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ORIGINAL ARTICLE

Analysis of physical therapy in carpal tunnel syndrome

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ABSTRACT

Aim: This disorder affects 1-5% of the population and is more common in women than in men.The aetiology usually consists in chronic segmental nerve compression and ischaemia under the flexor retinaculum. This results in impaired blood circulation in the vessels, leading to sensory and motor abnormalities in the region innervated by the median nerve.

Materials and Methods: The aim of this study was to assess the effects of physical therapy in the treatment of carpal tunnel syndrome and to find out whether the physical therapy procedures used in study patients influenced their condition. The study involved 19 individuals, including 12 women and 7 men, and the mean age was 51 years. Study patients underwent the following procedures for a period of 2 weeks: ultrasound therapy, laser therapy, cryotherapy, kinesiotherapy.

Conclusion: After physical therapy, the pain resolved or decreased and the condition of study patients improved; paraesthesia, numbness, and tingling were eliminated and better hand function was observed. Treatment of this patient population is based on physical therapy.

KEY WORDS: carpal tunnel syndrome, physical therapy

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INTRODUCTION

Carpal Tunnel Syndrome (CTS) is the most common form of compressive neuropathy, affecting approximately 1-5% of the population. It can be considered an occupational disease as it develops as a result of overload at work related to mechanical vibrations, repetitive movements, use of force, and body positions that put strain on the wrists. CTS is caused by the compression of the median nerve in the carpal tunnel. This neuropathy may also develop as a result of local, regional, and systemic changes [1-8].

This neuropathy usually occurs in the dominant hand, and 10% of cases occur in both hands. CTS was first described by Paget in 1863.

CTS is two to three times more common in women than in men. It usually occurs between the ages of 40 and 60 years. In the US, CTS is seen as an epidemic, with 2.8 million new cases diagnosed every year. The incidence of CTS with clinical and electrophysiological confirmation in the Swedish population was determined to be 2.7%, whereas Mondelli et al. conducted a study in Italy and found 329 CTS cases per every 100,000 people/year. A Danish study by Bogers showed an incidence of 180 per every 100,000 people/year. Bożek and Gaździk reported that CTS was present in approximately 1.5% of the Polish population [8-18].

Contributing factors may include pregnancy, hormonal contraception or alcoholism. Repeated movements performed by office workers, industrial workers, operators or installers also play an important role in the aetiology. Wrist flexion and extension, pronation, supination, and catching objects with one's fingers have all been documented to be associated with CTS. The risk of developing CTS increases in the presence of mechanical vibrations (for example, when using a drill, pneumatic drill or grinder) [12-16].

Obesity has been found to be an important factor in CTS in 2008 by Sharifi-Mollayousefi, in 2005 by Blanda, in 2004 by Geoghegan, in 2002 by Becker, in 1992 by de Krom, and in 1997 by Nordstrom. Blanda showed that obesity is an independent factor, especially in individuals under the age of 63 years.

According to research, obese individuals are 2-4 times more likely to develop CTS than slim ones, and the risk of CTS increases by 8% when the BMI increases by 1. Vessey et al. showed that the risk of developing CTS increases twofold in obese women versus slim ones. As adipose tissue is deposited around the median nerve, the pressure of the flowing blood is increased [1-7].

To date, research has shown that hypothyroidism also has a significant influence on the development of CTS; this neuropathy is present in 23–43.7% of people diagnosed with thyroid disease [6, 7].

There are also cases where a clear aetiology cannot be determined; this is so-called idiopathic carpal tunnel syndrome. Aroori and Spence reported that the cause can be established only in 50% of CTS cases.

Advanced CTS is associated with superficial sensory abnormalities, particularly on the thumb and index finger. With time, the sensory disturbance expands to the entire

region supplied by the median nerve. At this stage, patients experience atrophy of the head of the flexor pollicis brevis, extensor pollicis brevis, and opponens pollicis, which leads to difficulties with precise movements or to dropping objects held in the hand [24,29]. Symptoms that exacerbate at night are typical in CTS patients [14-17].

The Whitley and McDonnell classification is the most common CTS classification. It consists of three degrees:

- Early – mild; in this stage, patients complain of pain, tingling, and numbness, present usually at night; symptoms become more severe as the disorder progresses. Initially, shaking out the hand relieves the symptoms;
- Intermediate – moderate; in this stage, patients complain of weakened sensation, lack of precision of movement, loss of grip strength. Burning pain intensifies when the patient uses the hand and at night;
- Advanced – in this stage, patients experience atrophy of the thenar eminence muscles, impaired hand function, loss of normal sensation, and lack of precision of movement [14-17].

The following tests are used to diagnose CTS:

- Tinel's sign test – involves tapping the transverse ligament over the carpal tunnel, which causes pain or tingling due to increased pressure;
- Phalen's test – the patient is sitting down with their elbows supported and with full palmar flexion of the wrists for 0.5-2 minutes, which causes pain in the entire region innervated by the median nerve or increases paraesthesia;
- reverse Phalen's test consists in rapidly flexing the wrist joint, which produces the typical symptoms;
- Durkan's test – involves compressing the transverse ligament over the carpal tunnel, which results in pain, tingling, or numbness in the region innervated by the median nerve [14-17].

Nerve damage is evaluated using the Seddon classification, which was initially a three-point scale. In the first, mildest form, nerve structure is changed, leading to the inhibition of electrical impulses. Once the factor affecting the nerve is eliminated, the condition of the patient improves and normal function is restored. In the second stage, axon disruption occurs, which immediately inhibits nerve conduction, and the terminal segment of the nerve loses its excitability within 3 to 9 days. In this stage, patients require treatment that will help restore the damaged nerve. The third stage is the most serious one. It involves nerve paralysis, which can lead to muscle weakness or atrophy as well as loss of sensation in the innervated region. This stage of CTS is usually treated with surgery since restoring function through physical therapy procedures is very difficult [14-17].

The Seddon scale was modified in 1951 by Sunderland, who divided nerve damage into five stages. Stage 1 is associated with ischaemia, and recovery takes approximately 2 to 3 weeks; nerve continuity is preserved. Stage 2 is associated with axon damage, and nerve regeneration occurs at the speed of about 1 mm per day. In stage 3, nerve damage is the same, and fibrosis develops within the nerve bundle. Stage 4 is characterised by nerve enlargement, and stage 5 is associated with nerve rupture [14-17].

Muscle strength is usually measured with the Lovett scale, which was developed in 1932. The scale allows for conducting a subjective, manual assessment of muscle strength. This method requires appropriate positioning of the limb and isolating a specific movement [14-18].

Superficial sensation assessments include motor, sensory, and autonomic functions.

In 1993, the American Association of Electrodiagnostic Medicine determined that CTS diagnosis should be confirmed in an electrophysiologic study characterised by high sensitivity and specificity. This method is believed to be a golden standard.

When determining patient eligibility for treatment, one needs to consider the following: symptoms, nerve damage, comorbidities, and anatomical deformities. Before the decision is made to perform surgery, all conservative treatment options should have been exhausted, such as immobilisation, pharmacotherapy, automobilisation of the median nerve and brachial plexus, kinesio taping, physical therapy (ultrasound therapy, whirlpool massage, laser biostimulation, cryotherapy) [19-30].

AIM

The main aim of this paper is to assess the effects of physical therapy in the treatment of carpal tunnel syndrome and check how it contributed to a reduction in pain and an improvement in the condition of study patients.

MATERIALS AND METHODS

The study used an anonymous survey created by the authors. The survey consisted of 16 closed-ended and open-ended questions.

The survey asked about personal information such as age, gender, place of residence, and about CTS history and relevant health data such as comorbidities, time of onset of pain, time of day and activities associated with more severe pain, types of procedures with their outcomes. Pain was assessed using a VAS; Tinel's functional test was also used.

The study was conducted at the Zagnańska Medical Centre Rehabilitation Clinic and included 19 individuals (12 women and 7 men) with carpal tunnel syndrome. Women constituted more than a half of the study group (63%) and men constituted 37%. Study patients were 40-63 years old.

Physical therapy procedures performed in study patients over a period of 2 weeks included laser therapy, Magnetronic therapy, cryotherapy, ultrasound therapy, kinesiotherapy.

The results collected were then analysed. The study used descriptive statistics with tabular and graphical techniques and central tendency, which allowed for calculating arithmetic means, medians, and minimum and maximum values. The statistical analysis of the results also utilised the Mann Whitney U test, the Wilcoxon signed-rank test, and the sign test. The results of the analysis with their visualisation were prepared using Microsoft Excel, where the results were presented together with an initial analysis of the data entered.

The results were analysed taking into account the influence of different factors on the treatment process: age, gender, education, comorbidities (Table 1).

The mean age was 55 years in women and 45 years in men.

Table 2 presents the numerical values for the arithmetic mean, minimum and maximum values, and the median for the age of study patients. The graph shows the distribution of age divided into two groups (men and women).

Table 1. Gender distribution in the study group

	Number	Percentage
Women	12	63
Men	7	37
Total	19	100

Table 2. Age of study patients

	Women	Men
Arithmetic mean	55	45
Minimum	40	40
Maximum	63	59
Median	59	40

Table 3 presents both groups of patients. Women more often reported primary and vocational education while more men had higher education. There were no men with primary education in the study group.

The highest percentage of study patients had higher education (32%) and the lowest had primary or secondary education (21% each). Vocational education was reported by 26% of study patients.

The majority of study patients, both men and women, lived in rural areas (63%) while 37% lived in urban areas (Table 4).

Table 5 presents the effects of past surgeries on CTS in study patients. Both among women (8/12) and men (4/7), in most cases past surgeries did not have a significant effect on the disorder.

The figure below clearly shows that surgeries performed before the start of rehabilitation did not have an effect on CTS (63%). Only 37% of study patients underwent surgery.

Answers to question 6 about the cause of the onset of CTS among women included injury (8/12, 67%), overload (3/12, 25%), and no cause (1/12, 8%). The distribution of CTS causes in men was different than in women; most male patients reported overload (4/7, 57%) and a lower proportion of patients reported injury (3/7, 43%). No men gave the "no cause" answer (Table 6).

Table 3. Level of education

Level of education	Women	Men	Number	Percentage
Primary	4		4	21
Vocational	4	1	5	26
Secondary	2	2	4	21
Higher	2	4	6	32

Table 4. Place of residence

Place of residence	Women	Men	Number	Percentage
Rural area	7	5	12	63
Urban area	5	2	7	37
Total	12	7	19	100

Table 5. Past surgeries

Past surgeries	Women	Men	Number	Percentage
Yes	4	3	7	37
No	8	4	12	63
Total	12	7	19	100

Table 6. Distribution of causes of onset of CTS among men and women

	Women	Men	Number	Percentage
Injury	8	3	11	58
Overload	3	4	7	37
No cause	1	0	1	5
Total	12	7	19	100

The majority of the study group (58%) reported that the disorder started with an injury, 37% reported musculoskeletal system overload, and only 5% did not notice any specific cause responsible for the onset of their symptoms.

Hypertension was the most common comorbidity among both women and men (79%). Diabetes and hypothyroidism were reported as comorbidities by 11% of study patients. When looking at the men and women separately, one can see that the women were more commonly affected by hypothyroidism (17%) and the men more often had diabetes (14%) (Table 7).

The Table 8 shows that men saw a specialist sooner after the onset of wrist pain (below 1 month, 58%). 50% of women saw a specialist 1-3 months after the onset of pain and 25% of women each saw a specialist after less than 1 month and after more than 3 months. The distribution of answers in men is as follows: 1-3 months, 28%; over 3 months, 14%.

The largest proportion of patients (42%) saw a physician after 1 to 3 months after the onset of pain, 37% saw a physician after less than 1 month, and the lowest percentage (21%) saw a physician over 3 months after the onset of symptoms.

Question 9 asked study patients to mark the initial location of pain. The table below shows the results divided into two groups. Among women, more patients (58%) marked the location of pain around the fingers: thumb, index and middle finger, and 42% in the area of the wrist. In men, the distribution of answers was slightly different since wrist pain was reported by 71% of patients and only 29% noticed pain around the fingers.

The distribution of answers for the whole study group is shown in Table 9. The largest percentage of patients (53%) initially noticed wrist pain, and 47% of patients initially experienced pain around the fingers.

The time of day with pain was distributed evenly in women, while 71% of men reported experiencing pain in the evenings and 29% reported pain during the day. No men participating in the study experienced pain in the mornings.

The occurrence of pain depending on the time of day in the whole study group was varied. Table 10 shows that the largest group of patients (47%) reported experiencing pain in the evenings while the smallest group (21%) experienced pain in the mornings, with 32% experiencing pain during the day.

Table 11 shows the distribution of activities that exacerbate pain in men and women. Carrying heavy objects was the most common answer, given by 42% of women and 71%

Table 7. Comorbidities

Comorbidities	Women	Men	Number	Percentage
Hypertension	9	6	15	79
Diabetes	1	1	2	11
Hypothyroidism	2	0	2	11
Total	12	7	19	100

Table 8. Time of onset of wrist pain

Time of onset of pain	Women	Men	Number	Percentage
<1 month	3	4	7	37
1–3 months	6	2	8	42
>3 months	3	1	4	21
Total	12	7	19	100

Table 9. Initial location of pain

Initial location of pain	Women	Men	Number	Percentage
Wrist	5	5	10	53
Fingers: thumb, index, middle finger	7	2	9	47
Total	12	7	19	100

Table 10. Time of day with pain

	Women	Men	Number	Percentage
Morning	4		4	21
Daytime	4	2	6	32
Evening	4	5	9	47
	12	7	19	100

of men. No clear factor and pressing down were reported by 14.5% of patients each.

The figure below clearly shows that carrying heavy objects exacerbated pain (53%). Only 16% of study patients selected the answer "pressing down" and 31% did not notice any specific factor that would worsen the pain they experienced.

As shown in Table 12, all study patients started rehabilitation.

Among women, 58% of patients received laser therapy, cryotherapy, and ultrasound therapy while 42% performed individual exercises. Among men, 43% of patients received both a combination of laser therapy, cryotherapy, and ultrasound therapy, and individual exercises. Only 1 person received a combination of all of those procedures (Table 13).

More than a half of study patients (53%) underwent a combination of laser therapy, cryotherapy, and ultrasound therapy.

Table 14 shows that rehabilitation had a positive effect in 9 out of 12 women (75%) and in 5 out of 7 men (71%). Within the whole study group, 74% of patients underwent rehabilitation and experienced an improvement while 26% did not.

Table 15 presents the results for pain reduction separately in women and men. A reduction from 8 to 4 (by 50%) was the most common degree of pain reduction in women, while a reduction from 8 to 3 and no reduction were reported by 3 women each. The distribution of answers in a VAS was different in men; most male patients experienced a reduction to 3 (by approximately 62%) while two men did not experience any changes.

Within the whole study group, the highest percentage (42%) of patients experienced a reduction in pain to 3, 32% of patients had a reduction to 4, and 26% of patients did not experience any pain reduction.

Table 16 shows a clear difference in hand mobility between women and men. Most women (9 out of 12) did not experience limited joint mobility and only 3 out of 12 women noticed hand mobility problems. The situation in men was the opposite; most men (6 out of 7) noticed hand mobility limitations and only one male patient did not have any mobility problems.

When the men and women are analysed together, there is no considerable difference between the answers (only 6 percentage points). 53% of study patients did not report mobility limitations and 47% noticed mobility problems.

Table 17 presents the results of Tinel's test, in which patients point out their CTS symptoms. In women, paraesthesia consisting in peripheral nerve damage was the most common symptom (5 out of 12) while tingling was the least common symptom (3 out of 12). The male patients complained mostly of numbness and tingling, and only one male patient out of 7 experienced paraesthesia.

Before physical therapy, most patients complained of numbness; after physical therapy, this number was three times lower. Paraesthesia and tingling were reported by similar numbers of patients; however, after physical therapy, numbness resolved in half the patients and paraesthesia resolved in a third of the patients.

Results for the whole study group and described in Table 18 show that numbness was the most common symptom (37%) while paraesthesia and tingling were reported by 32% of patients each. After physical therapy, numbness was reduced to 11%, tingling to 16%, and paraesthesia to 21%.

Table 11. Activities that exacerbate pain

	Women	Men	Number	Percentage
Carrying heavy objects	5	5	10	53
No factor	5	1	6	32
Pressing down	2	1	3	16
Total	12	7	19	100

Table 12. Number of patients who started rehabilitation

Was rehabilitation started?	Women	Men	Number	Percentage
Yes	12	7	19	100
No	0	0	0	0
Total	12	7	19	100

Table 13. List of procedures

What procedures were used	Women	Men	Number
Laser therapy	7	3	10
Cryotherapy	6	5	11
Ultrasound therapy	19	17	36
Individual exercises	5	3	8

Table 14. Was rehabilitation effective?

	Women	Men	Number	Percentage
Yes	9	5	14	74
No	3	2	5	26
Total	12	7	19	100

Table 15. Distribution of pain reduction according to VAS

VAS score before therapy 8, after therapy:	Women	Men	Number
Reduction to 3	3	5	8
Reduction to 4	6	0	6
No change 8	3	2	5
Total	12	7	19

Table 16. Hand mobility

Is hand mobility limited?	Women	Men	Number	Percentage
Yes	3	6	9	47
No	9	1	10	53
Total	12	7	19	100

Table 17. Tinel's test results before physical therapy

Tinel's test	Women	Men	Numbers	Percentage
Paraesthesia	5	1	6	32
Numbness	4	3	7	37
Tingling	3	3	6	32
Total	12	7	19	100

Table 18. Tinel's test results before and after physical therapy

Tinel's test	Before therapy	After therapy	Percentage before therapy	Percentage after therapy
Paraesthesia	6	4	32	21
Numbness	7	2	37	11
Tingling	6	3	32	16
Total	19	9	100	47

Symptoms in the functional Tinel's test resolved in more than half of study patients.

DESCRIPTIVE STATISTICS

The mean age in the study group was 51.95 years. The standard deviation was 9.45. The youngest study patient was 40 years old and the oldest was 63 years old. 25% of study patients were 40 years old or younger and 75% were 40 years old or older. 25% of study patients were 59 years old or older and 75% were 59 years old or younger.

The mean VAS score after physical therapy was 4.63. The standard deviation was 2.11. The lowest score was 3 and the highest score was 8. 25% of study patients scored 3 or lower and 75% scored 3 or higher. 25% of study patients scored 8 or higher and 75% scored 8 or lower.

The mean VAS score before physical therapy was 8.05. The standard deviation was 0.23. The lowest score was 8 and the highest score was 9.

The Mann Whitney U test does not allow for rejecting at the significance level of $\alpha=0.05$ the hypothesis about the lack of differences in the characteristics assessed between men and women; therefore, there are no differences with respect to gender in the results of Tinel's test, hand mobility limitation, and VAS scores both before and after physical therapy (Table 19).

The Mann Whitney U test does not allow for rejecting at the significance level of $\alpha=0.05$ the hypothesis about the lack of differences in the characteristics assessed between people living in rural versus urban areas; therefore, there are no differences with respect to place

Table 19. Mann Whitney U test. Variable – place of residence

Variable	Mann-Whitney U test (with correction for continuity) For variable: place of residence Highlighted results are significant at p <.05000								
	Rank sum (rural area)	Rank sum (urban area)	U	Z	p	Z (correct.)	p	N of valid (rural area)	N of valid (urban area
Tinel's test	81.000	109.000	36.000	-0.694022	0.487669	-0.7358795	0.461804	9	10
Hand mobility limitation	93.500	96.500	41.500	0.244948	0.806496	0.3207134	0.748427	9	10
VAS score after therapy	100.500	89.500	34.500	0.816496	0.414217	0.8713442	0.383566	9	10
VAS score before therapy	85.500	104.500	40.500	-0.3265986	0.7439716	-0.8432744	0.399075	9	10

Table 20. Mann Whitney U test. Variable – past surgeries

Variable	Mann-Whitney U test (with correction for continuity) (Sheet 9) For variable: past surgeries Highlighted results are significant at p <.05000								
	Rank sum (no)	Rank sum (yes)	U	Z	p	Z (correct.)	p	N of valid (no)	N of valid (yes)
Tinel's test	103.000	87.000	25.000	-1.394505	0.16316627	-1.478609	0.1392458	12	7
Hand mobility limitation	131.000	59.000	31.000	0.887412	0.37485781	1.161895	0.24527898	12	7
VAS score after therapy	100.000	90.000	22.000	-1.648051	0.09934323	-1.758758	0.07861964	12	7
VAS score before therapy	123.500	66.500	38.500	0.253546	0.79984627	0.654654	0.51269123	12	7

of residence in the results of Tinel's test, hand mobility limitation, and VAS scores both before and after physical therapy (Table 20).

The Mann Whitney U test does not allow for rejecting at the significance level of α=0.05 the hypothesis about the lack of differences between people who underwent surgery versus those who did not undergo surgery; therefore, one can conclude that there are no differences in the characteristics assessed between these groups of patients (Table 21).

The Mann Whitney U test does not allow for rejecting at the significance level of α=0.05 the hypothesis about the lack of differences between people in whom symptoms were caused by an injury and those whose symptoms resulted from overload with respect to the results of Tinel's test, hand mobility limitation, and VAS scores before physical therapy. Therefore, one may conclude that there are no differences between these groups of patients in the characteristics assessed. There are, however, statistically significant differences (p-value=0.041) between people in whom symptoms were caused by an injury and those whose symptoms resulted from overload with respect to VAS scores after physical therapy. When an injury was the cause, the mean VAS score after physical therapy was 4.9; in case of overload, the mean score was 3.71.

The Mann Whitney U test does not allow for rejecting at the significance level of α=0.05 the hypothesis about the lack of differences between areas of pain in the characteristics assessed; therefore, there are no differences with respect to areas of pain in the results of Tinel's test, hand mobility limitation, and VAS scores both before and after physical therapy (Table 22).

At the significance level of α=0.05, both the sign test (p-value=0.021) and the Wilcoxon signed-rank test (p-value=0.026) indicate a significant difference in hand mobility before versus after physical therapy (Table 23).

Table 21. Mann Whitney U test. Variable – causes of symptoms

Variable	Mann-Whitney U test (with correction for continuity) (Sheet 9) For variable: causes of symptoms Highlighted results are significant at p <.05000								
	Rank sum (injury)	Rank sum (overload)	U	Z	p	Z (correct.)	p	N of valid (injury)	N of valid (overload)
Tinel's test	104.500	66.500	38.500	0	1	0.0000	1	11	7
Hand mobility limitation	99.500	71.500	33.500	-0.4076	0.6836	-0.5651	0.5720	11	7
VAS score after therapy	127.500	43.500	15.500	2.0378	0.0416	2.1886	0.0286	11	7
VAS score before therapy	99.000	72.000	33.000	-0.4528	0.6507	-1.1396	0.2545	11	7

Table 22. Sign test and Wilcoxon signed-rank test – hand mobility limitation

Pair of variables	Sign test Highlighted results are significant at p <.05000		
	Number (not bound.)	Percent (v < V)	Z
Hand mobility limitation before and after	19	78.94737	2.294157

Pair of variables	Wilcoxon signed-rank test Highlighted results are significant at p <.05000		
	N (of valid)	T	Z
Hand mobility limitation before and after	19	40.00000	2.213320

Table 23. Sign test and Wilcoxon signed-rank test – VAS

Pair of variables	Sign test		
	Number (not bound.)	Percent (v < V)	Z
VAS score before and after therapy	18	22.22222	2.121320

Pair of variables	Wilcoxon signed-rank test Highlighted results are significant at p <.05000		
	N (of valid)	T	Z
VAS score before and after therapy	18	10.00000	3.288052

At the significance level of α=0.05, both the sign test (p-value=0.033) and the Wilcoxon signed-rank test (p-value=0.001) indicate a significant difference in VAS scores before versus after physical therapy. The mean VAS score was 8.05 before physical therapy and 4.63 after physical therapy.

DISCUSSION

Carpal tunnel syndrome is one of the most common compressive neuropathies. Its aetiology encompasses such potential mechanisms as chronic segmental nerve compression and ischaemia under the flexor retinaculum, local inflammation, and axonal transport disruption. Initial symptoms include numbness or stiffness in the fingers and wrist as well as pain. In later stages, the symptoms worsen, causing muscle weakness, lack of precision of movement, dropping objects held in the hand, and in the last stage patients experience atrophy in the thenar eminence muscles. The onset and course of this neuropathy is different in each patient. CTS can start due to an injury, musculoskeletal overload, or with no clear cause.

The incidence of CTS depends on multiple anatomical, mechanical, and congenital factors. This neuropathy is associated with local, regional, and systemic changes.

The goal of physical therapy in CTS is to eliminate pain and improve hand function. CTS patients are initially managed with hand immobilisation at the wrist joint with an orthosis in order to relieve pain and prevent mechanical irritation of the nerve. CTS is treated with such physical therapy procedures as laser therapy, cryotherapy, ultrasound therapy, and heat therapy. Patients should perform special types

of exercises to decompress the nerve and increase the flexibility of the tendons and muscles.

Physical therapy is important in the conservative management of CTS. Study patients underwent procedures combining laser therapy, cryotherapy, and ultrasound therapy.

The results of the present study show a trend towards the development of CTS in middle-aged (55 years) women (63%) living in rural areas. The disorder is mostly caused by injuries (58%) and overload (37%). All study patients had comorbidities. Patients were assessed using a VAS for pain and Tinel's functional test.

The mean VAS score was 4.63 after physical therapy and 8.05 before physical therapy.

The VAS scores showed a pain reduction in 14 out of 19 people, and Tinel's test showed that symptoms such as numbness, tingling, and paraesthesia resolved in more than a half of study patients.

The Mann Whitney U test does not allow for rejecting at the significance level of α=0.05 the hypothesis about the lack of differences between people in whom symptoms were caused by an injury and those whose symptoms resulted from overload with respect to the results of Tinel's test, hand mobility limitation, and VAS scores before physical therapy. Therefore, one can conclude that there are no differences in the variables tested between these groups. There are, however, statistically significant differences (p-value=0.041) between people in whom symptoms were caused by an injury and those whose symptoms resulted from overload with respect to VAS scores after physical therapy. When an injury was the cause, the mean VAS score after physical therapy was 4.9; in case of overload, the mean result was 3.71.

At the significance level of α=0.05, both the sign test (p-value=0.021) and the Wilcoxon signed-rank test (p-value=0.026) indicate a significant difference in hand mobility before versus after physical therapy.

At the significance level of α=0.05, both the sign test (p-value=0.033) and the Wilcoxon signed-rank test (p-value=0.001) indicate a significant difference in VAS scores before versus after physical therapy. The mean VAS score was 8.05 before physical therapy and 4.63 after physical therapy.

The present findings are consistent with the results reported by other authors. The consistency of the demographic and clinical patient profiles was confirmed by Becker, who in his research found that CTS was two to four times more common in women than in men [41]. According to Yagci, Shoshtarii, and Heebner, the mean age of CTS patients is approximately 50 years. In this study, 63% of study patients were women and the mean age was also approximately 50 years. O'Connor proved in his research that ultrasound therapy and wrist mobilisation were the most effective methods of improving hand function. Piazzini conducted research in 1985–2006 and provided strong evidence for the efficacy of steroid therapy and for the moderate efficacy of ultrasound therapy, laser therapy, or yoga. In turn, Muller believed immobilisation, ultrasound therapy, magnetic fields therapy, yoga, wrist bone mobilisation, and median nerve glide exercises to be beneficial in CTS.

The treatment of this disorder is based on physical therapy.

CONCLUSIONS

1. Carpal tunnel syndrome is a difficult diagnostic and therapeutic problem.
2. Women develop CTS more often than men.
3. The physical therapy procedures performed in study patients reduced pain as assessed in a VAS.
4. After physical therapy, the following symptoms: numbness, tingling, and paraesthesia resolved in more than a half of study patients.
5. After physical therapy, study patients experienced an improvement in hand function.

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CONFLICT OF INTEREST

The Authors declare no conflict of interest

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ORIGINAL ARTICLE

Effectiveness of 6 weeks individual rehabilitation on the functionality and quality of life in patients with bilateral gonarthrosis

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ABSTRACT

Aim: The aim of the study was to assess the quality of life and functionality of patients with KOA. Knee osteoarthritis (KOA) leads to the destruction of articular cartilage and loss of its function. It has been shown that knee osteoarthritis is the leading cause of functional limitations worldwide. Patients experience pain that affects their daily activities, such as: getting out of bed or a chair, walking and climbing stairs. The deterioration of functionality in patients with gonarthrosis translates into their quality of life. It has also been shown that rehabilitation is effective in combating symptoms associated with gonarthrosis.

Materials and Methods: Two groups were distinguished among the participants – control (n=41) and study, in which random assignment was made to one of three groups – "Insoles" (n=43), "Exercises" (n=43), "Mixed" (n=39). In order to assess the quality of life and functionality, the following were used: KOOS questionnaire, 10 m Walk Test, Sensory Control Test, Five Time Sit to Stand Test. Diagnostics were performed twice – before and after 6 weeks of therapy.

Results: Statistically significant differences were obtained in the functional assessment and quality of life in patients compared to the control group ($p<0.05$), and a beneficial effect of the therapy was demonstrated ($p<0.05$). The greatest effectiveness was achieved in the group of people performing exercises and using orthopedic insoles at the same time.

Conclusions: Rehabilitation affects the functional improvement and quality of life in patients with bilateral gonarthrosis of the medial compartment, and the most effective method is a combination of exercises and the simultaneous use of orthopedic insoles.

KEY WORDS: gonarthrosis, rehabilitation, functionality, orthopedic insoles, training

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INTRODUCTION

Knee osteoarthritis (KOA) leads to the destruction of articular cartilage and loss of its function. Due to the aging of the population and changes in lifestyle leading to the development of obesity, an increase in the incidence of gonarthrosis is observed [1]. In 2018 The Food and Drug Administration (FDA) has recognized osteoarthritis (OA) as a serious disease [2, 3]. It is estimated that 8-9 million people suffer from it in Poland [4]. Gonarthrosis, which has become a global problem, significantly contributes to disability. It is also estimated that the incidence of OA will increase by 74.9% by 2050. Due to the alarming epidemiological data, the World Health Organization (WHO) has declared the years 2021-30 as the decade of healthy aging, which emphasizes the need to address diseases such as OA, which strongly affect functional capacity and quality of life. Therefore, there is an urgent need to introduce early diagnostics, effective therapeutic solutions, as well as monitoring the patient's health [5, 6]. Osteoarthritis begins in more than half of people over 40 years of age, and in every fifth person it causes reduced mobility and activity [4]. People with OA, compared to the healthy population, have more comorbidities and prefer a sedentary lifestyle, which results in a worse quality of life. In turn, reduced physical activity leads to a 20% higher mortality rate, correlated with age [7]. The most common symptom of KOA is pain in the area of knee joint. The pain leads to a reduced range of motion and muscle weakness. In addition, grinding or cracking is observed in the biomechanically changed joint, as well as frequent symptoms such as locking, swelling and instability of the knee [8]. KOA is also associated with short-term morning stiffness (<30 min), especially after sitting or lying down, as well as impaired balance and proprioception [9]. Pain-related impairments usually lead to difficulties in everyday activities such as walking, standing, and climbing stairs. They have a negative psychological impact and lead to a reduction in the quality of life. It is necessary to implement appropriate clinical pain assessment tools [8, 9]. Diagnosis is based on a history and physical examination as well as radiological

assessment. In clinical practice, many measures are used to assess the patient's condition, both in terms of radiological (Kellgren and Lawrence classification, Osteoarthritis Research Society International Joint Space Narrowing OARSI JSN, Fairbank or Jager-Wirth classification of OA) and functional (Western Ontario and Mcmaster University OA Index – WMOAC, Knee injury and OA Outcome Score KOOS, Community Balance and Mobility Scale – CB&M, Short Form – 36 – SF-36 arthritis-specific health index, Knee OA fears and beliefs questionnaire – KOFBeQ, Oxford Knee Score – OKS) [10]. It should be remembered that the lack of visible changes in the radiological assessment does not directly exclude the disease, and their presence is not key evidence that they are the source of the reported symptoms. Researchers emphasize that the confirmation of osteophytes visible in X-rays of the knee is characterized by a high sensitivity (91%) and specificity (83%), however, the simultaneous occurrence of osteophytes and knee pain shows good sensitivity (83%) and specificity (93%) in the diagnosis of gonarthrosis [7]. Therefore, it is important to assess the advancement of the disease not only by the X-ray, but also by taking into account the efficiency and quality of life of the patient with OA. Patients experience pain that affects daily activities, such as: getting out of bed or a chair, walking and climbing stairs. The most common tests used to assess the quality of life and functionality of people with gonarthrosis are the Western Ontario and McMaster Universities Osteoarthritis Index (WOMAC) and the Knee injury and Osteoarthritis Outcome Score (KOOS). In addition, in the functional assessment of people with KOA, OARSI recommends five key tests. These include the 30-s chair-stand test, the 40 m fast-paced walk test, a stair-climb test, the timed up-and-go test and the 6-min walk test [11, 12]. A comprehensive assessment of balance, both clinically and posturographically, is also recommended [13].

The deterioration of functionality of patients with gonarthrosis affects their quality of life. According to researchers, a significant deterioration of mental health is observed in the population of both men and women of older age in this group of patients [14]. In addition, low quality of life can be associated with a group of patients with demographic characteristics, such as a lower level of education or unemployment [15]. People with KOA in studies show significantly worse results in terms of mental well-being, independent living and social relationships compared to healthy people [16]. On the one hand, it is observed that patients with gonarthrosis are characterized by worse physical condition [17], and also have a higher BMI than healthy people [18]. On the other hand, studies indicate the benefits of using rehabilitation in this group of patients, which, together with patient education, improves the quality of life related to health [19]. It has also been shown that rehabilitation methods such as Mulligan, Pilates, Kinesiotaping, Aquatic Therapy are effective in combating symptoms related to gonarthrosis [20], and physical exercises effectively improve the patient's functionality [21, 22], even if performed at home [23, 24].

AIM

The aim of this study was to assess the quality of life and functionality of patients with KOA, using the Knee injury and Osteoarthritis Outcome Score (KOOS). The following research hypothesis was formulated – in patients with IIo advanced knee osteoarthritis, deficits in quality of life and functionality are observed, and individual home rehabilitation affects their improvement.

MATERIALS AND METHODS

The study was conducted with the consent of the Bioethics Committee of the Medical University of Białystok No. APK.002.103.2020 and included randomly selected patients reporting to the Rehabilitation Clinic of the Medical University of Białystok and the Emil Chojnowski Orthopedic and Prosthetic Center in Białystok with a diagnosis of bilateral knee osteoarthritis based on the ACR criteria, located in the medial compartment, in degree II according to the Kellgren and Lawrence scale. All participants were informed about the purpose of the study, methods of therapy and clinical evaluation, and they could clarify any unclear issues with the researcher. Then, each patient consented to participate by signing an appropriate declaration. The exclusion criteria included other diseases or injuries diagnosed in the patient that could directly affect their quality of life and functionality, namely: pregnancy, previous surgical procedures and injuries, especially in the spine and lower limbs, the presence of endoprosthesis, infections or congenital defects of the lower limb joints, and diseases of orthopedic-rheumatological, neurological, oncological, and internal medicine origin, as well as taking medications that may impair psychophysical activity.

During the qualification and functional assessment of the patients, a subjective examination was conducted, taking into account: patient data, BMI, type of changes in the X-ray examination. A detailed interview was conducted to determine whether the patient was eligible for further tests. The level of pain was determined on the VAS scale – people currently experiencing constant pain no higher than 5, located in the knee joint within the last month, were qualified for the assessment. Then, a physical examination was performed, including a manual assessment of the knee joint using functional tests, assessing the condition of the joint surfaces in the patellofemoral and femorotibial joints, the degree of meniscus damage and the efficiency of the ligament apparatus, in order to exclude other dysfunctions in the knee joint area, including the patella ballooning and displacement test, McConnell's test, ligament test – adduction – abduction, valgus – varus, anterior and posterior drawer and meniscal tests: Apley's, McMurray's and Steinmann's test. Ultimately, 125 people were qualified for the study group, while the control group consisted of randomly selected 41 people with a similar demographic structure to the study group.

In the next step, functional diagnostics were performed. The range of motion and muscle strength were assessed on the Lovett scale. Then, functional tests were performed that reflected the activities that people with KOA have

the most common problems with, i.e. a 10 m walk test for the values of time, speed and pain, as well as a test of moving from sitting to standing – Five Time Sit to Stand Test (5xSTS), consisting in measuring the time in which the patient has to stand up and sit on a chair (height approx. 43-46 cm) 5 times with their arms crossed on the chest. The next test was the assessment of sensorimotor control of the knee joint. The test proposed by Słupik A. et al. for the assessment of the knee joint in patients with gonarthrosis was used for this purpose. The test was performed in a sitting position with the knee and hip joints in 90o flexion, the foot resting on an exercise ball, and the patient's task was to keep the ball under the foot, against the force directed in different directions by the examiner, with both open and closed eyes. The test results were presented on a 6-point scale, where: 5 – the joint is stable, the patient keeps the ball under the foot, 4 – problems with keeping the ball in oblique or lateral movements, but there is no problem with movement in the sagittal plane, 3 – the patient keeps the ball without the examiner's movement, but there are problems when moving in any direction, 2 – the patient does not keep the ball with closed eyes, but with open eyes they keep it with slight resistance from the therapist, 1 – keeping the ball is possible only with open eyes, but without resistance, 0 – keeping the ball is impossible [25].

At the end of the study, participants were asked to complete the KOOS questionnaire – Knee injury and Osteoarthritis Outcome Score. This is a questionnaire that assesses knee-related pain, symptoms, activities of daily living, sports and recreational function, and quality of life on five separate subscales. Each item is answered by marking one of five response options on a Liker scale. A score from 0 to 100 is calculated for each of the subscales separately, where 100 means no problems and 0 means extremely serious problems [26, 27].

After the functional assessment, patients were randomly assigned to one of three therapeutic groups: a group subjected only to therapy consisting of a functional exercise program with elements of central stabilization training (n=43), a group subjected only to therapy consisting of wearing an individually performed method CNC milling of an orthopedic insole with elements of forefoot pronation, transverse pelotte and heel supination, with a Shore hardness scale of not less than 35, adapted to the patient's weight (n=43) and a group consisting of patients who simultaneously wore orthopedic insole and performed the recommended exercises (n=39).

The age structure and BMI in each group are presented in Table 1, while Figure 1 shows the random distribution of groups by gender.

The study group participants used the training recommendations for 6 weeks at home. Patients were previously instructed on how to use orthopedic insoles and how to perform the exercises recommended to them under the supervision of a physiotherapist. Supervision over the performance of the exercises was carried out through cyclical weekly check-ups with the patient, correcting the position of the foot or the position of the exercises. Both before and after the therapy with the selected method, the participants underwent a functional assessment. The obtained data were evaluated in the IBM SPSS Statistics version 27.0 program using the Mann-Whitney test to compare changes in individual measurements between the control group and the study group, and correlations were determined using the Spearman test. The level of significance was $p = 0.05$.

Institutional review board statement: Bioethical Commission no APK.002.103.2020, date: 25 February 2021.

Informed consent statement: Informed consent was obtained from all subjects involved in the study.

RESULTS

In the assessment of passive and active knee flexion, statistically significant differences were obtained between the assessed groups ($p<0.001$). In turn, in the assessment of muscle strength on the Lovett scale, statistically significant differences were obtained between the groups ($p=0.001$) for both flexion and extension of both knee joints. The study group obtained worse results in comparison with the

Table 1. Demographic structure of the study group

		N	M	Me	Min	Max	Q1	Q3	SD
Age	Total	166	49,31	54	28	63	42	58	10,53
	Exercises	43	52,12	54	28	62	50	57	7,72
	Orthopedic Insole	43	51,19	55	30	61	46	58	9,3
	Mixed	39	52,38	58	28	63	44	60	11
	Control	41	41,49	39	30	60	32	49	10,23
BMI	Total	166	27,52	26,47	18,52	39,79	24,03	30,12	4,73
	Exercises	43	26,36	24,39	20,07	37,4	23,57	28,08	4,24
	Orthopedic Insole	43	28,92	28,39	18,52	39,79	26,4	30,67	4,5
	Mixed	39	27,69	26,18	21,16	37,51	24,09	30,49	4,62
	Control	41	27,1	25,93	18,94	38,67	23,84	30,45	5,31

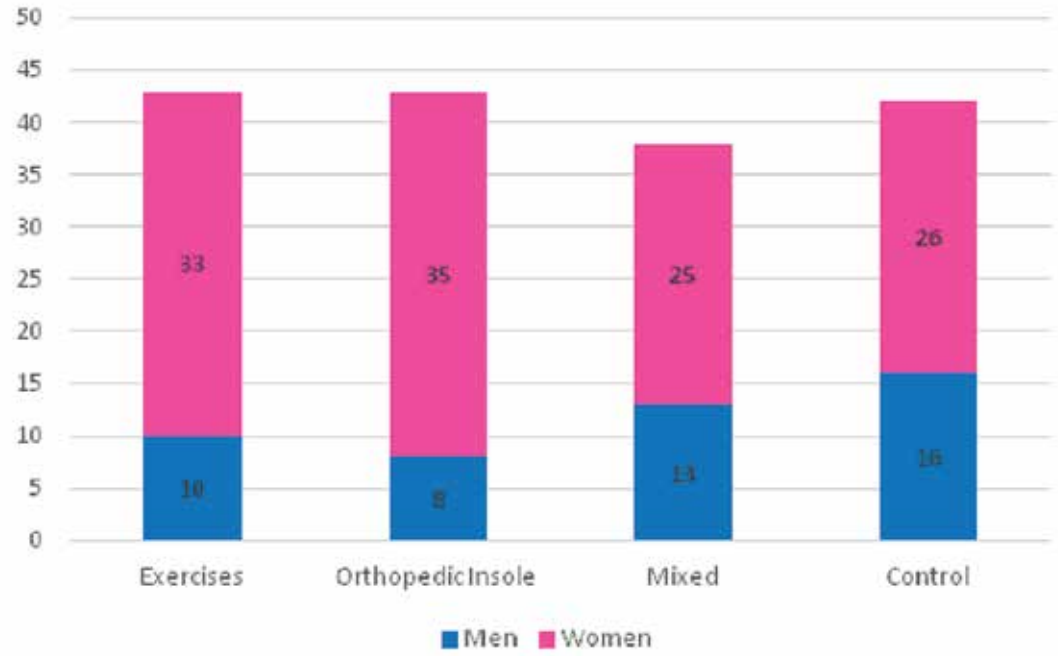

Fig. 1. Gender distribution in the individual study groups.

Table 2. Assessment of strength and range of motion between the control group and the study group

	Control group							Study group							
	M	SD	Min	Q1	Me	Q3	Max	M	SD	Min	Q1	Me	Q3	Max	p
Active flexion of the left knee	122,63	4,71	100	120	125	125	125	114,74	11,42	80	110	120	124,5	125	0,000
Passive flexion of the left knee	130,22	5,16	110	127	130	135	135	121,14	9,60	90	115	125	128	135	0,000
Active flexion of the right knee	122,68	4,71	100	120	125	125	125	114,58	11,56	80	110	120	122	125	0,000
Passive flexion of the right knee	130,22	5,16	110	127	130	135	135	120,91	10,86	81	116,5	125	128,5	135	0,000
Left knee flexion strength	4,99	0,08	4,5	5	5	5	5	4,81	0,35	4	4,5	5	5	5	0,001
Left knee extension strength	4,99	0,08	4,5	5	5	5	5	4,79	0,37	4	4,5	5	5	5	0,001
Right knee flexion strength	4,99	0,08	4,5	5	5	5	5	4,78	0,39	3,5	4,5	5	5	5	0,001
Right knee extension strength	4,99	0,08	4,5	5	5	5	5	4,80	0,37	4	4,5	5	5	5	0,001

control group, which may confirm the fact that weakened muscle strength is present in patients with OA (Table 2).

In the 10 m Walking Test, statistically significant differences were obtained for parameters such as: walking time – shorter in the control group, speed – longer in the control group and pain – shorter in the control group. In the Five Time Sit to Stand Test, statistically significant differences ($p<0.001$) were obtained in the assessment of their mean value. Healthy people performed the task faster than people with degenerative changes in the knee joints. Similarly, differences were shown in the sensorimotor assessment of the joint using SCT (sensorimotor control test) – better results were achieved by healthy people (Table 3).

The KOOS scale showed differences between the control group and the study group ($p<0.001$) in the assessment of each aspect – pain, symptoms, daily life activities, sports and recreational activities and quality of life. These results

suggest that knee OA directly affects the functionality and quality of life of patients in various areas (Table 4).

After the applied form of therapy in the assessment of the range of motion using the SFTR method after therapy, a statistically significant difference was obtained in the active and passive flexion of the knee joint in all the studied groups and an improvement in the strength according to the Lovett scale of flexion and extension in both knee joints. In each of the groups, in the assessment of the strength of flexion and extension of the right and left knee joint, no differences were obtained in the median value (equal to 5), nor in the assessment of the maximum degree (equal to 5). This fact may indicate good fitness and muscle strength of the people undergoing rehabilitation, therefore the upper values did not change significantly, and the median remained at a constant level.

The groups did not differ statistically significantly in assessing the range of mobility and muscle strength (Table 6).

In the 10 m Walking Test, statistically significant differences were obtained in the values of the results after the therapy compared to those before the therapy. In the evaluation of variables for the 10 m Walking Test, no statistically significant differences were obtained between the groups in the assessment of pain (p=0.316), which allows us to conclude that each form of therapy brings analgesic benefits. However, statistically significant differences were shown between the groups in the time parameter (p=0.030) and speed (p=0.010). For both time and speed, the best effect was achieved in the "Mixed" group, then in the "Orthopedic Insole" group, and later in the "Exercises" group.

Comparing the results of the five-time sit-to-stand test in the first and second attempts and their mean values, statistically significant differences were achieved in the assessment of the effects of the applied therapies. In the assessment of variables for the median value, the participants of the "Mixed" group coped with the task the fastest, followed by the "Exercises" and then the "Orthopedic Insole".

Similar significances in the assessment of the therapy effect were obtained in the SCT parameters, however, no significant differences were obtained between the assessed groups, which allows us to conclude that each of the therapies brings benefits (Tables 7 and 8).

In the assessment of quality of life and functionality according to the KOOS questionnaire, statistically significant differences were obtained before and after therapy in all groups in the following aspects: pain, symptoms, ADL, sports and recreation, and QOL. In the studies on the assessment of the obtained variables before and after therapy, statistically significant differences were obtained between the groups in relation to pain parameters, activities of daily living, sports and recreational activity, and quality of life. In the assessment of pain according to the KOOS (p=0.022), ADL (p=0.007), sports and recreation (p<0.001), and QOL (p=0.001), the greatest improvement was achieved in the group subjected to both forms of therapy, then in the group that performed only exercises, and the smallest in those using only orthopedic insoles (Table 9).

No statistically significant differences were found between the groups in relation to the symptoms studied. This may be confirmed by the fact that the physiotherapeutic interventions that the study participants were subjected to primarily affect pain relief, facilitate the performance of daily activities, enable better and easier activation of the patient in sports and recreational activities, as well as physical activity, and improve the quality of life in many aspects (Table 10).

In the assessment of age, statistically significant negative correlations were obtained for variables such as: KOOS score in the assessment of pain, symptoms, ADL, sports and recreation and QOL, right and left knee flexion, both active and passive, right knee flexion strength, speed during 10 m walking. The obtained correlations indicate that the older the patient, the lower the above parameters. In turn, a positive correlation was obtained in the assessment of: pain level, pain at rest, during exertion, during the day and at night, time to walk 10 m, as well as during the five-times standing up and sitting down test and for the level of pain during 10 m walking. After the therapy, in most cases, improvement was achieved without the existing correlation between variables – negative correlations increased and positive correlations decreased.

Table 3. Functional assessment in the gait test, 5xSTS and SCT for the right and left limbs between the control group and the study group

	Control group							Study group							p
	M	SD	Min	Q1	Me	Q3	Max	M	SD	Min	Q1	Me	Q3	Max	
10 m Walking Test – time	6,81	3,14	5,12	5,47	5,98	6,65	24	8,74	1,76	5,34	7,33	8,34	9,93	13,49	0,000
10 m Walking Test – speed	1,60	0,33	0,42	1,51	1,67	1,83	1,95	1,19	0,23	0,74	1,01	1,20	1,36	1,87	0,000
10 m Walking Test – pain	0,00	0,00	0	0	0	0	0	0,88	1,68	0	0	0	1	6	0,000
5xSTS	8,35	3,99	5,01	6,02	6,99	9,39	27,5	12,39	3,01	5,92	10,81	11,74	13,26	20,59	0,000
SCT right	5,00	0,00	5	5	5	5	5	4,42	0,53	3	4	4	5	5	0,000
SCT left	5,00	0,00	5	5	5	5	5	4,45	0,50	4	4	4	5	5	0,000

The assessment of the above variables allows us to state that there is a relationship between age and increased pain. This is confirmed by the fact that the older the patient, the worse their functionality and quality of life are.

In the BMI assessment, few correlations were obtained, which suggest that with increasing weight, patients indicate a worse result assessing the level of pain in relation to the KOOS questionnaire. Passive and active knee flexion also deteriorates with increasing weight. In addition, a positive correlation was observed in the case of pain level during the day and during the transition from sitting to standing – overweight and obese patients had more problems with faster performance of the task consisting in changing position in a short period of time and were characterized by greater pain with increasing weight. This is a correct correlation, because the higher the weight, the greater the load on the knee joints, and thus the feeling of pain may be intensified. This fact allows us to assume that the more obese patients are, the less functionally efficient they are, especially in the assessment of balance, range of motion or physical activity. However, after the applied rehabilitation, the correlation values improve, and sometimes the correlation with BMI does not appear at the level of statistical significance. It should therefore be concluded that rehabilitation has a beneficial effect on the functionality and quality of life of patients with knee OA, also in those who are overweight or obese (Table 11).

DISCUSSION

Gonarthrosis is a common rheumatic disease that causes pain that significantly reduces the quality of life. It has been observed that in a group of 5401 patients with OA, pain complaints mainly concerned the joints: hip, knee or lower spine. Moreover, significant associations are indicated between the location of pain and reduced mental health and quality of life. Considering the quality of life in relation to gender, in the case of men, hip joint pain has the greatest impact on the quality of life, while in women – knee joint pain [28]. A systematic review and meta-analysis by Yan H. et al. shows that the total mean quality of life score for each domain of the SF-36 questionnaire (physical function, physical role function, bodily pain, general health, vitality, social function, emotional role function, mental health) was lower in patients with osteoarthritis than in the control group consisting of healthy people [29]. In turn, in the study conducted by Adiguzel L. and Kilic D with the participation of 129 people with gonarthrosis, the results obtained in the KOOS Functioning and Daily Life scale showed the functional status of the participants at the level of 46.61 ± 16.17. The results in the Functioning and Sports/Recreational Activities subscale were 29.49 ± 23.73, and the mean results in the Quality of Life subscale were 34.15 ± 18.11 [30].

Similar observations were obtained in the current study – the study group significantly differed from the control group in the assessment of the KOOS questionnaire – patients with gonarthrosis achieved lower results at the determined level of statistical significance than the group of healthy people. This confirms the fact that the quality

Table 4. Functional and quality of life assessment on the KOOS scale between the control group and the study group

	Control group							Study group							
	M	SD	Min	Q1	Me	Q3	Max	M	SD	Min	Q1	Me	Q3	Max	p
Pain	98,98	2,30	91,67	100	100	100	100	67,71	15,44	33,33	58,33	66,67	77,78	100	0,000
Symptoms	98,87	3,52	85,71	100	100	100	100	76,09	16,89	28,57	64,29	78,57	89,29	100	0,000
ADL	99,18	1,80	92,65	100	100	100	100	71,78	17,97	33,82	52,94	76,47	86,76	100	0,000
Sport	97,56	6,53	75	100	100	100	100	47,04	24,92	0	30	45	70	100	0,000
QoL	97,71	5,55	81,25	100	100	100	100	52,25	18,62	12,5	37,5	56,25	68,75	93,75	0,000

Table 5. Assessment of strength and range of motion before and after the forms of therapy used

		Before therapy							After 6 weeks therapy							p
	Group	M	SD	Min	Q1	Me	Q3	Max	M	SD	Min	Q1	Me	Q3	Max	
Active flexion of the left knee	Exercises	119,70	6,85	85	118	120	125	125	123,63	3,27	110	125	125	125	125	0,000
	Orthopedic Insole	109,93	12,79	80	100	110	120	125	116,05	8,77	90	111	118	125	125	0,000
	Mixed	114,56	11,78	80	110	120	120	125	120,67	6,55	100	117	125	125	125	0,000
Passive flexion of the left knee	Exercises	124,44	6,95	90	123	125	130	135	130,49	5,26	110	128	130	135	135	0,000
	Orthopedic Insole	118,26	10,29	95	110	120	126	135	122,84	9,24	95	119	125	130	135	0,000
	Mixed	120,69	10,43	95	118	125	125	135	126,92	7,74	105	125	128	135	135	0,000
Active flexion of the right knee	Exercises	119,23	6,77	85	119	120	125	125	124,09	2,39	115	125	125	125	126	0,000
	Orthopedic Insole	109,49	13,20	80	100	110	120	125	115,58	10,31	85	112	120	125	125	0,000
	Mixed	115,08	11,78	80	110	120	120	125	120,44	7,82	100	117	125	125	126	0,000
Passive flexion of the right knee	Exercises	124,35	7,10	90	123	125	130	135	130,70	4,56	117	129	130	135	135	0,000
	Orthopedic Insole	117,84	11,87	81	110	120	129	135	122,53	10,60	90	120	125	130	135	0,000
	Mixed	120,51	12,21	82	120	125	125	135	127,03	7,62	105	125	129	135	135	0,000
Left knee flexion strength	Exercises	4,84	0,28	4	4,5	5	5	5	5,00	0,00	5	5	5	5	5	0,001
	Orthopedic Insole	4,79	0,40	4	5	5	5	5	4,97	0,13	4,5	5	5	5	5	0,004
	Mixed	4,81	0,36	4	4,5	5	5	5	5,00	0,00	5	5	5	5	5	0,004
Left knee extension strength	Exercises	4,74	0,37	4	4,5	5	5	5	5,00	0,00	5	5	5	5	5	0,000
	Orthopedic Insole	4,80	0,40	4	5	5	5	5	4,97	0,13	4,5	5	5	5	5	0,006
	Mixed	4,82	0,35	4	5	5	5	5	5,00	0,00	5	5	5	5	5	0,006
Right knee flexion strength	Exercises	4,76	0,37	4	4,5	5	5	5	5,00	0,00	5	5	5	5	5	0,000
	Orthopedic Insole	4,77	0,45	3,5	5	5	5	5	4,98	0,11	4,5	5	5	5	5	0,004
	Mixed	4,83	0,33	4	5	5	5	5	5,00	0,00	5	5	5	5	5	0,006
Right knee extension strength	Exercises	4,72	0,38	4	4,5	5	5	5	5,00	0,00	5	5	5	5	5	0,000
	Orthopedic Insole	4,83	0,38	4	5	5	5	5	4,98	0,11	4,5	5	5	5	5	0,009
	Mixed	4,85	0,33	4	5	5	5	5	5,00	0,00	5	5	5	5	5	0,010

Table 6. Assessment of strength and range of motion before and after the applied forms of therapy – comparison of groups

Exercises	p	Orthopedic Insole							Orthopedic Insole							Mixed						
		M	SD	Min	Q1	Me	Q3	Max	M	SD	Min	Q1	Me	Q3	Max	M	SD	Min	Q1	Me	Q3	Max
Active flexion of the left knee	0,348	3,93	4,30	0	0	5	5	25	6,12	7,63	0	0	3	10	27	6,10	6,84	0	1	5	7	30
Passive flexion of the left knee	0,094	6,05	4,15	0	4	5	10	20	4,58	4,39	0	0	5	5	15	6,23	4,75	0	3	5	10	20
Active flexion of the right knee	0,696	4,86	5,60	0	0	5	6	35	6,09	7,40	0	0	5	10	27	5,36	4,86	0	1	5	7	20
Passive flexion of the right knee	0,265	6,35	5,61	0	2	5	10	30	4,70	4,45	0	0	5	5	15	6,51	6,96	0	3	5	10	33
Left knee flexion strength	0,958	0,16	0,28	0	0	0	0,5	1	0,17	0,34	0	0	0	0	1	0,19	0,36	0	0	0	0,5	1
Left knee extension strength	0,264	0,26	0,37	0	0	0	0,5	1	0,16	0,34	0	0	0	0	1	0,18	0,35	0	0	0	0	1
Right knee flexion strength	0,471	0,24	0,37	0	0	0	0,5	1	0,21	0,43	0	0	0	0	1,5	0,17	0,33	0	0	0	0	1
Right knee extension strength	0,081	0,28	0,38	0	0	0	0,5	1	0,15	0,34	0	0	0	0	1	0,15	0,33	0	0	0	0	1

Table 7. Functional assessment in the 10 m walking test, 5xSTS and SCT for the right and left limbs before and after therapy

		Before therapy							After 6 weeks therapy							p
	Group	M	SD	Min	Q1	Me	Q3	Max	M	SD	Min	Q1	Me	Q3	Max	
10 m Walking Test – time	Exercises	8,80	1,68	5,63	7,45	8,56	9,95	12,4	7,51	1,44	4,89	6,78	7,23	8,1	12,15	0,000
	Orthopedic Insole	8,67	1,96	5,34	7,13	8,23	9,56	13,49	6,58	1,69	3,9	5,01	6,45	7,87	10,67	0,000
	Mixed	8,76	1,66	6,56	7,34	8,34	9,98	12,78	6,14	1,50	4,12	4,67	6,14	7,12	9,97	0,000
10 m Walking Test – speed	Exercises	1,18	0,22	0,81	1,01	1,17	1,34	1,78	1,38	0,25	0,82	1,23	1,38	1,47	2,04	0,000
	Orthopedic Insole	1,21	0,26	0,74	1,05	1,22	1,40	1,87	1,62	0,43	0,94	1,27	1,55	2,00	2,56	0,000
	Mixed	1,18	0,21	0,78	1,00	1,20	1,36	1,52	1,72	0,40	1,00	1,40	1,63	2,14	2,43	0,000
10 m Walking Test – pain	Exercises	0,56	1,35	0	0	0	0	6	0,07	0,46	0	0	0	0	3	0,011
	Orthopedic Insole	1,00	1,77	0	0	0	3	6	0,12	0,54	0	0	0	0	3	0,002
	Mixed	1,10	1,89	0	0	0	3	6	0,13	0,57	0	0	0	0	3	0,002
5xSTS	Exercises	11,92	2,33	7,935	10,625	11,68	12,56	18,56	10,26	2,31	6,015	8,825	10,05	11,4	17,265	0,000
	Orthopedic Insole	12,61	3,73	5,915	10,935	11,58	13,35	20,585	10,68	3,06	5,33	9,125	10,355	11,895	17,7	0,000
	Mixed	12,67	2,79	8,235	10,74	12,16	14,22	18,72	9,86	2,16	6,415	8,665	9,285	10,575	15,67	0,000
SCT right	Exercises	4,40	0,49	4	4	4	5	5	5,00	0,00	5	5	5	5	5	0,000
	Orthopedic Insole	4,44	0,55	3	4	4	5	5	5,00	0,00	5	5	5	5	5	0,000
	Mixed	4,41	0,55	3	4	4	5	5	5,00	0,00	5	5	5	5	5	0,000
SCT left	Exercises	4,58	0,50	4	4	5	5	5	5,00	0,00	5	5	5	5	5	0,000
	Orthopedic Insole	4,35	0,48	4	4	4	5	5	5,00	0,00	5	5	5	5	5	0,000
	Mixed	4,41	0,50	4	4	4	5	5	5,00	0,00	5	5	5	5	5	0,000

Table 8. Functional assessment in the 10 m walking test, 5xSTS and SCT for the right and left limbs before and after therapy - comparison of groups

	Exercises								Orthopedic Insole							Mixed						
	p	M	SD	Min	Q1	Me	Q3	Max	M	SD	Min	Q1	Me	Q3	Max	M	SD	Min	Q1	Me	Q3	Max
10 m Walking Test – time	0,030	-1,29	0,89	-4,22	-1,71	-1,12	-0,68	0	-2,09	2,39	-8,91	-2,67	-1,15	-0,69	-0,11	-2,63	2,18	-7,59	-4,13	-1,54	-0,88	-0,24
10 m Walking Test – speed	0,010	0,20	0,12	0,00	0,11	0,18	0,28	0,45	0,42	0,44	0,02	0,08	0,20	0,69	1,50	0,54	0,45	0,05	0,14	0,32	0,88	1,43
10 m Walking Test – pain	0,316	-0,49	1,24	-6	0	0	0	0	-0,88	1,50	-4	-3	0	0	0	-0,97	1,61	-6	-3	0	0	0
5xSTS	0,015	-1,66	1,29	-5,41	-1,83	-1,29	-0,83	-0,365	-1,93	1,69	-6,68	-2,68	-1,22	-0,74	-0,03	-2,81	2,16	-8,25	-3,36	-2,4	-1,17	-0,4
SCT right	0,877	0,60	0,49	0	0	1	1	1	0,56	0,55	0	0	1	1	2	0,59	0,55	0	0	1	1	2
SCT left	0,083	0,42	0,50	0	0	0	1	1	0,65	0,48	0	0	1	1	1	0,59	0,50	0	0	1	1	1

Table 9. Functional assessment in the KOOS questionnaire before and after therapy

	Group	Before therapy							After 6 weeks therapy							p
		M	SD	Min	Q1	Me	Q3	Max	M	SD	Min	Q1	Me	Q3	Max	
Pain	Exercises	72,03	16,72	33,33	61,11	72,22	88,89	100,	90,05	12,28	47,22	88,89	94,44	100	100	0,000
	Orthopedic Insole	67,38	14,59	38,89	58,33	69,44	75,00	100	82,82	13,85	50,00	72,22	80,56	94,44	100	0,000
	Mixed	63,32	13,88	38,89	52,78	63,89	72,22	94,44	86,04	12,28	55,56	77,78	88,89	94,44	100	0,000
Symptoms	Exercises	79,07	14,00	35,71	71,43	82,14	89,29	96,43	92,28	9,73	50,00	92,86	92,86	96,43	100	0,000
	Orthopedic Insole	77,24	18,80	28,57	67,86	78,57	96,43	100	87,54	14,01	50,00	82,14	92,86	100	100	0,000
	Mixed	71,52	17,04	28,57	60,71	71,43	85,71	92,86	86,90	11,83	53,57	78,57	89,29	96,43	100	0,000
ADL	Exercises	78,15	17,49	33,82	72,06	83,82	92,65	97,06	92,92	10,05	52,94	92,65	95,59	100,00	100	0,000
	Orthopedic Insole	72,09	18,43	38,24	55,88	76,47	86,76	100	85,36	15,07	51,47	75,00	91,18	98,53	100	0,000
	Mixed	64,40	15,44	38,24	51,47	63,24	76,47	95,59	85,63	12,68	54,41	79,41	89,71	95,59	100	0,000
Sport and Recreation	Exercises	49,42	25,08	0	30	50	75	80	80,00	18,13	30	70	80	100	100	0,000
	Orthopedic Insole	54,19	25,26	0	30	55	75	100	70,12	24,39	5	55	70	90	100	0,000
	Mixed	36,54	21,19	0	15	35	55	80	72,05	21,60	25	60	75	90	100	0,000
QOL	Exercises	57,12	17,01	12,5	50	56,25	68,75	81,25	81,10	14,53	50	68,75	81,25	93,75	100	0,000
	Orthopedic Insole	54,94	19,31	12,5	43,75	56,25	68,75	93,75	72,53	20,51	18,75	62,5	75	87,5	100	0,000
	Mixed	43,91	17,12	12,5	25	43,75	56,25	81,25	72,12	15,83	37,5	62,5	75	81,25	100	0,000

Table 10. Functional assessment in the KOOS questionnaire before and after therapy – comparison of groups

		Exercises							Orthopedic Insole							Mixed						
	p	M	SD	Min	Q1	Me	Q3	Max	M	SD	Min	Q1	Me	Q3	Max	M	SD	Min	Q1	Me	Q3	Max
Pain	0,022	18,02	11,10	0	11,11	16,67	25,00	47,22	15,44	9,14	0	8,33	13,89	19,44	47,22	22,72	12,24	2,78	11,11	22,22	33,33	50,00
Symptoms	0,093	13,21	10,59	0	3,57	10,71	17,86	46,43	10,30	8,96	0	0	10,71	17,86	35,71	15,38	11,15	0	3,57	14,29	21,43	39,29
ADL	0,007	14,77	10,43	0	7,35	13,24	20,59	52,94	13,27	10,05	0	4,41	10,29	19,12	41,18	21,23	12,75	1,47	11,76	19,12	27,94	52,94
Sport and Recreation	0,000	30,58	16,59	0	20	30	45	60	15,93	11,40	0	5	15	25	45	35,51	13,66	10	20	35	45	70
QOL	0,001	23,98	11,88	0	18,75	18,75	31,25	50	17,59	10,76	0	6,25	18,75	25	43,75	28,21	13,21	0	18,75	31,25	37,5	56,25

Table 11. Pre- and post-therapy correlations for age and BMI for individual functional tests

	Age before		Age after	
	r	p	r	p
KOOS Pain	-0,48	0,000	-0,32	0,000
KOOS Symptoms	-0,49	0,000	-0,23	0,011
KOOS ADL	-0,50	0,000	-0,36	0,000
KOOS Sport and Recreation	-0,49	0,000	-0,43	0,000
KOOS QOL	-0,44	0,000	-0,43	0,000
Active flexion of the left knee	-0,60	0,000	-0,48	0,000
Passive flexion of the left knee	-0,62	0,000	-0,51	0,000
Active flexion of the right knee	-0,55	0,000	-0,41	0,000
Passive flexion of the right knee	-0,60	0,000	-0,51	0,000
Right knee flexion strength	-0,16	0,035	0,09	0,307
10 m Walking Test - time	0,55	0,000	0,07	0,466
10 m Walking Test - speed	-0,55	0,000	-0,07	0,466
10 m Walking Test - pain	0,24	0,001	0,19	0,037
5xSTS	0,43	0,000	-0,03	0,738
	BMI before		**BMI after**	
	r	p	r	p
KOOS Pain	-0,17	0,025	-0,13	0,135
Active flexion of the left knee	-0,45	0,000	-0,37	0,000
Passive flexion of the left knee	-0,37	0,000	-0,31	0,000
Active flexion of the right knee	-0,47	0,000	-0,31	0,001
Passive flexion of the right knee	-0,36	0,000	-0,29	0,001
5xSTS	0,19	0,012	0,07	0,448

of life and functionality of people with gonarthrosis is lower than in the control group.

On the other hand, regular exercise and physical activity have a positive effect on the quality of life in patients with knee OA, which in the long term allows for the optimization of the quality of life and functionality of patients with OA. A study conducted by Lopes D.G et al. in a community sample of Portuguese adults with HKOA showed that regular physical activity was positively associated with long-term improvement in physical function and HRQoL. Using linear mixed models, frequent and very frequent physical activity were associated with improved physical function and quality of life compared with infrequent exercise, taking into account, among others, gender, age, years of education, BMI, comorbidity, hospitalization, clinical severity of symptoms and unmanageable pain levels [31].

Similar conclusions were also obtained in this study. After 6 weeks of rehabilitation, all groups achieved an improvement in functionality and quality of life assessed according to the KOOS questionnaire. Moreover, significant differences in the three study groups were achieved for KOOS variables such as: pain, activities of daily living (ADL), sports and recreation, and quality of life. The group with combined therapy performed best in this respect, the

second group was the group subjected to exercises, and the third to the insoles alone.

In the study by Master H. et al., it was proven that the slower the walking speed measured using the short and standard distance walking test, the higher the risk of mortality in adults with KOA [32].

In our study, a difference between the control group and the study group was also achieved at the level of statistical significance – people with KOA were characterized by an average speed at the median level of 1.2 compared to healthy people 1.67 m/s. Moreover, after the therapy, this value improved in each of the groups – for exercises from 1.17 m/s to 1.38 m/s, for inserts from 1.22 m/s to 1.55 m/s and for combined therapy from 1.2 m/s to 1.63 m/s.

Tong B. et al. in their study observed that the higher the BMI level in patients with KOA, the worse the knee pain and functioning. In KOA patients, fat mass was positively associated with pain in both knees, WOMAC and 5xSTS scores [33]. This study showed a negative correlation in KOOS pain scores – patients with a higher BMI achieved lower scores in the KOOS pain subscale and also needed more time in the Five Time Sit to Stand test. However, after the applied form of therapy, these correlations were not observed at the level of statistical significance, which means that the rehabilitation program significantly improved pain and functionality regardless of BMI.

CONCLUSIONS

Rehabilitation improves the functionality and quality of life of patients with bilateral medial compartment gonarthrosis

The most effective method is a combination of exercises and the simultaneous use of an orthopedic insert

Rehabilitation has a beneficial effect on the functionality and quality of life of patients with knee OA, also in overweight or obese patients

LIMITATION, RECOMMENDATIONS, AND GENERALIZATIONS

The research carried out had limitations as well as benefits. The limitations include the fact that the results of the functional tests could be influenced by the patient's state of rest or mood, which could lower the test values. In a future study, the inclusion of an addi-tional survey assessing the patient's mood and wakefulness should be considered. Additionally, the patients' level of physical activity may also have an impact on their ability to maintain functionally, which should be taken into account in further research. The presented clinical assessments can be used in the offices of both primary care physicians and physiotherapists to detect quality of life in people with early gonarthrosis, which is one of the advantages of this examination. Home based rehabilitation programe with orthopaedic insoles should be a practital form o therapy patients with bilateral medial gonarthrosis.

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The data presented in this study are made available at the request of the corresponding author due to the limitations of RODO data availability.

CONFLICT OF INTEREST

The Authors declare no conflict of interest

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ORIGINAL ARTICLE

Stress resistance as a professionally significant trait of the future rehabilitators in the system of physical education

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ABSTRACT

Aim: The aim of the study is to determine the level of stress resistance of the future rehabilitators in the system of physical education as a professionally significant feature and the impact of stress resistance on the preservation of mental health of participants in the educational process.

Materials and Methods: The study was conducted during 2022–2024, in which 320 respondents from following institutions took part: Luhansk Taras Shevchenko National University, Municipal Establishment «Kharkiv Humanitarian Pedagogical Academy» of Kharkiv, Regional Council, Poltava State Medical University, National University «Zaporizhzhia Polytechnic».

Results: The results of the study contributed to the development of research skills through the method of analysis and improvement of students' practical skills. They were involved in research work (writing qualification papers on the topic of research, writing articles and theses, participation in scientific and professional quests, conferences of various levels, including international ones; participation in trainings, master classes, development of mini-projects on health care activities). 12 discussions on the topic of research, 6 trainings, 6 guest lectures, 3 scientific and professional quests were held, the content of 10 educational programs was updated, students were trained in partner institutions under the internal mobility program.

Conclusions: The use of psychocorrective programs in working with young people to develop stress resistance and improve mental health allows to significantly improve their psychological state, adaptation and socialization.

KEY WORDS: physical activity, stress resistance, physical education, physical rehabilitation, mental health, future bachelors

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INTRODUCTION

In recent years, the growing volume of information in social networks, the intensification of studies, various stress factors caused by the state of war due to russian aggression, have affected the state of mental health of pupils and student youth. Therefore, the psychological effects of war can have a significant impact on our mental health long after the end of the conflict, and this impact can last at least 7-10 years. In the situation we have today, it is important to stay calm and maintain emotional stability. One of the key aspects in maintaining mental health is the development of stress resistance. This means the ability to effectively manage stress and restore emotional resources. One recommendation is to regulate the amount of information we consume. An excessive amount of negative information can increase the level of stress, so it is important to limit access to overly impressive news and focus on constructive actions during this difficult time, actively engage in physical activity.

A study noted that physical activity has a significant protective effect against depression in young people. This suggests that participating in sport or exercise may help prevent depression in young people. Scientists are also investigating how exactly physical activity is able to exert its antidepressant effect through biological and psychosocial mechanisms. Particular attention is paid to physical exercises, because they can have the greatest impact on mental health. Experts say that exercise, which is usually done during free time, is particularly beneficial for mental health, compared to activity done during school or work hours [1]. This may be because leisure time activities allow young people to relax and unwind, as well as reduce stress levels, which improves mood and mental well-being.

The issue of preventing stress and increasing the stress resistance of the individual was revealed in their works by such scientists [2-7]. Dynamics of students' fitness level while differentiating physical education classes in accordance with their health and nosology of diseases [8, 9]; Methodical system of using fitness technologies in physical education of students [10, 11]; System of preparation of future fitness coaches'for health-improving activity in the conditions of rehabilitation establishments[12]; Influence of different training activities on development of junior athletes' logical thinking [13]; Leisure and recreational activities of student youth in the context of healthpreservation [14]; Method of physical improvement of higher education students by means of functional training in the aspect of health-preservation [15]; Fostering the social activity of future specialists in physical education and sports in a health-preserving environment [16]; The influence of tae-bo on the development of motor potential of students of medical and pedagogical specialties and its efficiency in the process of extracurricular activitiesh [17]; Physical activity and incident depression: a meta-analysis of prospective cohort studies [1]. An analysis of studies in different countries shows that along with the threat to physical health, there is also a deterioration of the mental state in Germany, China, Israel, Turkey, Ukraine [18]. At the same time, despite a significant number of multifaceted studies, a small number of scientific works are tracked, in which the ways of forming stress resistance in order to preserve the mental health of pupils and student youth would be considered holistically and comprehensively.

It is common knowledge that mental health is extremely important for the successful and happy life of young people. It is a key factor affecting the achievement of life and professional goals, as well as general physical well-being. The term «mental health» is usually understood to mean «psychological health», but it encompasses more, including emotional, spiritual and social well-being. The World Health Organization defines mental health as a state of happiness and well-being in which a person develops his creative abilities, is able to withstand the stresses of life, work productively and contribute to social life [19-21]. Therefore, mental health provides a sense of value and control over oneself, contributes to the formation of the personality in all its aspects, helps to determine how we feel emotionally, how we react to stress, how we communicate with other people and what decisions we make. It is obvious that future professionals must be healthy, both physically and emotionally, have a high level of energy and vitality, be active, be able to communicate and have a high work capacity to be competitive in the labor market. Mental health allows us to cope with the normal stresses of life, be productive and make a meaningful contribution to society. This state gives us the opportunity to realize our potential, develop and overcome life's challenges. Mental health affects the way we think, act and communicate, helping us build meaningful relationships, make informed decisions and achieve our goals.

AIM

The aim of the study is to determine the level of stress resistance of the future rehabilitators in the system of physical education as a professionally significant feature and the impact of stress resistance on the preservation of mental health of participants in the educational process.

MATERIALS AND METHODS

The study was conducted during 2022-2024, in which 320 respondents educational and professional programs: «Therapy and rehabilitation», «Secondary education (Physical culture)», «Physical culture and sport (Fitness)» and «Physical culture and sport (Physical education)» from following institutions took part: Luhansk Taras Shevchenko National University, Municipal Establishment «Kharkiv Humanitarian Pedagogical Academy» of Kharkiv, Regional Council, Poltava State Medical University, National University «Zaporizhzhia Polytechnic». All educational and professional programs are united by a single goal – readiness for health-preserving activities.

The essence of the experiment was to improve and update the content of the educational components of the educational disciplines: «Psychology of physical culture and sports», «Health-preserving technologies in physical education and sports», «Pedagogical diagnosis of learning in physical culture», «Organization of health and sports and mass work», «Theory and technologies of health-recreational motor activity», «Health pedagogy», «Fitness technologies and recreation», «Sports medicine with the basics of physical culture and sports rehabilitation», «Medical medical care», «Moving and recreational games» with extensive use of the Internet, modern information tools, competency-based and student-centered approaches. This contributed to the determination of the impact of stress resistance on the preservation of mental health, the development of methodological support and recommendations for strengthening the motivation of education seekers for health-preserving activities. Thanks to the updated educational components, developed methodical support for conducting practical classes, and during practice, the practical component of training future rehabilitators has been improved. The obtained results were analyzed, summarized and discussed at the departments whose teachers participated in the experiment, as well as during presentations at scientific and practical conferences.

Building stress resistance and improving students' mental health are important tasks, especially in the conditions of modern workload and rapidly changing circumstances. At different stages we have used such set of research methods:

- *Theoretical* – methods of conceptual and comparative analysis, which compared the existing theoretical approaches on the basis of generalization of philosophical, methodological, psychological, pedagogical, educational literature and video materials; method of structural-system analysis and modeling.
- *Empirical* – pedagogical observation, questionnaires, surveys using the Spielberger anxiety method to deter-

mine the impact of stress resistance on mental health, a pedagogical experiment to identify the degree of development of the problem.

The work uses the following modern methods to achieve these goals: meditation and conscious attention (Mindfulness); the Spielberger Anxiety Questionnaire; physical activity as an anti-stress factor (cardio training, yoga, pilates, health fitness, team sports help to reduce the level of stress due to the release of endorphins; relaxation techniques (including stretching exercises and breathing techniques in the class schedule);functional training (performance of exercises for coordination, strength and endurance, which helps to strengthen the body and increase self-confidence), psychological support through physical education (integration of lectures on the impact of physical activity on stress and emotional state); motivational practices (organization of trainings aimed at developing internal motivation for sports). Practical methods – with the aim of forming practical movement skills and creative skills of rehabilitators in the system of physical education, further strengthening the motivation of higher education students for health-preserving activities: the method of meditation and conscious attention (Mindfulness), the method of playing roles, analysis of specific situations (case-study), problem method, project method, training, self-regulation breathing techniques, cognitive-behavioral therapy (CBT) technique, stress resistance training, relaxation techniques and stress management training, positive approach and strengthening of self-support; stress management training; development of reflection and self-observation; the method of expert evaluations and mathematical statistics. During the practical classes, examples of different types of physical activity as an anti-stress factor were provided, training exercises, discussion, brainstorming, teamwork, reflection-thinking, exercises for active leisure and relaxation were performed, and musical accompaniment was used.

– *Methods of statistical data processing* – for processing experimental data, their quantitative and qualitative analysis. They were used to identify the reliability of the difference between the studied indicators, the correct processing of the results, reflecting them in graphical and tabular forms, conducting experimental testing. The analysis of the results of the observation and questionnaire survey of future rehabilitators in the system of physical education was carried out using the methods of expert evaluation and Google Forms, taking into account the requirements for the organization and conduct of sociological research. The reliability of the results of the questionnaire of higher education applicants was assessed with the aim of acquiring competences in terms of readiness for health-preserving activities. Statistical analysis of the results was done by grouping answers according to the principle of similarity, and then the number of similar answers was counted and calculated as a percentage of the total number of respondents. The data of pedagogical observations, questionnaires and interviews were processed by the method of frequency distributions.

RESULTS

The educational and educational direction of the organization of the educational process in institutions of higher education involves improving the content of educational components of academic disciplines: «Psychology», «Health-preserving technologies in physical education and sports», «Pedagogical diagnosis of training in physical culture», «Organization of health and sports-mass work», «Theory and technologies of health-recreational motor activity», «Health pedagogy», «Fitness technologies and recreation», «Sports medicine with the basics of physical culture and sports rehabilitation», «Physical medical care», «Mobility and recreational games» with wide use of the Internet, modern information tools, competence and student-centered approaches.

The identified illuminating components included the following: «Meditation and Mindfulness», «Inflation of stress on mental health», «Psychological support for advanced training in teamwork (soft skills) in gaming activity», «Career stress under the hour, the work of rehabilitation therapists with athletes and in difficult situations», «Effective response to difficult situations under the hour of training and recovery», «Preservation of stable emotional state that copes with unique stress and reduced results», «Managing stress and developing stress resistance to achieve maximum efficiency» and so on. Lecture sessions were conducted in the form of a lecture-discussion, a lecture-dialogue and a problem lecture. The specificity of nutrition before studying the topic prompted us to ensure that those who obtain nutritional information were as active as possible in the search for the right solution.

The aim of enhancing and updating the list of light components with an emphasis on practical warehouse training of future rehabilitation therapists and physical therapists and sports and the promotion of appropriate techniques was determined by the influx of stress article on mental health, recommended daily approaches for regulating the level of stress and improving the level of mental health student youth.

Analysis of the results of the surveillance and questionnaire survey of current rehabilitation therapists and physical therapists and sports educators was carried out using expert assessment methods and Google Forms, which were regulated, were possible before organizing and conducting sociological research ejen. The reliability of the results of the questionnaire of educational professionals was assessed based on their competencies in order to be ready for healthy activities. Statistical analysis of the results was based on the additional grouping of species according to the principle of similarity, and then a number of similar species were identified and counted in hundreds of samples up to a total number of feedings. Data from pedagogical precautions, questionnaires and interviews were collected using the method of frequency divisions.

In our opinion, for future rehabilitators and specialists in physical education and sports, stress resistance is a professional trait that helps manage stress during competitions, significantly affects the state of spiritual,

mental and social health, a high level of self-esteem, as well as a constant desire for change, active self-development and self-realization [22].

Stress resistance plays an important role in the professional training of future rehabilitators and physical culture and sports specialists due to several key aspects:

1. Efficiency in working with clients and athletes: physical culture and sports professionals must have the ability to effectively manage the stress that can arise when working with clients and athletes, especially in high performance situations. The ability to remain calm and focused in stressful situations helps ensure efficient and productive work;
2. Coaching adaptation and response to unexpected situations: physical culture and sports specialists will often encounter unexpected situations during training, competition or interaction with athletes. The ability to effectively adapt and quickly respond to such situations is the key to successful work and ahieving results.
3. Stability of emotional state: physical culture and sports specialists must have a stable emotional state, especially during stressful situations or competitions. The ability to manage emotions and stay focused helps maintain a professional level and achieve high results.
4. Leadership qualities: stress resistance is one of the key characteristics of leaders. Specialists in physical culture and sports who have a high level of stress resistance, are able to lead a team, make decisions in non-signal conditions and confidently manage situations.
5. Health and well-being: stress resistance is also important for ensuring the physical and mental health of physical culture and sports specialists. Reducing stress levels helps maintain high energy levels, improves sleep quality, and overall health.

Therefore, stress resistance is an important component of the successful professional activity of physical culture and sports specialists, as it contributes to increasing the efficiency of work, ensures the stability of the emotional state and contributes to the preservation of health and well-being.

The mental health criteria of future rehabilitators and physical education and sports specialists in terms of personal manifestations regarding the formation of stress resistance include: self-discipline, emotional stability, flexibility of thinking, optimism, self-support, adaptability. The criteria of personal manifestations for maintaining mental health are defined as: self-perception, cooperation, empathy, self-actualization, the ability to maintain balance, self-recovery.

We defined the following levels of stress resistance formation: high, medium and low. The influence of stress resistance on the quality of professional training of future rehabilitators is considered in Table 1.

The use of specific techniques for the development of stress resistance may vary depending on the level of stress resistance. According to the specified criteria, we determined the following levels of stress resistance formation: high, medium and low. Therefore, we will consider the methods for each level separately (Table 2).

In accordance with the proposed methods for the increasing of stress resistance of future bachelors, various approaches were included to regulate the level of stress resistance and increase the level of mental health of young people:

1. *Gradual increase in load*: starting with light exercises and gradually moving to more difficult ones, it is possible to allow participants to get used to physical activity without excessive stress.
2. *Focus on breathing and stress management*: using breathing techniques during exercise can help participants manage their stress and focus on the positive aspects of exercise. For example, deep breathing exercises during breaks or during exercise can reduce stress levels and improve mental health.
3. *Use of musical accompaniment*: music can affect emotional state and mental health, lift the mood of participants and reduce stress levels.
4. *Elements of relaxation and meditation*: relaxation exercises or short meditation breaks during class can help reduce stress and improve focus. For example, a short meditation at the end of a workout can help participants focus and relax.
5. *A positive approach and strengthening of self-support*: during physical activity classes, you can actively encourage participants and strengthen their self-support.

Table 1. The influence of stress resistance on the quality of professional training of future rehabilitators in the system of physical education

Levels of stress resistance	Influence on the quality of professional training
High	Ability to effectively manage stress when working with athletes and in difficult situations.
	Effective response to unexpected situations during training and competitions.
	The ability to maintain a stable emotional state, which helps to avoid stress and improve results.
Medium	Requires additional stress management and development of stress resistance to achieve maximum effectiveness.
	There may be some risk of reduced performance in high stress situations.
	Can cause delays in completing tasks and achieving results due to inability to manage stress effectively.
Low	Increased risk of negative emotional reactions and deterioration of the quality of interaction with athletes and colleagues.
	It requires systematic work on the development of stress resistance and psychological training to improve results.

Table 2. Levels and methods for the increasing of stress resistance of future bachelors

Levels of stress resistance	Description of techniques for the increasing of stress resistance
High	Practice regular meditation: students with a high level of stress resistance can focus on relaxation practices that help maintain a stable emotional state.
	Self-regulation breathing techniques: Deep breathing and relaxation exercises can help you stay calm in stressful situations.
Medium	Techniques of cognitive behavioral therapy (CBT): working to manage thoughts and beliefs that contribute to stress can help maintain a more stable emotional state.
	Exposure methods: gradually getting used to stressful situations can help build greater resilience to stress.
Low	Psychoeducation and stress resistance training: an in-depth study of the causes and effects of stress, as well as methods of overcoming it to improve overall well-being and performance.
	Training in relaxation techniques and stress management: systematic use of various techniques such as meditation, yoga or deep breathing can help reduce the effects of stress.

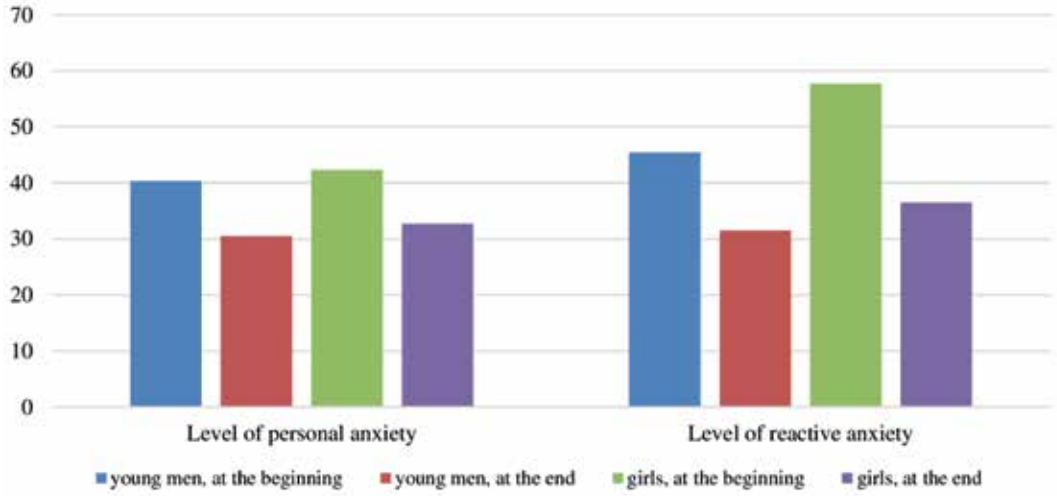

Fig. 1. Results of the Spielberger Anxiety Questionnaire.

A positive approach and reinforcement of one's own achievements can improve the emotional state and increase the level of mental health.

In the course of the research during 2022-2024, a survey of 320 respondents of higher education institutions was conducted. The results of the study are shown in Table 3.

According to the data in Table 3, higher education seekers put physical health and needs first, an active lifestyle – 100%; 94% of boys and 100% of girls would like to receive more information about methods of building stress resistance to increase the level of mental health, 51.8% of boys and 59.6% of girls know how stress resistance affects mental health. There are positive changes in the signs of anxiety in boys and girls. Thus, signs of anxiety among young men decreased from 51.8% to 31.5%, and among girls - from 61.5% to 38.5%. Signs of depression were still present at the end of the experiment in 27.7.5% of young men (compared to 59.9% at the beginning of the experiment) and from 36.5% in girls to 27.9%. This is traced to russian aggression during martial law. As a result of the survey, the strategies used by the students to improve the level of mental health, students' interest in extracurricular work and their interests in personal development, educational and professional plans, the need for professional psychological support, which led to the detection of signs of anxiety and depression, were determined. especially during martial law.

The results of the Spielberger Anxiety Questionnaire are shown in Fig. 1.

So, as we can see from Fig. 1, the level of personal anxiety among students of higher education decreased from 40.3% to 30.5% for boys, and from 42.3% to 32.7% for girls. The level of reactive anxiety decreased from 45.4% to 31.5%, and in girls from 57.7% to 36.5%. Evidence shows that it is very difficult to reduce the anxiety level of students during martial law.

The decrease in anxiety level was confirmed by repeated testing using the same methods as at the diagnostic stage. The expected decrease in indicators occurred on average by 10.0% (level of personal anxiety) and by 17.5% (level of reactive anxiety). At the same time, there were very minor changes (less than 1%) in the control group.

Table 3. Summary table of survey of respondents (all participants of the educational process by gender)

Do you know how stress resistance affects mental health?					
The beginning of the experiment			The beginning of the experiment		
Males, n 216			Females, n 104		
Yes: 112 (51.8%)	No: 54 (25%)	Hard to answer: 50 (23.2%)	Yes: 62 (59.6%)	No: 14 (13.4%)	Hard to answer: 28 (27%)
The end of the experiment			The end of the experiment		
Yes: 216 (100%)	No: 0	Hard to answer: 0	Yes: 104 (100%)	No: 0	Hard to answer: 0
Would you like to receive more information about stress-resistance techniques to improve mental health?					
The beginning of the experiment			The beginning of the experiment		
Males			Females		
Yes: 204 (94.4%)	No: 12 (5.6%)		Yes: 96 (92,3%)	No: 8 (7,7%)	
The end of the experiment			The end of the experiment		
Yes: 216 (100%)	No: 0 (0%)		Yes: 104 (100%)	No: 0 (0%)	
Physical health and needs					
Males			Females		
Beginning/end I lead an active lifestyle: 87 (40,3%) / 216 (100%) I do sports: 148 (68.5%) / 204 (94.4%) Eating right: 116 (53.7%) / 148 (68.5%) I have no bad habits: 87 (40.3%) / 108 (96.4%)			Beginning/end I lead an active lifestyle: 86 (82.7%) / 104 (100%) I do sports: 52 (50%) / 62 (59.6%) Eating right: 64 (61.5%) / 86 (82.7%) I have no bad habits: 86 (82.7% / 92 (88.5%)		
Interests and hobbies					
Males			Females		
Beginning/end Sports: 148 (68.5%) /204 (94.4%); Art: 4 (1.8%) / 8 (3.6%) Science: 8 (3.8%) / 60 (17.4%) Handicrafts: 0 (0%) / 0 (0%)/ Other: 0 (0%) / 12 (5.6%) At the end of the experiment, several young men developed two types of hobbies.			Beginning/end Sport: 52 (50%) / 68 (65.4%) Art: 12 (11.5%) /14 (13.4%) Science: 16 (15.5%) / 32 (31.0%) Needlework: 14 (13.4%) /15 (14.4%) Other: 10 (9.6%) / 8 (7.7%) At the end of the experiment, several girls had two types of hobbies.		
Educational and professional plans					
Continuation of higher education: 136 (63%) / 144 (66.6%)	Practical experience: 80 (37%) / 96 (44.4%) At the end of the experiment, several young men combined studies with practical experience.		Continuation of higher education: 60 (57.7%/ 65 (65.2%)	Practical experience: 44 (42.3%) / 50 (48.0%) At the end of the experiment, several girls combined education and practical experience.	
The need for professional psychological support					
Needed: 98 (45.4%)/160 (74.1%)	I will manage on my own: 56 (25.9%)/118 (54.6%)		Needed: 68 (65,4%)/52 (50%)	I will manage on my own: 36 (34.6%)/52 (50%)	
Do you have any signs of anxiety?					
Yes: 112 (51.8%)/68 (31.5%)	No: 104 (48.2%)/148 (68.5%)		Yes: 64 (61.5%)/30 (28.9%)	No: 40 (38.5%)/74 (71.1%)	
Do you have signs of depression?					
Yes, and it requires attention and support: 110 (59.9%)/60 (27.75%)	Yes, but this is a temporary phenomenon: 106 (40.1%)/156 (72.2%)		Yes, and it requires attention and support: 38 (36.5%) 29 (27.9%)	Yes, but this is a temporary phenomenon: 66 (63.5%)/75 (72.1%)	
Have you sought help from a psychologist?					
Yes, and it helped me increase my level of stress resistance: 87 (40.3%)/160 (74.1%)	No, but we are considering this possibility: 129 (59.7%)/56 (25.9%)		Yes, and it helped me increase my level of stress resistance: 60 (57.7%)/68 (65.4%)	No, but we are considering this possibility: 44 (42.3%)/36 (34.6%)	

Depression levels were determined by the Depression scale PHQ-9 (Fig. 2).

So, from Diagram 2, we can see that the levels of depression of students of higher education were: mild level – 33%, moderate – 17%, pronounced – 25%, absent – 25%, no severe form of depression was detected.

The depression level decreased according to the PHQ-9 depression scale. At the same time, the decrease in boys was on average by 21.2%, and in girls by 13.4%.

The data of monitoring the stress resistance of the personality of future rehabilitators are shown in Fig. 3.

From Fig. 3, it can be seen that 49% of achievers at the beginning of the experiment were at an average level, 32% at a low level, and only 18% of respondents had a high level of stress resistance. After conducting an experiment and updating educational components and methodological support for the development of stress resistance of the individual to improve the mental health of young people, new types of physical activity were introduced: yoga, pilates, health fitness, ultimate frisbee, etc.; relaxation techniques, meditation methods and conscious attention (Mindfulness); the Spielberger Anxiety Questionnaire; analysis of specific situations (case study), trainings on stress resistance, self-regulation breathing techniques, cognitive behavioral therapy (CBT) techniques, stress management training were conducted; development of reflection and self-observation. Examples of different types of physical activity were provided at practical classes, training exercises, discussion, brainstorming, team work, reflection-thinking, etc. were conducted. At the end of the experiment, the low level decreased from 32% to 16%, and the high level almost doubled from 18% to 35%.

After developing software and methodology to develop stress resistance and help students, we got the following visible results:

Lowering the level of anxiety. This was confirmed by retesting using the same methods as at the diagnostic stage. The expected decrease in indicators occurred on average by 10.0% (level of personal anxiety) and by 17.5% (level of reactive anxiety). At the same time, there were very minor changes in the control group (less than 1%).

The depression level decreased according to the PHQ-9 depression scale. On average, this indicator decreased by 34.6%. At the same time, the decrease in boys was on average by 21.2%, and in girls by 13.4%. At the beginning, the level of depression in girls was twice as high as in boys. In the control group, the changes were minimal, but the level of depression in girls was also higher than in boys.

In addition, the development of communication skills and confidence in communication took place. This was confirmed by observing the behavior of students and analyzing feedback from parents.

There was little room for improving the psychological climate in families. There were fewer conflict situations.

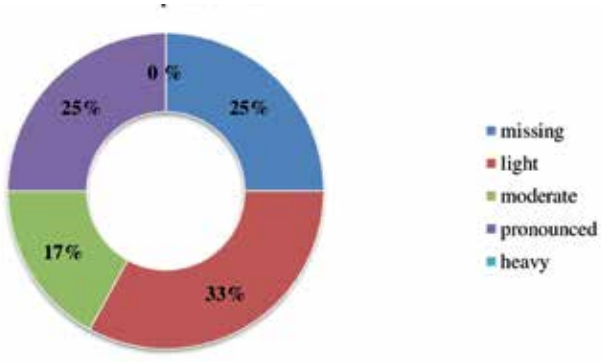

Fig. 2. Depression scale PHQ-9.

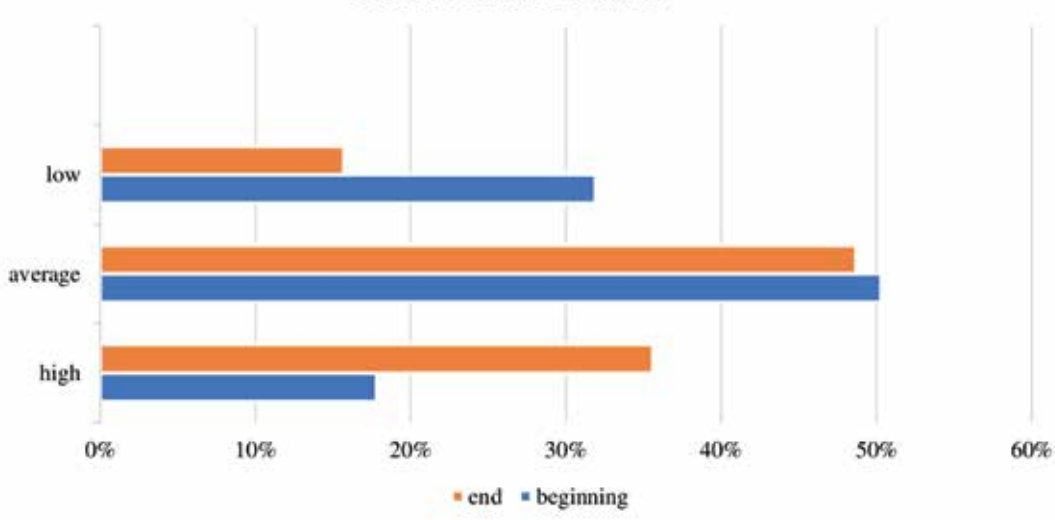

Fig. 3. Levels of personality stress resistance of future rehabilitators in the physical education system (beginning and end of the experiment).

Therefore, we can confirm the effectiveness and expediency of using psychocorrective programs in working with young people to develop stress resistance and improve mental health. This allows to significantly improve their psychological state, adaptation and socialization.

The methodical features of determining the level of stress resistance as a professionally significant feature of a future rehabilitator in the physical education system are defined as:

1. *Students' awareness*: most students recognize the importance of stress resilience and improved mental health for their well-being and success.
2. *Awareness of effective methods*: most respondents recognize the effectiveness of methods such as physical activity, breathing exercises, meditation and communication with loved ones to achieve these goals.
3. *The need for professional support:* education seekers do not have enough information about the availability of professional support in the formation of stress resistance and increasing the level of mental health.
4. *Desire to receive additional information:* a significant proportion of prospective undergraduates expressed a desire to learn more about these techniques and the resources available to support their mental health.

Taking into account these features, we will give specific examples that can be used to increase stress resistance and improve the mental health of students through physical exercises (Table 4).

These approaches help students not only improve physical health, but also increase stress resistance and mental well-being by releasing endorphins and reducing stress levels.

Next, we will give an example of tests that can be used to determine the level of stress resistance and the effectiveness of improving the mental health of students through physical exercises:

1. *Stressor Survey*. This test helps to identify the main factors that cause stress for a student. Students are asked to identify which situations, events, or factors have the greatest impact on their stress levels. After that, you can analyze the results and develop individual stress management strategies for each student.
2. *Stress Adaptability Test*. This test assesses the student's ability to adapt to stressful situations. Students are asked to answer a series of questions about their

Table 4. Examples of different types of physical activity

Type of physical activity	Specific examples that can be used to build stress resistance and improve students' mental health through exercise
Yoga and Pilates	Incorporating elements of yoga and relaxing Pilates exercises aim to combine physical exercise with a focus on breathing and relaxation. Different levels of difficulty should be offered so students can practice at their comfort level.
Outdoor training	Taking a morning or evening jog in the fresh air or attending physical education classes in the fresh air helps to reduce stress and improve mood due to the positive influence of the natural environment and relieve stress, improves mood. You can also take joint walks or bike rides to stimulate team spirit.
Dance classes	Organize a dance or zumba class. Dance activity not only increases physical activity, but also helps release endorphins, which improve mood. Allow students to express themselves through movement and music, which can relieve stress and improve well-being.
Strength training	Organize strength training classes that help increase physical strength and endurance. Include bodyweight exercises, dumbbells, or machines for variety.
Aerobic exercises and cardio training	Aerobic exercise such as running, swimming, cycling or dancing can help release endorphins, which boost mood and reduce stress. Regular physical activity also helps improve sleep and general well-being.
Group exercises and team games	Participating in group exercises and team games promotes cooperation, communication and a sense of belonging, which can have a positive impact on students' mental health.
Physical self-regulation and stress relaxation:	Physical education classes can use physical self-regulation and stress relaxation techniques, such as deep breathing, progressive muscle relaxation, and some yoga practices.
Student sports teams and sports competitions	Support the creation and active participation in student sports teams and competitions. Sports activities contribute to the feeling of belonging to the team and increase self-esteem. Organization of inter-university competitions in various sports to encourage healthy competition and cooperation between universities.
Overcoming challenges and achieving goals	Encouraging students to perform physical tasks and achieve new goals can contribute to improved self-esteem, a sense of achievement and overall well-being.
Maintaining a group atmosphere and positive communication	Creating a supportive and positive environment in physical education classes contributes to the formation of social support and reducing the feeling of social isolation, which is important for maintaining mental health.

reactions to stress and their ability to recover quickly from it. The test results will help determine the level of stress resistance and the effectiveness of stress management strategies.

3. *Physical Fitness Test*. This test assesses students' physical strength, endurance and flexibility. The inclusion of physical parameters in the testing will determine which aspects of physical health need improvement. The results of the test can also serve as a metric of the effectiveness of training and physical activity to reduce stress levels and improve mental health.
4. *Psychological Well-being Test*. This test assesses the level of psychological well-being and emotional state of students. Students are asked to answer questions about their emotional state, mood, sense of satisfaction, and relationships with others. The results of the test will help reveal how effectively physical exercises affect psychological well-being and stress resistance.

These tests can be adapted to the specific needs and context of the student audience. They will help not only to measure the current level of stress resistance and mental health of students, but also to track their improvements as a result of the use of physical exercises and other strategies.

The individual abilities of bachelors to increase stress resistance are compiled according to the criterion of mental health of future rehabilitators by personal manifestations and presented in the Table 5.

The individual abilities of bachelors to support mental health are developed according to the criterion of the formation of stress resistance as a professionally significant feature of the future rehabilitator in the system of physical education according to personal manifestations and are given in Table 6.

According to Table 5, 6 these individual abilities can be used to develop individual programs to support students in the formation of stress resistance and mental health support. Each ability can be developed and supported through appropriate educational and training programs that take into account the individual needs and capabilities of students.

One of the tasks for students' independent work was to develop an example lesson:

– An example of a lesson: Development of empathy and reflection. Perception of another person's position for students in physical education classes.
  – The purpose of the lesson: to develop the ability to empathically perceive other people, to enrich the idea of the inner world of another person, to form the skills of analyzing situations from different positions.
– The duration of the lesson: 90 minutes.

Materials:

- handouts with descriptions of situations for analysis, cards with emotions and feelings;
- sports equipment (balls, jump ropes, ultimate discs, etc.);
- flip chart or whiteboard;
- cards with discussion questions.

Lesson progress:

1. *Introduction (10-12 minutes)* – greeting students, checking their well-being; explanation of the purpose of the lesson and the importance of empathy and reflection in life and sports; a light warm-up to prepare for the main part of the lesson.

Table 5. Individual abilities of bachelors to increase stress resistance

Individual ability	Description	Examples
Self-discipline	The ability to control one's own actions and reactions.	Implementation of the schedule, self-regulation.
Emotional stability	Ability to manage emotions and stress.	Meditation, breathing exercises.
Flexibility of thinking	Ability to quickly adapt to new situations and changes.	Solving non-standard problems, increasing creativity.
Optimism	Positive perception of life and its complexities.	Working on positive thinking.
Self-support	The ability to support oneself in stressful situations.	Practice self-support and self-comfort.
Adaptability	The ability to quickly adapt to changes in the environment.	Reflection, learning new strategies.

Table 6. Individual abilities of bachelors to support mental health

Individual ability	Description	Examples
Self-perception	The ability to understand one's needs and emotions.	Controlling, regular self-checks.
Cooperation	Ability to work in a team and interact with others.	Participation in group projects, team games.
Empathy	The ability to empathize and understand the feelings of others.	Listening and talking with friends.
Self-actualization	The ability to develop one's own potential and achieve personal goals.	Self-development, attending master classes.
The ability to maintain balance	The ability to find a balance between study, work and leisure.	Keeping a schedule, regular rest.
Self-recovery	Ability to restore energy and positive mood.	Use of relaxation and rest techniques.

2. *Main part (70 minutes)*

• Empathy exercises (30 minutes):

Game «Change of roles» (15 minutes) - students are divided into pairs. One student plays the role of a coach, the other – an athlete; the coach must explain and show a certain exercise, and the athlete must perform it; after the performance, the roles change; discussion: how each party felt, what difficulties arose, what was understood about the role of the other person.

Exercise «Common goal» (15 minutes) - students form small groups of 4-5 people; each group receives a task: to organize a sports event (for example, a mini-tournament of Ultimate Frisbee or other physical activity); each student in the group has a role (organizer, judge, player, etc.); discussion after completing the task: which roles were the most difficult, how was it possible to reach an agreement, what was the feeling when performing the roles.

- Game and training exercises for various types of physical activity (ultimate frisbee, rugby, dodgeball) – (20 minutes).
- *Analysis of conflicts from different positions during the game (10 minutes)*:

The presenter offers the participants to consider several situations from different positions (Table 7). Preventing conflict situations during the game can include training team interaction, developing sportsmanship, respect for opponents and referees, as well as holding regular conversations about the importance of fair play and self-control.

• Reflection exercises (10 minutes):

Exercise «The mirror» (10 minutes) - students form pairs. One student performs the exercises, the second must repeat all the movements exactly as if he were his reflection in the mirror; after the performance, the roles change; discussion: how it felt, how difficult it was to synchronize the movements, what helped in achieving the result.

3. *The final part or the summary of the lesson (8-10 minutes)* – summary of the lesson.

• Reflection of empathy skills (5 minutes):

Group discussion «Reflection of the day»: students sit in a circle. Each student receives a card with a question (for example, «What new did you learn about yourself today?», «How did you perceive the position of others?», «What emotions arose during classes?»). Participants discuss what the lesson gave them. They also discuss how empathy can be developed.

Expressing gratitude to students for their participation. Recommendations for the development of empathy and reflection in everyday life.

Results: students have a better understanding of the importance of empathy and reflection; they get practical experience of perceiving another person's position and exchanging roles; they will be able to use the acquired skills in everyday life and professional activities.

Next, we will give specific examples and practical recommendations for human physical activity:

Breathing techniques. Breathing with slightly held inspiration. Students can learn to use this technique by holding their breath for a few seconds before exhaling slowly. This will help reduce stress levels and activate the parasympathetic nervous system. Breathing through the stomach. During a stressful situation, students can learn to focus on breathing through their belly rather than their chest. This contributes to the reduction of physiological indicators of stress.

Relaxation techniques. Progressive Muscle Relaxation: Future bachelors can learn to sequentially tense and relax muscle groups to reduce the physical manifestations of stress.

Visualization. Students should be encouraged to use visualization of a calm place or situation to reduce stress and increase inner comfort.

Time and task management strategies. The «Eisenhower Matrix» technique: It is necessary to teach future bachelors to classify tasks by importance and deadlines in order to effectively allocate time and avoid overload. This can help maintain productivity and reduce stress levels.

Techniques of cognitive-behavioral therapy (CBT): Reassessing Thoughts: Teaching Prospective Undergraduates to Examine Their Thoughts and Identify Negative Cognitive Biases That Can Increase Stress Levels. «The if – then» technique: to invite students to create a list of possible options for responding to a stressful situation and its consequences, which will help them find more rational and effective ways to overcome stress.

Development of action plans: teach future bachelors to create action plans for stressful situations in which they anticipate possible problems and ways to solve them.

These approaches can be individualized and adapted to the needs and capabilities of specific student audiences. It is important to give them the opportunity to choose and experiment with different methods to find the ones that are most effective in helping them manage their stress.

To calculate the Pearson test (χ2\chi^2χ2), it is necessary to compare the observed frequencies (actual frequencies) with the expected frequencies (Tables 8, 9, 10).

Pearson's test formula:

χ2=∑(O−E)2E\chi^2 = \sum \frac{(O−E)^2}{E}χ2=∑E(O−E)2

where: OOO – observed frequencies, EEE – expected frequencies.

Table 7. Conflict situations during the game

• Conflict between opponents during the game: due to unsportsmanlike behavior and insults, rude statements, humiliating players of the other team.
• Disputes with referees: disrespecting referees' decisions or disagreeing with referees' decisions and trying to challenge them on the field.
• Provocations: Deliberately provoking players of the other team to cause them to react aggressively or simulating injuries or fouls to gain an advantage.
• State of tension and stress: high level of tension and stress during the game, which can lead to aggressive behavior.
• Emotional reaction: excessive emotional reaction to game events, such as a sudden change in the score or failure to complete an important task.

Table 8. Output data

Males: 216 people	Females: 104 people
Anxiety	
Males: It was: 51.8%51.8%\51.8% → 216×0.518=111.888216 \times 0.518 = 111.888216×0.518=111.888 It became: 31.5%31.5%\31.5% → 216×0.315=68.04216 \times 0.315 = 68.04216×0.315=68.04	Females: It was: 61.5%61.5%\61.5% → 104×0.615=63.96104 \times 0.615 = 63.96104×0.615=63.96 It became: 38.5%38.5%\38.5% → 104×0.385=40.04104 \times 0.385 = 40.04104×0.385=40.04
Depression	
Males: It was: 59.9%59.9%\59.9% → 216×0.599=129.384216 \times 0.599 = 129.384216×0.599=129.384 It became: 27.7%27.7%\27.7% → 216×0.277=59.832216 \times 0.277 = 59.832216×0.277=59.832	Females: It was: 36.5%36.5%\36.5% → 104×0.365=37.96104 \times 0.365 = 37.96104×0.365=37.96 It became: 27.9%27.9%\27.9% → 104×0.279=29.016104 \times 0.279 = 29.016104×0.279=29.016

Table 9. Expected frequencies

Males: 216 people	Females: 104 people
Anxiety	
Total number: 216+104=320 216 + 104 = 320 216+104=320 Data at the beginning of the experiment: (111.888+63.96)=175.848(111.888+63.96) = 175.848(111.888+63.96)=175.848 Data at the end of the experiment: (68.04+40.04)=108.08(68.04 + 40.04) = 108.08(68.04+40.04)=108.08	
Expected frequencies (beginning of the experiment): males: 175.848×216320=118.4175.848 \times \frac{216}{320} = 118.4175.848×320216=118.4 Expected frequencies (end of experiment) males: 108.08×216320=72.96108.08 \times \frac{216}{320} = 72.96108.08×320216=72.96	Expected frequencies (beginning of the experiment): females: (68.04+40.04)=108.08(68.04 + 40.04) = 108.08(68.04+40.04)=108.08 Expected frequencies (beginning of the experiment): females: 175.848×104320=57.4175.848 \times \frac{104}{320} = 57.4175.848×320104=57.4 Expected frequencies (end of experiment) females: 108.08×104320=35.12108.08 \times \frac{104}{320} = 35.12108.08×320104=35.12
Depression	
Total number: 216+104=320 216 + 104 = 320 216+104=320 Data at the beginning of the experiment: (129.384+37.96)=167.344(129.384 + 37.96) = 167.344(129.384+37.96)=167.344 Data at the end of the experiment: (59,832+29,016)=88,848(59,832 + 29,016) = 88,848(59,832+29,016)=88,848	
Expected frequencies (start of the experiment): males: 167.344×216 320=113.0167.344 \times \frac{216}{320} = 113.0167.344×320 216=113.0 Expected frequencies (end of experiment) males: 88.848×216320=59.9488.848 \times \frac{216}{320} = 59.9488.848×320 216=59.94	Expected frequencies (beginning of the experiment): females: 167.344×104 320=54.34167.344 \times \frac{104}{320} = 54.34167.344×320 104=54.34 Females: 88.848×104320=28.9188.848 \times \frac{104}{320} = 28.9188.848×320 104=28.91

Table 10. Observed frequencies (according to the Pearson test)

Category	Males (before)	Males (after)	Females (before)	Females (after)
Anxiety	118.4	72.96	57.4	39
Depression	113.0	59.94	54.34	28.91

Expected frequencies are calculated based on the overall proportion. For each indicator (anxiety, depression), we will calculate the expected values.

According to the calculations: the decrease in the level of anxiety among young men (+49.44) is more pronounced than among girls (+18.4). For depression, the improvement is also more significant in boys (+53.06) than in girls (+25.43), which is possible during martial law.

DISCUSSION

We support the opinion of K. Bereznyak, O. Nakorchevska and O.Vasylieva, who noted that in order to preserve and restore mental health in providing students with psychological and emotional support, increasing their level of stress resistance, it is urgent to find forms, methods and methods of learning in institutions of higher education. As for the psychological factors of students' adaptation to educational and cognitive activities, they include several psychological options. Among them, the following are distinguished: organizational (study of the structure of the institution of higher education, its requirements and norms); activity (determination of the rights, obligations and behavior of education seekers, requirements for the quality of educational activities); professional (determines the understanding of the essence of the chosen profession, the place of the specialty in the general system and the desire to master professional activity); socio-psychological (getting used to the team, self-affirmation in the group, building relationships with teachers and administration); household (getting used to a new regime, increased psychological and mental loads, etc.) adaptation [23].

So, let's consider the definition of the concept of «stress resistance» according to different authors (Table 11).

In the monograph L. Omelchenko, V. Vus it is determined that it is necessary to take into account a tolerant relationship with each other, when a tolerant person can make decisions in conditions of uncertainty, contradiction, novelty of the situation, incomplete information, unknown consequences of the choice. People who have this feature are able to implement productive solutions and overcome stressful situations more easily [24].

It is important to overcome stress, as noted by T.Tsyganchuk, that emotional intelligence acts as a basis for self-regulation of the individual. Its high level of development allows you to understand your own emotions and perceive the emotional manifestations of others, to form personal qualities that help the subject overcome stressful situations: the ability to understand other people's emotions and manage them,

Table 11. Definition of the concept of «stress resistance» according to different authors

Author, year	Definition of the concepts of «stress resistance»
G. Dubchak, 2018	Professional stress resistance is a person's ability to resist the negative impact of stressful factors of professional activity, determined by an individual complex of his innate and acquired properties and processes, which ensure the optimal successful achievement of the goal of work in a complex emotional situation [19, p. 14].
R. Shevchenko, 2020	Stress resistance is a complex (integral) property of the individual, which is characterized by the necessary degree of adaptation to actions in extreme situations, contributes to the transfer of intellectual, volitional and emotional loads caused by the peculiarities of professional activity, without feeling adverse consequences for work, one's health and the health of the environment [2, p. 6].
Yu. Teptyuk, 2021	Stress resistance of a person is «an integrative dynamic formation that actualizes his ability to understand the specifics of a stressful situation and his ability to overcome it, adequately react emotionally to various stressors, actively change stressful conditions and maintain the effectiveness of the performed activity» [3, p. 18].
T. Dudka, 2022	Stress resistance is an integral property of a complete personality, which is interconnected with a multi-level system of elements represented by a complex of cognitive, intellectual, emotional, personal properties [4].
G. Myhal, O. Protasenko, 2022	Stress resistance provides a person's ability to resist the negative impact of stress factors, determined by an individual complex of innate and acquired psychological and physiological properties and processes [5, p. 249].
M. Shpak, 2022	Stress resistance is an integral property of a person, which includes a complex of cognitive, emotional, adaptive and personal properties that ensure a person's ability to withstand stress, to resist the negative impact of stress factors in order to maintain mental health [6, p. 202].
O. Otravenko, O. Dubovoi, V. Honcharenko, 2023	The stress resistance of the personality of the future physical education and sports specialist is a complex (integral) property of the personality that ensures a high level of self-regulation, self-control, reflection and meditation; the ability to withstand stress, to resist the negative impact of stressful factors in order to maintain mental, spiritual and social health; to a certain extent depends on the psychological well-being of the individual and life experience. This is facilitated by the analysis of pedagogical situations, conducting trainings, webinars, master classes, assessment of stress management methods and the ability to resist stressful situations during the war and in modern conditions [22, p. 80].
L. Potayuk, 2023	Stress resistance is a set of personal qualities that enable students to experience significant intellectual, volitional and emotional loads without particularly harmful consequences for activity and health; the individual reaction of students, which is determined by their subjective assessment of the threat and their resources to overcome this danger [7, p. 38].

the conscious perception of one's own emotions and their regulation, as well as the ability to manage as own and others' emotions. Therefore, stress is an integral part of our lives and most people have the ability to use strategies to cope with this stress. However, a certain minimum level of resources is required to successfully overcome stress. Without this level, adjustment problems can arise, and even a minor negative impact or failure can be very difficult to overcome. In the literature, the opinion is often expressed that overcoming stress is not only a waste of energy, but can also be a stimulus for personal development. When we face challenges and obstacles, it can motivate us to find new solutions, improve our skills and strengthen our inner strength. Thus, stress can act as a catalyst for personal growth and improvement [25-27].

Reflection in educational activities plays a key role in the conscious regulation of one's own actions, in the formation of purposefulness and in the design of future steps based on the analysis of past experience. It allows us to set adequate requirements for ourselves, taking into account both external requirements and our own beliefs. In the context of the pedagogical process, where the main thing is the development of the subject's personality, reflection becomes an important tool for evaluating this development. It allows teachers and students to organize and record the results of this development, track the factors affecting the positive and negative dynamics of this process. The object of reflection is self-awareness as a subject of activity, including motives, initiative, actions, experience and failures. Awareness of one's own activity in an activity means understanding one's own role at all stages of this activity. When reflective awareness intersects with action, it creates conscious and reflective action, which is the key to continuous self-improvement and development [26].

L. Potapyuk believes that «adaptation or avoidance of stress is its individual manifestations: self-assessment, conscious understanding of one's own problems and their solution. The individual model of personality stability is based on the following basic resources of stability – psychological, behavioral, physical, social, and character resources» [7].

According to the definition of World Health Organization (WHO), mental health (psychological health) is a state of well-being in which a person can realize his own potential, overcome life's stresses, work productively and fruitfully, and contribute to the life of his community [21].

We support the opinion of K. Ivanov and O.Otravenko that «psychological aspects include emotions, experiences, thoughts, reactions to events or decisions or communication, features of communication, character, temperament, features of memory, attention, imagination, creative and critical thinking. The speed of reactions and the ability to defend one's point of view when making a decision, the reaction and tone of response to appeals, requests, tasks, and the level of motivation to perform various types of activities depend on the development of all psychological aspects» [20].

The practical significance of the obtained research results lies in the development of practical recommendations for increasing stress resistance as a professionally significant feature of the future rehabilitator in the system of physical education.

1. *Breathing techniques.* Breathing with slightly held breath. Students can learn to use this technique by holding their breath for a few seconds before exhaling slowly. This will help reduce stress levels and activate the parasympathetic nervous system. Breathing through the stomach. During a stressful situation, students can learn to focus on breathing through their belly rather than their chest. This contributes to the reduction of physiological indicators of stress.
2. *Relaxation techniques.* Progressive Muscle Relaxation: Future undergraduates can learn to sequentially tense and relax muscle groups to reduce the physical manifestations of stress.
3. *Visualization.* Students should be encouraged to use visualization of a peaceful place or situation to reduce stress and increase inner comfort.
4. *Time and task management strategies.* The Eisenhower Matrix method: It is necessary to teach future bachelors to classify tasks by importance and deadlines in order to allocate time effectively and avoid overload. This can help maintain productivity and reduce stress levels.
5. *Cognitive Behavioral Therapy (CBT) Techniques:* Reassessing Thoughts: To teach future undergraduates to review their thoughts and identify negative cognitive biases that may increase stress levels. «What if» technique: ask students to create a list of possible options for responding to a stressful situation and its consequences, which will help them find more rational and effective ways to overcome stress.
6. *Development of action plans:* to teach future bachelors to create action plans for stressful situations in which they anticipate possible problems and ways to solve them.

These approaches can be individualized and adapted to meet the needs and capabilities of specific student audiences. It is important to give them the opportunity to choose and experiment with different methods to find the ones that most effectively help them manage stress and strengthen their motivation for health-care activities. The educational components of the mentioned educational programs have been updated, methodological support for conducting practical classes and during practice, practical recommendations have been provided for the direction of further strengthening and motivation of students of higher education for health-preserving activities.

CONCLUSIONS

Based on the works of scientists, the degree of development of the specified problem was determined, which significantly affected the effectiveness and feasibility of using psychocorrective programs in working with young people to develop stress resistance and improve mental health.

The results of the study contributed to the development of research skills through the method of analysis and improvement of students' practical skills. They were involved in research work (writing qualification papers on the topic

of research, writing articles and theses, participation in scientific and professional quests, conferences of various levels, including international ones); participation in trainings, master classes, development of mini-projects on health care activities. 12 discussions on the topic of research, 6 trainings, 6 guest lectures, 3 scientific and professional quests were held, the content of 10 educational programs was updated, internal mobility (studying in separate educational components at partner institutions): training of students in partner institutions under the internal mobility program in separate educational components that form similar learning outcomes related to health care.

We consider the stress resistance of the personality of the future therapist as a professionally significant feature of the future rehabilitator in the system of physical education as a complex (integral) property of the personality, which ensures a high level of self-regulation, self-control, reflection and meditation; the ability to withstand stress, to resist the negative impact of stressful factors in order to maintain mental, spiritual and social health; to a certain extent depends on the psychological well-being of the individual and life experience. This is facilitated by holding lectures-discussions, lectures-dialogue, problem lectures, trainings, webinars, master classes, analysis of pedagogical situations, the ability to resist stressful situations during the war and in modern conditions.

It is important to further work on popularizing information about various approaches to the formation of stress resistance and increasing the level of mental health among students, as well as ensuring access to professional support in a higher education institution. There are positive changes, as evidenced by the obtained results: the decrease in the level of anxiety among boys (+49.44) is more pronounced than among girls (+18.4). For depression, the improvement is also more significant in boys (+53.06) than in girls (+25.43), which is possible during martial law. Evidence suggests that it is very difficult to reduce anxiety and depression levels in higher education students during martial law.

The results of the study can be used in the research work of students, the creation of teaching and methodical manuals, self-education activities of future rehabilitators in the system of physical education. Thus, the proposed set of measures contributed to determining the level of stress resistance as a professionally significant feature of the future rehabilitators in the system of physical education, reducing the levels of anxiety and depression in students of higher education, and improving the practical component of the training of future specialists in institutions of higher education. The results obtained at the stages of the experiment were analyzed, summarized and discussed at the departments whose teachers participated in the experiment, as well as during our presentations at scientific and practical conferences. In further work, a program for conditioning training should be developed, aimed at forming health-saving competence and reducing the level of stress resistance of recruits during martial law.

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CONFLICT OF INTEREST

The Authors declare no conflict of interest

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ORIGINAL ARTICLE

Does infrared light therapy improve the biomechanical properties of the paraspinal muscles, preparing the patient for kinesitherapy?

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ABSTRACT

Aim: Objective, quantitative assessment of the impact of light therapy procedure with the use of infrared radiation on the biomechanical properties of the paraspinal muscles in the course of chronic pain syndrome affecting the lumbar spine .

Materials and Methods: The study involved 64 subjects (29 men and 35 women). The biomechanical properties of paraspinal muscles were assessed by myotonometry both before, during, and after exposure to infrared radiation. The lamp Sollux LUMINA V5.0 Polska, generating infrared radiation (IR) having the wavelength in the range of 830 nm, was used in the research. In each of the examined patients, a single irradiation procedure was performed, the duration of the procedure was 15 minutes.

Results: At the beginning of the procedure, an increase in muscle tone and stiffness as well as a decrease in muscle flexibility were noted, as compared to baseline values before exposure to infrared radiation. With the passage time during which irradiation was performed, decrease in tone and stiffness, as well as increase in muscle flexibility were observed. After the procedure, elasticity increased above the values observed before the procedure, while tone and stiffness did not decrease below those initial values.

Conclusions: Infrared radiation has neither significantly reduced tone and stiffness nor has it significantly increased the flexibility of paraspinal muscles.

KEY WORDS: infrared light, kinesitherapy, lumbar spine, myotonometry, paraspinal muscles

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INTRODUCTION

The local application of heat to skeletal muscles is commonly used in the rehabilitation of overloaded vertebra and paraspinal soft tissues which are associated with degenerative changes. Understanding the physiological basis of local heat applications developed over the last several years, and it has become increasingly clear that skeletal muscles undergo significant functional and structural changes in response to repeated thermal stimuli. It has been shown that heat contributes to the increase of muscle strength by improving the contractility of muscle fibers [1], it also supports the growth of capillaries, improving their blood supply [2, 3], and induces the biogenesis of mitochondria in muscle cells [4]. However, translating basic knowledge into clinical conditions must be combined with efforts to determine optimal treatment features and characteristics, including duration of exposure and use of appropriate temperatures. Answers to such questions will provide a solid framework for future research. The heat-induced effects associated with relaxation, reduced stiffness and improved flexibility of both muscle fibres and the surrounding connective tissue are commonly recognized. Such adaptive changes can protect body structures from further deepening of existing structural damage during transmission of mechanical forces [1, 5].

In previous studies, many interesting and apparently not always predictable reactions of both contractile muscle fibers and connective tissue forming individual layers of the surrounding fascia have been shown. Inconsistent formation of muscle tone at rest, isometric and tetanic contraction forces during changes in muscle temperature has been observed. The available evidence demonstrates that non-contractile endo-sarcomaric components, which build muscle cells, are highly sensitive to temperature changes [6]. Experiments which have been conducted have also shown that fast- and slow-twitch muscles have different properties as regards changes in resting tone observed during temperature changes [7]. Other studies have shown that the relationship between sarcomere length and tetanic tone does not change in dependence on temperature [8].

Despite a long history of research, there is still much to find out as regards the effect temperature has on the biomechanical properties of skeletal muscles. Despite the long history of research, much remains to be determined concerning the effect of temperature on the biomechanical

properties of skeletal muscles. As is the case with almost all biological systems and structures, skeletal muscles are sensitive to temperature. Changes in skeletal muscle temperature occur under the influence of internal (endothermic) processes and those happening in the environment (exothermic processes). The final effect observed concerning the effectiveness of muscle contraction and motor activities is the result of a combination of changes in the properties of contractile elements (sarcomers) and non-contractile ones (connective tissue), as well as metabolic and neuronal processes occurring in temperatures that are lower and higher than physiological ones. These changes in individual muscle structures are inextricably linked. Gaining a deeper understanding of the nature of these changes requires further studies [9].

The increase in tone and stiffness of the paraspinal muscles observed in the course of chronic pain occurring in the spine is reflected in the changed values of biomechanical parameters. An objective way of assessing the effectiveness of physical medicine treatment methods is, among others, enabled by myotonometry, which is a non-invasive method of quantitative assessment of the mechanical properties of muscle tissue and connective tissue, and which can successfully replace the subjective examination by palpation and has been extensively described in the literature. Statistical analysis revealed good intra-rater reliability with the ICC of 0.88 (95% CI [0.76-0.94]) for the stiffness of the left erector spinae and excellent intra-rater reliability with the ICC of 0.91 (95% CI [0.82-0.95]) for the right erector spinae, both in the prone position. The results for the left-sided prone position showed good inter-rater reliability with the ICC of 0.87 (95% CI [0.73-0.94]). The prone position on the right side also showed good inter-rater reliability with the ICC of 0.84 (95% CI [0.68-0.92]) [10, 11].

AIM

Our study has had the aim to provide objective assessment of the impact of phototherapy using infrared radiation (IR) resulting in substantial overheating of tissues, on the biomechanical properties of paraspinal muscles in chronic pain syndrome affecting the lumbar spine. These treatment procedures, according to data from the literature, are commonly recommended as preparation of the patient for kinesitherapy. We hypothesized that the use of infrared radiation (IR) helps to reduce tone and stiffness, and increase muscle flexibility.

MATERIALS AND METHODS

PARTICIPANTS

The study comprised 64 subjects (29 men and 35 women). The criteria for inclusion into the study were as follows: age ranging between 50 and 70 years, both sexes (women and men), BMI in the range of: 18.5-29.9 (kg/m^2), occurrence of chronic pain in the lumbar spine which was treated conservatively for at least 5 years. The criteria for exclusion from the study were the following: acute, post-traumatic back pain, occurrence of sciatica, previous orthopedic treatment of the lumbar spine and of intake of drugs for the purpose of reducing muscle tone.

STUDY DESIGN

The prospective clinical study reported here involved 64 subjects with chronic lumbar spine pain. The order of conducting the experimental procedures was as follows: measurements by myotonometer, performed before exposure to infrared radiation (IR) using Sollux lamp (LUMINA V5.0) applied in the form of a single treatment, subsequent measurements by myotonometer successively after 5, 10, and 15 minutes of exposure to infrared radiation. In total, the participants underwent 4 series of myotonometric measurements. Measurements and therapeutic interventions were carried out between 09:00 and 14:00 hours. Before starting the study, participants were asked to fill and submit a consent form to confirm their informed participation in the study. Participants had the opportunity to opt out of the study at any time. During the tests, the same ambient conditions prevailed: air temperature of 22°C and air humidity of 50%.

The study was performed in the Didactic and Scientific Centre of Warsaw Medical Academy of Applied Sciences in Warsaw, Poland. The study was conducted in accordance with the Declaration of Helsinki (1964) and its protocol has been accepted by the Bioethics Committee (approval reference number: 2022/09/MUM-01).

THERAPEUTIC INTERVENTIONS

The Sollux LUMINA V5.0, Poland, lamp was used for carrying out the therapy, the lamp generated infrared radiation (IR) with the wavelength in the range of 830 nm. The therapeutic set consisted of a tripod, a special bulb, a red filter, a protective mesh for the filter (protection in the event of bulb break) and a tube limiting the field illuminated by the lamp. Before the start of infrared radiation procedure, the patient assumed a comfortable prone position, the body area meant for undergoing the procedure was exposed so that the radiation directly affected the skin. The person performing the procedure set the lamp at the distance of 50 cm from the body of the person undergoing the procedure, in such a way that the main beam was perpendicular to the place undergoing the treatment. During the exposure, the person undergoing the procedure had protective glasses on. The duration of the procedure was 15 minutes [12, 13].

MYOTONOMETRY MEASUREMENTS

MyotonPRO (Myoton, Estonia) was used to assess the biomechanical parameters of muscles, the apparatus is a digital device consisting of a body and a depth gauge. The gauge was applied perpendicularly to the examined tissue. The myotonometer applied uses the Mechanical Dynamic Response method, which consists in a non-invasive and accurate application of a mechanical pulse to the examined tissue, with registration of the dynamic response of the tissue in the form of signal of physical displacement and acceleration of oscillation, followed by calculating the parameters characterizing the tested biomechanical properties: tone [Hz], stiffness [N/m], and decrement (D) [log], which characterizes elasticity – the lower the value, the higher the elasticity. The device automatically exerted

a preliminary pressure by applying the force of 0.18 N, and then, after calibration, automatically generated a 5-fold short mechanical pulse with the force of 0.4 N and duration of 15 ms to deform the tissue. The accelerometer recorded oscillations of the examined tissue [14]. During the test, the coefficient of variation (CV) of each test result was observed, and if the CV exceeded 3%, the test was repeated once again. All the treatment and measurement procedures were performed by an experienced physiotherapist, trained in the field of myotonometry and performing scientific research. During the measurements, the subject was in prone position, with knees straight and feet without support, protruding beyond the edge of the couch. Myotonometer measurements were performed on belly of erector muscle of the spine, 2.5 cm from the lateral surface of the spinous process on the right and left side, at the level of vertebrae L1 to L5 [15]. One measurement procedure lasted 3 to 5 seconds. In total, 10 measurements were made, the results of which were averaged. Carrying out a series of 10 measurements took < 1 min. The lamp was on throughout the measurements, the treatment procedure was not interrupted during taking the measurements.

STATISTICAL ANALYSIS

Means and standard deviations were used to represent the average and the typical spread of demographic data. The nature of the distribution of the studied variables was tested using the Shapiro-Wilk test. The data were not normally distributed. The results of all measured variables were presented using median and lower – upper quartile (Q1-Q3). Friedman's ANOVA – for repeated measures analysis of variance by ranks was used to examine the changes in examined variables (before therapy and 5,10,15 min. after therapy). Post-hoc tests with Bonferroni correction was used to analyze the pairwise comparisons. All statistical analyses were performed using PQStat 1.8.6. The statistical significance threshold was set at $p<0.05$.

RESULTS

The average age of the subjects was 60.1±7.1 years. The average BMI values amounted to 25.49±2.66 (kg/m^2). The results of successive myotonometric measurements were compared. There were statistically significant changes in muscle tone (Friedman's ANOVA; $p<0.001$). Multiple comparisons showed significant tone differences between the measurements taken before treatment and after 5 minutes of its duration (POST-HOC Dunn Bonferroni; $p<0.001$). Tone increased over that time, from 14.66 (13.33-16.29) [Hz] to 15.66 (14.02-16.47) [Hz]. Then, in subsequent measurements taken until the end of the procedure, the tone decreased, reaching 15.07 (13.84-15.9) [Hz] after 15 minutes. The differences between the measurements of tone taken after 5 and after 15 minutes of the procedure were statistically significant (POST-HOC Dunn Bonferroni; $p=0.001$). However, statistical significance was not observed in case of the difference in tone between the measurements taken before and after the procedure (Fig. 1).

The changes in stiffness observed were at the borderline of statistical significance (Friedman's ANOVA; $p=0.052$). However, the development of stiffness values in successive measurements during the treatment procedure and after its completion was similar to that in the case of tone. Initially, an increase in stiffness was observed, with maximum values

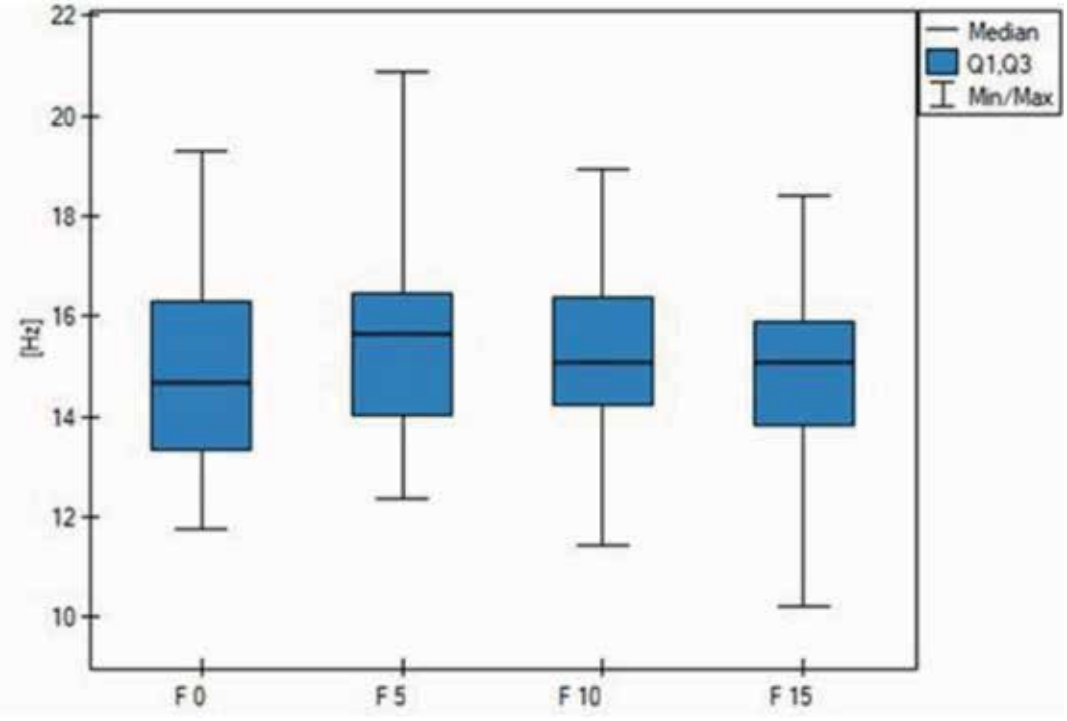

Fig. 1. Changes in tone of the erector spinae muscle – results of the MyotonPRO measurements at particular time intervals.

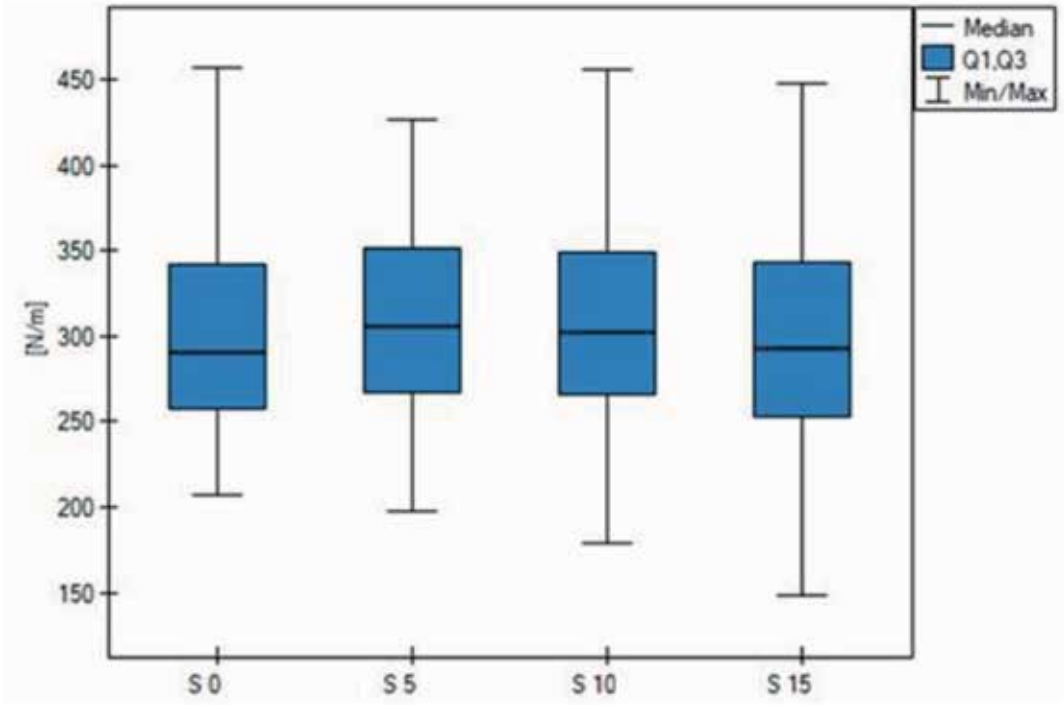

Fig. 2. Changes in stiffness of the erector spinae muscle – results of the MyotonPRO measurements at particular time intervals.

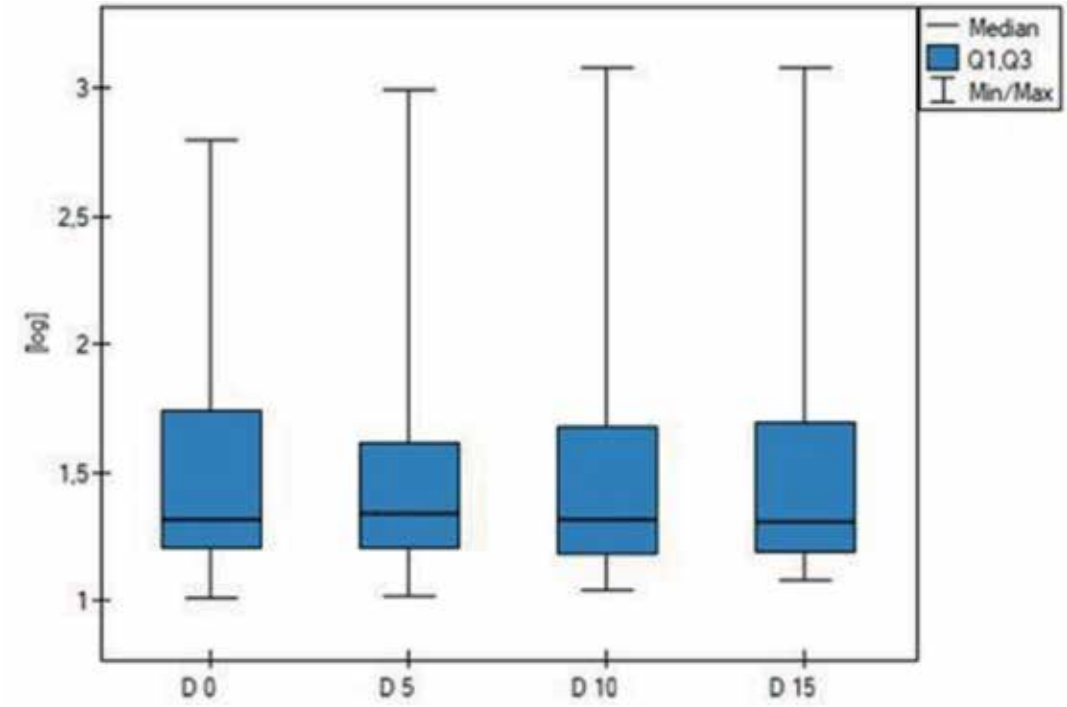

Fig. 3. Changes in decrement of the erector spinae muscle – results of the MyotonPRO measurements at particular time intervals.

amounting to 305.4 (266.42-351.63) [N/m] after 5 minutes of the procedure. Subsequently, stiffness decreased in subsequent measurements taken until the end of the procedure, reaching the value of 293.08 (252.35-343.13) [N/m] after 15 minutes of treatment (Fig. 2).

The changes noted in case of decrement were not statistically significant (Friedman's ANOVA; p=0.716). The development of the value of decrement in successive measurements during the procedure and after its completion was similar to that in the case of and stiffness. Initially, an increase

was observed, with maximum values of 1.34 (1.21-1.61) [log] after 5 minutes of treatment. Then, the values of decrement decreased in subsequent measurements until the end of the procedure, reaching the value of 1.31 (1.19-1.69) [log] after 15 minutes of the treatment (Fig. 3). When analyzing these changes, it should be noted that because the value of decrement is inversely proportional to flexibility, thus during the procedure a decrease in elasticity (up to 5 minutes into the procedure) was initially observed, and then the flexibility kept increasing until the end of the procedure (15 min).

DISCUSSION

The improvement of biomechanical properties of spinal muscles in the course of degenerative changes affecting the spine, with accompanying chronic pain, plays a key role both in maintaining their performance and preventing overloads. It is commonly assumed that heat, as thermal stimulus, leads to changes in blood supply to the muscles, reduces their tone and restores their required flexibility [3, 16].

The study reported here assessed the impact of the use of infrared radiation treatment upon normalizing biomechanical parameters of superficial paraspinal muscles, which undergo changes in the course of chronic lumbar spine pain [17]. The methodology of the treatment procedures performed corresponded to the commonly used treatment belonging to the domain of light therapy applied with the use of a Sollux lamp emitting infrared radiation (IR), performed as preparation for kinesitherapy [13, 18, 19]. The main findings of the study are as follows: Infrared radiation (IR) treatment procedures in their initial phase increased tone and stiffness, and decreased the flexibility of paraspinal muscles. This occurred during the first 5 minutes of the procedure. After that time, 10 and 15 minutes into the procedure, a decrease in tone and stiffness, as well as an increase in muscle flexibility were observed, with only flexibility increasing above the values recorded before the procedure. The values of tone and stiffness, despite their decrease, did not reach the values observed before the start of the procedure.

Each tissue and organ reacts to external stimuli in a strictly defined way, which is appropriate due to the structure and function of the given organ or tissue. Also the duration of the stimulus matters, as well as the physiological properties of the tissue (its type, body area in which it is located, or the size of the affected surface) and the individual properties of the individual (age, sex, health status, etc., type and length of illness, etc.). Increasing the intensity of action of a given factor or extending its duration intensifies the tissue reaction. There are also differences in the response of individual parts of the body to a physical stimulus, due to differences in the number of receptors involved, blood supply, and innervation. It is also worth keeping in mind that the action of a specific physical stimulus may differ, depending on the lesions or excessive sensitivity of the organism [5, 20].

The penetration of IR light into the skin is in the range of a few millimetres, among the effects it causes there are: vasomotor changes, changes in the permeability of vascular walls, changes in the excitability of nerve endings, and stimulation of receptors. In contrast, in case of muscles, IR's (infrared radiation) task is to improve blood supply, increase the supply of oxygen and energy substrates, as well as influence the acceleration of metabolism and changes in muscle tone and contractility [20-22].

In our study, we found an increase in tone and stiffness that took place first, and was subsequently followed by a decrease of those two parameters. This fact may result from the initial reaction of the neuromuscular system to the stimulus applied, which initially could cause a strong response (instantaneous sense of discomfort associated with intense heat sensation or even a slight burning sensation). After prolonged exposure to the same stimulus, the response to it became less and less intense. It was due to the adaptation of tissues to changing conditions, causing a gradual weakening of the body's response to a repeated stimulus. In rehabilitation, one refers to the so-called habituation mechanism, which is one of the basic neurophysiological processes consisting in the gradual weakening of the body's response to a repeated stimulus. Although habituation to stimulus is a natural adaptation mechanism, it can also have its drawbacks in the context of the therapies used. Therefore, it is important in rehabilitation, particularly in case of physical therapy, to change the parameters of the stimuli used (e.g. frequency, intensity, duration of the procedure) or to change the method of therapy applied, to prevent the waning of therapeutic effects as a result of habituation [3, 17, 20]. Therefore, we can suggest that the routinely performed infrared radiation treatment which usually lasts about 15 minutes should be extended to at least 20 minutes, so that and stiffness (judging from the fact that they have decreased after 5 minutes of the procedure) will be able to be reduced below the initial values (from before therapy). This, in turn, would be desirable for attaining the goal of irradiation, which is preparation for exercise (kinesiotherapy) when the effect of full overheating of tissues is achieved.

Continuing on the subject of assessing the effectiveness of phototherapy treatment procedures, Borsa et al. provided a critical assessment of the original research concerning the ability of phototherapeutic devices, such as lasers or light-emitting diodes (LEDs), to improve the contractility of skeletal muscles, and reduce muscle fatigue resulting from physical activity, as well as facilitate post-workout regeneration. The authors queried databases (PubMed, SPORTDiscus, Web of Science, Scopus, and Rehabilitation & Physical Medicine), twelve randomized controlled trials met the inclusion criteria. Exposing skeletal muscle to single-diode and multidiode laser or multidiode LED therapy was shown to positively affect physical performance by delaying the onset of fatigue, reducing the fatigue response, improving post exercise recovery, and protecting cells from exercise-induced damage [23].

Tsiakgaris, in the review of available databases (PubMed-MEDLINE, Scopus, and Cochrane Library-Cochrane Central Register of Controlled Trials) concerning the effectiveness of applying infrared radiation (IR) in the treatment of musculoskeletal disorders and chronic pain, included 13 publications in the qualitative assessment according to

the assumed criteria. The analysis showed that infrared radiation reduces the level of pain assessed using a visual analog scale (VAS). Nevertheless, IR does not make muscle recovery easier after sports injuries [18].

In another review, conducted by Kyselovic et al., the authors indicate that as many as 33% of members of general population worldwide suffer from musculoskeletal disorders, with low back pain being the main cause of disability. There are multimodal treatment options available to relieve the pain associated with muscle problems, including physical, complementary, and pharmacological therapies. In this context, the authors examined the use of infrared light provided by means of patches, fabrics, and clothing containing infrared-emitting bioceramic minerals and its biological effects, focusing on those which could potentially explain the mechanism of action that is responsible for relief of musculoskeletal pain. Based on the results obtained, the authors have pointed out to increased level of endothelial nitric oxide synthase, increased bioavailability of nitric oxide, anti-inflammatory effect, and reduction of oxidative stress as influenced by infrared radiation [17].

A similar study which concerned the comparison of monochromatic infrared photo-energy (MIPE) and low-energy laser therapy (LLLT) was conducted by Ammar, who also indicated that low back pain (LBP) was the most common musculoskeletal disorder. The evaluation focused on reducing functional disability and pain, as well as improving the range of motion (ROM) in the lumbar region in 70 patients with chronic LBP. Both groups received 2 treatment procedures per week, for 6 weeks. The outcome measures were: functional rating index (FRI), visual analogue scale (VAS), and modified Schober test carried out at the beginning of and after 6 weeks of treatment. The author found a statistically significant improvement in the evaluated parameters, not noting significant differences between the two study groups ($p>0.05$) [24].

Crow, in his study, examined the effect of PBMT (photobiomodulation therapy) applied to 20 healthy males as a preparation procedure before high-intensity and high-volume exercises, for relieving muscle fatigue and enhancing the performance of the group of external rotator muscles in the shoulder. The therapy was carried out using a near-infrared laser (λ = 810/980 N•m, 1.8 W/cm2, surface of the radiated area = 80-120 cm2) on the muscles of external rotators of the shoulder, with exposure to radiation with energy density of 10 J/cm2. The study participants were required to perform 12 series of isokinetic shoulder exercises. The last series of exercises (series 9-12) revealed that all performance measures for the active PBMT condition were from 6.2% to 10% higher than the apparent values of PBMT ($p<0.02$ do $p<0.001$) [25].

Knowledge of site reactions and specific tissue reactions and their skilful use for therapeutic purposes determines the effectiveness of physical treatment. However, it should be remembered that hypersensitivity to certain forms of energy may occur. Therefore, understanding the mechanisms of their actions still poses a challenge for many researchers dealing with the use of specific physical stimuli in modern medicine and physiotherapy.

CONCLUSIONS

Exposure of paraspinal muscles in individuals suffering from chronic lumbar spine pain to infrared radiation (IR) procedures with the use of Sollux lamp, in the form of routine procedure before kinesitherapy neither caused significant reduction of tone and stiffness nor did it increase flexibility substantially. It seems justified to consider extending the duration of the procedure in order to obtain the intended therapeutic effect, which is the preparation of the paraspinal muscles for kinesitherapy. It is also worthwhile to consider a change in the methodology of the procedure, starting application of IR from a greater distance to avoid involuntary increase in tone and stiffness in the initial stage of the procedure, which precludes habituation to the physical stimulus used. After about 5 minutes and adaptation to a temperature higher than the physiological one, the distance of IR application should be reduced, via increasing the temperature, to achieve the goal of treatment. Such topics should become the subject of further clinical trials to optimize the therapeutic parameters of IR. In our study, a single treatment procedure was performed to assess its effectiveness in accordance with the principle that the effectiveness of a single therapeutic intervention is the basis for the effects aggregating in the course of a series of treatment procedures.

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CONFLICT OF INTEREST

The Authors declare no conflict of interest

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ORIGINAL ARTICLE

Hand strength in systemic sclerosis patients during two years of rehabilitation

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ABSTRACT

Aim: The study aimed to analyze hand strength in patients with systemic sclerosis treated at the Dermatology Clinic of National Medical Institute of the Ministry of the Interior and Administration, using an electronic dynamometer, over a two-year rehabilitation period.

Materials and Methods: The study group consisted of 55 patients aged 27 to 80 years (average age: 56.4) with systemic sclerosis, who regularly received rheological treatment at the Dermatology Clinic. Additionally, for two years, patients were supported with individually selected manual exercises and upper limb self-massage. Hand strength was measured before, during, and after the therapy using an electronic dynamometer. Forty-two patients completed the study.

Results: The analysis showed that hand strength in patients with systemic sclerosis did not significantly change during the study period. The greatest changes in hand strength were observed when comparing the period from the mid-study assessment to the end of the study, rather than from the start to the mid-study assessment.

Conclusions: The results suggest that the hand strength of patients did not improve significantly during the study period. However, comparing the period from the mid-study assessment to the conclusion showed better outcomes than comparing the period from the start to the mid-study assessment.

KEY WORDS: Systemic scleroderma, manual exercises, self-massage, hand strength, electronic dynamometer

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INTRODUCTION

Patients at modern centers undergo physiotherapeutic assessment, and treatment goals are established based on preliminary tests. Rehabilitation must be tailored to the patient's needs and exclude any contraindications. A dynamometer serves as a tool to measure strength and assess the effectiveness of physical exercises, physiotherapy treatments, and balneological therapies supporting the overall treatment process. Hard-to-heal ulcers, which lead to scarring and associated pain, often alter treatment plans. The most important aspect is the patient's independence, the development of compensatory mechanisms, and the protection of joints from further deformities.

AIM

The study aimed to analyze hand strength in patients with systemic sclerosis treated at the Dermatology Clinic of National Medical Institute of the Ministry of the Interior and Administration, using an electronic dynamometer, over a two-year rehabilitation period.

MATERIALS AND METHODS

At the Dermatology Clinic of National Medical Institute of the Ministry of the Interior and Administration, patients with systemic sclerosis, a chronic and progressive disease, have been treated for over 20 years. The hospital's Bioethics Committee approved rehabilitation during the patients' stays at the clinic. Physiotherapy consisted of individually tailored exercises based on measurements taken with an electronic dynamometer to assess hand strength in kilograms (kg).

RESULTS

During the study, the average strength of the right hand slightly increased from 34.03 kg to 34.33 kg, and eventually to 36.52 kg. In contrast, the median initially decreased from 30.00 kg to 25.2 kg, only to slightly increase to 30.40 kg by the end of the study. The standard deviation also increased, indicating that the average deviation of the results from the arithmetic mean grew during the study. Both the coefficient of variation and the skewness coefficient increased, which points to a greater asymmetry in the distribution (Fig. 1).

During the study, the average strength of the left hand decreased from 32.11 kg to 29.64 kg, and by the end of the study, it reached 36.56 kg. The median changed in a similar pattern, starting at 26.00 kg at the beginning of the study, dropping to 24.20 kg during the study, and finally reaching 31.60 kg at the conclusion of the study. The standard deviation increased throughout the study,

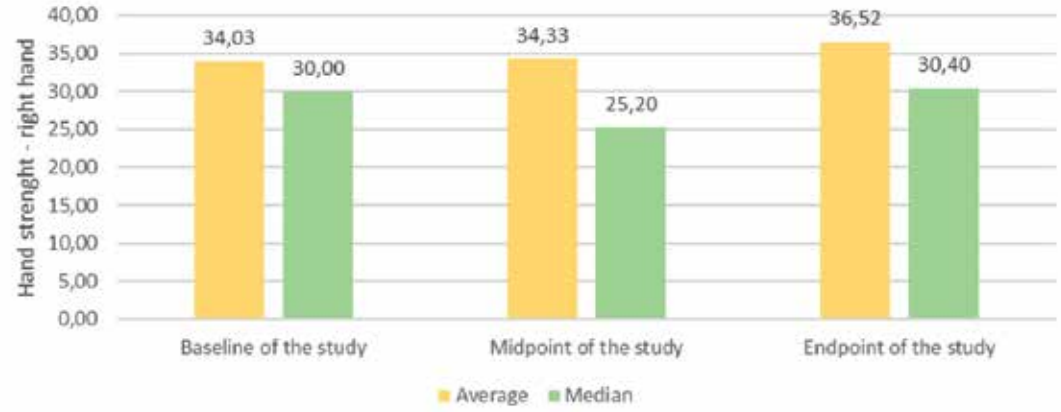

Fig. 1. Comparison of the mean and median values of right hand strength during the study.

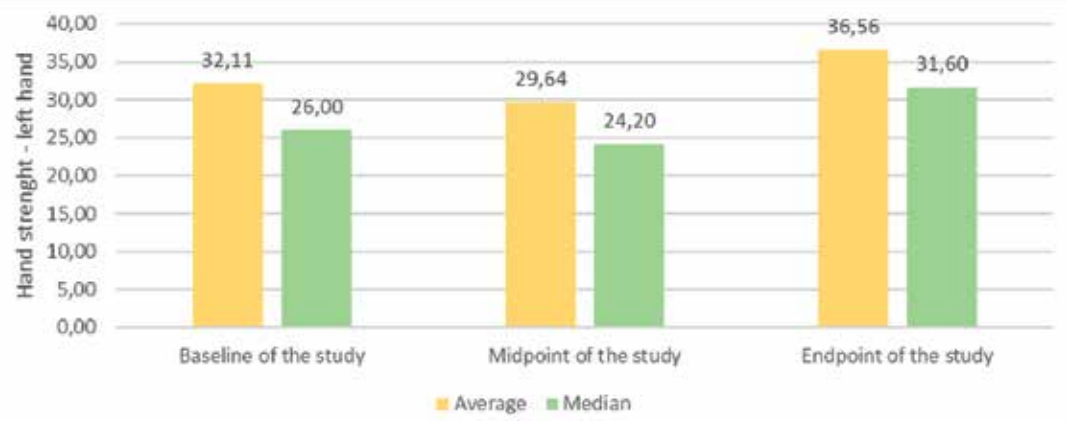

Fig. 2. Comparison of the mean and median values of left hand strength during the study.

meaning the average deviation of the results from the arithmetic mean also grew. The obtained values indicate that left hand strength increased during the study. The distribution became more spread out around the mean value, while also becoming more symmetric (Fig. 2). Analysis of the measurement results confirmed that the hand strength of patients with systemic sclerosis did not change significantly during the study period.

DISCUSSION

The human hand serves a gripping function, and its disorders affect the patient's quality of life. The main cause of disability is the musculoskeletal limitations of systemic sclerosis (SSc) and the ulcers that develop as a result. Studies confirm that non-pharmacological methods also influence the effectiveness of treatment [1-5]. Daily physical exercises, especially for the hands and face, support treatment [1-4]. Additionally, physiotherapeutic and balneological treatments accelerate the healing of wounds and erosions. The selection of appropriate treatments and the treatment plan depends on the patient's condition and any contraindications. Choosing the right exercises and therapeutic methods is crucial, especially in the early stages of the disease, when changes in the musculoskeletal system are not yet permanent. It is important to teach proper compensatory mechanisms and protect the joints from further deformities. The mobility disability of patients with generalized scleroderma makes it difficult for them to access treatments offered in their place of residence or in outpatient clinics. It is worth noting the rich therapeutic offerings available in health resorts and sanatoriums. These facilities, which are prepared for disabled individuals, allow patients to benefit from them while also providing an opportunity to change the environment and take advantage of the therapeutic effects of the climate. Numerous studies have documented the effectiveness of exercises tailored to the patient's abilities [1-4, 8, 11, 13, 18, 19, 22]. The assessment of hand grip capacity is conducted using various questionnaires and parameters [7, 9-10, 12, 14-16, 19-21]. The use of a dynamometer (force gauge) as a device for measuring force in accordance with Hooke's law (specifically for grip strength) seems to provide an objective measurement. For healthy people, it certainly works, including young and older individuals, both male and female, highly athletic and less athletic, in North America (USA) and Europe (Sweden, Switzerland) [23-32]. The use of an electronic dynamometer to measure hand strength

in kilograms (kg) in chronic diseases, where pain, erosions, and ulcers that heal and new ones that develop can also influence the result, opens up a discussion [13]. It is difficult to find the ideal objective measurement method, and it seems impossible; the search for one is ongoing.

CONCLUSIONS

The average strength of the left hand decreased during the study but improved by the end of the study period. In contrast, the average strength of the right hand increased throughout the study. In both cases, better results were seen when comparing the mid-study assessment to the final assessment, rather than comparing the start to the mid-study assessment. This suggests that no noticeable effects were observed at the beginning of the study. The Wilcoxon test for the population showed no statistical basis to conclude that the hand strength significantly changed during the study.

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ORIGINAL ARTICLE

Health and rehabilitation of the population through the prism of monitoring and control of pesticide impact: the negative legal experience of Ukraine

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ABSTRACT

Aim: To collect, assess, and summarize legal norms, organizational measures, and the competence of state authorities that form the basis of the legal protection of public health and rehabilitation procedures through the monitoring and control of pesticide impact. To answer the question: Does Ukraine have a system for monitoring the impact of pesticides on human health during their use? As well as subsequent rehabilitation.

Materials and Methods: An inquiry was made to nine Ministries and other central executive authorities of Ukraine to obtain information on existing databases regarding the impact of pesticides on human health, as well as the level of openness and accessibility of this data to the public.

Results: Seven out of nine respondents stated that they do not possess such information, as it falls outside their competence. The State Water Agency of Ukraine conducts state monitoring of surface water bodies based on various specific indicators, including pesticides. The State Statistics Service of Ukraine monitors only the volumes and areas of pesticide use to analyze anthropogenic pressure on soils. There is no separate record of pesticide poisoning cases in Ukraine (Ministry of Health).

Conclusions: Inquiries to Ukrainian state authorities proved to be not very effective, as most of them responded that they do not possess such information since it falls outside their competence. Other agencies do not maintain separate records on the impact of pesticides on human health.

KEY WORDS: pesticide toxicity, environmental effect, health hazards, monitoring

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INTRODUCTION

The legal protection of public health through the monitoring and control of pesticide impact plays a significant role in the modern world. Pesticides are mainly used for the elimination, control of reproduction, and prevention of various pests, combating agricultural plant diseases, and increasing their yield and resistance. Pesticides are also used in other sectors of the economy, including the food industry, forestry, aquaculture, and more [1]. At the same time, pesticides can also be used in areas such as public health protection against certain diseases, controlling unwanted plants in park and garden landscapes, as well as various pests and disease carriers in homes and on the streets [2]. Despite all the advantages of such use, there is one major drawback – the negative impact on human health. Therefore, worldwide, significant attention is given to monitoring and controlling the effects of these hazardous compounds. Unfortunately, in most countries, control and monitoring focus primarily on the pesticides themselves, their application methods, and residual pesticide levels. However, violations of established pesticide use regulations primarily lead to various adverse health effects, including the emergence of acute or delayed chronic diseases. It has already been established that pesticides can negatively affect human health and quality of life in various ways: they can remain in food products after field treatment, contaminate water sources, enter the bodies of agricultural workers during their tasks, or affect people simply due to the proximity of their homes or offices to treated fields [3, 4]. It has even been found that agricultural workers carry pesticides home on their clothing, putting their family members at risk [5]. The specific risks of the negative impact of pesticides on human health are difficult to calculate due to the involvement of many different factors. However, accurate assessment is possible if monitoring and control are organized at an appropriate level. Therefore, there is an urgent need for a scientific study on the organizational and legal measures to ensure the monitoring and control of pesticide impacts on human health to mitigate their adverse effects. This scientific work will address this issue.

AIM

The main objective of the study was to collect, assess, and summarize legal norms, organizational measures,

and the competencies of state authorities that form the basis of legal protection of public health and rehabilitation through the monitoring and control of pesticide impacts. Additionally, this research aimed to answer the question, using Ukraine as a case study: Does monitoring of the impact of pesticides on human health exist during their use? As well as subsequent rehabilitation.

MATERIALS AND METHODS

Given the specificity of the topic and research objectives, the authors conducted an informational and analytical search in electronic and printed sources. The analysis of scientific research databases allowed the use of approximately 30 scientific and analytical sources relevant to the study. Legal norms and doctrinal positions of scholars were examined using scientific methods of analysis, comparison, and generalization from both medical and legal perspectives. This scientific study is also based on dialectical, analytical, and comprehensive research methods. To assess the existing system of monitoring and control of pesticide impact on human health and to determine the level of governmental informational interest in pesticide-related health risks, Ukraine – one of the largest agricultural countries – was chosen as a case study. Requests for clarification and information were sent to nine Ministries and other central executive authorities of Ukraine to obtain details on existing databases regarding the impact of pesticides on human health and the environment, as well as the level of openness and accessibility of this data to the public. The key questions posed in the inquiries to state authorities included:

1. Are there any official programs at the local or state level for studying the impact of pesticide use on public health?
2. Is there statistical data on the impact of pesticides on public health and cases of pesticide poisoning?
3. What types of information are collected regarding pesticide contamination of ecosystems?
4. Are there any control and monitoring programs for pesticide residues in agricultural products and the environment?
5. Are the collected data on the impact of pesticides accessible to the public?

RESULTS

The inquiries to state authorities turned out to be not very effective, as most of them – including the Ministry of Agrarian Policy and Food of Ukraine, the State Labor Service of Ukraine, the Ministry of Environmental Protection and Natural Resources of Ukraine, the State Environmental Inspectorate of Ukraine, and the State Service for Geodesy, Cartography, and Cadastre – stated that they do not possess such information, as it falls outside their jurisdiction. However, the following authorities provided responses to the above-mentioned questions:

1. The State Agency of Water Resources of Ukraine (hereinafter referred to as Derzhvodagentstvo) conducts state monitoring of surface water bodies based on chemical, synthetic, and non-synthetic priority and basin-specific indicators, which include pesticides. Water sampling and measurements are carried out monthly at observation points specified by the State Water Monitoring Program. Information on the conducted surface water quality studies is published on the Derzhvodagentstvo website through the "Monitoring and Environmental Assessment of Water Resources" web system. However, access to this system is currently restricted due to ongoing military actions [6]. The monitoring data is also published on the official resource of the Ministry of Environmental Protection and Natural Resources of Ukraine – the "EcoThreat" dashboard – in the thematic layer "Monitoring and Environmental Assessment of Water Resources" [7]. In addition, Derzhvodagentstvo ensures the publication of monitoring data on the Open Data Portal [8]. However, a detailed analysis of the above-mentioned information databases reveals that there is no separate systematic information specifically on the impact of pesticides within these resources.
2. The State Service of Ukraine on Food Safety and Consumer Protection (hereinafter referred to as SSUFSCP) responded that the monitoring in question refers to state socio-hygienic monitoring, which aims to observe, analyze, assess, and forecast the health status of the population and the human living environment, as well as to identify cause-and-effect relationships between public health and the impact of environmental factors. According to its assigned authority, this type of monitoring in Ukraine is carried out by the Ministry of Health of Ukraine.
3. The State Statistics Service of Ukraine (hereinafter – Derzhstat) reported that state statistical observation is conducted under the topic "Use of Fertilizers and Pesticides for Agricultural Crop Yields," which is included in the section "Economic Statistics/Economic Activity/Agriculture, Forestry, and Fisheries." This statistical observation provides information exclusively on: the volume of pesticides and other agrochemicals used by enterprises for agricultural crop yields, the area of land where these substances were applied, the dynamics of these indicators to support the analysis of anthropogenic pressure on soils [9].
   According to the information provided in the response to the inquiry, the collection and processing of data on pesticide contamination of ecosystems, monitoring of pesticide residues in agricultural products and the environment, as well as the impact of external factors on public health and disease incidence are not included in the plan and methodological provisions for the organization of state statistical observations.
4. The Ministry of Environmental Protection and Natural Resources of Ukraine (hereinafter referred to as MinDovkillia) stated in response to the inquiry that the outlined issues do not fall within its competence. It should be emphasized that MinDovkillia is responsible for preparing the annual National Report on the State of the Environment in Ukraine. In the section

"Agriculture and Its Impact on the Environment," there is only a selection of information regarding pesticide use [10].

5. The Ministry of Health (hereinafter referred to as MOH) responded that, to date, there is no proper record of pesticide poisoning in Ukraine. Most mild cases of poisoning remain unregistered, as affected individuals resort to self-help or seek pre-medical assistance at healthcare facilities. Statistical data on population morbidity is available on the official website of the State Institution "Public Health Center of the Ministry of Health of Ukraine" [11]. In the existing official statistical forms, all pesticide poisonings are categorized under the section "other diseases". Additionally, due to changes in property ownership, the establishment of small private farms, and the use of seasonal workers, farm owners are not interested in officially recording poisoning cases. Only officially registered employees who have suffered from group poisonings are admitted for examination at the clinic of the Institute of Ecohygiene and Toxicology of the State Enterprise "Scientific Center for Preventive Toxicology, Food, and Chemical Safety named after Academician L.I. Medved of the Ministry of Health of Ukraine". Furthermore, toxicology laboratories of the departments for the study of physical and chemical factors at regional Centers for Disease Control and Prevention under the MOH of Ukraine systematically monitor open water bodies and soil for residual pesticide (toxic chemical) content. The issue of programs for monitoring and controlling pesticide residues in agricultural products and the environment falls outside the competence of the MOH.

In turn, the "Public Health Center of the Ministry of Health of Ukraine" provided a brief response: Regarding question 1: The Center does not have programs for studying the impact of pesticide use on public health. Regarding question 2: The reporting form for entities engaged in medical practice does not provide for a separate classification of the disease category "Toxic effects of pesticides". Regarding questions 3 and 4: The Center stated that these issues fall outside its competence.

Other state authorities did not respond to the inquiry at all. This, of course, does not contribute to the development of legal protection of public health from the effects of pesticides and indicates an inadequate level of state interest in monitoring and controlling pesticide exposure.

DISCUSSION

Health is a state of complete physical, mental and social well-being and not merely the absence of disease or infirmity [12]. At the official level, the concept of pesticides has been defined by the World Health Organization (WHO) as a chemical compound used to eliminate insects, rodents, fungi, and weeds. In turn, the Food and Agriculture Organization of the United Nations has repeatedly defined pesticides, particularly as a substance or a mixture of chemical or biological ingredients that repel, destroy, or control any pests or act as plant growth regulators [13]. Given that most pesticides are toxic, they pose significant risks to the human body. Pesticides can enter the human body through the mucous membranes of the eyes, respiratory organs, skin, or through food and water. Chemical pesticides can cause the most severe diseases, including cancer, cardiovascular, respiratory, and neurological disorders [14].

There are various databases related to the assessment of pesticide impacts and risks. For example, in the United States, there is a specially authorized federal government agency, the Environmental Protection Agency (EPA), whose task is to protect human health and the environment, as well as to regulate the production, processing, distribution, and use of chemicals and other pollutants. The EPA maintains various databases, including those on the impact of pesticides on the environment, the impact of pesticides on water resources, their effects on human health, and regulatory information [15]. However, unfortunately, not all countries have the appropriate legislative frameworks and such extensive databases on the impacts and risks of pesticides on human life and health, as well as other effects. Many countries do not pay sufficient attention to monitoring the impacts of pesticides [16, 17]. Therefore, scientists and international organizations continuously call for the improvement and strengthening of research and monitoring systems in the fields of agroecology and organic farming concerning the negative impact of pesticides [18].

At the European Union level, the issue of the lack of systematic monitoring, data collection, and analysis regarding the impact of pesticides on human health has been recognized. Currently, data on pesticide use are not available at the EU level, but according to the Regulation on Agricultural Input and Output Statistics, their collection will become mandatory starting in 2028 [19]. Since 2011, the EU has only been collecting data on pesticide sales volumes. The new data collection will aim to create more accurate statistics on pesticides.

Recent studies on this topic emphasize the importance of political measures, which researchers believe are more powerful and influential in reducing the impact of pesticides on health than even existing pesticide prices [20]. That is why new research organizations and alliances are strengthening their presence and activities at the European level to counter the challenges posed by pesticide use and to reduce their application on the current scale. Notably, the unprecedented unification of the European research community around the scientific vision of agriculture free from chemical compounds has gained significant momentum. This refers to the creation of the European Research Alliance, whose first step was the adoption of a joint declaration of intent, "Towards a Chemical Pesticide-free Agriculture," on February 23, 2020. This declaration was signed by 24 research organizations from 16 European countries. Its goal is to reconsider existing research approaches and develop new joint research and experimental strategies, not only at the national level but also globally [21].

It is also essential to mention another significant political decision by the European Commission – the Green Deal [22],

which places particular emphasis on reducing the use of chemical pesticides across the European continent. Accordingly, a proportional reduction in the risks associated with pesticide use for public health is expected. These legislative proposals align with biodiversity strategies and can help ensure the safety of food production and consumption both in the EU and globally. The proposed changes are primarily driven by concerns over the accumulation of pesticide residues in the environment. The final report of the Conference on the Future of Europe [23] highlights the provisions of the Directive on the Sustainable Use of Pesticides [24], which, unfortunately, has not become an adequate and effective tool for regulating the risks associated with pesticide use. Insufficient progress has also been made in addressing the harm to human health caused by pesticide exposure. In response, the European Commission proposed establishing and legally enshrining new regulations at both the EU and national levels. These include: a 50% reduction in the use of hazardous pesticides by 2030; the widespread adoption of alternative ecological pest prevention and control methods in agriculture, resulting in an increase of organic farming to 25% of EU agricultural land; a ban on the use of chemical pesticides in urban green areas; a prohibition on the sale of imported food products within the EU that contain measurable residues of banned substances [25].

It is especially important to focus on the legislative regulation of pesticide use and permissible exposure levels in individual countries. Scientific literature presents research data indicating that pesticide legislation for health protection is absent in 25% of the world's countries [26]. Scientists have repeatedly pointed out that developed countries are significantly more effective in preventing and reducing the negative impact of pesticides on human health and the environment during their application compared to developing countries [4]. Therefore, a crucial task is to engage developing countries in the process of regulation, control, and statistical data collection on the impact of pesticides on human health. This raises a debate on whether the measures adopted at the international and European community levels truly influence the willingness of individual countries to monitor and control pesticide exposure on public health.

CONCLUSIONS

A global and local assessment of existing monitoring and control measures regarding the impact of pesticides on public health has been conducted. The main goal of such measures is to minimize risks to human health and to rehabilitate the body. The position of the international and European communities on pesticides and their potential negative effects emphasizes that states bear the responsibility for implementing control and monitoring measures, ensuring their funding, and being held accountable in cases of inadequate oversight. The study, using Ukraine as an example, has shown that not all countries utilize all available means to collect and maintain statistical data on health impacts and pesticide poisoning. Regular violations of pesticide use regulations, along with a lack of proper monitoring, make it impossible to prevent the negative consequences of such substances. In our opinion, all possible measures should be employed to collect reliable data at both regional and national levels. In addition, it is necessary to maintain statistics on the impact of pesticides on human health, identify all side effects associated with the use of pesticides, and take appropriate measures to reduce potential risks and ensure timely rehabilitation.

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REVIEW ARTICLE

New directions for TENS applications: use beyond pain management

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ABSTRACT

Aim: The aim of this paper is to provide an overview of research on the technique of transcutaneous electrical nerve stimulation (TENS) in applications other than pain management.

Materials and Methods: PubMed, Google Scholar and Medline databases were searched to prepare the manuscript. Original papers, meta-analyses and review papers were included in the review, while conference proceedings and publicity materials were discarded.

Conclusion: There is evidence that transcutaneous electrical nerve stimulation (TENS) may have applications beyond pain management. Studies indicate its effectiveness in treating xerostomia, sleep apnea, improving sleep quality, pruritus, gastrointestinal motility disorders, urinary incontinence and wound healing. It can also be used for some indications in children. It is indicated that its effectiveness depends on individual stimulation parameters. In some areas, the effects are not superior to placebo, which requires further research, including long-term studies. Due to its safety and therapeutic potential, TENS can be a complement or alternative to traditional therapies.

KEY WORDS: insomnia, pain, xerostomia, TENS, PubMed, Google Scholar, Medline

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INTRODUCTION

Transcutaneous electrical nerve stimulation (TENS) is based on the application of low-voltage, pulsating electrical current in the form of waves of different shapes [1]. It is a non-invasive and non-pharmacological method [2] Its effectiveness in the treatment of pain began to be studied as early as the 1970s [3]. Nowadays, TENS therapy can be carried out with a small, portable, battery-powered device [4]. This device generates electrical impulses that are transmitted through adhesive electrodes placed on the skin [5]. When the current is applied to the surface of the skin, its main purpose is to relax overactive muscles and relieve pain. TENS works by stimulating nerves at different levels: subthreshold (≤5 Hz, <5 mA, no sensation), sensory (50-150 Hz, tingling), motor (<20 Hz, vibration) and pain (above the comfort threshold), improves circulation through reflex activation of autonomic nerves and muscle contractions, inhibits pain by control gate theory (stimulation of large A-alpha/A-beta fibers blocks pain signals from A-delta/C fibers), releases endorphins (1-10 Hz), and reduces muscle tension and metabolites, relieving chronic pain [1]. TENS was originally designed primarily for pain management, but its application is much broader. It can be used for lower back pain, diabetic neuropathy, postoperative pain or fibromyalgia [4]. It has been suggested that this method may find application in the treatment of pruritus, wound healing, obstructive sleep apnea [5], sleep disorders, nausea and vomiting, Raynaud's syndrome, edema and even depression [2, 4-6]. In addition, its use in the treatment of masticatory disorders , facial nerve palsy, wrinkle reduction and incontinence disorders is described [1, 7]. It is indicated, the high safety profile of TENS therapy [3, 8, 9]. Among the side effects, contact sensitization to electrode adhesive components is mentioned [2]. Some patients have experienced nausea and dizziness [2, 3]. TENS is contraindicated in pregnant women, those with pacemakers, venous or arterial thrombosis. Therapies should be used with caution in patients with epilepsy [10].

AIM

The purpose of this study is to provide an overview of research on the contemporary TENS technique used in physiotherapy and balneology for applications other than pain management

MATERIALS AND METHODS

PubMed, Google Scholar and Medline databases were searched to prepare the manuscript. Original papers, meta-analyses and review papers were included in the review, while conference proceedings and publicity materials were discarded. The review was conducted from October 2024 to January 2025.

REVIEW AND DISCUSSION

TINNITUS

Tinnitus, the perception of sound without an external source, affects 12-30% of the global population, though its exact cause remains unclear [8, 11]. Studies on TENS for

tinnitus compared unilateral (Group A) and bilateral (Group B) stimulation to a placebo group (Group C). Both Groups A and B showed significant improvements in Depression, Anxiety, and Stress Scale (DASS) and Tinnitus Handicap Inventory (THI) scores compared to Group C, with no difference between unilateral and bilateral stimulation [8]. Another study compared manual acupuncture (MA), electroacupuncture (EA), and TENS for chronic tinnitus, finding no significant differences in THI scores but higher improvement rates with EA [12]. A 2025 study on TENS for tinnitus in normal-hearing patients reported significant symptom reduction, with 45 of 64 patients improving and nine achieving complete remission, though long-term data is lacking [11]. Another study on transcutaneous vagus nerve stimulation (tVNS) found no direct reduction in tinnitus symptoms but observed changes in EEG theta waves, suggesting potential long-term benefits with further research [13].

SALIVA SECRETION

Saliva is crucial for oral health, maintaining neutral pH, mineralizing enamel, and aiding speech, swallowing, and oral cleansing. Reduced saliva flow, or xerostomia, often caused by systemic diseases, medications, radiation therapy, or dehydration, is common, especially in the elderly [14,15]. A study on TENS for saliva-deficient patients, with electrodes placed in the parotid region, found that 76% of participants experienced increased saliva secretion. However, efficacy was lower in those taking saliva-enhancing drugs, and men responded better than women. The mechanism may involve TENS stimulating the auricular nerve, which acts as a secretory-motor nerve for the parotid gland, making TENS a potential alternative for those allergic to saliva-stimulating drugs [14].

In hemodialysis patients, who often experience xerostomia due to poor salivary function and fluid restrictions, high-frequency, high-intensity TENS applied for 20 minutes three times a week over 14 days significantly increased saliva flow, with effects lasting seven days post-therapy. A control group receiving low-frequency, low-intensity stimulation showed no improvement, highlighting the importance of stimulation parameters [16]. A meta-analysis of nine studies confirmed electrostimulation's effectiveness in reducing xerostomia in Sjögren's syndrome, while another study suggested TENS may alleviate thirst post-general anesthesia [17, 18].

SLEEP APNEA

Obstructive sleep apnea (OSA), characterized by repeated upper airway obstruction during sleep, affects up to 39% of adults, particularly men and the elderly, and is a risk factor for cardiovascular disease, hypertension, obesity, and depression [19]. The standard treatment is continuous positive airway pressure (CPAP), while surgical implantation of a hypoglossal nerve stimulation (HNS) implant is another option. However, TENS has emerged as a non-invasive alternative, delivering electrical stimulation without surgery. A meta-analysis found TENS significantly improved the apnea-hypopnea index (AHI) with a weighted mean difference of -12.89. Studies also reported improvements in oxygen saturation (SaO_2), lowest saturation levels (LSAT), and apnea index (AI). Continuous TENS stimulation reduced awakenings and alleviated OSA symptoms more effectively than intermittent stimulation, as it maintains neuromuscular tension with less effort [5]. In a study, TENS applied to the sub-chin area significantly improved AHI (mean difference: -11.5), reduced snoring, and improved sleepiness scores (ESS) by 3 points, though quality of life showed no significant difference compared to CPAP. While TENS was slightly less effective than HNS implants (AHI reduction of 11.5 vs. 17.3), it is cheaper, simpler, and safer, making it a viable option for patients intolerant to CPAP or as a secondary treatment [20]. Limitations include short follow-up and a 27.6% non-response rate, highlighting the need for further research on long-term efficacy [20]. Another review of the literature indicates that there is insufficient evidence on the benefits of TENS on cardiovascular parameters, neurocognitive function and behavior in patients suffering from sleep apnea [21].

SLEEP DEPRIVATION

Common sleep disorders, such as insufficient sleep duration (5-6 hours) and poor sleep quality, increase the risk of cardiovascular disease, obesity, hypertension, cancer, and depression, underscoring the need for research on improving sleep quality [22]. A study compared ACUTENS, acupressure, and standard care in pregnant women with insomnia or poor sleep quality. After 6 weeks, the standard care group showed the least improvement (score: 5.0), followed by ACUTENS (4.5), and acupressure (4.0). However, no significant differences were found, suggesting neither ACUTENS nor acupressure provided additional benefits over standard care. The authors recommend using polysomnography for more objective assessments [23]. Another study evaluated daily tVNS using TENS for two weeks, targeting the auricular branch of the vagus nerve. While participants reported improved sleep quality, the results were not statistically significant. The authors suggested the electrode placement or short study duration may have limited effectiveness, calling for longer studies and parameter adjustments [22]. A four-week study on 160 participants aged 40-80 found that low-frequency TENS improved sleep quality and reduced cortisol levels in those over 60, potentially by regulating the hypothalamic-pituitary-adrenal axis and reducing inflammation. No significant effects were observed in younger participants [6]. An EEG study found that TENS can modulate sleep through neuronal synchronization. Stimulation modes with 50% high-frequency components (M1, M3, M4) slowed neural activity, broadened theta waves, and increased activity in sleep-related brain areas. In contrast, the M2 mode (65% high-frequency) hindered sleep transition, highlighting the importance of frequency proportions in achieving therapeutic effects [24].

PRURITUS

TENS therapy has shown promise in treating pruritus, particularly in dermatology. A study involving 30 patients with lichen planus and intense pruritus applied TENS three times weekly for four weeks. Significant improvements were observed: VAS scores decreased from 8.30 ± 1.18 to

5.63 ± 1.65 after two weeks and to 2.13 ± 0.97 after four weeks, while DLQI scores dropped from 16 to 10 after two weeks and to 5.5 after four weeks [2]. Another study with 46 chronic pruritus patients found TENS most effective for atopic dermatitis (AD) and lichen chronicus (LSC), with sustained VAS score improvements (2.7 for AD and 3.3 for LSC) after one month. However, patients with liver disease-associated pruritus showed less improvement [25]. A comparison of TENS and narrow-band ultraviolet B (NBUVB) phototherapy for lichen planus (LP) found both effective, but TENS was superior, as evidenced by greater reductions in VAS and DLQI scores [26]. TENS also reduced the need for topical therapies in dermatoses [4]. While TENS shows moderate efficacy for localized pruritus, evidence for generalized pruritus remains limited. Nevertheless, current findings suggest TENS is a promising option for pruritus relief [27].

GASTROINTESTINAL MOTILITY

Postoperative bowel obstruction, a common complication of abdominal surgery, prolongs hospitalization, increases infection risk, and raises medical costs. TENS significantly reduces the time to first bowel movement or stoma function (82.6 hours in the standard group vs. 50 hours in the TENS group) and is well tolerated [28]. It shows potential in treating gastrointestinal motility disorders like dysphagia, GERD, gastroparesis, functional indigestion, and constipation, alleviating pain, nausea, vomiting, delayed gastric emptying, and swallowing difficulties. For GERD, TENS increases LES pressure and reduces reflux episodes. tVNS also appears promising for gastroparesis and IBS but requires further research. Long-term efficacy and safety data are lacking, and developing universal therapeutic protocols remains challenging [29]. A 2025 study found TENS more effective

Table 1. Summary of information on the use of TENS in various indications

Health Issue	Potential lessons from TENS therapy	Other remarks
Tinnitus	– Reduction of tinnitus severity [11]. – Improvement in scores on the DASS and THI scales [8].	– Requires further research on long-term effects [11].
Saliva secretion	– Increase saliva secretion [14]. – Alternative to saliva stimulant drugs [14].	– Limited effectiveness in those using saliva-enhancing drugs [14]. – Men may respond better than women [14]. – Effectiveness of TENS depends on stimulation parameters [16].
Sleep Apnea	– Improvement in apnea-hypopnea index (AHI) [5]. – Reduction of snoring [20]. – Improvement in sleepiness (as measured by the ESS scale) [20].	– Less effective than invasive methods [20]. – Good alternative for those intolerant to CPAP [20]. – Individual adjustment of stimulation parameters may optimize effects [5]. – Further research on long-term efficacy is needed [20].
Sleep deprivation	– Improvement in sleep quality (especially in the elderly) [6]. – Reducing cortisol levels [6].	– Effects may be age-dependent [6]. – Results are not always superior to placebo [22]. – Studies should use polysomnography [23].
Pruritus	– Reduction of pruritus severity (especially in atopic dermatitis and lichen planus) [2, 25]. – Reducing the need for topical therapies [4].	– More research is needed on generalized pruritus [27].
Motility of the Gastrointestinal Tract.	– Shortening the time to first bowel movement after surgery [28]. – Mitigating symptoms of dysphagia, GERD, gastroparesis and constipation [29]. – Improvement of biochemical parameters and intestinal microbiota in functional constipation [30].	– Requires further research on long-term efficacy and safety [29].
Urinary Incontinence	– Reduction of symptoms and improvement of quality of life [31, 33, 34]. – Reduction of cases of frequent urination, urge incontinence, urinary tract infections and constipation (in children) [7].	– Studies on long-term effects are needed [7]. – More effective when combined with medications [32]. – Postoperative stimulation reduces the risk of recurrence [34].
Wound Healing	– Acceleration of wound healing by reducing inflammation and increasing granulation tissue formation [35]. – Improving blood flow, reducing pain [36]. – Bacteriostatic effect on wounds [37].	– Lower effects than saline and iodopovidone [35]. – Reduced need for antibiotics after cesarean section [38].

AHI – Apnea-Hypopnea Index, CPAP – Continuous Positive Airway Pressure, DASS – Depression Anxiety Stress Scales, ESS – Epworth Sleepiness Scale, GERD – Gastroesophageal Reflux Disease, TENS – Transcutaneous Electrical Nerve Stimulation, THI – Tinnitus Handicap Inventory

than lactulose for functional constipation, improving bowel movements and symptoms. It increased motilin and VIP levels, reduced interleukin-12, and positively influenced gut microbiota by increasing Bacteroidetes and lowering the Firmicutes-to-Bacteroidetes ratio [30].

URINARY INCONTINENCE

More than 60% of adult women in the US have experienced incontinence [5]. Risk factors include obesity, aging, pregnancies, and nicotinism. Untreated incontinence affects quality of life, limiting occupational and social functioning and impacting physical and psychological well-being. A systematic review of 30 studies found that transcutaneous tibial and vaginal stimulation effectively reduced symptoms, with most methods-except pelvic floor stimulation-improving quality of life. However, percutaneous tibial stimulation requires clinic visits, and vaginal stimulation poses discomfort and infection risks [31].

In pediatric urology, incontinence also affects quality of life. The Tugtepe study on 27 children (mean age 7.2) with refractory incontinence found full improvement in 70.4%, partial in 22.2%, and no effect in 7.4% after three months of TENS therapy. It reduced frequent urination, urge incontinence, UTIs, and constipation, though effects on fractional urinary output were not significant. Long-term data and maintenance therapy studies are needed [7]. Another study found TENS combined with oxybutynin more effective than TENS alone, reducing oxybutynin's side effects, including residual urine volume after PVR micturition [32].

Stress urinary incontinence (SUI) occurs due to increased abdominal pressure from sneezing, coughing, or exercise. A study on five women over eight weeks showed TENS improved urogynecological mechanics, muscle thickness, and strength, as well as subjective incontinence and sexual function. TENS was suggested as a first-line therapy before surgery [33]. Another study found TENS reduced recurrent SUI to 10% post-surgery (vs. 17.8% in controls) and improved quality of life [34].

WOUND HEALING

The wound healing process involves inflammation, granulation, re-epithelialization, angiogenesis, matrix formation, and remodeling. Pro-inflammatory cytokines (IL-1β, IL-6, TNF-α) released by various cells regulate infection control, keratinocyte migration, fibroblast proliferation, chemotaxis, and extracellular matrix degradation. A study on an animal model comparing TENS, saline, and iodopovidone showed that TENS significantly accelerates healing by reducing inflammation and increasing granulation tissue formation, outperforming the other treatments [35].

Another study on elderly patients with lower extremity sores found that TENS improved blood flow in the posterior tibial artery, reduced wound area, and accelerated healing. Effect sizes were small for wound area and blood flow, moderate for skin temperature and pain, and high for healing rate, highlighting its potential for chronic wound treatment [36]. External electrical stimulation also exhibits bacteriostatic effects against common wound-colonizing bacteria, potentially reducing infection risk and promoting healing [37]. In post-cesarean women, TENS accelerated wound healing at all stages and reduced infection rates at 30 days (7.4% vs. 22.2% in the control group). Antibiotic use was lower in the TENS group (18.5% vs. 40.7%), suggesting improved circulation and immune response. Additionally, 64.8% of TENS users reported high satisfaction, compared to 40.7% in the control group [38]. A 2023 study on chronic prostatitis found that combining TENS with levofloxacin and tamsulosin reduced inflammation and pain without increasing side effects, improving overall treatment efficacy [9]. A summary of information on the use of TENS in various indications is provided in Table 1.

CONCLUSION

TENS can find application in various entities. In xerostomia, it increases saliva secretion, especially in patients after radiation or chemotherapy, providing an alternative to medication. In obstructive sleep apnea, TENS may be an option for those intolerant of CPAP, although its effectiveness is lower than invasive methods. In the treatment of pruritus, TENS reduces symptoms, especially in dermatological diseases such as atopic dermatitis and lichen planus. In gastrointestinal motility disorders, TENS relieves symptoms of dysphagia, GERD, gastroparesis and constipation, although further research is needed. In urinary incontinence, TENS, especially when combined with medication, improves quality of life and reduces symptoms. In wound healing, TENS accelerates recovery by reducing inflammation and improving circulation, which is important in patients with chronic wounds. The effectiveness of TENS depends on individual stimulation parameters, which requires personalization of therapy. In some cases, such as in the treatment of sleep apnea or sleep disorders, the effects of TENS are not always superior to placebo, indicating the need for further research.

In conclusion, TENS is a safe and effective method that can be a complement or alternative to traditional therapies in some indications other than pain management.

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CONFLICT OF INTEREST
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REVIEW ARTICLE

Peculiarities of formation of readiness of future specialists in physical rehabilitation to use health-preserving technologies in their professional activity

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ABSTRACT

Aim: The aim of the study is to theoretical substantiation of the effectiveness of the model developed by us for forming the readiness of future physical rehabilitation specialists to use health-preserving technologies.

Materials and Methods: To solve the tasks and achieve the goal of the article, we used general scientific methods of the theoretical level (analysis, synthesis, comparison, systematization, generalization of scientific and theoretical data), peculiarities of formation of readiness of future specialists in physical rehabilitation to use health-preserving technologies in their professional activity.

Conclusions: The model of the readiness of future physical rehabilitation specialists to use health-preserving technologies in professional activities should contribute to the actualization of purposefulness in education, the formation of an active professional position and professional motivation; secondly, the model should contribute to increasing the level of professional readiness, which will improve the process of physical rehabilitation of clients. The specified model was implemented in the following sequence of stages: informational and operational; technological and procedural; personal-motivational and pedagogical-oriented.

KEY WORDS: professional activity, model, readiness, health-saving technologies, specialists in physical rehabilitation

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INTRODUCTION

A modern person is under the influence of many negative factors (poor nutrition, pollution of the natural environment, socio-economic problems, bad habits, etc.), which worsen the state of mental and physical health, and lead to the emergence of various diseases. In turn, any disease requires both medical treatment and further restoration of health through non-medicinal methods and means of physical rehabilitation, namely: corrective physical exercises, massage, gymnastics, diet, training, etc. The outcome of the treatment and the patient's continued full life depends on the quality of the rehabilitation process. Providing quality assistance to a person helps to return to the usual full-fledged way of life, and, if necessary, to change it. Such help also allows to preserve health, actualizes the need to form the readiness of physical rehabilitation specialists to use health-preserving technologies in professional activities.

The analysis of scientific works on the problem proves that most of them characterized mainly the formation of readiness for the use of medical health-preserving technologies of physical rehabilitation [1-4].

The theoretical basis of the study of the scientific and methodological foundations of the formation of the readiness of future specialists in physical rehabilitation to use health-preserving technologies in professional activity is the works of modern scientists in the field of pedagogy, theory and methodology of higher education, in psychology, in social pedagogy, in the field of physical rehabilitation, physical therapy, occupational therapy [1, 2, 5-10].

The systematization of scientific sources proved that the formation of the readiness of future specialists in physical rehabilitation to use health-preserving technologies in professional activity was not the subject of a separate scientific study.

AIM

The aim of the study is to theoretical substantiation of the effectiveness of the model developed by us for forming

the readiness of future physical rehabilitation specialists to use health-preserving technologies.

MATERIALS AND METHODS

To solve the tasks and achieve the goal of the article, we used general scientific methods of the theoretical level (analysis, synthesis, comparison, systematization, generalization of scientific and theoretical data), peculiarities of formation of readiness of future specialists in physical rehabilitation to use health-preserving technologies in their professional activity.

In order to realize the goal of the research and to fulfill the tasks, we determined the main methodological approaches for the implementation of the model for the formation of the readiness of future specialists in physical rehabilitation for the use of health-preserving technologies in professional activities:

- The humanistic approach allows considering the participants of the pedagogical process as whole individuals, and their health (psychological, physical, moral, social) as the highest value.
- The axiological approach to solving global problems of higher education presupposes, first of all, the education of a humanistic type of student personality. The most important criterion for the humanization of higher education is not so much acquired knowledge, skills and abilities, but the awareness and acceptance of humanistic ideals by each student, the desire for constant self-improvement.
- The competence approach is also considered as a system of technologies that ensure the formation of key, basic and special competencies of the future specialist in physical rehabilitation, which ensure the effective application of health-preserving technologies in professional activities.
- The active scientific approach consists in stimulating cognitive processes, actualizing the creative potential of students, in forming the desire to act and improve. This approach makes it possible to explore the individual's ability for self-development, to form the ability to navigate in a continuous flow of information, to choose a strategy for achieving defined goals.
- The systemic approach assumes that all links of pedagogical education should maximally stimulate the active state of all the main structural components of the student's personality in their unity. This approach makes it possible to analyze the process of formation of professional readines from the point of view of integrity, to reveal the components of the system, to reveal themechanisms of their mutual influences and relationships.

REVIEW AND DISCUSSION

The analysis of scientific works on the problem proves that most of them are mainly characterized by the formation of readiness to use medical health-saving technologies of physical rehabilitation [1, 2, 5, 10]. The works are devoted to individual physiotherapeutic methods of health care: theoretical and methodical aspects of massage, kinesiotherapy in restoring and preserving health, therapeutic and preventive properties of reflexotherapy, laser therapy, magnetotherapy, hirudotherapy, climate therapy[10-13, 16-18].

Among the scientific studies, the most significant for the development of the chosen topic are domestic studies, in which the peculiarities of the formation of the readiness of future specialists in physical rehabilitation to use health-saving technologies in professional activities, taking into account socio-psychological and pedagogical aspects, are explained [1, 2]; a significant addition is the works that highlight the foreign experience of using psychological and pedagogical technologies in the formation of professional readiness of future specialists in physical rehabilitation in the system of higher education [6-9].

The theoretical basis of the study of the scientific and methodological foundations of the formation of the readiness of future specialists in physical rehabilitation to use health-preserving technologies in professional activity are the works of modern scientists in the field of pedagogy, theory and methodology of higher education, psychology, social pedagogy, the field of physical rehabilitation, physical therapy, occupational therapy[1, 5, 8, 11, 15].

The systematization of scientific sources proved that the formation of the readiness of future specialists in physical rehabilitation to use health-saving technologies in professional activity was not the subject of a separate scientific study. The generalization of available scientific research, the study of the experience of the practical activities of institution of higher education in the formation of the professional readiness of future specialists in physical rehabilitation for the use of health-saving technologies made it possible to identify a number of unresolved contradictions:

- Between the growth of the social order for rehabilitation services and insufficient professional readiness of future physical rehabilitation specialists to provide them.
- Between the dynamic process of formation of new technologies of physical rehabilitation and health care and the traditional principles, content and methodology of the process of forming the readiness of future physical rehabilitation specialists for their application.
- Between the need to introduce health-saving technologies into the professional activity of physical rehabilitation specialists as a means of preventing morbidity and the lack of development of educational and methodological support for their preparation for the use of these technologies.

The relevance and theoretical and practical significance of the issue, the lack of special scientific research devoted to the substantiation of the essence, the identification of the features of the structure, content, organization, effective methods and technologies of forming the readiness of future specialists in physical rehabilitation for professional activity led to the need to develop a model of the formation of the readiness of future specialists in physical rehabilitation to the use of health-saving technologies in professional activities [5, 7, 10, 12, 16].

The model developed by us for forming the readiness of future physical rehabilitation specialists to use health-preserving technologies in professional activities contains the following blocks:

- *Target block* – ensures the unity of the goal, methodological approaches, principles of implementation and tasks, the definition of which contributed to the specification of the content of organizational work; pedagogical conditions, the implementation of which ensures the effectiveness of the implementation of the model.
- *Organizational and methodological block* – reflects the structural components of the process of formation of future specialists in physical rehabilitation for the use of health-preserving technologies in professional activities: mastering the system of theoretical knowledge on the problem of using health-preserving technologies; mastering the algorithm of using health-preserving technologies; formation of psychological readiness of physical rehabilitation specialists to use health-preserving technologies in professional activities; mastering pedagogical skill, which is a system of interconnected elements, such as: pedagogical abilities, pedagogical orientation, pedagogical tact and pedagogical technique.
- *Content-procedural block* represents the content, means, methods and forms, pedagogical conditions selected taking into account the main goals of each stage of model implementation.
- *Criterion-evaluation block* characterizes the degree of achievement of the set goal and provides diagnostics of the readiness of future physical rehabilitation specialists to use health-preserving technologies in professional activities based on defined criteria, indicators and levels, as well as the identification of the main promising directions for improving the quality of professional training.

The schematically developed model of formation of the readiness of future specialists in physical rehabilitation to use health-preserving technologies in professional activities is presented in Figure 1.

The model of formation of the readiness of future physical rehabilitation specialists to use health-preserving technologies in professional activity is considered by us as a systemic, multidimensional process, which is integral and continuous in nature and includes the following components: informational, technological, psychological and pedagogical readiness.

The specified model was implemented in the following sequence of stages: informational and operational; technological and procedural; personal-motivational and pedagogical-oriented.

At the first, informational and operational stage, the formation of informational readiness of future physical rehabilitation specialists for the use of health-preserving technologies in professional activities took place.

The goal of the specified stage was the formation of the necessary scientific-theoretical base on the problem of the application of health-preserving technologies in professional activity; introducing students to the types of health-preserving technologies, the main purpose of their use; proving their influence on the effectiveness of the physical rehabilitation process; correction of students' ideas about the concept of «norm» of the rehabilitation process and the essence of the concept of «physical rehabilitation».

The second stage of the model for forming the readiness of future physical rehabilitation specialists for the use of health-preserving technologies in professional activity is technological and procedural, which involves the formation of technological readiness. The main goal of the specified stage was the assimilation by students of the technological stages of each presented socio-psychological and pedagogical health-preserving technology.

The third stage of the model for forming the readiness of future physical rehabilitation specialists for health-saving technologies was defined as personal-motivational, on which the formation of such a component as the psychological readiness of students took place. Also, at this stage, special attention was paid to the formation of professional motives and needs of future specialists in physical rehabilitation. We consider the inclusion of students in a wide field of professional activity as the main method of forming the desire to work and improve, what happened during various types of practices and the inclusion of students in various forms of non-formal education, in which the formation of social skills takes place. It is the participation of students in trainings, webinars, workshops that allows you to begin the formation of a professional circle of communication, to act and be formed in a professional environment, to get acquainted with innovative methods and forms of work.

The fourth, pedagogical-oriented, stage of the model is aimed at forming the pedagogical readiness of future specialists in physical rehabilitation. This involves the formation of pedagogical skills of students, which includes the following components: pedagogical abilities, pedagogical orientation, pedagogical tact, pedagogical technique. Students mastered the main pedagogical methods aimed at forming consciousness, certain concepts, assessments, judgments, and worldview of the individual.

In determining the principles of organizing the readiness of future specialists in physical rehabilitation to use health-preserving technologies in their professional activities, we focused on the generally accepted principles of organizing the educational process in higher education institutions, which are specified in the Law of Ukraine on Higher Education. Thus, the following principles were chosen: the principle of organic unity of theoretical and practical training; the principle of the professional orientation of education, which regulates the ratio of general and specific, determines the dialectic of the interaction of the holistic development of the personality, its professional features and plays the role of a system-forming element for the entire learning process; the principle of student-centered learning, which involves the formation of the subject's position in future specialists in physical rehabilitation, providing opportunities for the formation of an individual professional trajectory, mutual respect, partnership in the educational process. Special

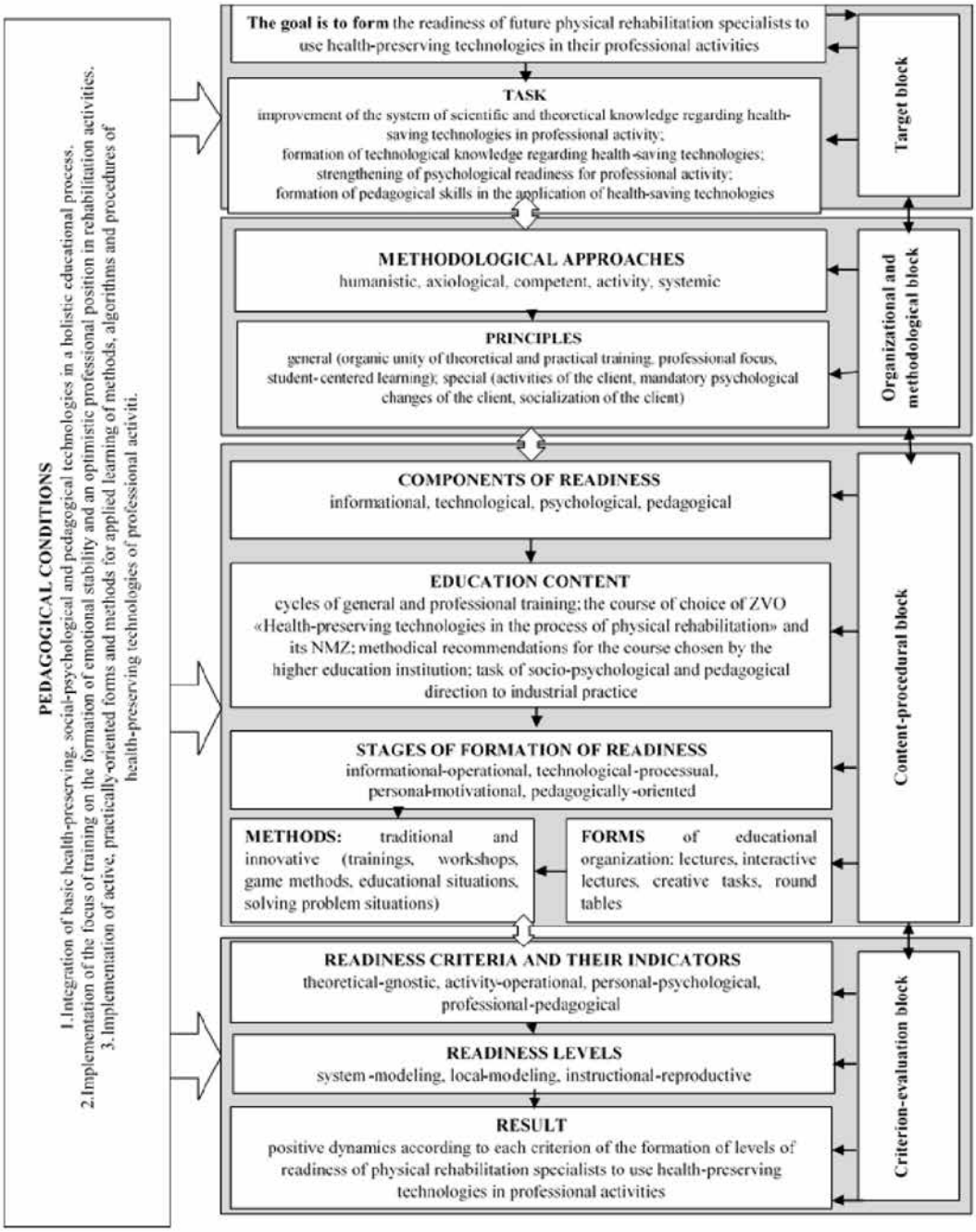

Fig. 1. A model for the formation of the readiness of future physical rehabilitation specialists to use health-preserving technologies in their professional activities.

principles for the organization of effective implementation of health-saving technologies in the physical rehabilitation process were also highlighted: the principle of client activity; the principle of the obligational change of the psychological state of the client; the principle of client socialization [11, 12].

Guided by the specified principles, forms and methods of readiness formation were selected. In the educational process, traditional and innovative methods were combined, covering all areas of specialist training in higher education institutions – theoretical, practical training, research activities and independent work, used the following forms of education: formal, informal, non-formal. Thus, interactive, multimedia lectures, the purpose of which was to optimize and intensify the educational process; seminar-practical, laboratory classes using training methods and exercises, the method of discussion, discussion, brainstorming; participation in webinars, workshops, and trainings were used [13, 14].

The following were defined as the main criteria and indicators corresponding to the outlined structure of organizational content:

– The theoretical-gnostic criterion assumes the formation of a scientific-theoretical knowledge base and has the following indicators: mastery of such basic concepts as «social-psychological health-preserving technologies»,

«pedagogical health-preserving technologies»; knowledge of their types; the main purpose of their use in the process of physical rehabilitation; the concept of «norm» of the rehabilitation process.

– The activity-operational criterion assumes the formation of technological knowledge and skills and has the following indicators: the ability to use socio-psychological, pedagogical health-preserving technologies; the ability to combine medical, physical culture and health, socio-psychological and pedagogical health-preserving technologies; carry out a comprehensive diagnosis of the rehabilitation potential of the client and the rehabilitation potential of his environment; the ability to create individual programs for the use of health-saving technologies.

– The personal-psychological criterion provides for the psychological readiness of future physical rehabilitation specialists to use health-preserving technologies and has the following indicators: the formation of such personal traits that contribute to the formation of a leadership position in the professional sphere as sociability; tolerance, flexibility, perseverance, emotional stability.

– The professional-pedagogical criterion provides for the pedagogical orientation of physical rehabilitation specialists in the application of health-preserving technologies in professional activities and has the following indicators: formation of pedagogical abilities, pedagogical orientation, pedagogical tact, pedagogical technique, which are components of pedagogical mastery [15].

Auditory and non-auditory forms of work on the formation of the readiness of future specialists to use health-preserving technologies in professional activities were conducted in a healthy psychological atmosphere of the group. The teacher was focused on the success of students, students were constantly motivated to demonstrate leadership qualities, they used forms of work and by their own example, the formation of students' pedagogical skills was carried out.

The validity of the conclusions depended on the adequacy of the selected criteria and evaluation parameters. First of all, the quality and effectiveness of the training was evidenced by the positive changes observed in the behavior of students, in their attitude to learning and to themselves personally. For example, to what extent the student's optimistic position is formed, the level of manifestation of his initiative, leadership position, attitude to the learning process and his development, and most importantly, awareness of personal motives and needs for knowledge acquisition [17, 18].

CONCLUSIONS

The model of the readiness of future physical rehabilitation specialists to use health-preserving technologies in professional activities should contribute to the actualization of purposefulness in education, the formation of an active professional position and professional motivation; secondly, the model should contribute to increasing the level of professional readiness, which will improve the process of physical rehabilitation of clients.

The conducted research does not encompass all aspects of the formation of the readiness of future specialists in physical rehabilitation to use health-preserving technologies in professional activities.

Prospective areas of further scientific research are: the development of separate methods of training future specialists in physical rehabilitation for the use of health-preserving technologies in preschool, primary and secondary education institutions; development of special health-preserving technologies for working with persons with deviant behavior.

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CONFLICT OF INTEREST
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CASE STUDY

Physical treatment in patient with severe disorders after muti-organ trauma. Case study

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ABSTRACT

Patients with multi-organ injuries, who have undergone neurosurgical decompression of a hematoma within the central nervous system are common in rehabilitation units. Patients of this kind are placed in the rehabilitation unit after metabolic disturbances accompanying severe CNS injuries have been adequately managed. At this stage of treatment, cases lacking metabolic stabilization are uncommon. However, the case presented by our team demonstrates that such instances cannot be entirely ruled out.

Case report: A 64-year-old patient was referred to the Rehabilitation Clinic following a multi-organ injury. The patient sustained an intracranial hemorrhage in the left hemisphere, which required surgical intervention. In the initial days at the Rehabilitation Clinic, the patient's general condition suddenly deteriorated to a critical level, characterized by severe bradycardia and a significant drop in arterial blood pressure. The extensive diagnostics performed revealed severe thyroid and parathyroid insufficiency. Gradual rebalancing of the patient's metabolic condition led to a significant improvement of his clinical condition. This article presents a case of exceptionally severe thyroid insufficiency, a condition rarely encountered even in endocrinology clinics, as patients with such a critical state are most likely to succumb before reaching a hospital setting.We also present a modern therapeutic approach to the rehabilitation of a patient with a severe CNS trauma, whose general condition is internally unstable.

We hope that the case will make readers aware of a potential possibility of the occurrence of thyroid gland disturbances in post-trauma patients which is important as thyroid problems become more and more common in the population.

KEY WORDS: intracranial haematoma, rehabilitation after TBI, thyroid insufficiency, parathyroid insufficiency

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CASE REPORT

64-year-old patient sustained multiple bone fractures and an intracranial hemorrhage in the left frontoparietal region as a result of a fall from scaffolding approximately 3 meters high. The patient was initially in a moderately severe overall condition, presenting with profound mixed aphasia and severe right-sided hemiparesis. Two days later the patient was treated surgically with CNC haematoma drainage and three weeks later after stabilization of the neurological condition, the patient underwent orthopedic treatment: surgical fixation of numerous fractures in the region of the pelvis.

More than a month after the accident, the patient was admitted to the MIM-SRI Rehabilitation Clinic for rehabilitation treatment of right-sided hemiparesis, accompanied by mixed dysphasia and functional pelvic insufficiency, following the stabilization of pelvic fractures. According to family the patient underwent a thyroid excision due to medullary carcinoma twenty years before and was on thyroid hormone supplementation, but the information about his information was not passed on transition to the traumatology centre. In addition, the postoperative scar perfectly fit the fractures and wrinkles of the neck and was practically indiscernible.

On admission to the MIM-SRI Rehabilitation Clinic, the overall condition of the patient was satisfactory. The patient was conscious, afebrile, and cardiovascularly and respiratorily stable, with blood pressure of 110/70 mmHg and a heart rate of 81 bpm, regular. Vesicular respiratory sounds were normal over the lung fields but slightly diminished at the lung bases. The abdomen was soft, non-tender on palpation, with no pathological resistance, and peristalsis was preserved. Physiological needs were managed with diapers and a Foley catheter. Notably, the patient exhibited

psychomotor slowness, a waxen skin tone, facial edema despite a slim body build, and receding mixed dysphasia. Moderate right-sided hemiparesis was present. The patient was entirely dependent on third-party assistance for self-care. The Barthel ADL scale score on admission to the clinic was 2/20 points.

A few days after hospitalization, the patient suddenly experienced weakness while changing body position and lost consciousness. Hypotension of 60/30 mmHg and bradycardia of 30 bpm were observed. A cardiology consultation was conducted, and an echocardiogram revealed no abnormalities. Pulmonary angiography (CT angiography of pulmonary vessels) ruled out pulmonary embolism. Laboratory tests showed no elevation in troponin T, CK-MB, or D-dimer levels; however, electrolyte analysis revealed a critically low calcium concentration. TSH – 137 uiU/ml (with 0.27-4.2 norm), calcitonin < 0.50 pg/ml (norm 8.31-14.3), parathormone – 2 pg/ml (norm 15-65). The patient was diagnosed with deep, iatrogenic thyroid and parathyroid insufficiency, supplementation was instituted in accordance with endocrine recommendations described in the discussion. On subsequent days the patient was drowsy, low values of arterial hypertension persisted, so did the tendency towards bradycardia. On the following days, the patient's condition showed a tendency towards stabilization. Slow, gradual improvement of the general and neurological condition of the patient was observed.

KINESIOTHERAPY APPLIED

Physiotherapeutic assessment on the patient's admission to the Rehabilitation Clinic

On the level of participation: poor verbal-logical contact, the patient dependent on third persons, requiring assistance in the majority of everyday activities, including change of body position and self-service.

On the level of activity: the patient recumbent, cannot change to a side position or move within the bed. He can sit on the bed with legs down with a therapist's assistance and safeguarding.

On the level of structure and function: significantly impaired pelvic structure. Muscle strength acc. to MRC scale: 3-4, which means independent performance of movements against gravitational force. Superficial and deep sensation maintained.

Plan and implementation of therapeutic goals:

- The short-term goal was to enable the patient to move within his bed, change position to lying on his side, proceed to a sitting position and self-service [1].
- Long-term goal:
- Transfers and locomotion-teaching with the help of third persons.
- Bedside rehabilitation initially focused on the patient's spatial orientation, learning to take a sitting position on his own, making attempts at passive verticalization and active-passive verticalization with safeguarding.

Rehabilitation in the exercise room:

- In the course of further therapeutic activization, rehabilitation focused on restoring muscle strength, improvement in the performance of individual activities and continuation of active verticalization. The teaching of transfers and movement with a walker with and without assistance on short distances with safeguarding.
- The procedures applied in the therapy included: respiratory exercises, passive exercises, active-passive exercises, exercises with support, guided exercises, passive verticalization, active-passive verticalization, active verticalization. balancing exercises, coordination exercises, PNF method, learning of walker-assisted locomotion activities, learning of unassisted walking, learning of walking up and down stairs [2].
- Once the patient's metabolic disturbances had been taken under control, his overall condition improved significantly in terms of self-service capacity, coordination of movement, locomotion. Further rehabilitation is recommended including changes of body position and movement from place to place, for instance, when the patient gets up from a chair to go to bed or to adopt a kneeling position, practising coordinated actions to move an object with the help of upper extremities or continuation of building up muscle strength, sense of balance, performance of exercises in both recumbent and sitting position.

NEUROPSYCHOLOGICAL THERAPY

On admission, the patient's assessment revealed limited verbal-logical contact, with visual and emotional contact present. The patient's ability to formulate utterances within developed dialogue interchange or narration was limited to single words with articulatory correctness maintained. The patient had dominant, deep difficulties as regards executive functions, having secondary disruptive effect on cognitive and language functions. Speech reception was impaired, performance of simple orders remained labile. Deeply disturbed actualization of names of objects and activities was observed in result of frequent perseverations (i.e. repetition of previously actualized names), paraphasia (i.e. replacement of words with other, inadequately used) and periodical neologisms with accompanying postponement and evident time necessary to think. The implementation of automated sequences (i.e. days or months) was similarly disturbed, requiring assistance in their initiation by the therapist. Text perception was maintained on the level of simple sentences, with coexistent deep agraphia (disturbed letter shape). The ability to repeat sentences was normal. The above listed language function deficits had a significant influence on the objective assessment of memory disturbances, yet the clinical picture of the patient suggested disturbances in the auto- and allopsychic orientation, retrograde oblivion, memory gaps as well as impermanence of the memory traces. The patient was characterized by lack of spontaneity, lack of initiative as regards everyday activities. Deficits of executive function could be observed on the level of initiation, planning as well as monitoring of actions. The patient remained cooperative, showed stable mood and incomplete awareness of his own psychophysical abilities.

The patient takes part in neuropsychological rehabilitation consistent with the recommendations in force [3] the aims of which include: improvement of the patient's contact with the environment, increase of activization in everyday activities through improvement of cognitive functions (i.e. memory, attention, executive functions), broadening of the awareness of the patient's own psychophysical abilities, emotional support, strengthening of motivation in the process of functional improvement.

At the present stage of rehabilitation, significant improvement had place with respect to the actualization of names (covering objects and activities). Improvement was also noted in speech reception (the patient can correctly respond to simple orders, adequately confirms and negates, understands, on his own, simple sentences read) as well as in writing (the patient can correctly render the shape of individual letters). The patient is better oriented in the place he is in. Also, he is gradually more and more aware of his own psychophysical abilities.

NEUROLOGOPEDIC THERAPY

On the first neurologopedic examination, the patient showed deeply disturbed verbal communication [4]. He could establish visual and emotional contact, but his spontaneous utterances were very limited. He could answer without mistakes only when asked about personal information or his son's name. A helpless smile was his response to questions about names, place of residence or work of other family members. Disturbances of orientation in place and time he compensated with schematic or stereotype expressions or with content generated by the first association available. Asked about his place of residence, he would list a variety of places in different regions of Poland and Europe. Asked about the date of birth, he would give each time a different one, asked about his age – any age from 16 to 58.

The patient was able to function very well within a scheme. Words taken out of a sentence context were as a rule adequate. His production of automated sequences was flawless. He was able to complete phraseological sequences mostly correctly, but he was never able to explain them or to match them with a situation presented by the therapist. In answer to the question: "what month is it?", he usually answered " honeymoon" because this association seemed to be most permanent and hard to overcome. He was unable to generate any longer, spontaneous statements. What often appeared were echolalia, perseverations, verbal paraphasia and very sporadically neologisms. The patient's obvious embarrassment in trying to recall the name of an everyday object could be indicative of the presence of a dissociation between how the word sounded and what it meant.

Visual material and/or a prompt in the form of the onset syllable constituted significant help- in actualization attempts. The patient had fewer problems with designates known from everyday life. Names of things came to him more easily than names of phenomena; nouns definitely more easily than verbs or adjectives. Actualization of a name on the basis of a definition was impossible, verbal fluency, both acc. to the semantic and to the formal criterion, was extremely limited. Categorization and abstract thinking were non-existent.

In the first hospitalization period, the patient failed to respond to any orders. Only sporadically was he able to respond adequately to an order such as: please, raise your hand, open your mouth or point to the window. It was impossible to obtain any understanding of complex orders or short texts. The implementation of expected behaviour was made difficult not only by the disturbance if speech reception, but, to a large extent, due to the disturbance in executory functions, in particular, on the level of initiating or monitoring activities.

The patient was quite efficient at reading aloud short texts (paralexia was sporadic), but he failed to understand a large part of their content. What posed particular difficulties were complex logico-grammatical constructions, inversions, case government, passive voice or exponents of time-space relations. Global reading – where it referred to words of high frequency in the language – was as a rule correct. The patient tended to recognize correctly most letters and all figures.

Writing was deeply disturbed – on the level of shapes of letters. The patient would write a sequence of signs similar to one another which did not resemble letters. Copying created great difficulties because of perseverations.

The executive aspect of speech did not require a lot of therapeutic intervention. The face was symmetrical, slightly masque-like, yet without evident motor difficulties as regards mimic muscles. Articulation was normal, voice resonant, expiratory phase within normal limits. What attracted attention was only flat prosody and slight slowing down of speech [4]. Full examination of the lip and tongue aspects was impossible to perform as cooperation with the patient was difficult and his ability to follow orders limited. Swallowing was within normal limits from the beginning – the reflex switched on without delay, the mobility of the trachea was maintained, velopharyngeal reflexes were present on both sides, though slightly diminished. In the initial period, the patient received food with the consistency of mush as he had to remain in semi-recumbent position (necessary due to the process of fractured pelvic bones reunification).

The neurologopedic therapy commenced with the emphasis on the maintenance of language competences: perceptual thinking and scheme within which the patient functioned so well.

The work on pictorial material [5] gradually, though slowly, came to bring ever better results. The first exercises consisted in naming elements of a picture, creating short sentences concerning the function of people [6] and destination of different objects [7], developing associations (what matches what and what doesn't?), creating contrasts (starting from big – small), moving on to more abstract words (focused – scattered, etc.) [8] and finally creating semantic fields, e.g. around words like apple or book. The thematic scope of the contents presented in the pictures also came to be gradually broadened.

Later, step by step, work on short texts [9] was introduced – texts read by the patient on his own or just listened to. Initially, the patient found it difficult to seek information in the text, trying to fill memory gaps with confabulations or associations, with no support in a given text fragment. Yet, gradually, he came to join and remember the presented content better and better. What appeared fostered along with the improvement of language functions was the patient's ability to make better use of recent memories and keep his attention focused on a given task.

To stimulate spontaneous speech, the patient was encouraged to compose and tell pictures-based stories of different complexity [10] as well as to think about the causes and consequences of the situations presented in the photos [11].

At present, after long weeks (of the continuing) therapeutic process, the patient is definitely much better at undertaking a conversation about a longer text read or heard. He can speak spontaneously, building short sentences on its subject. Also, the patient can flawlessly name all his family members and give his place of residence. He can tell a picture-based story about everyday activities. He can make correct associations and attempts at categorization. He is able to build a sentence according to a given scheme (e.g. who? what he is doing? with what?) [12] though perseverations may still appear in the process. Long-term observation of the patient during his therapeutic efforts leads to a conclusion that their intensification tires him out. It is then necessary to finish exercising so that the accruing language difficulties would not discourage the patient from undertaking independent communication attempts. It is worth emphasizing that the significant improvement in the language (as well as cognitive) function in the patient followed the restoration of his metabolic balance.

What still remains the greatest challenge is to encourage the patient to make free statements on any subject (restoration of internal speech) and to overcome difficulties in the paradigmatic selection of words creating logical sentences, expressing authentic needs, thoughts and emotions (not only those learned and repeated inertially).

OCCUPATIONAL THERAPY

The first assessment by the therapist: a non-ambulant, recumbent patient with impaired verbal-logical contact, with right upper limb paresis, weakened muscle strength, precise movements, coordination of upper extremities, fully dependent on third persons in terms of self-service.

At the first stage, exercises mobilizing the right upper extremity with the use of aids for hand therapy which can be grasped – mugs, balls, blocks in the shape of geometrical figures, logical puzzles. They were aimed not only to improve grasping and precision, but also visual perception and cognitive functions.

The tasks consisted in segregation according to shape, colour, size, copying and naming.

Gradually, the exercises began to require from the patient greater precision as well as better eye-hand coordination.

As the rehabilitation proceeded, the patient began to obtain ever better effects as regards motor and cognitive functions.

Fig. 1. In the picture, the patient's face with deep thyroid insufficiency – characteristic waxen colour of the skin, visible oedemas within the facial region.

At later stages of the therapy, exercises of a higher degree of difficulty were introduced developing processes of logical thinking, concentration of attention, perceptivity, precision grasping (lacing, sowing, screwing on and off, threading). All sorts of puzzles were used (logical, pictorial), graphomotor and cognitive function exercises, work sheets (copying of words, combining them in logical pairs), exercises with text.

The patient's right extremity motor skills, grasping precision as well as coordination of upper extremities, eye-hand coordination as well as logical thinking continued to improve during his stay in the clinic. The patient was willing to cooperate. Also, the speed of his task performance improved (Fig. 1-4).

DISCUSSION

In most cases, hypothyroidism is a chronic condition that necessitates lifelong management through thyroid hormone replacement therapy. Biochemically, overt primary hypothyroidism is marked by elevated serum thyroid-stimulating hormone (TSH) levels and reduced serum free thyroxine (T4) levels, often accompanied by clinical symptoms. However, the manifestation of these symptoms can vary widely based on factors such as the patient's age at onset, as well as the duration and severity of the hormone deficiency. The average full replacement dose of T4 in adults is around 1.6 mcg/kg of body weight per day. While young and otherwise healthy patients can

Fig. 2. CT of the abdominal cavity and pelvis without the i.v. administration of the contrast medium, performed with 64-slice CT scanner GE Revolution EVO by GE MEDICAL SYSTEMS 120 kV, 103 mA, 2.5 mm slice, presents, in transverse images, liquid and atelectatic condensations over the liquid in both pleural cavities (arrows).

Fig. 3. CT of the abdominal cavity and pelvis without the i.v. administration of the contrast medium, performed with 64-slice CT scanner GE Revolution EVO by GE MEDICAL SYSTEMS 120 kV, 103 mA, 2.5 mm slice, presents thickening of the rectal wall (short arrow) and condensations in the adipose tissue of the mesorectum (long arrow).

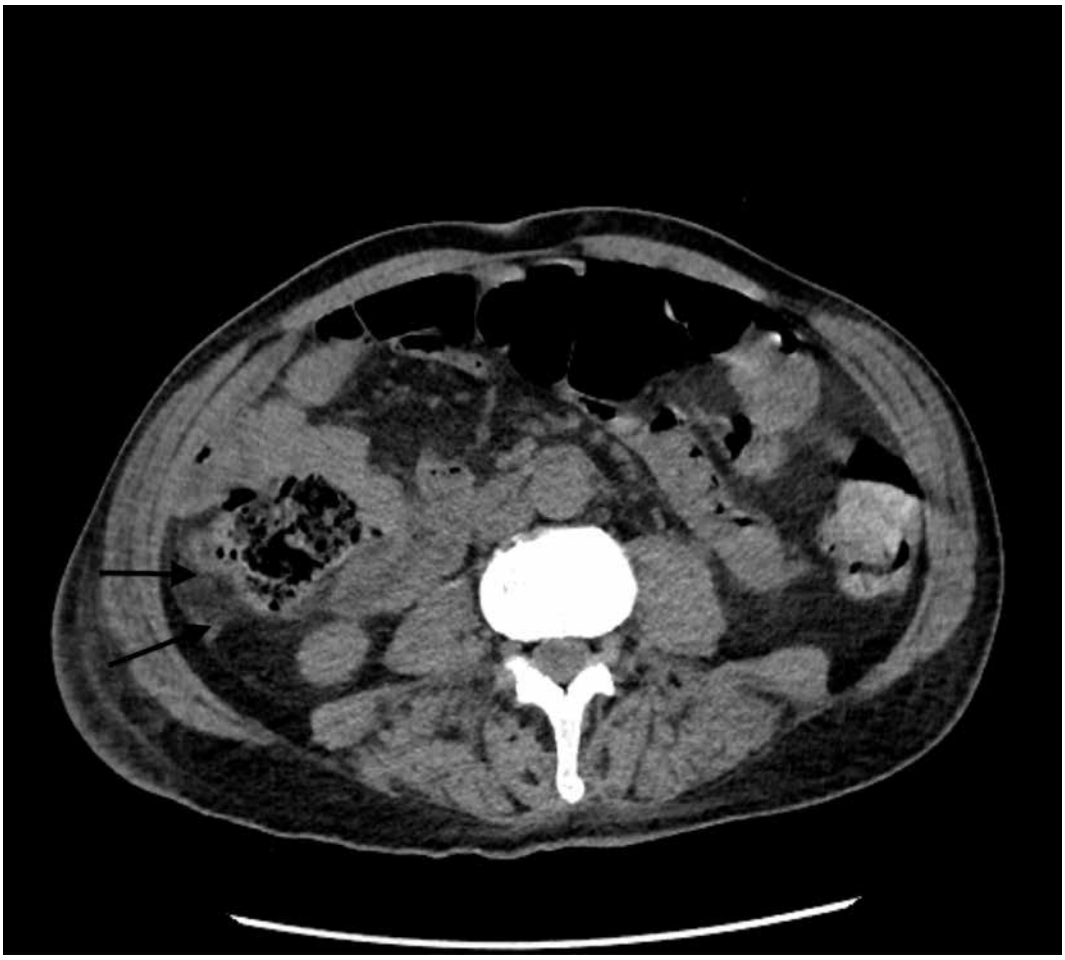

Fig. 4. CT of the abdominal cavity and pelvis without the i.v. administration of the contrast medium, performed with 64-slice CT scanner GE Revolution EVO by GE MEDICAL SYSTEMS 120 kV, 103 mA, 2.5 mm slice, presents, in transverse images, intraperitoneal condensations and a fluid layer along the peritoneum in the right midabdominal space (arrows).

often start with the full anticipated dose, most patients-especially the elderly, those with cardiovascular diseases, or those with an uncertain duration of hypothyroidism-should begin treatment at a lower dose, typically 25-50 mcg daily.

Myxedema coma, a rare but critical endocrine emergency, carries a mortality rate of up to 50%, with an estimated incidence of 1.0-2.5 cases per million people annually, primarily affecting older women [14, 15]. Symptoms of severe thyroid hormone deficiency may include altered mental status (ranging from confusion and lethargy to obtundation or full coma, and in some cases, psychosis), hypothermia (due to reduced thyroid-mediated thermogenesis and metabolic decline), hypoglycemia (stemming from hypothyroidism or concurrent adrenal insufficiency), hypoventilation (resulting in respiratory acidosis caused by central depression of respiratory drive, muscle weakness, airway obstruction, or sleep apnea), and hyponatremia (found in roughly half of myxedema coma patients). Cardiovascular manifestations such as cardiac dysfunction with poor contractility and/or dilatation of left heart ventricle, exertional dyspnea, bradycardia, hypotension and pericardial effusion are also common. The hallmark physical signs include puffiness of the hands and face, thickened skin, swollen lips, and an enlarged tongue, attributed to the deposition of albumin and mucin in tissues, giving rise to the term "myxedema."

This condition can develop as the culmination of severe, prolonged hypothyroidism or may be triggered in poorly managed hypothyroid patients by acute events such as infections, myocardial infarction, cold exposure, surgery, or sedative medications (notably opioids) [16].

Prompt and aggressive treatment is essential due to the high mortality risk. Factors such as advanced age, cardiac complications, low consciousness levels, mechanical ventilation requirement, persistent hypothermia, and sepsis are significant predictors of mortality. Treatment should not be delayed while awaiting laboratory results, especially in unresponsive patients with evidence of previous thyroid surgery, radioiodine treatment, or a history of hypothyroidism. Clinicians should consider the diagnosis in patients with coma or altered mental status accompanied by hypothermia, hyponatremia, or hypercapnia. A scoring system for diagnosing myxedema coma, has also been proposed [17].

If myxedema coma is suspected, blood samples for TSH, free T4, and cortisol should be collected before initiating treatment. Management requires intensive care, including mechanical ventilation if needed, cautious intravenous fluid replacement with glucose and electrolytes, gradual warming to correct hypothermia, and treatment of underlying infections. Glucocorticoids should be administered until adrenal insufficiency is ruled out. Thyroid hormone therapy typically involves intravenous levothyroxine (200-400 mcg initially, followed by 50-100 mcg daily) alongside triiodothyronine (5-20 mcg intravenously initially, followed by 2.5-10 mcg every eight hours). Clinical and biochemical improvements are generally evident within a week.

Thyroid hormone plays a role in blood pressure homeostasis and in cases of hypothyroidism and myxedema coma, arterial blood pressure undergoes characteristic changes. Hypothyroidism is characterized by increased diastolic blood pressure (due to increased peripheral vascular resistance, which results from reduced metabolism and decreased vascular elasticity), decreased systolic blood pressure (due to reduced metabolic activity and cardiac output) and narrowed pulse pressure. Hypotension is characteristic of myxedema coma and results from a severe drop in metabolism, reduced cardiac output (due to bradycardia, decreased contractility and/or dilatation of hear ventricles as well as reduced circulating blood volume as a result of water retention in the interstitial spaces), and vasodilation caused by insufficient vascular tone.

Hypocalcemia in the course of hypoparathyroidism is often associated with hypothyroidism following a total thyroidectomy. Low serum calcium levels may affect the functioning of the cardiovascular system by reducing the strength of cardiac contractions and the tone of smooth muscles in blood vessels, what can result in a decrease in blood pressure. In the available medical literature, numerous cases of severe, treatment-resistant hypotension associated with hypocalcemia can be found [18-20].

CONCLUSIONS

It appears that in the described case, the cause of the severe, resistant hypotension in the patient was the combination of severe hypothyroidism and hypocalcemia resulting from iatrogenic, postoperative hypoparathyroidism.

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CONFLICT OF INTEREST
The Authors declare no conflict of interest

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MINISTRY OF HEALTH OF UKRAINE
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Dear Colleagues!
We are pleased to invite you to participate in the International Scientific and Practical Conference

"Second Scientific Readings in Memory of Professor D. O. Alpern: Current Issues in Pathological Physiology".
This event will be held in a mixed (online-offline) format on May 8-9, 2025, at the Kharkiv National Medical University.
We welcome representatives from scientific institutions, higher education institutions, young scientists, graduate students, and healthcare professionals to join us at the conference.

Conference topics:
1. History of pathophysiology in Ukraine and the world
2. Pathophysiology as the foundation of interdisciplinary scientific research: "windows of opportunity" in wartime, international experience
3. The impact of destructive factors of war on the human body and adaptive processes
4. Pathophysiology as the foundation and theoretical basis of clinical medicine
5. Mechanisms of formation and development of typical pathological processes, diseases, and their complications
6. Molecular-genetic foundations of pathology
7. Innovative etiopathogenetically based technologies for diagnosing, preventing, and treating diseases
8. Pathogenetic platform of comorbid pathology
9. Age-related features of disease development
10. Pathomorphosis of diseases
11. Ethical aspects of conducting experimental research
12. Features of teaching pathological physiology in Ukraine and the world. Training of scientific and pedagogical staff

Working languages of the conference: Ukrainian, English

Forms of participation in the conference:
- Oral presentation
- Poster presentation
- Listener
- Publication of abstract in the conference materials
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During the conference, a competition for scientific works titled "Pathology Through the Eyes of Young Scientists" will be held among higher education students and young scientists. The winners will be announced on May 9, 2025. The participant of the competition, whose scientific work will take the first place, will have the opportunity to publish the article for free in a foreign journal of ALUNA Publishing House (Warsaw, Poland). To participate in the competition, you must register by April 30, 2025, by following the link (https://forms.gle/WkEWd-MDHkd76p49z7) and send your research to the e-mail of the organizing committee.

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