) better all studied indicators of physical health (body mass, heart rate, duration of breath holding) than in the CG. At the same time, during the research period, all indicators deteriorated in the CG ($p < 0.05$-0.001) and in the EG – improved ($p > 0.05$), which indicates a positive effect of motor activity on the state of health of students during their studies under stress. A comparative analysis of the mental health indicators of the EG and the CG students at the beginning of the research also showed no significant difference ($p > 0.05$). The analysis of the dynamics of students' mental health indicators while studying under stress revealed that the indicators did not change significantly ($p > 0.05$) in the EG and even improved, and in the CG – significantly ($p < 0.05$) deteriorated, both in boys and girls (Table 3). The difference between the 2023 and 2024 indicators in the CG is 3.5 and 3.8 points in stress resistance in boys and girls, respectively, 1.1 and 1.1 points in reactive anxiety, and 2.8 and 1.4 points in terms of tendency to stress development.

At the end of the research (June 2024), both male and female students of the EG had significantly ($p < 0.05$) better indicators than the CG. The results obtained indicate that systematic physical exercises during sports club training sessions (regardless of the sport) have a positive effect not only on the indicators of students' physical health but also on mental health, increasing the level of students' stress resistance, reducing anxiety and tendency to stress development. All this will help improve students' academic and, in the future, professional performance.

DISCUSSION

The main task of the educational sector during the war is to ensure the quality of education at all levels. Still, stress, anxiety, and mental stress of children, adolescents, and students can significantly affect the results of educational activities. Therefore, according to scientists [11], searching

Table 3. Dynamics of mental health indicators of the EG (n = 63) and the CG (n = 98) students in the course of their studies under stress (2023-2024)

Mental health indicators	EG (n = 63)		CG (n = 98)		Reliability of the difference between the EG and the CG (t; p)	
	September 2023	June 2024	September 2023	June 2024	September 2023	June 2024
			Boys (n = 75)			
S, points	25.1±1.41	23.7±1.35	24.4±1.23	27.9±1.29	0.37; >0.05	2.25; <0.05
A, points	49.3±1.84	45.1±1.92	50.4±1.69	51.5±1.71	0.44; >0.05	2.49; <0.05
TSD, points	27.5±1.57	25.4±1.63	26.8±1.18	29.6±1.24	0.36; >0.05	2.05; <0.05
			Girls (n = 86)			
S, points	29.3±1.37	27.5±1.28	27.8±1.31	31.6±1.32	0.79; >0.05	2.23; <0.05
A, points	52.7±2.04	46.8±1.99	53.1±1.75	54.2±1.82	0.15; >0.05	2.74; <0.05
TSD, points	28.2±1.48	25.9±1.51	28.6±1.24	30.1±1.28	0.21; >0.05	2.12; <0.05

Legend: S – stress tolerance, A – anxiety, TSD – tendency to stress development, t – Student's t-test value; p – confidence interval.

for effective means of building stress resistance in students is an effective way to psychologically support young people and increase the efficiency of the educational process.

According to scientists [12], it is impossible to eliminate the source of stress during war, but it is possible to try to manage it. According to research by experts [13], today, about 30 % of people use regular exercise to cope with stress, anxiety, and depression. It has been found that regular exercise reduces overall stress levels, improves and stabilizes mood, improves sleep, and boosts self-esteem. In addition, motor activity effectively reduces fatigue, helps increase alertness and concentration, and improves cognitive function. This is especially useful during chronic stress caused by the war, as it is exhausting and reduces the ability to concentrate [14].

According to scientists [15], exercise reduces stress in several ways. Firstly, motor activity helps to reduce the level of the hormones adrenaline and cortisol, which are responsible for the physiological stress response. Secondly, motor activity stimulates the production of endorphins, neurotransmitters that are natural painkillers and are responsible for improving mood. Thirdly, motor activity can be a kind of meditation that helps a person to distract from obsessive thoughts. Repetition of movements during exercise allows you to focus on your body rather than on "chewing on thoughts." This focus can help maintain calmness and clarity of mind. Fourthly, exercise helps the human body relieve stress by simulating the consequences of the "fight or flight" response and helping the body's systems "let off steam" through the joint work of all organs during physical activity. Exercise also helps to get rid of muscle tension caused by hormone stress. Fifthly, regular motor activity can help people lose weight, increase strength and endurance, and improve well-being. This will help to gain awareness of control over the body and the situation and self-confidence.

According to scientists [16], any physical exercise will be useful to combat stress: running, brisk walking, cycling, playing football or other sports games, visiting gyms or fitness centers, dancing, swimming, etc. Experts [17] advise that, first of all, motor activity should be enjoyable, so it is important to find the type of activity you would enjoy. You don't have to buy a gym membership; you can do it at home or on the street with like-minded people, which can be an additional incentive not to miss training sessions. At the same time, when choosing a type of motor activity, one should consider the conditions of stay: the possibilities of students staying in a basement (bomb shelter) under fire or occupation radically differ from what a person in the deep rear might prefer. Therefore, one should choose the type of physical activity based on one's preferences, safety, and the amount of space available for exercise.

Studying the amount of motor activity of students during martial law, researchers [18] have found a decrease in the majority of respondents. The authors argue that the level of psychological exhaustion plays an important role in motivating students to exercise and note the need to use traditional and non-traditional means of physical education to prevent stress, optimize the psycho-emotional state, and promote students' health. The results of our research confirmed the conclusions of many scientists about the effectiveness of motor activity in increasing students' stress resistance and improving their mental and physical health.

CONCLUSIONS

The positive influence of physical exercises during sports club training sessions (regardless of the sport) on students' physical and mental health indicators has been revealed. In the EG, the studied indicators tend to improve during students' studies under stress, and in the CG – to deteriorate. At the end of the research, all indicators of physical and mental health in the EG were significantly better than in the CG.

It has been found that motor activity effectively prevents stress in students, reducing the manifestation of intellectual, behavioral, and emotional symptoms of stress. It has been found that regular physical exercises in the university sports clubs have a positive effect on the dynamics of mental and physical health indicators of students, which, in general, contributes to increasing students' resistance to stress and reducing anxiety, i.e., the formation of their stress resistance. In turn, this will positively influence the results of their academic performance and further professional activities.

We see prospects for further research on the effectiveness of other means of forming students' stress resistance while studying under martial law.

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ORIGINAL ARTICLE

Improving high school students' somatic and mental health through interactive methods of physical education

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ABSTRACT

Aim: To investigate the effectiveness of using interactive methods of physical education to improve the physical and psycho-emotional state of high school students.
Materials and Methods: The research involved 42 high schoolers (boys) aged 16-17. Two groups were formed (CG and EG) of 21 persons in each. Mainly interactive physical education methods in the natural environment were used in the physical education of the EG schoolers. In the CG, the traditional method of physical education was used, which included various types of physical exercises with the predominant use of the reproductive method. The following indicators were studied: the level of somatic health according to the method of H. L. Apanasenko; the level of mental health according to the WAM questionnaire.
Results: A methodology for physical education of high schoolers has been proposed, which includes the predominant use of interactive methods, in particular creative motor tasks, game interactivity (outdoor games, sports games, psycho-technical games, quests), active walks, competitions, orienteering, hiking, geocaching, etc. Testing the methodology's effectiveness shows that EG schoolers showed significantly better results than those of the CG in all the studied indicators due to the introduction of interactive methods in the process of their physical education.
Conclusions: As a result of physical exercises according to the author's methodology with the use of interactive physical education methods, the EG schoolers revealed a significant improvement in the indicators of psycho-emotional state, as well as the functional state of the main life support systems of the body.

KEY WORDS: schoolers, high school students, physical state, psycho-emotional state, health, interactive methods, physical education

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INTRODUCTION

The challenges of our time, such as the introduction of martial law in Ukraine, the coronavirus pandemic, quarantine restrictions, information progress, etc. have significantly worsened the health and limited the motor activity of high schoolers, increased stress levels, and worsened the mental and somatic health of children and youth [1, 2]. Preserving the health of the younger generation can be achieved through the use of special didactic approaches, such as problem-solving and practice-oriented approaches, which involve increasing independence and creativity in learning [3, 4]. This leads to the introduction of interactive methods in the educational process of physical education of high schoolers that increase the health-improving orientation of its content, based on the active interaction of high schoolers with nature, the formation of their valeological thinking, the ability to control their emotions, movements, behavior [5, 6]. The strategic objective of incorporating interactive methods is to ensure an adequate level of the psycho-emotional and physical state of high schoolers as the main signs of resilience and indicators of mental and somatic health. Interactive methods of physical education promote effective communication and emotional contact between participants in the educational process and can provide comfortable learning conditions where high schoolers feel their intellectual capability and success in motor activity [7]. The inclusion of interactive methods in the process of physical education of senior high schoolers can influence the resilience of young people, prepare them for independent living by forming motor experience, healthy lifestyle habits, motivation and need for motor activity, improving physical and psycho-emotional state, increasing psycho-physical conditions, developing soft skills [8].

The analysis of pedagogical theory shows that some methodological developments of researchers [9, 10] and the practical experience of physical education teachers described in various information sources address the use of interactive methods in the physical education of high schoolers of different school ages. In the practice of school physical education, there is experience of using interactive methods of collective, group and individual nature, mainly for the formation of theoretical knowledge on the basics of health, physical culture and sports, including interactive lectures, creative tasks, the use of multimedia, methods of

problem-based and discussion learning ("Decision Tree", "Brainstorming", "Debate", "Round Table", "Aquarium", "Circle of Ideas", "Microphone", etc.) [11, 12]. However, the effectiveness of using practical interactivity directly during specially organized motor activity to improve the physical and psycho-emotional state of high schoolers has been little studied, and this practice is not systematic.

AIM

The aim is to investigate the effectiveness of using interactive methods of physical education to improve the physical and psycho-emotional state of high school students.

MATERIALS AND METHODS

The research involved 42 high schoolers (10-11 grade boys) aged 16-17 ("Obolon" Gymnasium, Kyiv). The research was conducted in 2023-2024. Two groups were formed (CG and EG) with 21 people in each group. There was no special selection of high schoolers in the CG and the EG, the groups were formed randomly. Interactive physical education methods were used in the physical education of the EG boys. In the CG, traditional methods of physical education were used. The pedagogical experiment lasted 10 months (during the academic year). At the beginning and at the end of the academic year (in September and May) the following indicators were recorded in the young men: the level of somatic health according to the method of H. L. Apanasenko by body mass index (kg/m^2), strength index (%), vital index (ml/kg), Robinson index (points), Rufier index (points) [13]; the level of mental health was determined by indicators of psycho-emotional state (well-being, activity, mood) according to the WAM questionnaire [14].

The developed content of physical exercises included the use of interactive methods directly in high schoolers' motor activity, namely: creative motor tasks, game interactivity (outdoor games, sports games, psycho-technical games, quests), active walks, competitions, orienteering, hiking, geocaching, etc., which were used mainly in open areas, in the natural environment. The main idea of planning motor activity was active, creative, problem-solving, and searching. Interactive methods were used in physical education lessons (three hours per week), as well as during short motor activities as part of breaks and in the course of the school day, in school sports clubs, in the process of school and extracurricular fitness and health recreation as well as sporting and mass participation events.

Research methods included: literature analysis, medical and biological methods, pedagogical experiment, and statistical methods. Before the experiment, both groups of young men were tested for normality of distribution using the Kolmohorov-Smyrnov test in IBM SPSS Statistics 23.0. It was found that the samples were subject to normal distribution, which allowed for statistical calculations using Student's t-test.

The process of conducting this research was based on the relevant ethical rules. First of all, all ethical requirements were considered before conducting this research. Then, the authors obtained the consent of the Ethics Committee of Ukrainian State Drahomanov University (protocol No.2 of 08.09.2023). After that, the participants were informed about the aim and objectives of the research. They were also informed that participation in the research was voluntary, and they had the right to withdraw at any time. The participants were young men aged 16-17 years, so we also obtained permission from their parents for their children to participate in the research. This research also complies with the provisions of the Declaration of Helsinki of the World Medical Association.

RESULTS

The results of the study of the level of somatic health in young men of the EG and the CG according to the method of H. L. Apanasenko at the beginning of the experiment are presented in Table 1.

It has been recorded that at the beginning of the experiment, no significant difference was found between the EG and the CG young men in all the studied indicators in terms of their somatic health ($p > 0.05$).

Table 2 shows the results of the study of certain indicators of psycho-emotional state (well-being, activity, mood) in young men at the beginning of the experiment.

It has been found that at the beginning of the experiment, there was no significant difference between the EG and the CG young men in all studied mental health indicators ($p > 0.05$).

Practical interactive methods used in physical education training sessions with the EG high schoolers included game interactivity (situational, role-playing, outdoor games,

Table 1. Characteristics of somatic health indicators of the EG and the CG young men at the beginning of the pedagogical experiment (X ± m)

Indicators of somatic health	EG (n = 21)	Level according to the age norm*	CG (n = 21)	Level according to the age norm*	The difference, %	p**
Body mass index, kg/m^2	20.8 ± 1.4	average	21.3 ± 2.1	average	2.4	> 0.05
Strength index, %	50.1 ± 2.5	below average	52.9 ± 3.6	average	5.4	> 0.05
Vital index, ml/kg	48.4 ± 3.0	low	48.5 ± 5.7	low	0.2	> 0.05
Robinson index, points	84.5 ± 5.7	average	86.6 ± 6.2	below average	2.5	> 0.05
Rufier index, points	9.8 ± 1.3	average	9.7 ± 1.5	average	1.0	> 0.05

*Legend: * – the level of compliance of morphological and functional indices with age norms according to the method of H. L. Apanasenko for high schoolers; ** – the reliability of the difference between the EG and the CG.*

Table 2. Characteristics of psycho-emotional state indicators of the EG and the CG young men at the beginning of the pedagogical experiment (X ± m)

WAM indicators (points)	EG (n = 21)	CG (n = 21)	The difference, %	p*
Well-being	46.2 ± 10.3	44.7 ± 9.1	3.3	> 0.05
Activity	44.5 ± 9.8	43.5 ± 10.2	4.2	> 0.05
Mood	44.9 ± 11.2	42.7 ± 10.4	5.0	> 0.05

*Legend: * – the significance of the difference between the EG and the CG.*

Table 3. Characteristics of somatic health indicators of the EG and the CG young men at the end of the pedagogical experiment (X ± m)

Indicators of somatic health	EG (n = 21)	CG (n = 21)	The difference, %	p*
Body mass index, kg/m^2	20.3 ± 1.1	22.5 ± 1.7	10.3	p≤0.05
Strength index, %	57.2 ± 2.9	53.8 ± 2.7	6.1	p≤0.05
Vital index, ml/kg	55.9 ± 2.7	52.3 ± 2.4	6.7	p≤0.05
Robinson index, points	83.3 ± 2.4	76.6 ± 2.2	8.4	p≤0.05
Rufier index, c. u.	8.1 ± 0.9	9.6 ± 1.1	16.9	p≤0.05

*Legend: * – the significance of the difference between the EG and the CG.*

Table 4. Characteristics of psycho-emotional state indicators of the EG and the CG young men at the end of the pedagogical experiment (X ± m)

Indicators of psycho-emotional state	EG (n = 21)	CG (n = 21)	The difference, %	p*
Well-being	47.6 ± 4.8	57.9 ± 5.1		
Activity	47.4 ± 3.9	58.4 ± 4.2	20.8	p ≤ 0.05
Mood	48.2 ± 3.7	57.3 ± 4.1	17.3	p ≤ 0.05

*Legend: * – the significance of the difference between the EG and the CG.*

sports games, psycho-technical games, quests, etc.) and interactivity using external resources (active walks, hiking, geocaching). Games in addition to developing motor skills and improving physical condition, depending on the nature of the game, taught high schoolers to navigate, act on the basis of independent decision-making, helped to develop the ability to predict the course of a situation, choose a model of safe behavior, allowed them to gain new knowledge and practice certain motor skills, and provided psychological comfort. Psycho-technical games have creative content and use psycho-techniques to influence the psycho-emotional state of high schoolers. The use of such games created favorable conditions for behavioral correction, education of personal and social-communicative qualities. The quests were of research, educational, cognitive, and entertaining nature in the genre of adventure games based on a specific plot. Interactive activities involving the use of external resources were based on the use of the natural environment, street workout areas, and parks at any time of the year if weather conditions permitted. During the implementation of active walks, hiking, and geocaching that is tourist games with elements of orienteering, motor skills were developed, and orienteering skills were formed.

After 10 months of the pedagogical experiment, a study was conducted to evaluate the effectiveness of the author's methodology using the same indicators of somatic and mental health. It was found that at the end of the experiment, the indicators of the EG young men were significantly ($p < 0.05$) better than that of the CG young men in all the studied parameters (Table 3, Table 4).

Thus, the difference between the indicators of body mass index in the EG and the CG young men was 10.3 %, between the indicators of strength index – 6.1 %, between the indicators of vital index – 6.7 %, between the indicators of Robinson index – 8.4 %, between the indicators of Rufier index – 16.9 %. The difference between the indicators of well-being of the EG and the CG high schoolers was 19.5 %; activity indicators – 20.8 %; mood indicators – 17.3 times.

Thus, the research on the implementation of interactive methods in the process of physical education of high schoolers aged 16-17 years shows a positive result. It can be argued that the proposed methodology helps to improve the somatic and mental health of high schoolers due to its positive impact on morphological and functional indicators of body development and psycho-emotional state.

DISCUSSION

At the current stage of development of school education, teachers are increasingly paying attention to interactive methods in teaching mathematics, Ukrainian and foreign languages, biology, geography, history, and other subjects. At all levels of school education, there is an active use of interactive methods, which contributes to the creation of comfortable learning conditions, active and conscious acquisition of knowledge, motor experience, development of motor skills and realization of high schoolers' potential, in which each child feels successful and capable [15].

Currently, pedagogical theory and practice have accumulated experience in using interactive methods not only in the process of forming theoretical and methodological knowledge in the field of physical culture but also in the process of teaching physical exercises [16, 17]. In contrast to traditional methods based mainly on reproductive methods of teaching physical exercise techniques, interactive learning involves the formation of motor skills and abilities based on high schoolers' creative and search activities [18]. Researchers have proposed various methodological developments of interactive physical education aimed at mastering educational material from different sections of the school curriculum for high schoolers of different school ages [19]. There are studies of peculiarities of interactive methods application in physical education lessons of primary schoolchildren, and high schoolers of basic school, based on game activity, formation of special knowledge, and social skills [20]. However, these studies are isolated, and therefore there is no scientifically based methodology for the use of interactive methods in physical education of high schoolers of different school ages, including senior high schoolers.

Modern educational challenges require the introduction of effective innovative teaching methods, ensuring educational, upbringing, health, developmental orientation, application of a personality-oriented approach, development of creativity, initiative, and independence, as well as the formation of key competencies, vital and applied motor experience [21, 22]. The expediency of interactive physical culture teaching of senior high schoolers is justified by age peculiarities of mental development and pedagogical tasks of physical education of senior adolescents. Interactive physical culture teaching can provide optimal motor regime and personal development, the full realization of high schoolers' motor potential based on their capabilities, abilities, and experience. The use of interactive methods in physical education training sessions allows for the most productive activity of high schoolers, mobilizes and reveals their abilities to the fullest extent possible, and fosters positive life values. The peculiarity of interactive physical education training sessions is to prepare young people for life by forming cognitive skills, developing motor abilities, forming motor experience, healthy lifestyle habits, motivation, and the need for motor activity. Interactive methods make it possible to achieve high activity in high schoolers and allow for the comprehensive application of verbal, visual, and practical methods in combination with the natural environment.

The best international experience in providing conditions for improving the health of the population in our country is implemented through the education of children and youth, the idea of health protection is embodied through the formation of appropriate value and behavioral orientations, competencies, ensuring active and healthy leisure, the introduction of modern and effective didactic methods in the educational process [23].

In high school, a person is directly prepared for adulthood and social functions, and a healthy lifestyle and life perspective are formed. In organizing educational activities, it is necessary to take into account the age characteristics of senior high schoolers, in particular their morphological and functional as well as motor development, and mental properties of adolescence. Today, there is a tendency to decrease the health indicators of learner youth with age, in addition, the current military-political, economic, epidemiological situation in Ukraine has significantly worsened the health and limited the motor activity of high schoolers through online learning, increased stress levels, worsened mental health, provoked significant mental disorders and the emergence of new somatic diseases in children and youth. Therefore, taking care of the health of senior high schoolers, and increasing their ability and desire to maintain health is an important component of the educational process. The expediency of using interactive methods and technologies in various forms of physical education in high school is justified by the age-related peculiarities of the mental development of adolescent children and the pedagogical tasks of teaching physical education to senior high schoolers.

Rationally organized motor activity of high schoolers based on interactive methods can be the most effective today in terms of forming high schoolers' ability to act in different conditions and circumstances, relying on the learned system of skills, knowledge, abilities, ways of thinking, values, and ideological beliefs. Given their focus, the introduction of interactive methods can have a positive impact on the physical condition and psycho-emotional state of school youth. These conclusions are confirmed by the results of our research.

CONCLUSIONS

The author's own methodology of using interactive methods in the process of physical education of high schoolers has been developed. The interactive methods included simulation, situational, role-playing, outdoor games, sports games, psycho-technical games, quests, active walks, hiking, and geocaching. Physical exercises took place mainly in the natural environment, street playgrounds for workouts, and parks at any time of the year if weather conditions allowed.

Testing the effectiveness of the author's methodology during 10 months of the pedagogical experiment showed that young men of the EG had a significant improvement in all the studied indicators compared to the CG. At the end of the experiment, it was found that the difference between the indicators of body mass index in the EG and

the CG young men was 10.3 %, between the indicators of strength index – 6.1 %, between the indicators of vital index – 6.7 %, between the indicators of Robinson index – 8.4 %, between the indicators of Rufier index – 16.9 %; the difference between the indicators of well-being of the EG and the CG high schoolers was 19.5 %; activity – 20.8 %; mood – 17.3 times.

We see prospects for further research in the implementation of the author's methodology in the process of physical education of university students.

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ORIGINAL ARTICLE

Restoration of the psycho-physical state of future law enforcement officers during recreational and health-improving training sessions

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ABSTRACT

Aim: To investigate the influence of recreational and health-improving training sessions on the dynamics of indicators of the psycho-physical state of future law enforcement officers during tactical and special training exercises at shooting grounds.

Materials and Methods: The research, which involved 95 future law enforcement officers (male cadets of the 4th training year) aged 20-22 years, was conducted in 2024 during 2 weeks of tactical and special training at the shooting ground. Three groups of cadets were formed: Groups A (n = 31) and B (n = 30) were engaged in physical training three times a week for 1 hour, using the author's methodology of recreational and health-improving orientations, respectively, and Group C (n = 34) did not engage in physical exercises at all.

Results: The positive influence of both recreational and health-improving training sessions on the dynamics of indicators of the psycho-physical state of future law enforcement officers during tactical and special training at the shooting ground has been established. It has been found that recreational training sessions are more effective in restoring mental state indicators, and health-improving training sessions – in restoring the physical state of future law enforcement officers.

Conclusions: It has been proved that rationally organized motor activity training sessions are an effective means of restoring the psycho-physical state of future law enforcement officers during tactical and special training at shooting grounds.

KEY WORDS: psycho-physical state, stress, future law enforcement officers, cadets, motor activity

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INTRODUCTION

Since the beginning of the full-scale invasion of Ukraine by the russian occupiers, the practical component of the educational process has been significantly strengthened in higher educational institutions with specific learning environment, as well as in academic institutions of other law enforcement agencies and departments [1, 2]. This is especially true for senior cadets who will soon join the ranks of practical units where they will be engaged in service activities in the difficult current conditions of the martial law regime. The strengthening of the practical component of the educational process of future law enforcement officers is reflected in a significant increase in the volume of tactical and special training exercises at shooting grounds, which are conducted to acquire and improve practical skills in performing special service tasks within the expanded range of powers assigned by the state to internal affairs agencies during the war [3, 4].

Tactical and special training exercises at shooting grounds are accompanied by several negative factors (stressors) that worsen the psycho-physical state of future law enforcement officers, namely: high intensity of tasks; intensity of actions; physical and mental stress; the need for intensive perception, processing and interpretation of large amounts of information; performing tasks under severe time pressure, physical fatigue, high psycho-emotional stress and many others [5, 6]. Along with adequate sleep, rational nutrition, and methods of mental self-regulation organized motor activity (physical training) is of great importance among the main areas of restoration of the psycho-physical state of future law enforcement officers during tactical and special training exercises at shooting grounds that take place under stressful conditions [7-9]. At the same time, there has been insufficient research on the impact of physical training of various kinds on the restoration of the psycho-physical state of future law enforcement officers during tactical and special training at shooting grounds under the legal regime of martial law, which led to the choice of the topic of our work.

AIM

The aim is to investigate the influence of recreational and health-improving training sessions on the dynamics

of indicators of the psycho-physical state of future law enforcement officers during tactical and special training exercises at shooting grounds.

MATERIALS AND METHODS

The research, which involved 95 future law enforcement officers (male cadets of the 4th training year of the specialty "Law Enforcement") aged 20-22 years, was conducted in 2024 during 2 weeks of tactical and special training at the shooting ground of the National Academy of Internal Affairs (Kyiv, Ukraine). Three groups of cadets were formed: Groups A (n = 31) and B (n = 30) were engaged in physical training three times a week for 1 hour in extracurricular time to restore their psycho-physical state after the exercises, using the author's methodology of recreational and health-improving orientations, respectively, and Group C (n = 34) did not engage in physical exercises at all. There was no special selection of cadets in the studied groups; they were formed according to the academic groups of one training year.

The author's methodology aimed to restore cadets' psycho-emotional state after performing practical tasks during tactical and special training exercises at the shooting ground. We have substantiated two types of physical training of different orientations: recreational and health-improving. Recreational training sessions were conducted to restore the physical, mental, and moral as well as psychic forces of cadets caused by intense training activities at the shooting ground, eliminating the effects of fatigue, increasing working capacity, and enjoying physical exercises. The effect of recreational training sessions was seen in optimizing the morphological and functional state, health (preventive health care and prevention of various diseases), psycho-emotional state of cadets, regulation of stressful neuropsychological states, improvement of well-being, mood, cheerfulness, and a sense of mental balance. The main means of recreational and health-improving training were sports and outdoor games (volleyball, football, etc.), as well as recreational running and walking.

The main purpose of conducting health-improving training was to maintain the achieved level of development of motor skills, improve special skills, and maintain the morphological and functional state and health of cadets at a level that ensures the quality of tasks during tactical and special training exercises at shooting grounds. Therefore, according to our methodology, we developed sets of physical exercises, which included exercises with the weight of one's own body; exercises with the weight of objects; exercises with resistance; exercises with the use of improvised means; and isometric (static) exercises. The vast majority of the developed sets were built based on the modern system of circuit training referred to as "CrossFit".

Research methods: bibliosemantic, psychodiagnostic, medical and biological, statistical, and pedagogical experiment. The bibliosemantic method was used to study scientific sources on the research topic. 27 sources from the databases Web of Sciences Core Collections, Scopus, PubMed, Index Copernicus and others were investigated. The psychodiagnostic method allowed us to evaluate the dynamics of indicators of the mental state of future law enforcement officers during tactical and special training at the shooting ground. For this purpose, 3 methods were used ("Assessment of Neuro-Psychic Tension", "Assessment of Psychological Stress", and "Assessment of Psycho-Emotional State" [10, 11]), which allowed to determine the index of neuro-psychic tension, index of psychological stress, and index of emotional state, respectively. The method referred to as the "Assessment of Neuro-Psychic Tension" contains 30 characteristics of this condition, divided into three degrees of severity (a – low degree, b – average degree, c – high degree). By choosing one of the three options, the cadets assessed their current state of neuro-psychic tension. The data was processed by summing the scores: for answers a – 1 point, b – 2 points, c – 3 points. The range from 30 to 50 points characterizes a low level of cadets' neuro-psychic tension, 51-70 points – an average level; from 71 to 90 points – a high level. The method referred to as the "Assessment of Psychological Stress" contains 25 questions-assertions, answering which the cadet chose the frequency of their manifestation from 1 to 8, where 1 – never, 8 – constantly. Stress was assessed by the sum of points, where a low level of stress corresponded to the sum of 99 points or less; average – 100-125 points; high – 125 points or more. The method referred to as the "Assessment of Psycho-Emotional State" allows for the diagnosis of the following characteristics: well-being, proactive attitude, mood, working capacity, and self-confidence. The cadets were asked to evaluate the characteristics of their state from 1 to 100 points. The number of points from 1 to 20 corresponded to a low level of psycho-emotional state; from 21 to 40 – below average; from 41 to 60 – average; from 61 to 80 – above average; from 81 to 100 – high.

The medical and biological method allowed us to assess the physical state of future law enforcement officers by the following indicators: Rufier index; vital index, and strength index. The Rufier index allows evaluation of the performance of the heart and it is determined by the rate of heart rate recovery after exercise (30 squats in 45 seconds). The vital index is a criterion for the reserve of external respiratory functions, determined by the ratio of lung vital capacity to body weight of future law enforcement officers. The strength index characterizes the state of the muscular system of cadets; it is determined by the ratio of the indicator of hand dynamometry of the stronger hand to the body weight of cadets [12, 13].

The pedagogical experiment involved a comparative analysis of the dynamics of indicators of the psycho-physical state of future law enforcement officers of three groups: A and B, whose cadets were trained according to the author's methodology, but the training sessions had different focuses, and C, whose cadets did not use physical exercises at all to restore their psycho-physical state.

The statistical method was used to process the data obtained. The compliance of the sample data distribution with the Gauss' law was assessed using the Shapiro-Wilk W test. The reliability of the difference between the indicators was determined using the Student's t-test. The reliability

of the difference was set at $p<0.05$. All statistical analyses were performed using SPSS software, version 10.0, adapted for medical and biological research.

This research was carried out in accordance with the requirements of the Regulations on academic integrity at the National Academy of Internal Affairs. This document was approved by the Academic Council of the National Academy of Internal Affairs (protocol No. 5 of 27.03.2018) and put into effect by order of the rector of the Academy (Order No. 422 of 30.03.2018). Also this study followed the regulations of the World Medical Association Declaration of Helsinki. Prior consent to participate in the study was obtained from all respondents.

RESULTS

The results of the study of the dynamics of the cadets' mental state during tactical and special training exercises at the shooting ground by three methods are presented in Table 1. It was found that at the beginning of tactical and special training exercises, all indicators of the cadets' mental state did not have a significant difference between the groups ($p > 0.05$). There were certain changes in the studied indicators during tactical and special training. The most pronounced significant ($p < 0.05$-0.01) negative changes in all indicators were found in group C. The least pronounced changes were observed in group A, whose cadets attended recreational training sessions. In group B, whose cadets were engaged in health-improving training sessions, the changes were negative, but no significant difference was found at the beginning and the end of tactical and special training in all the studied parameters ($p > 0.05$).

At the end of the tactical and special training, group C showed the worst level of all mental state indicators among the studied groups. Moreover, at the beginning of the experiment, the indices of neuro-psychic tension and psychological stress in all groups corresponded to the average level, and at the end – the level did not change in groups A and B, and in group C – it was low. The index of psycho-emotional state at the beginning of the experiment in all groups was assessed as above average and at the end – in group C it decreased to average, in other groups – did not change. This indicates that recreational training sessions are the most effective for restoring the mental state of future law enforcement officers during tactical and special training exercises at shooting grounds.

The results of the study of the dynamics of cadets' physical state during tactical and special training exercises at the shooting ground are presented in Table 2. As with the indicators of the mental state, no significant difference was found between all the studied indicators of the cadets' physical state of the three groups at the beginning of the experiment ($p > 0.05$), which confirms the homogeneity of the studied groups.

The analysis of the Rufier index, the increase of which indicates a deterioration in the activity of the cardiovascular system of cadets, showed that there were no significant changes in groups A and B during the experiment, and in group C there was a significant deterioration of the index during tactical and special training by 0.90 c. u. ($p < 0.05$). At the same time, the least pronounced changes occurred in group B, whose cadets attended health-improving training sessions. A significant ($p < 0.01$) decrease in the vital index from the average level to below average was also observed in group C, which suggests a deterioration in the functional state of the respiratory system in cadets who did not exercise during tactical and special training at the shooting ground. In groups A and B, there were no

Table 1. Dynamics of indicators of the mental state of future law enforcement officers during tactical and special training at the shooting ground (n = 95, points, Mean ± m)

Groups of cadets	n	Stages of the experiment		Reliability of the difference	
		Before the tactical and special training	After the tactical and special training	The difference	t; p
Index of neuro-psychic tension					
A	31	45.37±1.88	47.16±1.90	1.79	0.67; >0.05
B	30	44.29±1.85	48.26±1.87	3.97	1.51; >0.05
C	34	46.34±1.79	53.02±1.84	6.68	2.60; <0.05
Index of psychological stress					
A	31	96.8±2.32	97.1±2.36	0.30	0.09; >0.05
B	30	94.9±2.35	98.9±2.38	4.00	1.20; >0.05
C	34	95.3±2.28	108.1±2.34	12.8	3.92; <0.01
Index of emotional state					
A	31	63.84±2.04	61.95±1.99	1.89	0.66; >0.05
B	30	65.29±1.96	61.13±1.94	4.16	1.50; >0.05
C	34	64.51±1.92	56.47±1.95	8.04	2.94; <0.05

Note: n – number of cadets; Mean – arithmetic mean; m – standard deviation error; t – Student's t-test value; p – confidence interval.

Table 2. Dynamics of indicators of the physical state of future law enforcement officers during tactical and special training at the shooting ground (n = 95, Mean ± m)

Groups of cadets	n	Stages of the experiment		Reliability of the difference	
		Before the tactical and special training	After the tactical and special training	The difference	t; p
Rufier index; c. u.					
A	31	9.21±0.26	9.83±0.27	0.62	1.60; >0.05
B	30	9.43±0.29	9.72±0.30	0.29	0.72; >0.05
C	34	9.24±0.22	10.11±0.25	0.87	2.70; <0.05
Vital index, ml/kg					
A	31	56.92±0.90	55.61±0.92	1.31	1.01; >0.05
B	30	56.15±0.93	55.73±0.92	0.42	0.31; >0.05
C	34	56.73±0.85	52.34±0.88	4.39	3.66; <0.01
Strength index, %					
A	31	63.88±0.71	61.94±0.75	1.94	1.88; >0.05
B	30	62.45±0.67	62.36±0.68	0.09	0.09; >0.05
C	34	62.74±0.63	59.95±0.67	2.79	3.03; <0.01

Note: n – number of cadets; Mean – arithmetic mean; m – standard deviation error; t – Student's t-test value; p – confidence interval.

significant changes in the vital index ($p > 0.05$). A similar trend was observed in the study of the strength index. The most pronounced reliable ($p < 0.01$) negative changes at the end of the experiment were found in group C, and the smallest changes occurred in group B, which indicates the effectiveness of health-improving training for the restoration of the physical state of cadets during tactical and special training at the shooting ground. At the same time, at the end of the experiment, it was found that in group C all the studied indicators of physical state were the worst, which indicates a decrease in the functional state of the main systems of the cadets' body.

DISCUSSION

During the war, all citizens of Ukraine experience stress, however, the most stressful symptoms are found in professionals whose activities are associated with risk and take place in difficult and extreme conditions [14, 15]. Tactical and special training at shooting grounds is a certain stressor for cadets, which generally leads to a deterioration in the psycho-physical state of cadets.

In general, according to scientists [16], stress and stressful phenomena are considered a completely normal part of human life. However, depending on its specificity, stress can be a short, situational, and positive factor that motivates and determines the development of productivity, but if stress is experienced over a long period, it can become chronic and significantly affect health. According to scientists [17, 18], law enforcement is one of the professions whose employees carry out their activities under the constant influence of stressors. Law enforcement officers perform their duties in extremely difficult conditions: an aggressive communication environment, a shortage of working time, high responsibility for work results, and the presence of various extreme circumstances. Every day, they face a variety of specific stressors, most of which are persistent and long-term, leading to overwork, general and occupational diseases, professional burnout, and premature aging [19, 20]. According to scientists [21-23], stress can lead to a deterioration in the quality of law enforcement officers' professional activities, which can affect not only the personal physical, and mental health of law enforcement officers, but also other people. Therefore, finding ways and developing measures to prevent professional stress and restore and preserve the mental and physical health of law enforcement officers is one of the most pressing issues. In our research, we used physical training of different orientations to restore the psycho-physical state of future law enforcement officers during tactical and special training at the shooting ground. The effectiveness of recreational training sessions was revealed in the dynamics of indicators of the mental state of future law enforcement officers, and health-improving training sessions can be an effective means of restoring and improving the physical state of future law enforcement officers. Instead, in the future law enforcement officers who did not use motor activity as a means of restoring their psycho-physical state, all the studied indicators had a more pronounced and significant deterioration during the experiment. Our results confirmed the conclusions of many scientists [24-27].

CONCLUSIONS

The positive influence of both recreational and health-improving training sessions on the dynamics of indicators of the psycho-physical state of future law enforcement officers during tactical and special training at the shooting ground has been established. It has been found that recreational training sessions are more effective in restoring mental state indicators, and health-improving training sessions – in restoring the physical state of future law enforcement

officers. Thus, at the end of the experiment, the cadets of group A showed the best indicators of indices of neuropsychic tension, psychological stress, and psycho-emotional state. In addition, the cadets of group B had the highest values of Rufier's indices, vital and strength indices. In group C, at the end of the experiment, all the studied indicators were the worst, and in this group, the most pronounced significant ($p < 0.05$-0.01) negative changes in all indicators were observed. Thus, it has been proved that rationally organized motor activity training sessions of different orientations are an effective means of preventing stress and restoring the psycho-physical state of future law enforcement officers during tactical and special training at shooting grounds.

PROSPECTS FOR FURTHER RESEARCH

We plan to investigate the effectiveness of the author's methodology during the performance of service and combat tasks by law enforcement officers in practical units after graduation.

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ORIGINAL ARTICLE

Peculiarities of physical therapy for persistent bronchial asthma in order to preserve physical capacity and improve the psycho-emotional state of patients

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ABSTRACT

Aim: The aim of the study is to experimentally determine the effectiveness of the author's technique of respiratory gymnastics and psychocorrective exercises for use in the polyclinic period during the rehabilitation of patients with persistent bronchial asthma of moderate severity in the exacerbation stage.

Materials and Methods: The program of the local pedagogical experiment was implemented through the realization of ascertaining and formative stages. The study was conducted on the basis of the therapeutic department of the Communal establishment «Poltava Regional Clinical Hospital named after M. V. Sklifosovsky». A total of 30 people aged 35 to 47 with a diagnosis of «Persistent moderate bronchial asthma in the exacerbation stage» took part in the study.

Results: After analyzing the duration and intervals of respiratory phases (according to Buteyko), we developed our own program of physical therapy for patients with persistent bronchial asthma of moderate severity in the exacerbation stage (aging 35 to 47 years). The essence of the author's technique developed by us is to increase the duration of each period, as well as to increase the time of each phase when performing respiratory gymnastics.

Conclusions: Therefore, the author's method of respiratory gymnastics presented in this scientific study for the rehabilitation of patients with persistent bronchial asthma of moderate severity in the exacerbation stage is effective for the rehabilitation of patients at the polyclinic stage, and its effectiveness has been proven experimentally.

KEY WORDS: bronchial asthma, respiratory gymnastics, health, physiotherapy and occupational therapy, patients

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INTRODUCTION

Bronchial asthma is one of the most common chronic diseases, which represents a significant medical and social problem for adults and children. According to World Health Organization, between 5% and 15% of the world population suffers from bronchial asthma. This means that there are about 300 million asthmatics in the world [1-3].

Currently, many different methods of treatment for bronchial asthma are proposed, but unfortunately, there is still no single scientifically proven, highly effective treatment regimen, so the vast majority of patients require systematic drug therapy and periodic hospitalization. At the same time, the insufficient effectiveness of drug therapy, the high cost of treatment, and the unsatisfactory quality of life of patients remain. Thus, bronchial asthma is a global problem in all countries of the world, regardless of their level of development [1].

Physiotherapy and occupational therapy play an important role in the rehabilitation of asthma patients. Physiotherapy methods can be used both during an exacerbation of the disease and during remission. Many methods have proven themselves as effective means of helping patients with bronchial asthma. That is why the development of original methods of physiotherapy in the treatment of bronchial asthma is a relevant and important direction of scientific work.

Experimental methods of physical therapy in the treatment of bronchial asthma in a state of exacerbation can help patients to overcome the inconveniences that arise during the exacerbation of the disease, reduce the intensity of medical treatment and improve the quality of life of patients.

Taking into account the actuality of the problem of rehabilitation of patients with bronchial asthma, the National Academy of Medical Sciences of Ukraine, the Ministry of Health of Ukraine, the State Institution «National Institute of Phthisiatry and Pulmonology named after F. G. Yanovsky of the National Academy of Medical Sciences of Ukraine», the National Medical Academy of Postgraduate Education named after P. L. Shupyk and the Association of Pulmonologists of Ukraine have developed «Adapted evidence-based clinical guideline «Bronchial asthma» [2].

This instruction is dedicated to the current problem of pulmonology, namely, to bronchial asthma. It is based on the modern evidence base. The latest revisions of the generally accepted international standards for the management of asthma patients (GINA), national experience, research by national scientists were taken as prototypes for it. Definitions and classifications of bronchial asthma, modern epidemiological data on its prevalence, mortality and lethality rates are given in it. Issues of etiology, pathogenesis and diagnosis of the disease are covered in detail. Modern approaches to the treatment of patients with bronchial asthma, and the criteria for evaluating the effectiveness of treatment are described in detail. Algorithms for the treatment of patients with bronchial asthma during a stable course and during exacerbation are given, which will allow unifying the requirements for providing quality medical care to such patients and increase the effectiveness of their treatment in different departments of multidisciplinary medical institutions.

Despite the existence of such an instruction, the analysis and comparison of modern domestic and foreign practices of providing rehabilitation care to persons with bronchial asthma showed that in Ukraine there are insufficiently developed recommendations for physical therapy in inpatient and outpatient settings. Home programs, on-line support and patient education are lacking, just as there is no effective program aimed at a long-term therapeutic effect [4-8]. Regarding the effectiveness of some therapeutic exercises and optimal tools for evaluating physiotherapeutic interventions, research and discussions are being conducted.

AIM

The aim of the study is to experimentally determine the effectiveness of the author's technique of respiratory gymnastics and psychocorrective exercises for use in the polyclinic period during the rehabilitation of patients with persistent bronchial asthma of moderate severity in the exacerbation stage.

MATERIALS AND METHODS

The program of the local pedagogical experiment was implemented through the realization of ascertaining and formative stages. They made it possible to state the state of the researched problem, to understand and formulate the purpose of the research, to outline the tasks of the experimental work, to clarify the theoretical foundations of the determine the effectiveness of the author's technique of respiratory gymnastics and psychocorrective exercises for use in the polyclinic period during the rehabilitation of patients with persistent bronchial asthma of moderate severity in the exacerbation stage.

The confirmatory experiment provided for highlighting the state of the investigated problem, formulating the purpose of the study, outlining the tasks of the experimental work, clarifying the theoretical foundations of determining the effectiveness of the author's technique of respiratory gymnastics and psychocorrective exercises for use in the polyclinic period during the rehabilitation of patients with persistent bronchial asthma of moderate severity in the exacerbation stage. Experimental verification of the effectiveness of the program (formative experiment) was 35 days – 5 weeks.

The study was conducted on the basis of the therapeutic department of the Communal establishment «Poltava Regional Clinical Hospital named after M. V. Sklifosovsky». Patients were involved in the study after receiving secondary (specialized) medical care, the basis of which was physical therapy treatment and exercise therapy in accordance with the clinical protocol approved by the internal order of the health care institution. A total of 30 people aged 35 to 47 with a diagnosis of «Persistent moderate bronchial asthma in the exacerbation stage» took part in the study. The main complaints were: progressive difficult cough with shortness of breath, wheezing, chest tightness.

The hypothesis of our research predicted that the duration of getting used to respiratory gymnastics will be longer, due to which the body's adaptation to new exercises will be gentler. At the same time, we slightly increased the duration of each phase and pauses to increase the effectiveness of breathing exercises.

According to the adapted evidence-based clinical guideline dated 01/21/2020, in the traditional program, patients were recommended a general rehabilitation program, a daily 20-minute walk and upper body muscle training. The experimental technique was based on supplementation and adaptation of voluntary elimination of deep breathing according to K. P. Buteyko (VEDB), according to the functional state of patients.

The so-called volitional elimination of deep breathing developed by K.P. Buteyko (VEDB) was the basis for the author's technique. It was decided to work with this technique for the rehabilitation of patients with persistent bronchial asthma of moderate severity in the exacerbation stage due to several factors:

- the Buteyko's method guarantees the safety and effectiveness of bronchial asthma treatment, especially in the acute phase, which allows you to eliminate the manifestations of the disease in a matter of minutes: an attack of hay fever, stop coughing and reduce shortness of breath, reduce the manifestations of allergies and nasal congestion;
- the Buteyko's method has been repeatedly studied in order to find out its effectiveness: the first foreign studies were carried out in 1999, since then the method is constantly in the field of view of foreign researchers;
- the Buteyko's method was included in the unified clinical protocol of primary, secondary (specialized) medical care «Bronchial asthma», approved by the Ministry of Health of Ukraine in 2013.

Buteyko's original method is as follows: voluntary elimination of deep breathing training is done in conditions of rest and muscle relaxation. At the same time, you should breathe only through your nose [7]. When holding your breath, you need to pinch your nose and make sure that your breath is shallow. After every 3-4 days of classes, the

duration of the breathing phases and the intervals between them should be increased. The duration of the first delays is 10 s, then they lengthen to 180-240 s. Breathing is held during inhalation and exhalation. The exercise time is 15-20 minutes. The duration of rehabilitation is 3 weeks. Exercises should be continued even after the period of exacerbation of the disease has subsided (Table 1).

The duration of the program was 5 weeks. The condition of the patients was assessed before and after 5 weeks of performing experimental respiratory gymnastics. We selected two groups of patients (15 patients each). Two groups of patients participated in the experimental study: control and experimental. The first group consists of patients who receive medical treatment, perform physiotherapeutic measures and breathing exercises according to the Buteyko's method. The second group consists of patients who receive medical treatment, perform physiotherapeutic measures and breathing exercises developed by the authors of the scientific study and psychocorrective exercises (methods of self-regulation). In turn, each group of patients was divided into three microgroups (5 people in each microgroup) for the purpose of more thorough control of patients by a physical therapist, because it is possible to qualitatively control the functional state of the patient and his performance of therapeutic exercises only in a small group [9].

It was planned to examine the patients before the beginning of breathing exercises and after 35 days. After 18 days, patients who performed classical breathing gymnastics according to Buteyko had their physical therapy sessions adjusted: they performed a complex of inhaling for 7 seconds, pause after inhaling for 14 seconds, exhaling for 9 seconds, pause after exhaling for 12 seconds.

It was expected that patients who will perform the author's complex of breathing exercises will have better results than those who performed breathing exercises according to Buteyko, as well as significantly better results than those who were treated only with medication.

A set of following research methods was used to achieve the goal and to test the hypothesis:

– *methods of psychological and pedagogical research:* assessment of disease symptoms, assessment of physical performance and movement, active daily activities, assessment of the level of anxiety and depression, quality of life (SF–36), self-assessment of emotional states, study of volitional organization of the individual, assessment of perseverance, etc. A pedagogical experiment was used to determine the effectiveness of the rehabilitation program. Questionnaires of self-actualization test (SAT), hospital anxiety and depression scale (HADS), activity of daily living (ADL) recommended in many pulmonary rehabilitation programs were used;
– *medical and biological research methods*. In order to obtain a complete picture of the disease, we used clinical and anamnestic methods: analysis of medical documentation, study of anamnesis, complaints, smoking status. Physical methods, examination of the patient: attention was paid to the pattern of breathing, changes in the frequency of breathing, decrease in the depth of breathing, the shape of the chest, percussion of the limits of cardiac dullness and auscultation, pulse oximetry, tonometry were performed. We used following tests: the Asthma Control Test, which is widely used by medical professionals around the world, is scientifically based and verified on hundreds of patients with asthma; spirometry; morning and evening peak flowmetry;
– *methods of mathematical statistics.* Reliable conclusions about the effectiveness of the rehabilitation program can be obtained with the help of quantitative analysis, which is based on mathematical processing using statistical methods. Based on these measurements, the statistical reliability of the program's impact on the patients' functional state is determined. The comparison between the result before and after the intervention was performed using the paired t-test and the Wilcoxon signed-rank test. Correlation between was analyzed using Spearman's correlation. Correlation strength: correlation coefficients 0-0.19 very weak, 0.2-0.39 weak, 0.4-0.59 moderate, 0.6-0.79 strong, 0.8-1 very strong. Parametric (paired t-test) and non-parametric degrees of influence (Spearman's test) are used to analyze the reliability of the program's impact on the functional state of patients and to compare the strength of the program's impact on certain indicators of the functional state. Correlation between changes in spirometry indicators: the vital capacity of the lungs; inspiratory reserve volume; expiratory reserve volumes; forced vital capacity of the lungs; volume of forced exhalation in the first second; volume of forced exhalation in the second second; volume of forced exhalation in the third second; volume of forced exhalation in final second; R. Tiffeneau index; volume of forced exhalation in the first second/Forced

Table 1. Duration and intervals of respiratory phases (according to Buteyko)

Training days	Inhalation phase, s	Pause after inhalation, s	Exhalation phase, s	Pause after exhalation, s
1–3	2	4	4	6
4–6	3	6	5	7
7–9	4	8	6	8
10–12	5	9	7	8
13–15	6	12	8	10
16–18	7	14	9	12

vital capacity of the lungs; peak expiratory volume rate; instantaneous volume velocity 25; instantaneous volume velocity 50; instantaneous volume velocity 75; average volume exhalation rate 25-75 after the rehabilitation program was analyzed using Spearman's correlation.

The normality of the distribution was determined by the Spearman method. t-criterion was used by us to compare indicators of assessment of the functional state of patients, measured before and after the application of the rehabilitation program in the control and experimental groups.

The Ethics Commission of National University «Yuri Kondratyuk Poltava Polytechnic» National University «Yuri Kondratyuk Poltava Polytechnic» has no comments on the methods used in this study.

RESULTS

After analyzing the duration and intervals of respiratory phases (according to Buteyko), we developed our own program of physical therapy for patients with persistent bronchial asthma of moderate severity in the exacerbation stage (aging 35 to 47 years). The essence of the author's technique developed by us is to increase the duration of each period, as well as to increase the time of each phase when performing respiratory gymnastics. The suggested endurance and respiratory phase intervals according to the author's methodology are presented in table 2.

Also, with obstructive lung diseases according to the International Classification of Functioning, Disability and Health (ICF), following changes occur in patients: b130 Volitional and drive functions (General mental functions of physiological and psychological mechanisms that force an individual to constantly move to satisfy certain needs and general goals, which includes: functions of willpower, motivation, appetite, desire power (including the power of desire for substances that can be abused), impulse drive control; b134 Functions of sleep (General mental functions of periodic, reversible and selective physical and mental withdrawal directly from the environment, which is accompanied by characteristic physiological changes); b152 Functions of emotions (Specific mental functions related to sensory and affective components of mental processes, which include: functions of adequacy of emotions, regulation and range of emotions; affect; sadness, happiness, love, fear, anger, hatred, tension, restlessness, joy, grief; instability of emotions; smoothing of affect); b1522 Range of emotions (Mental functions that provide the full range of experienced affects and feelings, such as love, hate, anxiety, sadness, joy, fear and anger). These indicators can be studied using the method «Self-assessment of emotional states» by A. Wesman and D. Ricks, the Hospital Anxiety and Depression Scale (HADS), the method of researching the volitional organization of the personality by M. Gutkin, the method «Readiness for risk» (Schubert's RFR), a questionnaire for assessing perseverance by E. Ilyin and E. Feshchenko, etc [12-16].

We were offered to use psychocorrective exercises for self-regulation of one's emotional state, namely [9]: exercise «5-4-3-2-1» aimed at focusing on your 5 senses (visual, tactile, auditory, olfactory, taste); the «Radio» exercise, which helps control intrusive thoughts, voices, and negative emotions; exercise «Who am I?», which gives an opportunity to focus on the present and return to reality; the «Visualization» exercise, which allows you to distract yourself from unwanted thoughts and feelings, focus on something pleasant, etc.

We selected two groups of patients (15 patients each). In turn, each group of patients was divided into microgroups (5 people in each microgroup) for the purpose of more careful control of patients by a physical therapist. The first group consisted of patients who received medical treatment, performed physiotherapeutic measures and breathing exercises according to the Buteyko's method. The second group consisted of patients who received medical treatment, performed physiotherapeutic measures and breathing exercises developed by the authors of this scientific study and executed special psychocorrective exercises (methods of self-regulation).

It was planned to examine the patients before the beginning of breathing exercises and after 35 days. After 18 days, patients who performed classical breathing gymnastics according to Buteyko had their physical therapy sessions adjusted: they performed a complex of inhaling for 7 seconds, pause after inhaling for 14 seconds, exhaling for 9 seconds, pause after exhaling for 12 seconds.

It was expected that patients who will perform the author's complex of breathing exercises will have better results than those who performed breathing exercises according to Buteyko, as well as significantly better results than those who were treated only with medication.

Table 2. Duration and intervals of respiratory phases according to the author's method

Training days	Inhalation phase, s	Pause after inhalation, s	Exhalation phase, s	Pause after exhalation, s
1–5	3	6	5	7
6–10	4	8	6	8
11–15	5	9	7	8
16–20	6	12	8	10
21–25	7	14	9	12
26–30	8	16	10	14
31–35	9	18	11	16

The study of the functional state of patients of group 1 with persistent bronchial asthma (asthma control test and peak flowmetry) before the start of the experiment revealed the results listed in Table 3, the spirometry indicators of patients of group 1 are given in Table 4.

The study of the functional state of patients of group 2 with persistent bronchial asthma (asthma control test and peak flowmetry) before the start of the experiment revealed the results listed in Table 5, the spirometry indicators of patients of group 1 in Table 6.

The results of the studies performed 5 weeks after the start of the experiment are shown below.

The study of the functional state of patients of group 1 with persistent bronchial asthma (asthma control test, and peak flowmetry) after the experiment revealed the results listed inTtable &, the spirometry indicators of patients of group 1 in Table 8.

The study of the functional state of the patients of group 2 with persistent bronchial asthma (asthma control test, and peak flowmetry) after the experiment revealed the results listed in Table 9, the spirometry indicators of patients of group 2 in Table 10.

The data in Table 1 contain well-known initial data Table 2 presents the intervals of respiratory phases according to the author's method (the essence of the author's method developed by us is to increase the duration of each period, as well as to increase the time of each phase when performing respiratory gymnastics). Tables 3-10 present the results of diagnosing patients' condition according to the well-known methods of researching patients' functional condition described in the article.

The study of the functional state of patients of group 1 with persistent bronchial asthma (asthma control test, spirometry and peak flowmetry) before the start of the experiment revealed the results listed in Table 3, the spirometry indicators of patients of group 2 in Table 4. The obtained results indicate the absence of a statistically significant difference between the functional condition of patients of both groups.

The results of the self-assessment study of the emotional states of patients of groups 1 and 2 with persistent bronchial asthma (after the experiment) revealed the results shown in Fig. 1.

After analyzing the data of the experimental study of the first group presented in the tables, we found the following: the indicators of the asthma control test in the first group are on average equal to 20 peak flowmetry indicators (morning and evening, average result) – 83%; the indicators

Table 3. Indicators in the first group of subjects

The table shows the average indicators of the functional state in microgroups	Asthma control test	Peak flowmetry (morning and evening, average result)
Microgroup 1 (n=5)	15	55%
Microgroup 2 (n=5)	10	35%
Microgroup 3 (n=5)	12	60%

Table 4. Results of spirometry of patients of group 1

Parameter	Units of measurement	Norm	m 1 (n=5)	m 2 (n=5)	m 3 (n=5)
The vital capacity of the lungs	L	4.63	2.33	2.55	1.98
Inspiratory reserve volume	L	2.32	1.35	1.24	1.35
Expiratory reserve volumes	L	1.62	0.75	1.1	1.02
Forced vital capacity of the lungs	L	4.26	2.48	3.47	2.45
Volume of forced exhalation in the first second	L	3.26	1.55	2.15	1.51
Volume of forced exhalation in the second second	L	4.17	2.18	2.97	2.17
Volume of forced exhalation in the third second	L	4.35	2.85	2.65	2.69
Volume of forced exhalation in final second	L	1.02	0.159	0.42	0.159
R. Tiffeneau index	%	69.4	35.8	39.7	41.9
Volume of forced exhalation in the first second /Forced vital capacity of the lungs	%	76.9	39.7	46.5	43.8
Peak expiratory volume rate	L/s	8.3	3.48	4.36	3.45
Instantaneous volume velocity 25	L/s	7.48	1.45	2.19	1.17
Instantaneous volume velocity 50	L/s	4.47	0.70	1.20	0.81
Instantaneous volume velocity 75	L/s	1.35	0.472	0.91	0.380
Average volume exhalation rate 25-75	L/s	3.45	0.645	0.754	0.954

Table 5. Indicators in the second group of subjects

The table shows the average indicators of the functional state in microgroups	Asthma control test	Peak flowmetry (morning and evening, average result)
Microgroup 1 (n=5)	15	55%
Microgroup 2 (n=5)	12	40%
Microgroup 3 (n=5)	13	50%

Table 6. Results of spirometry of patients of group 2

Parameter	Units of measurement	Norm	m 1 (n=5)	m 2 (n=5)	m 3 (n=5)
The vital capacity of the lungs	L	4.63	2.28	2.17	2.96
Inspiratory reserve volume	L	2.32	0.98	1.02	1.49
Expiratory reserve volumes	L	1.62	1.0	1.12	0.89
Forced vital capacity of the lungs	L	4.26	2.69	3.57	2.48
Volume of forced exhalation in the first second	L	3.26	1.60	2.12	1.64
Volume of forced exhalation in the second second	L	4.17	2.23	3.12	2.19
Volume of forced exhalation in the third second	L	4.35	2.35	2.48	2.79
Volume of forced exhalation in final second	L	1.02	0.16	0.49	0.27
R. Tiffeneau index	%	69.4	40.5	50.2	38.9
Volume of forced exhalation in the first second /Forced vital capacity of the lungs	%	76.9	42.6	45.8	42.8
Peak expiratory volume rate	L/s	8.3	3.12	4.98	3.85
Instantaneous volume velocity 25	L/s	7.48	1.63	2.54	2.18
Instantaneous volume velocity 50	L/s	4.47	0.98	1.50	0.98
Instantaneous volume velocity 75	L/s	1.35	0.560	0.745	0.520
Average volume exhalation rate 25–75	L/s	3.45	0.985	1.05	0.974

Table 7. Indicators in the first group of subjects (5 weeks after the start of the experiment)

The table shows the average indicators of the functional state in microgroups	Asthma control test	Peak flowmetry (morning and evening, average result)
Microgroup 1 (n=5)	18	80%
Microgroup 2 (n=5)	20	84%
Microgroup 3 (n=5)	22	86%

of the asthma control test in the first group are on average equal to 23, the indicators of peak flowmetry (morning and evening, average result) – 93%. The results of spirometry of patients of group 1 are as follows: The vital capacity of the lungs – 4,2 (Normal – 4,63); Inspiratory reserve volume – 2.23 (Normal – 2.32); Expiratory reserve volumes – 1.22 (Normal – 1.62); Forced vital capacity of the lungs – 4.20 (Normal – 4.26); Volume of forced exhalation in the first second – 3.17 (Normal – 3.26); Volume of forced exhalation in the second second – 4.9 (Normal – 4.17); Volume of forced exhalation in the third second – 4.22 (Normal – 4.35); Volume of forced exhalation in final second – 0.97 (Normal – 1.02); R. Tiffeneau index – 66.1 (Normal – 69.4); Volume of forced exhalation in the first second/Forced vital capacity of the lungs – 74.4 (Normal – 76.9); Peak expiratory volume rate – 8 (Normal – 8.3); Instantaneous volume velocity 25 – 7.15 (Normal – 7.48); Instantaneous volume velocity 50 – 4.23 (Normal – 4.47); Instantaneous volume velocity 75 – 1,1 (Normal – 1.35); Average volume exhalation rate 25–75 – 3,1 (Normal – 3.45).

After analyzing the data of the experimental study of the second group presented in the tables, we found the following: the asthma control test scores in the first group are on average equal to 23, the peak flowmetry scores (morning and evening, average result) are 93%. The results of spirometry of patients of group 2 are as follows: The vital capacity of the lungs – 4.63 (Normal – 4.63); Inspiratory reserve volume – 2.37 (Normal – 2.32); Expiratory reserve volumes – 1,62

Table 8. Results of spirometry of patients of group 1 (5 weeks after the start of the experiment)

Parameter	Units of measurement	Norm	m 1 (n=5)	m 2 (n=5)	m 3 (n=5)
The vital capacity of the lungs	L	4.63	4.00	4.10	4.50
Inspiratory reserve volume	L	2.32	2.25	2.20	2.18
Expiratory reserve volumes	L	1.62	1.45	1.63	1.58
Forced vital capacity of the lungs	L	4.26	4.25	4.19	4.17
Volume of forced exhalation in the first second	L	3.26	3.20	3.21	3.12
Volume of forced exhalation in the second second	L	4.17	4.02	4.10	4.15
Volume of forced exhalation in the third second	L	4.35	4.30	4.12	4.25
Volume of forced exhalation in final second	L	1.02	0.98	0.98	0.95
R. Tiffeneau index	%	69.4	65.8	69.0	64.3
Volume of forced exhalation in the first second /Forced vital capacity of the lungs	%	76.9	74.2	73.9	75.0
Peak expiratory volume rate	L/s	8.3	8.1	7.98	7.85
Instantaneous volume velocity 25	L/s	7.48	7.02	7.12	7.35
Instantaneous volume velocity 50	L/s	4.47	4.15	4.30	4.26
Instantaneous volume velocity 75	L/s	1.35	0.99	1.10	1.2
Average volume exhalation rate 25–75	L/s	3.45	3.12	3.30	2.98

Table 9. Indicators in the second group of subjects (5 weeks after the start of the experiment)

The table shows the average indicators of the functional state in microgroups	Asthma control test	Peak flowmetry (morning and evening, average result)
Microgroup 1 (n=5)	22	90%
Microgroup 2 (n=5)	23	100%
Microgroup 3 (n=5)	25	90%

Table 10. Results of spirometry of patients of group 2 (5 weeks after the start of the experiment)

Parameter	Units of measurement	Norm	m 1 (n=5)	m 2 (n=5)	m 3 (n=5)
The vital capacity of the lungs	L	4.63	4.63	4.60	4.68
Inspiratory reserve volume	L	2.32	2.45	2.30	2.40
Expiratory reserve volumes	L	1.62	1.60	1.63	1.61
Forced vital capacity of the lungs	L	4.26	4.26	4.30	4.27
Volume of forced exhalation in the first second	L	3.26	3.25	3.45	3.30
Volume of forced exhalation in the second second	L	4.17	4.17	4.20	4.18
Volume of forced exhalation in the third second	L	4.35	4.35	4.41	4.30
Volume of forced exhalation in final second	L	1.02	1.0	1.10	1.07
R. Tiffeneau index	%	69.4	70.0	69.5	71.3
Volume of forced exhalation in the first second /Forced vital capacity of the lungs	%	76.9	77.0	79.3	80.1
Peak expiratory volume rate	L/s	8.3	8.25	8.40	8.36
Instantaneous volume velocity 25	L/s	7.48	7.49	7.56	7.50
Instantaneous volume velocity 50	L/s	4.47	4.48	4.49	4.55
Instantaneous volume velocity 75	L/s	1.35	1.39	1.42	1.26
Average volume exhalation rate 25–75	L/s	3.45	3.60	3.56	3.45

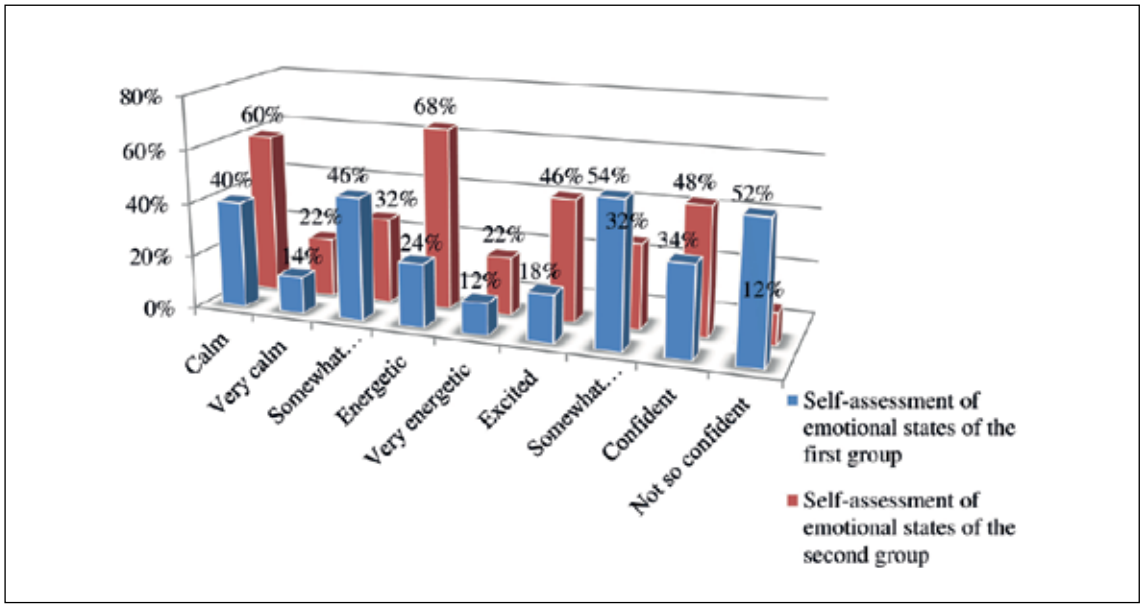

Fig. 1. Indicators of the manifestation of emotional states in the first and second groups of subjects after the psychocorrective influence.

(Normal – 1.62); Forced vital capacity of the lungs – 4.27 (Normal – 4.26); Volume of forced exhalation in the first second – 3.32 (Normal – 3.26); Volume of forced exhalation in the second second – 4.19 (Normal – 4.17); Volume of forced exhalation in the third second – 4.35 (Normal – 4.35); Volume of forced exhalation in final second – 1.2 (Normal – 1.2); R. Tiffeneau index – 69.9 (Normal – 69.4); Volume of forced exhalation in the first second / Forced vital capacity of the lungs – 77.4 (Normal – 76.9); Peak expiratory volume rate – 8.32 (Normal – 8.3); Instantaneous volume velocity 25 – 7.53 (Normal – 7.48); Instantaneous volume velocity 50 – 4.5 (Normal – 4.47); Instantaneous volume velocity 75 – 1.35 (Normal – 1.35); Average volume exhalation rate 25–75 – 3.5 (Normal – 3.45).

So, as shown by the presented data, the indicators of the functional state of the representatives of the second group reached normative values, in contrast to the indicators of the representatives of the first group. We found a significant improvement in a number of the following indicators in the patients of the second group in comparison with the patients of the first group: the indicators of the asthma control test in the first group prevailed by an average of 3 units; peak flowmetry by 10%; all the results of spirometry of the patients of the second group compared to the patients of the first group are significantly better: The vital capacity of the lungs – 0.43; Inspiratory reserve volume – 0.14; Expiratory reserve volumes – 0.4; Forced vital capacity of the lungs – 0.07; Volume of forced exhalation in the first second – 0.15; Volume of forced exhalation in the second second – 0.71; Volume of forced exhalation in the third second – 0.13; Volume of forced exhalation in final second – 0.23; R. Tiffeneau index – 3.8; Volume of forced exhalation in the first second / Forced vital capacity of the lungs – 3; Peak expiratory volume rate – 0.32; Instantaneous volume velocity 25 – 0.38; Instantaneous volume velocity 50 – 4.23 (Normal – 4.47); Instantaneous volume velocity 75 – 0.7; Average volume exhalation rate 25–75 – 0.4.

When comparing the indicators of the manifestation of emotional states of the first and second groups after psychocorrective influence, we can see that the emotional state of people who underwent psychocorrection of mastering their emotions improved significantly (Fig. 1). Moreover, the indicators of the first group remained unchanged at all stages of the study. Thus, the representatives of the second group became more calm (40% before and 60% after), very calm (14% before and 22% after), the number of slightly anxious people decreased (from 46% to 32%), a larger number of people became energetic (from 24% to 68%), very energetic (from 12% to 22%), elated (from 18% to 46%), the number of somewhat depressed decreased (from 54% to 32%), the number of confident increased (from 34% to 48%) and the number of not so confident decreased (from 52% to 12%).

DISCUSSION

The analysis and generalization of research results aimed at solving the problem of improving the functioning and life of people with persistent bronchial asthma due to the use of effective pulmonary rehabilitation programs, comparison with modern scientific data, makes it possible to claim that scientific information has been obtained that complements, clarifies and expands theoretical and methodological data on the issues of rehabilitation care of the specified nosological group of patients.

Peculiarities of the systemic nature of persistent bronchial asthma, the combination of pathology with other concomitant diseases, clinical features of the course of the disease were studied by Horvath I, Sorkness RL, Sterk PJ [10], Pinto Pereira LM, Seemungal TA [11], Humbert M, Boulet LP, Niven RM, Panahloo Z, Blogg M, Ayre G [12]. In the scientific works of the mentioned authors, the recommendations regarding

the scope and appropriate evaluation tools, the lack of a comprehensive system for evaluating the effectiveness of physical therapy, and the lack of recommendations regarding ways of implementing the psycho-emotional approach in physical therapy are insufficiently substantiated. This information was further developed in our scientific work, in particular, in the author's methodology of respiratory gymnastics as a supplement to the main treatment, general physiotherapy and the use of psychocorrective exercises to improve the psycho-emotional state of patients.

The work confirmed the data on the improvement of changes in peak flowmetry and spirometry indicators after the use of physical therapy and pulmonary rehabilitation programs; low indicators of the manifestation of emotional states in patients with persistent bronchial asthma were confirmed Cheung TK, Lam B, Lam KF, Ip M, Ng C, Kung R, et al. [13], Sundberg R, Toren K, Franklin KA et al. [14] and the possibility of improving these indicators through the use of the author's program of pulmonary rehabilitation has been proven.

In bronchial asthma, the leading pathophysiological mechanism of external breathing failure is violation of bronchial patency. In this regard, patients try to increase the volume of ventilation by hyperventilation, which leads to a higher tension of oxygen in the alveolar air and a low tension of carbon dioxide. This has a positive meaning, because it facilitates the diffusion of gases through the alveolar-capillary membrane [1-3, 5, 7].

On the other hand, hyperventilation leads to negative consequences, because the turbulence of the air flow in the bronchi and bronchial resistance increases. In addition, the functional dead space increases, excess removal of carbon dioxide from the alveoli and the body occurs, which reflexively increases the tone of the bronchial muscles, increasing their obstruction [15-21].

Breathing gymnastics techniques help to eliminate hyperventilation, keep the carbon dioxide content in the blood at an optimal level and eliminate bronchospasms. The most effective way to eliminate hyperventilation, keep the carbon dioxide content in the blood at an optimal level, and eliminate bronchospasms is the technique of respiratory gymnastics [3, 6, 8].

The basis for the development of the author's methodology, presented in this scientific study, became voluntary elimination of deep breathing according to K. P. Buteyko [1-3, 22, 23]. The essence of the author's technique developed by us is to increase the duration of each period, as well as increase the time of each phase when performing respiratory gymnastics. Thus, the duration of the rehabilitation period is extended to 5 weeks.

CONCLUSIONS

So, as shown by the presented data, the indicators of the functional state of the representatives of the second group reached normative values, in contrast to the indicators of the representatives of the first group. We found a significant improvement in a number of the following indicators in the patients of the second group in comparison with the patients of the first group: the indicators of the asthma control test in the first group prevailed by an average of 3 units; peak flowmetry by 10%; all the results of spirometry of the patients of the second group compared to the patients of the first group are significantly better: The vital capacity of the lungs – 0.43; Inspiratory reserve volume – 0.14; Expiratory reserve volumes – 0.4; Forced vital capacity of the lungs – 0.07; Volume of forced exhalation in the first second – 0.15; Volume of forced exhalation in the second second – 0.71; Volume of forced exhalation in the third second – 0.13; Volume of forced exhalation in final second – 0.23; R. Tiffeneau index – 3.8; Volume of forced exhalation in the first second / Forced vital capacity of the lungs – 3; Peak expiratory volume rate – 0.32; Instantaneous volume velocity 25 – 0.38; Instantaneous volume velocity 50 – 4.23 (Normal – 4.47); Instantaneous volume velocity 75 – 0.7; Average volume exhalation rate 25–75 – 0.4.

When comparing the indicators of the manifestation of emotional states of the first and second groups after psychocorrective influence, we can see that the emotional state of people who underwent psychocorrection of mastering their emotions improved significantly (Fig. 1). Moreover, the indicators of the first group remained unchanged at all stages of the study. Thus, the representatives of the second group became more calm (40% before and 60% after), very calm (14% before and 22% after), the number of slightly anxious people decreased (from 46% to 32%), a larger number of people became energetic (from 24% to 68%), very energetic (from 12% to 22%), elated (from 18% to 46%), the number of somewhat depressed decreased (from 54% to 32%), the number of confident increased (from 34% to 48%) and the number of not so confident decreased (from 52% to 12%).

The given indicators of research results (asthma control test, peak flowmetry and spirometry) in the control and experimental groups allow us to draw the following conclusions:

- the initial check of the functional status of both groups of patients with the diagnosis «Persistent bronchial asthma of moderate severity in the exacerbation stage» revealed practically the same indicators;
- after drug treatment, the results of the first group of patients became satisfactory and correspond to expectations in the stage of remission;
- patients from group 2 showed better results than patients from group 1, because the author's method of breathing gymnastics was added to the drug treatment as an addition to the main treatment and general physiotherapy;
- indicators of volitional functions, sleep functions, and emotional functions in group 2 improved due to the addition of psychocorrective exercises to improve their psycho-emotional state.

Therefore, the author's method of respiratory gymnastics presented in this scientific study for the rehabilitation of patients with persistent bronchial asthma of moderate severity in the exacerbation stage is effective for the rehabilitation of patients at the polyclinic stage, and its effectiveness has been proven experimentally.

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CONFLICT OF INTEREST
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REVIEW ARTICLE

Balneotherapy in osteoporosis

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ABSTRACT

Aim: This article draws on recent scientific developments and clinical knowledge to offer a thorough assessment of balneotherapy's role in managing osteoporosis, particularly focusing on its therapeutic potential.

Materials and Methods: A comprehensive literature review was conducted using databases such as PubMed and Google Scholar. The search focused on peer-reviewed publications from 2000 to 2024 that examined the effects of balneotherapy for osteoporosis. Keywords included osteoporosis, balneotherapy, hydrotherapy, peloid, radon, sulfur, mineral waters, bone metabolism, and alternative treatments. Out of 236 initially identified articles, 24 key sources were selected and analyzed in detail for their clinical relevance and scientific rigor.

Conclusion: Balneotherapy offers a holistic and complementary approach to managing osteoporosis through its mechanical, thermal, and chemical mechanisms of action. Its therapeutic benefits include enhanced bone formation, reduced bone resorption, pain relief, improved joint mobility, and cartilage stimulation. Additionally, it promotes overall well-being in patients. Given the significant economic burden of osteoporosis, balneotherapy provides a cost-effective and sustainable alternative for improving bone health. While the outcomes are promising, more research and clinical trials are needed to optimize its use, fully understand its mechanisms, and position it as a potential key component in osteoporosis care.

KEY WORDS: osteoporosis, bone metabolism, balneotherapy, spa therapy

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INTRODUCTION

Osteoporosis is a metabolic bone disorder characterized by a reduction in both cortical and trabecular bone mass. Unlike osteomalacia, which involves defective bone mineralization, osteoporosis affects bone tissue that is adequately mineralized, leading to structural weakening. This results in increased bone fragility and a heightened risk of fractures, most commonly affecting the vertebrae, distal forearm, and femoral neck. These fractures are classified as low-energy, meaning they occur from forces insufficient to fracture healthy bone. Osteoporotic fractures not only significantly increase morbidity but also elevate mortality rates and the risk of associated comorbidities, presenting a direct threat to patient survival [1, 2]. While pharmacological medications and lifestyle modifications constitute the bulk of traditional treatments, research has brought attention to the possible advantages of complementary therapies, such as balneotherapy, in the management of osteoporosis. Traditionally, balneotherapy has encompassed immersion in thermal or mineral waters sourced from natural springs, along with the application of balneological treatments involving mud or natural gases. As a non-invasive therapeutic approach, balneotherapy has been proposed as a potentially beneficial adjunct in the management of various pathological conditions. Its appeal lies in its recreational nature, making it more acceptable to patients compared to lifestyle modifications or pharmacological interventions. However, despite its long-standing history and widespread utilization, the effects of balneotherapy on bone metabolism remain a topic of ongoing debate within the scientific community [3].

AIM

This article leverages recent scientific advancements and clinical insights to provide a comprehensive evaluation of the role of balneotherapy in the treatment of osteoporosis.

MATERIALS AND METHODS

An extensive literature review was performed using the PubMed and Google Scholar databases, focusing on publications from 2000 to 2024 that explored the use of balneotherapy in the treatment of osteoporosis. The review aimed to identify the most frequently utilized physical medicine therapies for addressing osteoporosis. Studies were selected based on the inclusion of the following keywords: osteoporosis, balneotherapy, hydrotherapy, peloid, radon, sulfur, mineral waters, thermal waters, bone metabolism and musculoskeletal pathologies. From an initial pool of 236 articles, 24 sources were identified as containing key information pertinent to the subject of this review and were subsequently analyzed in detail.

REVIEW AND DISCUSSION

The treatment of osteoporosis primarily focuses on prophylaxis, aiming to prevent fractures. Pharmacological

therapies often yield suboptimal results, with the adverse effects of medications frequently outweighing their therapeutic benefits. Bisphosphonates are the most commonly used agents in osteoporosis management, functioning by inhibiting bone resorption through osteoclast apoptosis and delaying osteoclast formation. Strontium ranelate is the only approved agent that both stimulates bone formation and inhibits bone resorption; however, due to its contraindications, it is recommended only for severe cases of osteoporosis. Denosumab, a human monoclonal antibody targeting RANKL, inhibits osteoclast formation and prolongs osteoclast survival. In cases where these treatments prove ineffective, teriparatide, a recombinant fragment of parathyroid hormone, is utilized to stimulate bone formation, increase bone density, and potentially regenerate lost bone tissue. Hormone replacement therapy is rarely prescribed due to its association with an increased risk of breast and cervical cancers, as well as thrombosis. Raloxifene, a selective estrogen receptor modulator, reduces the risk of these cancers and lowers the incidence of vertebral fractures. While calcitonin is approved for pain management following osteoporotic fractures, its use is limited due to the elevated risk of malignancy associated with prolonged treatment [4, 5].

Early diagnosis of at-risk patients is crucial for effective fracture prevention. In addition to pharmacological treatment, lifestyle modifications such as increased physical activity and improved nutrition are essential for managing osteoporosis. Physiotherapy is also important for pain reduction, improving functional capacity, and minimizing fracture risk. Furthermore, social support and psychotherapy are vital, as osteoporosis often leads to depression and social isolation. Spa medicine offers a holistic approach, combining pharmaceutical treatments, physiotherapy, psychotherapy, and dietary interventions, utilizing the local climate and natural healing resources. Treatments are typically administered in cycles, with effects developing over time and lasting longer than those from pharmaceutical treatments, with fewer side effects. Balneotherapy, a key component of spa medicine, involves the use of mineral waters for therapeutic baths, drinking, and inhalation, as well as peat for massages, compresses, and baths [6-8].

THERAPEUTIC MINERAL WATERS

The waters utilized in balneotherapy for osteoporosis are complex mixtures of organic and inorganic compounds. They are administered both as therapeutic baths and for oral consumption. Calcium, magnesium, boron, and fluoride in mineral waters play a significant role in bone development, formation, and the prevention of bone loss. The bioavailability of these minerals in mineral waters is comparable to that found in dairy products and supplements. However, careful monitoring of fluoride intake is essential. While fluoride has beneficial effects, such as anti-cariogenic properties and the stimulation of bone mineralization, excessive consumption of fluoride-rich mineral waters should be limited due to its potential carcinogenic effects and the risk of fluorosis [9, 10].

Therapeutic mineral waters are also employed in baths, leveraging physicochemical properties such as the solubility of minerals in water and fats, along with the skin's varying ability to absorb these components. Once absorbed, mineral elements accumulate in the stratum corneum and subsequently enter the bloodstream, eliciting a systemic response within the body [9, 11].

In balneotherapy for osteoporosis, radon and sulfurous baths are commonly used. Radon baths, often recommended for patients with musculoskeletal disorders, emit ionizing radiation that induces various beneficial excitatory responses in the body. Thermal sulphurous waters, in contrast, involve the absorption of sulphur compounds through the skin during the bath, which leads to the synthesis of chondroitin sulfate, a fundamental component of joint cartilage. This process enhances bone calcification, a critical factor in the management of osteoporosis [12, 13]. Furthermore, it was specifically shown that sulfur baths promote osteogenic differentiation of mesenchymal stromal cells (MSCs), thereby stimulating bone anabolism [14-16].

Previous human studies have demonstrated that radon and sulfur baths can positively influence bone metabolism, promoting anabolic processes. A reduction in bone resorption markers, including RANKL, PTH, and CTX-I, was observed. Although an increase in OPG levels occurred during the intervention, this was followed by a subsequent return to baseline. Nonetheless, the increase in the OPG/RANKL ratio suggests a weakening of bone resorption processes, indicating a shift towards more favorable bone metabolism. Additionally, a reduction in somatic complaints and pain intensity was reported by patients, which was associated with an improvement in their overall quality of life [3, 17, 18].

PELOIDOTHERAPY

Peloidotherapy is also used in the treatment of osteoporosis [8, 20].

Peloid therapy utilizes a blend of mineral and organic or inorganic substances obtained through geological or biological processes, such as volcanic mud, clays, and mud from marine or lake environments. These materials are applied in the form of baths or localized wraps [21].

Peat possesses the ability to absorb and retain heat for extended periods, gradually releasing it to prolong the thermal effect. This sustained heat provides analgesic benefits and improves joint range of motion. Additionally, it enhances the density of chondrocytes and collagen [22, 23].

Peat also contains hormones relevant to gynecological treatments. Animal studies suggest that peat may influence the pituitary-gonadal-thyroid axis, with its application leading to the restoration of functionality and structural integrity of endocrine glands in cases of dysfunction. This is particularly significant in the context of osteoporosis, which is often linked to estrogen deficiency. Reduced estrogen levels negatively impact the regulatory role of bone metabolism, ultimately leading to a decrease in bone mass [8, 24].

CONCLUSIONS

Balneotherapy offers a promising and holistic approach to managing osteoporosis, with potential benefits stemming from a combination of mechanical, thermal, and chemical effects. The hydrostatic pressure, mineral water temperature, and composition have been shown to enhance bone formation, reduce bone resorption, and improve musculoskeletal health. Moreover, the integration of balneotherapy, including the use of peloids like peat, contributes to pain relief, increased joint mobility, and cartilage stimulation.

Given the rising economic burden of osteoporosis, balneotherapy represents a cost-effective and sustainable alternative for addressing bone health concerns. Its preventive potential, as highlighted in this study, makes it a viable option for both men and women. However, further research is needed to optimize treatment protocols and fully understand its mechanisms. As evidence grows, balneotherapy may become a key component of osteoporosis care, improving patient outcomes and quality of life while offering economic and therapeutic advantages [6, 9].

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REVIEW ARTICLE

Cryotherapy for improvement of cognitive functions and mental wellbeing

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ABSTRACT

The possibility of improving cognitive functions by cryostimulation gathers increasingly more interest as the general public becomes more health-oriented and populations of many countries are aging. While there is plenty of research on the beneficial effects of cryostimulation on physical health, disproportionately less is known about its impact on mental wellbeing and cognition. This review summarizes the outcomes of currently available, up-to-date studies on this topic, to inspire future research focused on solidifying guidelines and limitations of cryostimulation use for improving cognitive performance. The topical research yielded promising results, giving hope for improving the functioning of the central nervous system with cold exposure, both in healthy individuals and in persons with cognitive impairment. However, evidence is still very limited and unequivocal, indicating that not all cryostimulation conditions can produce such a beneficial effect and that different numbers of sessions may be necessary depending on the recipient's sex, lifestyle, and comorbidities. While the mechanism of cryostimulation-induced cognitive improvement is unknown, proposed theories rely on changes in brain-derived neurotrophic factor (BDNF) concentrations, parasympathetic tone, or cerebral oxygenation. Cryostimulation potentializes the beneficial cognitive effects of physical and mental training, enhancing therapeutic progress in persons suffering from cognitive impairment, as well as improving the athletic performance of physically active healthy individuals.

KEYW ORDS: cognition, cognitive dysfunction, exercise, brain-derived neurotrophic factor, athletes, cryotherapy

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INTRODUCTION

Cryostimulation gathers a growing amount of attention among those wanting to improve their wellbeing, as the general population becomes more health-oriented. Enthusiasts of ice water swimming or cryosaunas give a wide account of the miraculous effects of such treatments, inspiring the researchers to test those reports experimentally. Among the described benefits of cryostimulation appears improvement in cognitive functioning and mood, however research on this subject is still very limited as of now, and its outcomes are unclear. It is apparent that more studies are needed to prove or disprove the theory that cold exposure improves the functioning of the central nervous system (CNS).

Exposure to cold has been used for centuries in various cultures, with a belief that such treatment would preserve one's health and promote longevity [1, 2]. Based on their own observations, our ancestors were using cold not only as a health-promoting, preventive measure against broadly understood illness but also as a therapeutic intervention for numerous indications. To this day it is used in the treatment of multiple morbidities of considerable prevalence, including ankylosing spondylitis, rheumatoid arthritis, fibromyalgia, multiple sclerosis, obesity and diabetes [3]. Majority of the population would benefit from cryotherapy, as it exerts antioxidative properties [4], improves functioning of the endothelium [5, 6] and improves blood lipid profiles both in healthy individuals [7] and in those affected by inflammatory processes [1, 8].

Cryotherapy is a very inclusive term, embracing all physical treatments based on local or general application of cold for therapeutic causes [9]. Cryostimulation, in turn, is a relatively new term, reserved for the use of certain methods typical of cryotherapy, mostly in athletes, but also in average healthy individuals seeking to improve their well-being [10]. Technics used within the scope of cryostimulation mostly rely on short-term general application of extreme cold, which can be conducted as cold water immersions or exposure to cold air in the form of Whole Body Cryotherapy/Cryostimulation (WBC) and Partial Body Cryotherapy/Cryostimulation (PBC) [11].

WBC and PBC are particularly convenient for assessment of the impact of extreme cold on human physiology, in account of easier standardization and easily repeatable experimental conditions. However, there are significant

differences between those two methods, which could lead to different outcomes of those two interventions. During WBC the individual stays for 1-4 min in a cryochamber composed of 1-3 rooms, with their entire body exposed to low temperature created by injections of refrigerated air into the chamber. The cold inside the chamber can either be static (-60 to -160°C) or based on forced wind chill convection (-40 to-60°C). WBC enables cryostimulation without exposing the body to tissue anoxia. PBC is conducted in less complex tanks, called cryosaunas, that can be used by one person at a time. Session duration is the same as in the case of WBC, but temperatures in PBC technologies are lower (-110 to -195°C) [2]. While staying in a cryosauna, the individual has their head above the tank, while the lower portion of their body is inside of it, exposed to a vaporized cryogenic fluid that is being directly injected inside. This technique carries a higher risk of tissue anoxia and cold burns compared to WBC [11]. Unfortunately, the amount of research on the impact of the cryochamber type on therapeutic results is relatively poor. The literature focuses mainly on comparing parameters like skin temperature, blood flow, or the size of oedema directly after the procedure [12] without noticing any differences in long-lasting results. When compared based on their effectiveness in treating post-exercise muscle damage, both techniques had similar effects [13].

Exposure to cold is frequently used by physically active individuals and athletes, to help them recover after an injury or simply after a period of intensified training. Cryostimulation suppresses the inflammatory reaction, which has been observed locally through the reduction of oedema and heat as well as by a decrease in serum concentrations of cytokines and muscle damage markers. In addition, it exerts an analgesic effect, soothing muscle soreness and improving individual perception of recovery. The use of cryostimulation after training to enhance recovery is an acclaimed procedure, whereas scientific inquiries are needed to justify its application before the training since it has been proposed as a potential performance-improving intervention [11]. Researchers hypothesized that induced by cryostimulation shift in cytokine concentrations, with a decrease in pro-inflammatory and increase in anti-inflammatory ones, would enhance the functioning of the CNS leading to improvement in performance and cognitive functioning – effects frequently attributed to cryostimulation by its enthusiasts [14].

The current body of evidence shows improvement in cognitive functions following cryostimulation in various study populations: in healthy individuals including professional athletes [14-16] as well as in persons suffering from CNS function disorders, such as mild cognitive impairment (MCI) [17, 18]. Research revealed that WBC modifies only certain cognitive functions, with no effect on the remaining ones. One of those reportedly improved by cryostimulation was reaction time [14-16], which would be a particularly interesting outcome from sportsmen's point of view. Therefore, research is needed to specify the conditions required for beneficial cognitive changes to occur.

From currently existing studies arises that physical conditions of cryostimulation can determine whether reaction time improves or not. Reported improvement resulted from the use of WBC with static cold of -120°C [14], while higher temperature (-70°C) complemented with wind chill technique yielded no change in this matter [19]. Research showed that the autonomic nervous system activates at -110°C and below, suggesting a possible connection between that activation and reaction time improvement [20]. Certainly, the occurrence of at least some physiological changes caused by cryostimulation depends not only on applied temperature [20] but also on the number of sessions [21]. So far researchers established that more than 10 sessions are necessary for beneficial hormonal changes to appear [21]. While some studies report a similar dependence for cognitive function improvement [14] others achieved such an effect after 10 sessions or even less [15, 16].

This review aims to define the conditions to be met for cryostimulation to exert a positive influence on human cognitive functions. Hypothetical mechanisms, suggested by the researchers, will be discussed and confronted with the existing body of evidence. Answering those questions could be a crucial step towards understanding the importance of cryostimulation in prophylaxis and therapy of cognitive impairment as well as determining if pre-training application of cryostimulation should be recommended to improve athletic performance.

DESCRIPTION OF THE STATE OF KNOWLEDGE
CRYOSTIMULATION AND COGNITIVE PERFORMANCE

While investigating the link between cryostimulation and cognitive performance improvement, research seems especially focused on the group of subjects that would benefit from it the most – the elderly suffering from MCI. MCI is known to be a state preceding dementia and is characterized by cognitive dysfunction that can manifest itself in the form of various combinations of symptoms [18]. Since at that stage cognitive deterioration can still be reversed, MCI sufferers are strongly advised to employ therapeutic interventions as soon as possible. The existing body of evidence gives hope that WBC can be highly advantageous for the improvement of numerous brain functions, so understandably it is a part of MCI treatment (Table 1).

The majority of experimental data in this study population was acquired after 10 WBC sessions. In a group of 62 mostly female adults at the age of 60-70 years this amount was sufficient to improve orientation and immediate recall, as well as alleviate depressive symptoms in the experimental group subject to WBC at temperatures ranging between -110°C to -135°C. In the control group, where the participants stayed in a cryochamber at -50°C, no similar changes were noticed [18]. Another study on MCI sufferers observed improvement in memory processes following 10 WBC sessions, which was accompanied by an increase in nitric oxide and a decrease in interleukin-6 concentrations [22]. There is also evidence that MCI sufferers benefit from the use of WBC, as it can boost the therapeutic effects of other

Table 1. Reported effects of cryostimulation on cognitive functions with essential study characteristics

Cognitive function improved by cryostimulation	Source	Applied technique	Temperature [°C]	Number of sessions	Participants
Reaction time	[14]	WBC	-120	20	Healthy men aged 22,5
Reaction time, stroke effectiveness	[16]	WBC	-120	10	Male professional tennis players
Reaction time	[15]	PBC	-150	1	Healthy men and women aged 22,5
Orientation, immediate recall	[18]	WBC	-110-(-135)	10	Adults aged 60-70
Memory	[22]	WBC	-120	10	Older MCI sufferers
Delayed memory, processing speed	[17]	WBC	-110-(-135)	10	Older MCI and subjective cognitive decline sufferers
Processing speed, cognitive flexibility and executive control	[24]	WBC	-120	10	Men and women, including chronic fatigue sufferers

cognition-improving interventions. In a study on 84 older adults with MCI and subjective cognitive decline, three therapeutic approaches were compared – one experimental group received Computerized Cognitive Training with psychoeducation while the other was also subject to 10 sessions of WBC in addition to those interventions. When used in combination with Computerized Cognitive Training, WBC resulted in some unique improvements that were not observed in the participants that did not undergo cryostimulation: WBC improved delayed memory and sped up the information processing, as well as decreased the prevalence of depressive symptoms [17].

Athletes constitute another study population that would profit greatly from interventions improving the functioning of the central nervous system considering that mental strength and reflexes play a huge part in professional sports performance [15, 23]. To establish if cryostimulation could be such an intervention, we inquired about the studies on healthy, young persons. Most studies on cryostimulation's impact on cognitive performance in athletes are conducted on males, which to some extent limits the possibility to make general conclusions. The data derived from studies on healthy individuals is not as equivocal as in MCI sufferers, since the employed methods differ more. For example, in a group of eighteen male motocross riders, a single use of WBC with wind chill did not improve the reaction time in assessments conducted shortly after the cryostimulation session. In the face of a lack of similarly designed studies, it remains unclear if the reaction time could be reduced by the use of WBC with static cold, or if more than one WBC session should be conducted [19].

There are distinctly fewer studies using PBC as the mean of cryostimulation than there are with WBC, and we were able to find only one study investigating the possible impact of PBC on cognitive functions. It was conducted in a controlled counterbalanced crossover design, with eighteen healthy young adults (half males and the other half females) taking the Stroop cognitive inhibition test before and after one single session of PBC. The results showed that only in male participants did the reaction time decrease, without changes to the accuracy of responses. In females, this single PBC session yielded no significant changes in Stroop test results [15]. This observation signals that men and women respond differently to cryostimulation, and this difference must be further researched to establish the reasons. Further studies concerning PBC's impact on cognitive functions would be necessary to find out if with more sessions the improvement observed in males would occur also in females.

To our knowledge, 10 WBC sessions are the smallest reported number sufficient to produce advantageous cognitive changes in healthy persons, irrespective of whether sessions were scheduled once or twice a day. After 10 sessions, held once a day for 10 days, and combined with static stretching, an improvement was observed in speed and accuracy in a mixed-gender group of healthy controls and patients with chronic fatigue syndrome [24]. Progress in cognitive functioning was measured using Trail Making Tests, which assess multiple executive functions, mostly visual search speed and processing speed, but also mental flexibility. Also when 10 WBC sessions were scheduled twice a day, on 5 consecutive days, executive functions were enhanced, which was observed in a group of six male, high-ranking professional tennis players, training every day with moderate intensity. The athletes who underwent WBC exhibited a slightly greater than the control group improvement in stroke effectiveness, measured by its accuracy. More importantly, they were able to maintain this improvement throughout the second performance of the tennis drill, while controls suffered mental deterioration, not an uncommon problem in tennis players. Alongside cognitive benefits, WBC made the cytokine profiles of the athletes more favorable, by decreasing the concentrations of pro-inflammatory cytokine TNFα and increasing the concentrations of pleiotropic one - interleukin 6. Heart rate (HR) recovery was also faster, both during the drill and the rest afterwards [16]. This finding suggests that even though cognitive benefits are scientifically proven to appear only after 10 sessions of cryostimulation, this amount can be fit into a period shorter than 10 days, which could be of interest to athletes and their coaches. During phases of the training cycle, when the athlete is subject to an intensified training regimen, with shorter rest breaks, they are at the greatest risk of fatigue - the adverse effect

of insufficient recovery. Therefore, maximizing recovery by enhancing it with cryostimulation helps maintain a rested mind, which increases the athlete's performance.

There is also evidence that even though beneficial cognitive changes were observed after 10 WBC sessions, it might not be enough for everyone, and in some populations more sessions may be necessary for that aim. In a group of twenty-five young, healthy men, 10 WBC sessions did not elicit any changes, while at 20 and 30 sessions they exceeded the control group concerning position sense and simple reaction time [14]. Notably, the experimental procedure of this study did not include any physical activity, while the studies reporting cognitive improvement after 10 WBC sessions did (tennis practice, static stretching). Therefore, it can be concluded that physical training potentialized the benefits of WBC, and vice versa.

The mechanism explaining the observed influence of cryostimulation on cognitive functions remains unclear as of now. Suggested explanations of this phenomenon include changes in brain oxygenation or changes in the parasympathetic tone of the autonomic nervous system [15], while several studies implied the role of brain-derived neurotrophic factor (BDNF) [17, 22].

BDNF CONCENTRATION AND COGNITIVE EFFICIENCY

BDNF belongs to a family of proteins promoting survival, development, and proper function of the neurons, and is the most abundantly expressed neurotrophin in the mature CNS [26]. In the mature brain, it regulates both inhibitory and excitatory synaptic impulses, as well as activity-dependent neuroplasticity [27]. It is crucial for the growth, survival, and neuroplasticity of many neuron types, especially in brain areas responsible for memory, learning, and mood regulation. The expression of BDNF genes is highly regulated at the level of transcription and translation, the product of which can also be subject to epigenetic changes. Such complex control over BDNF synthesis implies that environmental circumstances dynamically influence this process. This conclusion is also supported by the evidence of modifiable factors imposing changes on the BDNF levels, e.g. mental or physical activity, sex hormone levels, stress, or medications [27, 28]. The high amount of impacting factors results in a great inter-individual variability of BDNF concentrations.

There are grounds to believe that decreased BDNF concentrations are typical of states unfavorable for brain functioning, while increased values follow improvement in cognitive performance [22, 27, 29]. However, some studies reported an opposite relationship, where BDNF concentrations were elevated in persons suffering from cognitive impairment [27, 30]. The correlation between brain tissue BDNF concentration and cognitive efficiency is relatively well established, as post-mortem examination of human brains as well as one transgenic model revealed decreased BDNF concentrations in neuronal tissue related to Alzheimer's Disease (AD) [31, 32]. Nevertheless, several studies reported increased serum BDNF in AD sufferers [30], which leads researchers to question whether increased serum BDNF levels are a good or bad sign. Given the known biological effects of BDNF, it would only be intuitive to hypothesize that increased serum BDNF levels correlate positively with improvement in cognitive performance, and there is plenty of research to validate this reasoning [26, 29, 33]. Therefore it seems that the negative relationship between serum BDNF and cognitive performance observed in AD patients is not representative of the general population, in which it appears to be positive.

The role of the lack of BDNF in the development of mental disorders is best evidenced by mood disorders. Serum BDNF increases as an effect of antidepressant treatment, while decreased serum BDNF concentrations have even been proposed as a prognostic tool in suicidal behavior [34]. There is also ground to suspect its role in stress-induced disorders like PTSD [35]. While its role in the pathogenesis of schizophrenia is uncertain, this disease was found to be connected to the immaturity of the interneurons of the prefrontal cortex, and neuronal maturation is mediated by BDNF [36]. It is a fact that physical exercise enhances cognitive ability and protects the nervous system against various neuropsychiatrist disorders [37]. Studies show increases in BDNF concentrations following exercise sessions, through activation of several signaling pathways which could point to this neurotrophin as the mechanism of beneficial neuroprotective effects of the exercise [26,29].

Taken together the correlation between BDNF and cognitive performance appears to be positive for serum in the healthy population and for brain-tissue in AD sufferers. The link between serum BDNF and cognition in persons with cognitive impairment is as of now unclear.

EXERCISE, CRYOSTIMULATION, AND BDNF

Meta-analytic data confirm that peripheral blood BDNF increases not only as an effect of chronic physical activity [38] but even after a single exercise bout [28]. This led researchers to investigate the interventions that could potentialize this effect of training. Even though cryostimulation is widely believed to be advantageous not only for physical but also for mental functions, the amount of research on the effect of cryostimulation on BDNF concentrations is limited [39]. The studies on this matter yielded contradicting outcomes – rise [22, 23, 40, 41], decrease [18], and lack of change [39] in BDNF concentrations were all reported following WBC treatment. All of the studies we are going to discuss used 10 or more WBC sessions, which, as we mentioned above, is the smallest reported number of sessions able to improve human cognition.

Physical training alone already increases serum BDNF, which must be taken into consideration when analyzing the results of studies where both training and WBC were included in the experimental procedure. There is some evidence of this effect of training being amplified by WBC in mixed-sex groups of professional judokas [23] as well as healthy college-aged people subject to specific volleyball training [40]. However, several studies reported no difference in BDNF levels between the control and WBC-treated groups – such observation was made on

male professional wrestlers [39] and in a mixed-sex group of untrained university students subject to short-term resistance training [41]. This juxtaposition suggests that BDNF reaction to WBC does not simply depend on the level of training experience, as similar reactions were observed in professional sportsmen and untrained healthy individuals. It remains unknown what could therefore be the deciding factor for the WBC-induced amplification of the post-exercise BDNF rise. Perhaps the answer lies in the character of the sports discipline applied. It was previously stated that combat sports, such as judo, are a greater exciter for BDNF release than other forms of exercise. The authors suggest that it results from combat being more stimulating for CNS as it demands tactical thinking and constant readiness to react to unpredictable opponents. If the amount of BDNF released after exercise depends on the sports discipline, it could be so as well for WBC-induced amplification of this reaction.

Investigation of the effect of WBC on serum BDNF comprises a very limited amount of evidence coming from various populations. Interestingly, two similarly designed studies on MCI sufferers, both reporting an improvement in cognitive performance in WBC-treated persons, yielded contradictory results regarding serum BDNF concentrations – one of them showed an increase [22] while the other a decrease [18]. A study comparing the influence of WBC on BDNF in women with multiple sclerosis (MS) and healthy controls revealed no WBC-induced change in serum BDNF, equally in both groups [43]. Conflicting results of studies created to date point to the necessity of discussing possible causes of such notable contradictions.

One of the reasons might be the fact that some of the commercially available BDNF assays do not discriminate between mature BDNF, responsible for the above-mentioned neuroplasticity and neuroprotection, and its precursor protein, pro-BDNF, which promotes cell death [43]. Those two proteins have opposite effects on the nervous system, therefore adding up their serum concentrations and treating them as one may contribute to mistaken conclusions about the biological actions of the BDNF. Hence the recommendation to use the assays indicated as selective to mature BDNF, which are known to be created by Aviscera-Bioscience and R&D System-Quantikine® [44]. The problem of lack of assay specificity does not play a significant role in this manuscript, as the majority of reviewed studies used R&D System-Quantikine® BDNF Elisa Kit.

Insulin-like Growth Factor 1 (IGF-1) is engaged in numerous biological processes such as the development and differentiation of somatic cells, regulation of neuronal development and activity, as well as promotion of longevity and prevention of protein katabolism [45]. IGF-1 also plays an important role in the transformation of pro-BDNF to its mature form in the CNS, which suggests that reduced IGF-1 levels could potentially limit mature BDNF production [23]. Moreover, research shows that cryostimulation can also modify IGF-1 concentrations, and similarly to BDNF, results are not equivocal when it comes to the direction of change [23, 39, 42]. Therefore it seems reasonable to determine IGF-1 alongside BDNF in the course of studies on the impact of cryostimulation on this growth factor. This could not only explain part of the reported decreases in BDNF concentrations but also contribute to the investigation of the interplay between those two proteins.

Overall, there is promising evidence that exercise-induced increase in BDNF concentration can in some cases be enhanced by cryostimulation, however more research is necessary to determine the conditions necessary for this to happen.

INCREASED PARASYMPATHETIC TONE

Cognitive performance deteriorates with an increase in the sympathetic tone of the autonomic nervous system and improves when the parasympathetic tone prevails. Since the autonomic nervous system controls both brain function and heart rate, heart rate variability (HRV) is used to assess the sympathetic/parasympathetic balance [46]. HRV refers to the variation in the time interval between heartbeats; in a great simplification, HRV frequency tends to increase when the parasympathetic nervous system is activated and decrease with sympathetic activation. Thus, for instance, a high-to-low frequency ratio is used for the assessment of sympathovagal balance [20]. HRV frequencies indicative of increased sympathetic tone have been proposed as an early marker of cognitive impairment [47]. Similarly, an increase in parasympathetic tone attained by a single PBC session was accompanied by improved cognitive performance in males. Interestingly, in female participants of the same study, HRV indices of parasympathetic tone did not increase as distinctly, and cognitive performance did not change, which could point to parasympathetic stimulation as a mechanism linking cryostimulation and cognition [15]. In favor of this theory are also the observations that cognitive improvement can be noticed above a certain number of cryostimulation sessions [14] combined with the gradual shift of the sympathovagal balance towards parasympathetic activity, reported throughout 5 days of cryostimulation [20].

However, another study reported an improvement in cognitive performance in all participants who underwent WBC, but only in healthy individuals was it accompanied by increased parasympathetic tone, while in chronic fatigue syndrome sufferers, an increase in sympathetic activity was observed. It indicates that the pro-cognitive effect of cryostimulation overpowered the adverse influence of sympathetic activity on cognitive functions [24]. This outcome shows that the parasympathetic tone of the autonomic nervous system can not be the sole mechanism driving cryostimulation-induced cognitive improvement.

BRAIN HEMODYNAMIC CHANGES

Changes in cerebral oxygenation and oxygen extraction in the brain were also proposed as a mechanism of post-cryostimulation cognitive improvement. While peripheral vascular responses to cold are relatively well understood, our knowledge about the influence of cryostimulation on brain blood vessels is based on two studies: one using cold water immersions and another using PBC as the

experimental intervention. Both found a reduction in cerebral oxygenation during the interventions, but only in the case of PBC was that reduction followed by an increase after the session [48]. Similarly to the parasympathetic theory, differences between sexes were noticed – during PBC cerebral oxygenation decreased to a similar degree in all participants, but only in males did the cerebral extraction of oxygen remain increased after cold exposure, and only in males cognitive performance improved [15]. The study on cold water immersions concerned only men and did not assess potential changes in their cognitive performance [49]. Out of a dearth of evidence, it is impossible as of now to draw constructive conclusions about the differences between those two techniques, or the role of cerebral haemodynamics in cryostimulation-induced improvement of cognitive functions.

CONCLUSIONS

Cryostimulation can distinctly improve cognitive functioning, however contradicting results of scarce evidence on this matter indicate that the effect depends on the conditions in which the intervention is conducted as well as on some characteristics of the person subject to the treatment. Temperature, number of sessions, and technique, as well as sex, lifestyle, and comorbidities of the recipient can all influence the effect of cryostimulation on CNS functioning. Future studies should focus on creating cryostimulation guidelines for different populations that would define the limitations and dose needed to achieve cognitive improvement.

Cryostimulation potentializes beneficial cognitive effects of both physical and mental training, and vice versa. Physical training may help achieve improvement in cognitive functions after a smaller number of cryostimulation sessions compared to cryostimulation used exclusively.

At least to some extent, the number of sessions appears to matter more than the number of days when cryostimulation was used, which gives hope that by increasing the number of daily sessions, improvement of cognitive performance can be reached faster.

FUTURE DIRECTIONS

Future research is needed to further prove and reproduce the findings of publications available to date. Although the mechanism of cognitive function improvement remains unknown, current research suggests the parasympathetic activity of the autonomic nervous system may contribute to this process but is not the leading factor. Reproduction of the outcomes of studies on cryostimulation-related changes in BDNF concentrations and cerebral oxygenation is needed to test their role in this phenomenon. While investigating BDNF concentration changes, one must limit the confounding factors by choosing an assay selective to the mature form of BDNF and by indicating IGF-1 concentrations.

Increasing interest in the potential of cryostimulation demands scientific evidence of its effects on the human mind concerning summarized here indications drawn from the current state of knowledge.

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CONFLICTS OF INTEREST

The Authors declare no conflict of interest

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CLINICAL CASE

Promising challenges in the rehabilitation of a patient after a sustained multi-organ trauma with a dominant cranio-cerebral trauma. Case report

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ABSTRACT

Cranio-cerebral trauma is one of the main causes of death as well as long-term or even permanent disability in Europe and globally. TBI complications require long-term specialist care and incur high economic costs. We are describing a method of rehabilitation of a patient after a sustained multi-organ trauma with a dominant cranio-cerebral injury due to a fall from a 15m height. The patient was brought to the Hospital Emergency Department in a critical condition – GCS of 3 pts, narrow, non-responsive pupils, respiratory insufficiency, intubated. Thanks to early professional care in the Intensive Care Clinic, as well as intensive holistic rehabilitation, the patient is now in full verbal-logical contact, independent within the patient room. Describing progress in the rehabilitation of this patient, we want to present the original programme applied in the Military Medical Institute, Public Research Institute (WIM-PIB). The described case of the patient after multi-organ with a dominant cranio-cerebral injury sustained shows how enormous is the recovery potential of a young man in the process of treatment. Extensive damage to the brain tissue and the initially severe neurological condition of the patient not showing cooperation in the rehabilitation process should not be seen as counterindication to undertaking an attempt at hospital-based rehabilitation of the patient. Early, properly designed and carried out kinesiotherapy, speech therapy, neuropsychological therapy and occupational therapy undertaken in the case described confirm the existence of a potentially positive prognosis of a full return of a TBI patient to normal social life.

KEY WORDS: post-traumatic brain injury rehabilitation, patient after cranio-cerebral injury, intracranial haematomas, cranial fractures, post-traumatic changes in the brain on CT examinations

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INTRODUCTION

Post-traumatic brain injury affects annually 64-74 million people globally [1, 2]. Their number has kept increasing successively over the past three decades [3]. According to the results of reports from the pre-covid-19 period, the estimated average annual incidence of cranio-cerebral injuries amounted to 346/100 000 of the population in 2016 [4]. During the pandemic period, the number of cranio-cerebral traumas declined significantly secondary to travelling restrictions and restrictions in practising sports imposed on the population. In 2016, estimated 759 people per 100 000 were affected by disability caused by post-traumatic brain injury [4]. In 2021, the Trauma Centre of the Military Medical Institute (WIM) in Warsaw, the largest centre of this kind in Poland, admitted 351 patients with TBI and provided medical assistance within the A&E Department of the Military Medical Institute.

CLINICAL CASE

PATIENT DESCRIPTION

The patient, a young, 19-year old, Caucasian man sustained multi-organ trauma following a fall from an 15 m height. Prior to the current accident the patient was not diagnosed with any chronic disease, neither did he take any medicaments regularly. He was not diagnosed with any genetic defects; his family history was non-contributary.

PHYSICAL EXAMINATION

Examination on admission to the the Hospital Accident and Emergency Department (A&E) revealed the patient is in a critical condition: GCS of 3 pts, narrow, non-responsive pupils, respiratory insufficiency, he was intubated. Cardiovascular performance was maintained by continuous infusion of pressor amines.

IMAGING FINDINGS BRAIN AND OTHER ORGANS

Imaging tests revealed numerous foci of haemorrhagic contusions of cerebral tissue in frontal, temporal and occipital lobes bilaterally, a haemorrhagic contusion focus in the right parietal lobe and in the right cerebellar hemisphere (Fig. 1A and 1B). There was blood in the cerebral fissures of both hemispheres as well as along the tentorium cerebelli and the parasicle (Fig. 2). Haemorrhagic foci were present

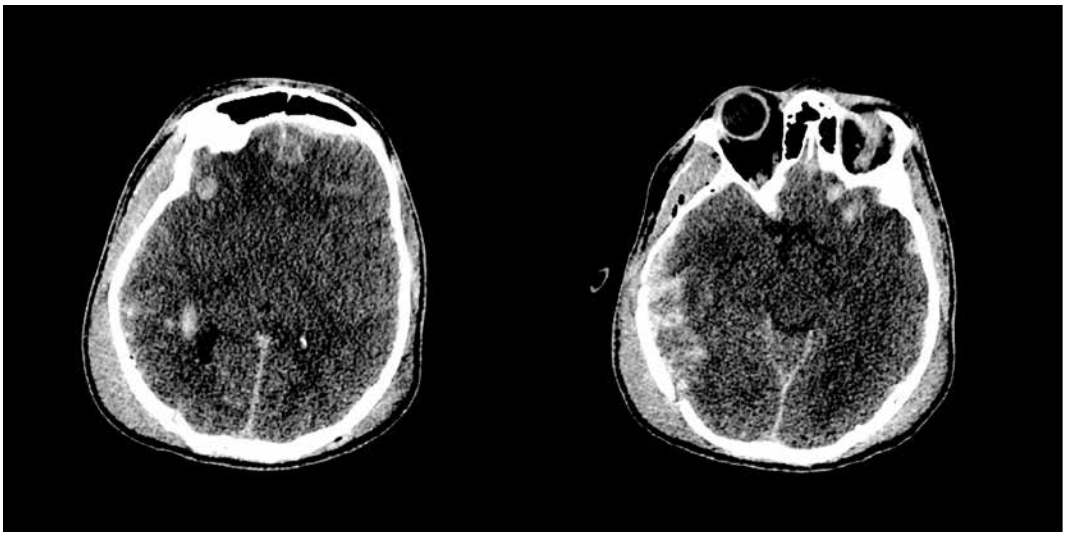

Fig. 1A and 1B. CT of the head on admission to hospital performed with a 64-slice CT Revolution EVO GE MEDICAL SYSTEMS, 120 kV, 160 mA, images on the transverse plane, slice thickness 0.625 mm. Visible are numerous midbrain haematomas of the right brain hemisphere, subdural haematoma along the right brain hemisphere and along the left frontal lobe as well as blood in the brain fissures evidence of subarachnoid bleeding. Also visible are numerous cranial bones fractures. Intracranial gas bubbles on the border of the right temporal and occipital lobe.

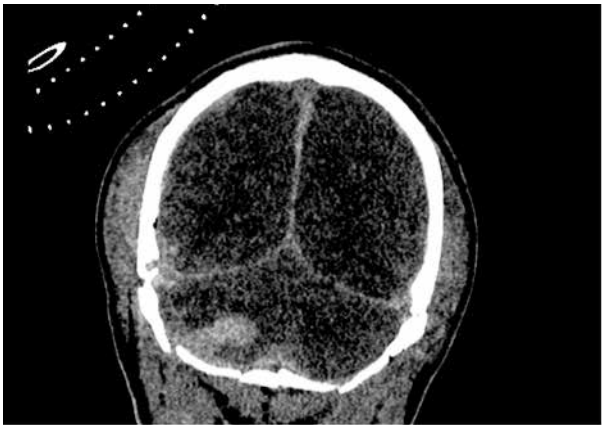

Fig. 2. CT of the head on admission to hospital performed with a 64-slice CT Revolution EVO GE MEDICAL SYSTEMS, 120 kV, 160 mA, frontal reconstructions, slice thickness 0.625 mm. Visible are midbrain haematomas of the right hemisphere of the cerebellum, subdural haematoma along the right hemisphere of the brain and blood in the brain fissures evidence of subarachnoid bleeding. Also visible are numerous cranial bones fractures. Intracranial gas bubbles on the border of the right temporal and occipital lobe.

within the brain stem and the cisterns of the posterior cranial cavity. There were small paracerebral haematomas in the right temporal region and the frontal region bilaterally as well as multiple fractures of cranial bones: compound fractures of the pyramids of temporal bones bilaterally – blood in the mastoid processes and tympanic cavities, comminuted, bilateral fracture of the occipital bone, fracture of the temporal squamae bilaterally, of the right squama of the right parietal bone and fracture of the clivus.

Injuries to other organs included: right-sided pneumothorax, which was treated with a suction drainage, trace of left-sided pneumothorax, slight mediastinal pneumothorax, lung contusion, injury to the vascular pedicle of the left kidney with the dissection of the renal artery with a mural thrombus, retroperitoneal haematoma and numerous fractures to pelvic bones.

THE COURSE OF TREATMENT

The patient was seen by a general surgeon, an otolaryngologist and a neurosurgeon. There were no indications for emergency surgical intervention. The patient was transferred to the Clinical Intensive Care Unit (CICU). In the course of hospitalization, the patient's vital functions were monitored, his general condition was stabilized, respiratory therapy, analgosedation and fluid therapy with correction of electrolyte imbalances were applied. The patient required transfusion of blood products, application of antibiotic therapy and diuresis stimulation. The circulatory system required stabilization with infusions of pressor amines and subsequently Urapidil. In the following days, the patient required administration of hypotensive drugs. On Day 5 of hospitalization, the drain was removed from the patient's pleural cavity. On Day 15 of hospitalization, due

to improvement in the respiratory mechanics, mechanical ventilation was withdrawn. From that moment the patient respired spontaneously through the created tracheostomy with small oxygen supplementation. On Day 22 from the accident, tracheostomy was removed and the patient proceeded to respire independently using the natural respiratory tract. During his stay in the CICU of the Military Medical Institute, the patient received enteral nutrition with industrial diet through a gastric tube, parenteral alimentation being applied periodically. Oral nutrition came to be applied once the patient regained consciousness. After the stabilization of the patient's general condition, intensive bedside rehabilitation and visible improvement of the clinical condition, on Day 47 from the accident, the patient was transferred to the Rehabilitation Clinic of the Military Medical Institute (WIM-PIB) for further rehabilitation. The imaging tests performed 2.5 months after the sustained TBI show a significant regression of post-traumatic brain lesions, resorption of hemorrhagic foci of brain tissue contusion as well as regeneration of the fractured scull bones (Fig. 3A and 3B, 4A and 4B).

PHYSICAL REHABILITATION

Assessment of the patient's condition on the initial examination by the physiotherapist: the patient recumbent, with difficult verbal contact, drowsy, capable of performing simple orders and changing body position in bed. Flaccid quadriparesis. Muscle power in the lower extremities: MRC 3/5 - right, MRC 2.5/5 - left, in the upper extremities: MRC 3/5 bilaterally, exteroceptive and deep sensation within normal limits [7]. Due to the necessary immobilization of the pelvis after fracture, the patient was not assessed in a sitting position.

ICF Classification:

- d 330.03 – speaking – significant difficulties
- b 730.02 – muscle power related functions – moderate impairment
- b 760.01 – voluntary movements control functions – moderate impairment
- d 430.01 – lifting and moving objects – significant difficulties
- d 440.02 – precise hand position maintenance

Motor rehabilitation according to ICD-9 procedures was initiated:

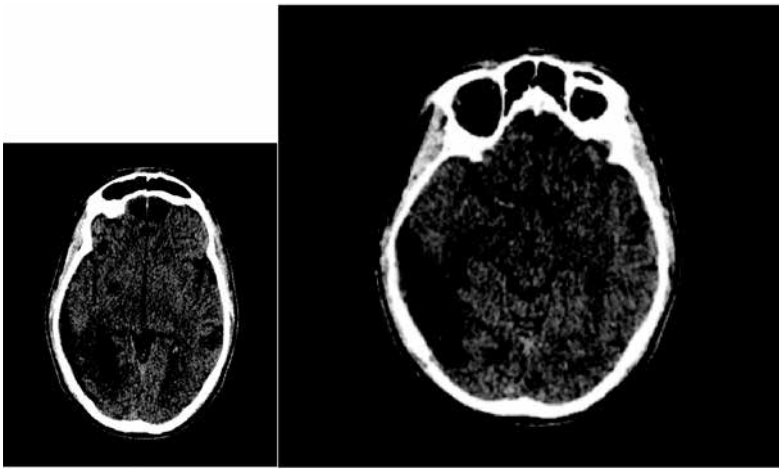

Fig. 3A and 3B. CT of the head 2.5 months from the trauma performed with a 64-slice CT DICOVERY EVO CT 750 HG GE MEDICAL SYSTEMS, 120 kV, 280 mA, images on the transverse plane, slice thickness 0.625 mm. Midbrain haematomas, subdural haematoma, blood in the brain fissures and intracranial gas receded. Secondary post-traumatic changes appeared in the form of post-haemorrhagic cavities, dilation of pericerebral spaces and asymmetric dilation of the ventricular system. Cranial bones fractures healed.

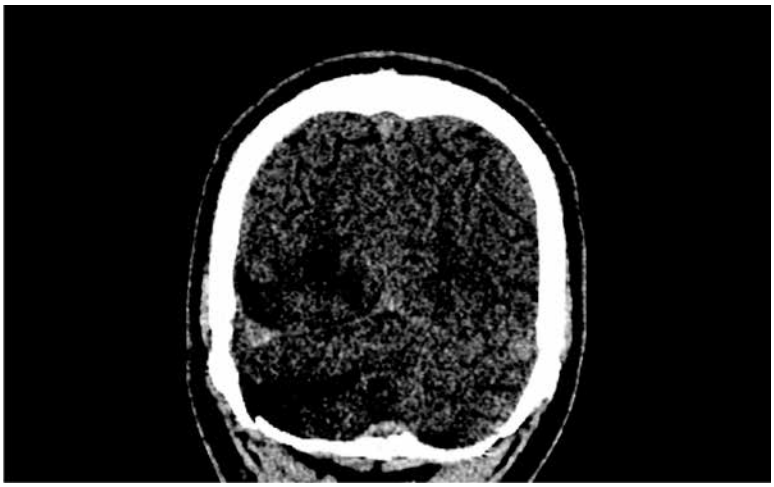

Fig. 4. CT of the head 2.5 months from the trauma performed with a 64-slice CT DICOVERY EVO CT 750 HD GE MEDICAL SYSTEMS, 120 kV, 280 mA, frontal reconstructions, slice thickness 0.625 mm. Midbrain haematomas, subdural haematoma, blood in the brain fissures and intracranial gas receded. Secondary post-traumatic changes appeared in the form of post-haemorrhagic cavities, dilation of pericerebral spaces and asymmetric dilation of the ventricular system. Cranial bones fractures healed.

– guided exercises (93.1133),
– slow active exercises (93.1202),
– breathing exercises (93.1812),
– motor coordination exercises (93.1911),
– neurophysiological (PNF) methods (93.3808).

In the course of hospitalization, muscle power was seen to improve and paresis recede. After verticalization, the patient showed motor coordination disturbances and visual disturbances in the form of blurred vision diplopia.

On the final assessment at the end of hospitalization in the Rehabilitation Clinic of the MMI, the patient was in full verbal-logical contact, independent in self-service, without paresis. Balance and motor coordination disturbances as well as blurred vision diplopia were still present, but much less severe. The patient moves with the help of a high walker on wheels and goes to the toilet without assistance.

NEURO-SPEECH REHABILITATION

On the first neurologopedic examination: the patient shows severely disturbed verbal contact, drowsiness, difficulties in maintaining visual contact, tends to turn his head to the right, close or squint his eyes. Shallow breathing. Phonation disturbed – after repeated presentation by the therapist, quiet, but resonant and prolonged vowels were obtained. The patient says the word [mama] – with active visual prompting by the therapist who presents how lips should be shaped. Naming and repeating severely disturbed. Automated sequences not maintained. Sentence context does not help in recalling a word. The patient can read and understand simple words and short sentences.

At rest, the patient's face is symmetrical. During performance of motoric tests, the mobility of the right mouth corner is limited, the tongue discretely deviates to the right after leaving the oral cavity. Lateral movements of the tongue as well as its verticalization possible, but inaccurate and uncoordinated. Diadochokinesis disturbed.

The patient can swallow saliva on request – the larynx moves up normally. Velopharyngeal reflexes present bilaterally. In a task situation, when the liquid portion is specified (ca. 10 ml), swallowing remains within normal limits. Yet left to himself, the patient drinks greedily without observing the principles of higher position – that's why liquids are recommended to be densified with a densifying preparation to the consistency of syrup. When recumbent, the patient chokes with saliva, so he is recommended to be kept with a slightly elevated head. The patient can swallow pulpy foods without problems. The patient can also chew solid food and form a mouthful. Yet, he should eat solid food in the presence of another person as he finds it difficult to adjust his body position adequately (he often reaches for food when recumbent). Effective swallowing of food of mixed consistency (e.g. vegetable soup) is also causing problems – choking. Pulpy-food diet is recommended till the patient gains better self-control.

The patient shows language disturbances secondary to cognitive disturbances – dysphonia, dysarthria and receding dysphagia.

Initially, therapy focused on supporting the patient's communication competences and neuro-muscular stimulation of affected orofacial regions.

The clinical speech therapist applied breathing exercises prolonging the expiratory phase, restoring the rhythm of breathing and manually stimulating the movement of the ribs and and the diaphragm. The breathing exercises were accompanied by phonation exercises – repetition of vowels: initially whispering, then gradually more loudly, utterance of a prolonged sound [m] and transition to prolonged vowels, staccato [a] and legato [8]. Visual afference helped the patient obtain properly sounding vowels. Gradually, disyllabic words consisting of open syllabi appeared. Longer words were initially difficult to be said aloud. Yet the expiration phase became longer from day to day.

Initial manual stimulation concerned suboccipital muscles, occipitofrontal muscles, regulation of the tension of infrahyoid muscles and activation of neuro-motor regions of the face (in particular, lip corners, chin and oral cavity floor) [8]. The patient was relatively fast in beginning to use sonorous voice, initially quiet, then raised. Speech became the instrument of communication for the patient.

Examination on Day 27 showed that 'the patient began to establish verbal contact and take part in a dialogue, give adequate answers to questions about everyday activities. Naming was normal. Talking about abstract subjects was difficult. His speech was slurred, with spontaneous utterances often difficult to understand. The expiration phase was significantly shortened. Voice was rather quiet, often emitted with an effort. The emission of individual sounds and compound consonant groups was difficult. The patient remained sluggish, easily tired and often drowsy. The patient had dysarthria and receding dysphagia.'

Gradually, the patient's language-use disturbances related to poor verbal fluency, slight disturbances in syntagmatic and paradigmatic selection as well as the dominant model of perceptual thinking began to decrease.

Due to the patient's easy fatigability and attention lability, the therapy had to be conducted in several short sequences a day. All language exercises were based on a hearing analyser (the patient's visual acuity was faulty – he could not read). The exercises included: work with a text, storytelling, answers to open questions, building sentences from a few words given, formation of logical combinations of words on the basis of one verb, adjective or noun, explanation of idiomatic expressions.

Simultaneously, work was started on improving the quality of the patient's articulation. The patient's speech was often slurred, with the work of the lips and the tongue devoid of precision and fluency. Speech was significantly slowed down. Prosody significantly flattened, inadequate to the content rendered.

Apart from orofacial massage normalizing muscle tension, resistance exercises with a spatula were introduced for lips and tongue, active exercises of the articulatory apparatus with the use of the myofunctional strategy as well as maneuvers strengthening the posterior wall of the pharynx and improving swallowing (pronunciation of syllabi, words

and sentences containing velolingual sounds [k, g, h], intensive swallowing, swallowing with the head bent over towards the sternum) [9, 10]. After approximately a month of therapy, the control of his body by the patient improved. He could consciously adjust the position of his body while eating. Difficulties with swallowing receded and normal velopharyngeal reflexes appeared. The patient began to ingest foodstuffs of diversified consistency.

At the last stage (towards the end of hospitalization in the Rehabilitation Clinic of WIM, the therapy consisted in improving the quality of articulation and functioning of lips and tongue which still remained inadequate to the pronounced sounds. Difficulties were still observed in producing compound groups containing sequences of labial and detailed sounds. Motoric tests revealed slight involuntary movements of the apex (in particular, when movements required significant precision). Diadochokinesis was still disturbed. Speech became slightly faster, but still remained slow. Speech was fully understandable for the recipient. The patient was capable of producing, relatively easily, longer fluent utterances on any subject. He cooperated with the speech therapist very willingly. As the therapy progressed, so did the patient's motivation and his conviction that the rehabilitation should be continued. The patient was instructed how he continue rehabilitation exercises in home conditions.

NEURO-PSYCHOLOGICAL REHABILITATION

Initially, the patient with a significantly disturbed verbal contact did not initiate verbal contact. Sporadic attempts at communication involved deficits dominating as regards lip movement, with phonation absent (the tracheotomy tube being removed ca. 4 weeks earlier). The patient did not reveal disturbances in the form of oral apraxia. Periodically, the patient attempted to establish visual contact, but that process was very labile – with dominant deficits in maintaining attention, significant fatigability, drowsiness and psychomotor slowdown. The patient remained non-spontaneous with regard to performing targeted actions and independent activities.

In subsequent, numerous attempts made at verbal communication, adequate responses in the form of single words, sporadically simple sentences (of still largely poorly expressive speech) gradually came to be obtained. Comprehension remained on the level of performing simple orders, expressing adequate confirmation or negation. It was possible to obtain correct actualization of names of objects, automated chains and reading with comprehension of simple sentences. Weakened hand skills made objective assessment of writing impossible.

The patient was partially oriented in time, but showed no orientation as regards the current situation and the circumstances of the trauma. The patient revealed absence of retrograde memory covering the period before the event, with autobiographical memory deficits in the form of memory gaps, without visible tendencies towards confabulation. The patient showed weakened ability to search the visual field and deep visuomotor coordination disturbances. Periodically, especially in the evening, psychomotor stimulation appeared. In spite of the difficulties which were present, the patient became gradually more and more involved in cooperation.

During his stay in the WIM Rehabilitation Clinic, the patient participated in neuropsychological therapy. In accordance with the recommendations in force, behavioural training was applied based on the patient's individual possibilities and preferences, external compensation methods and education aimed at improving the patient's insight into his own psychophysical abilities and motivation for therapy [12].

At present (towards the end of hospitalization) the patient is in full logical and verbal contact. He is eager to take part in the therapy. He is quite talkative and does not show aphasia-type language deficits. Significant improvement can be seen in his ability to read which was initially poor due to deep attention deficits and diplopia (still persisting, but less intensive). Gradual improvement was also observed in functions such as attention and memory, executive and visuospatial functions as well as visuomotor coordination (in spite of remaining deficits). Loss of retrograde memory related to the period prior to the accident substantially diminished, the number of memory gaps concerning facts and events from the patient's life has decreased. Also, the patient's ability to learn from auditory-verbal sources has improved. At present, the patient shows greater readiness to independently initiate actions concerning both self-service and development of his own interests. At the present stage of the disease process, moderate changes can be observed in the emotional and personality functioning of the patients as regards partially maintained insight into the situation which developed (in consequence, the patient required multiple reinforcement in the process of therapy) as well as periodic difficulties in hampering his reactions and shortening the distance. His mood remains stable.

OCCUPATIONAL THERAPY

The first assessment by the occupational therapist: the patient recumbent, with difficult verbal contact, drowsy, with upper extremities paresis, the deficit being greater on the right side. The patient is able to follow simple orders. In self-service actions, the patient is fully dependent on third persons. On the performance of manual actions, visual disturbances were observed as well as disturbances in visuomotor coordination – eye-hand.

At the initial stage, attempts were made at the application of manual exercises with the use of larger objects (which the patient could grasp and see) – balls, mugs, blocks in the shape of geometrical figures. They were aimed not only to improve the grasp, but also to provide visual perception training. The tasks consisted in segregation according to shape, colour and size [13].

Gradually, exercises came to require from the patient ever higher precision and better visuomotor perception. During the rehabilitation process, the patient obtained ever better effects in performing motor and cognitive functions. Additional exercises of a higher difficulty grade were introduced to develop thinking processes, improve

concentration of attention, memory and perception. Aids for hand therapy, jigsaw puzzles and logical games were used [13].

Further therapy involved the use of a hand-therapy device – Pablo [14,15]. The patient was taught how to use cutlery, write, cut things out and draw. Arcade games were used [16]. Noticed during the patient's stay in the Clinic was improvement of the motor efficiency, upper extremities, visuomotor coordination, concentration of attention and self-service activities.

The patient was eager to cooperate and establish verbal contact. The speed of performing tasks also improved.

DISCUSSION

Post-traumatic brain injury should be seen as a certain pathological process extended in time and not as a single physiological phenomenon having place at the time of the accident itself. It is a protracted medical condition developing in time and involving numerous metabolic routes. What takes place during the so-called primary trauma is damage due to the action of physical factors dependent on the direction of the action as well as intensity and type of forces involved. Skin and subcutaneous tissues are ruptured, fractures within the cranium, contusion foci in brain tissue, haematomas within the cranium and diffuse axonal damage appear. The secondary trauma covers phenomena observed within the CNS which are secondary to the progress of the multi-organ trauma. Its course usually leads to cerebral oedema and aggravates the primary situation [4]. Contusion foci in the brain tissue develop due to the nearly simultaneous exposure of the head to significant acceleration and rapid deceleration. Cumulated foci of haemorrhagic conversion of brain tissue are then observed, in the so-called reflex mechanism, in areas remote from the place of the primary impact. A similar effect can be seen when the cranium is exposed to negative pressures arising during the accident. The diffuse axonal trauma is the most treacherous injury as the CT of the brain made after the event often fails to reveal macroscopically visible lesions or shows merely tiny diffuse petechiae localized in the brain stem, corpus callosum as well as other areas of the cerebellum. In spite of the absence or presence of only tiny lesions, the brain damage process proceeds within neurons, microglia and small vessels of the CNS leading to frequently severe, motor or/and cognitive deficits visible clinically.

Features of secondary injury to the CNS can be delayed in time from a few minutes to a few years after the sustained primary trauma. They include the action of a number of products of a cascade of chains of biochemical processes such as disturbances in the ionic economy, degradation of the proper pathways of signal conducting routes, disturbances of the mitochondrial function, harmful action of neurotransmitters (glutamate), toxic action of mechanisms accompanying the inflammatory condition, immunological reactions. The action of prostaglandins, cytokines and chemokines produces oxidation stress and peroxidation of lipids, resulting in damage to the blood brain barrier and increased cerebral vascular permeability which leads to an excessive diffusion of water particles to the hyperosmotic brain tissue and its oedema [3]. Finally, the processes referred to contribute to increased neuron apoptosis with secondary atrophy [3, 4]. Additionally, the local growth of intracranial tension intensifies pathological processes leading to progression of ischaemic changes as well as secondary bleeding which contributes to the variability of the clinical course [4-6].

Severe and moderate TBI is characterized by a longer Phase 1 in which quantitative disturbances of consciousness from pathological drowsiness to stupor or coma are observed. Phase 1 can last for weeks and even become permanent. Disturbances of consciousness are characteristic of Phase 2. They include disturbances of both short and long-term memory which may cover even months prior to the trauma, disorientation, raving as well as accompanying behavioural disturbances in psychomotor stimulation (agitation). The patient may then constitute a threat to himself and others [4]. What is often observed are cognitive deficits (as regards attention, concentration, fluency and verbal activity, intellectual prowess), mood disturbances (depression), features of the post-traumatic stress disorder (PTSD), sleep disturbances [4].

The prognosis in TBI is uncertain. Particular prognostic models are applied depending on the assessment of the initial clinical condition (on admission to hospital) and the initial CT [4].

Based on the patient's clinical condition, we assess the Glasgow Coma Scale (GCS), duration of the persistence of consciousness disturbances as well as appearance of post-traumatic amnesia [4]. In the GCS 3 group, mortality reaches 90%, with GCS estimated at 6-7 pts. It thus amounts to 50%. Depending on the GCS score, traumas are divided into light (GCS , no or short loss of consciousness and/or transient loss of retrograde memory), moderate (GCS of 9-12 pts, with accompanying loss of consciousness and/or retrograde memory of below 24 h) and severe (GCS , loss of consciousness of over 24 h, retrograde memory loss of over 24 h). 60% of severe traumas are accompanied by multi-organ injuries and 25% of patients require interventional treatment of other concomitant injuries.

The TBI patients' prognosis is determined with the use of Marshall scale or Rotterdam scale applied to the CT assessment of: the compensatory capacity of the cerebrum, the scope of post-traumatic lesions and the assessment of the arachnoid cisterns (Table 1) [4].

Where we recognize the presence of isolated encephalic oedema without an accompanying dislocation of brain structures of the brain midline (Grade III Marshall Scale), we estimate the mortality rate at 34% and when the brain structures of the brain midline are dislocated by more than 5 mm (Grade IV Marshall Scale) at 50%.

It is to the current studies in the field of EBM that we owe a significant progress in the treatment of TBI patients which has been witnessed recently. At present, TBI patients are provided with multi-specialty comprehensive care aimed not solely at the treatment of the primary trauma, but also

Table 1. Evaluation scale for cranio-cerebral injuries on Rotterdam computed tomography

Arachnoid cisterns	Brain dislocation beyond the midline	Supradural haemorrhage	Intraventricular or subarachnoid haemorrhage	Mortality rate after 6 months
0: normal	0: not present or ≤5 mm	0: not present	0: not present	1: 0% 2: 7% 3: 16% 4: 26% 5: 53% 6: 61%
1: squeezed	1: dislocation > 5 mm	1: present	1: present	
2: not visible				

at the prevention of the secondary trauma complications referred to above. Patients with severe trauma are usually placed in intensive care units within neurosurgical centres as they require observation towards performance of surgical decompression in a situation of a direct threat to life due to mounting oedema or development of a delayed bleeding into the CNS within the first days of hospitalization. Due to improving TBI patient care, their higher survival rate makes care over TBI patients a real challenge for the healthcare system. Patients after CNS injuries require long-term, multi-specialty treatment, including rehabilitation. Statistically significant increased mortality of patients after cranio-cerebral injury was reported in the first year after the injury due to sepsis, pneumonia, epilepsy as compared to same-age patients with similar concomitant health problems [6]. In the distant perspective patients after TBI have an increased risk of neurodegeneration what is associated with increased brain tissue atrophy [17, 18].

CONCLUSIONS

Early, properly designed and carried out kinesiotherapy, speech therapy, neuropsychological therapy and occupational therapy undertaken in the case described confirm the existence of a potentially positive prognosis of a full return of a TBI patient to normal social life.

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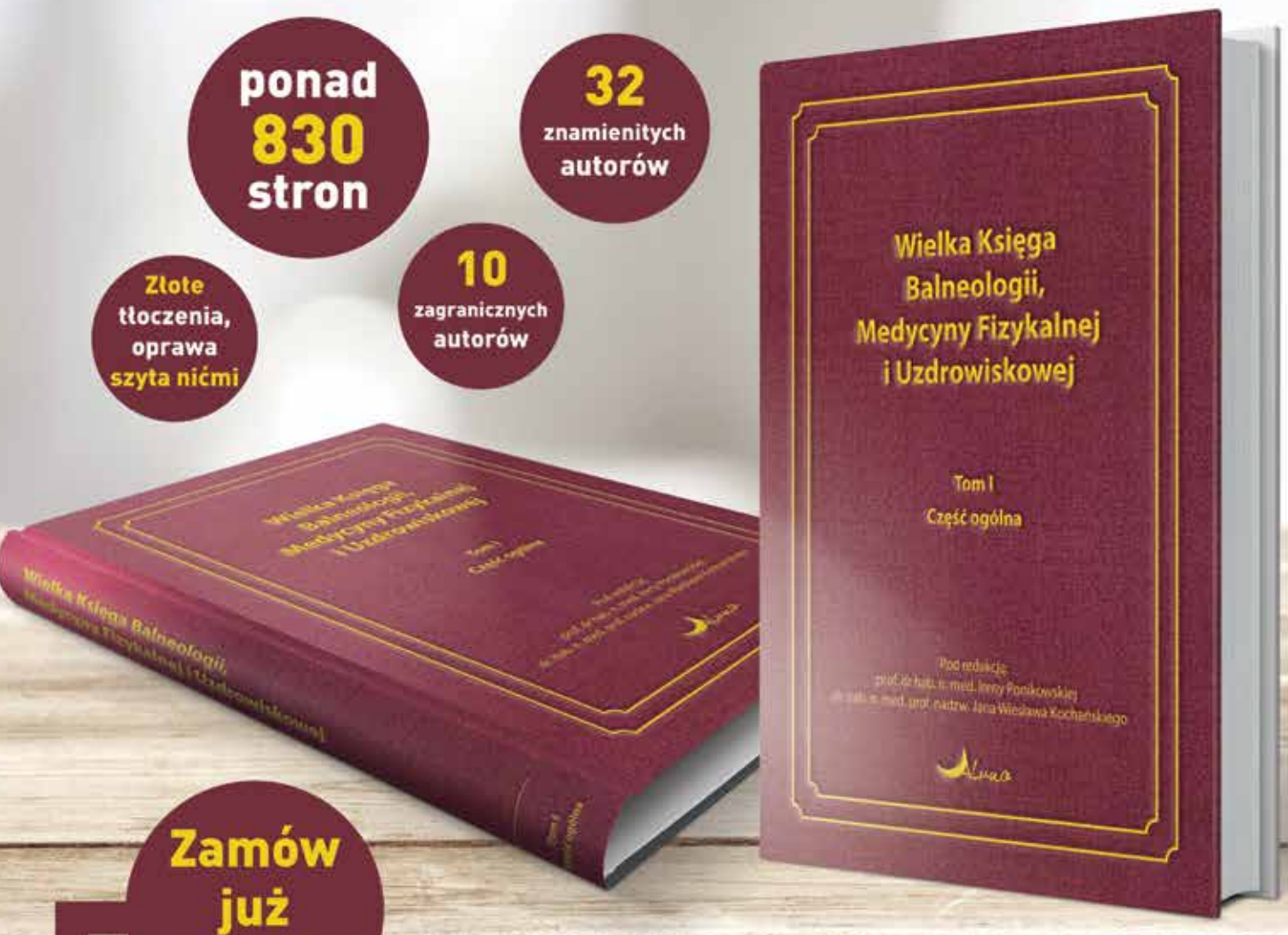

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