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Original Article

The dynamics of the functional indicators of the upper limb with firearm wounds of the forearm and the hand brush in the combination with peripheral nerves damage

BISMAKHELEN[1], SHESTOPAL NATALIIA[2]
[1,2]Physical Therapy and Occupational Therapy Department,
National University of Ukraine on Physical Education and Sport, UKRAINE

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Abstract:
Objective: To investigate and determine the indicators of the movable and sensory functions in persons with the firearm wounds of the upper limb in the combination with peripheral nerves damage and to evaluate the effectiveness of the developed program of physical therapy in this pathology during the period of recoverness.*Materials and methods:* The investigation was based on the clinical and neurological examination of 76 men with firearm wounds of the forearm and the hand brush in the combination with peripheral nerves damage. The patients were arbitrarily divided into 2 groups: the main group (38 people) and the control group (38 people). The duration after the combat trauma was from 6 to 18 months. The age of the surveyed ranged from 18 to 52 years, averaging 33.8 ± 6.7 years. 82.3% of patients had a partial lesion of the peripheral nerves, 17.7% of the persons had a complete lesion. For men of the main group there was a comprehensive program of physical therapy after surgical treatment of the firearm wounds of the forearm and the hand brush in the combination with peripheral nerves damage of the upper limb was developed and implemented, which included the use of kinesitherapy, elements of reflexology (method of application, Lyapko,M.G., 1997, 2005) massage by the method of Efimenko, P.B. (2013); procedures of manual therapy according to the method of Gubenko, V.P. (2006) and mechanotherapy by the method of Popadyukha, Yu.A. (2018).*Results*: The introduction of a physical therapy program was contributed to a positive changes in the functional parameters of men with bones fractures of the forearm and the hand brush, combined with peripheral nerves injuries. *Conclusions*: The tools of physical therapy contributed to the regression of pain, increased the range of motion and muscle strength, improved the movable and sensory function of the injured limb.
Keywords: physical therapy, upper limb, injury, movable, sensory function, pain.

Introduction

The last decades have been characterized by the increasing of the frequency of military local conflicts with different intensity around the world that have not missed Ukraine. During the fighting in April 2014 on eastern Ukraine, a significant number of people were injured. There were not only servicemen but also civilians who suffered from gunshot wounds of varying complexity (Boyarintsev, V.V., Gavrilin, S.V., Ganin, V.N., 2008).

Combat injuries of the upper limb are among the most common injuries of persons (35-45%) in the area of active fighting, and lead to the loss of a large part of functions, including the possibility of self-care, significantly reducing the independence and quality of life of the victims (Kapustin, R.F., Gombalevsky, D.V., 2004;Saiko, O.V., Luchkevich, M.P., 2012). In the structure of combat traumas, the refractory fractures of the humerus are 22.3%, the forearm bones - 11.8% (Belsky, A.N., 2013). According to various authors, gunshot wounds account for 9.3% to 25.2% of all limb segments (Shapovalov, V.M., Gladkov, R.V. 2014).

The researches which were conducted in Ukraine show that among the refractory fractures which were obtained in the case of injuries of modern weapons 35.1% are fragile and 41.3% are fragmented (Rushai, A.K., Klimovitsky, V.G., 2002).The damage of the main vessels occurs in 10% of cases, and the nerves damage occurs in 15-20%. Traumatic shock develops in 8-10% of victims (Kryzhanovsky YA, Cherenok EP, 2002; OA Buryanov and others, 2015). During the war more often than other damage the radial, middle and elbow nerve trunks of the upper limb are exposed, each individually in 13-28% of cases (Naumenko, L.Yu., 2008;Saiko, O.V., Luchkevich, M.P., 2012).

According to Sokolov, V.A., Didenko, O.A., Bialik, E.I. et al. (2010), Khominets V.V. (2012), the most commonly combined bones and nerves damage were noted in areas of close anatomical location of nerve trunks and blood vessels, respectively: in the subclavian cavity and in the area of elbows.Simultaneous damage of the nerve trunks , the bones of the forearm and brush are manifested in various forms of disorders, from mild

Corresponding Author: BISMAK HELEN, E-mail: ebismak@gmail.com

manifestations of sensory, movable and trophic disorders to sharply pronounced forms of severe paralysis and contractures.In the case of gunshot and non-gunshot injuries,may happen a complete anatomical break of the nerve trunk, a partial anatomical break of the nerve trunk, and an intraosseous nerve damage may occur. Depending on the character of the nerve damage, a complete or a partial break in the conductivity of the nerve trunk occurs, accompanied by appropriate movement disorders, sensory disorders, and autonomic functions in certain anatomical areas(Goldblat, Yu.V., 2015

Such difficult characters of lesions and the high frequency of their complications cause difficulties in the choice of rehabilitation tactics. At the same time, the extreme importance of the upper limbs, which plays an important role in multifaceted human activity, requires special efforts in seeking the fullest possible functional recovery of the wounded by means of physical therapy and ergotherapy. The adequacy and speed of restoration of functional capacity and morphological structure of limb dependence on the adequacy of selection of specific rehabilitation means.

In the world of rehabilitation of individuals after the injury of upper limbs to gain the optimal independence, the leading place is a multidisciplinary approach, it`s the participation of several specialists: a physician of physical and rehabilitation medicine, which organizes the process of rehabilitation of this category of patients, provides physical therapy. rehabilitation of patients,ergotherapist who is engaged in restoration of the functions of the upper limb and adapts to daily life, medical First psychologist who monitors the patient's psychological state and prevents depression and others. specialists (Bogolyubov, V.M., 2006; Marchettini, P., Lacerenza, M., Mauri, E., Marangoni, C., 2006).

Consideration of current research in Ukraine on the problems of restorative medicine and physical rehabilitation of persons with musculoskeletal disorders (Kozlov, V.K., Akhmedov, B.G., Chililov, A.M., 2017) shows that until recently the issue of rehabilitation of patients with gunshot wounds has not been the subject of specialization only recently have emerged as essential in the surgical profile (Chaplik, V., Oliynik, P., Tsegelsky, A., 2015), but aspects of the development of recovery measures for such patients by physical therapy and ergotherapy ,often, the needs of the present are often overlooked specialists.

In the available literature, no works have been found that would contain methodological recommendations for the use of physical therapy and ergotherapy in wounded with combined gunshot lesions of the upper limbs, and there are practically no works on systemic aspects. Shortcomings in the system of rehabilitation of victims of gunshot wounds lead to the need for long-term, often repeated treatment, which raises the issue of the development and implementation of effective rehabilitation measures aimed at restoring or maximally compensating for impaired functions and achieving a quality of life for independence gunshot wounds of the upper limb.

It is very important to restore the movable and sensory functions of the injured hand, as these indicators reduce the performance and lead the wounded to disability.

Objective: To investigate and determine the indicators of the movable and sensory functions in persons with the firearm wounds of the upper limb in the combination with peripheral nerves damage and to evaluate the effectiveness of the developed program of physical therapy in this pathology during the period of recoverness.

Material&methods

Materials and methods: The investigation was based on the clinical and neurological examination of 76 men with firearm wounds of the forearm and hand brush in the combination with peripheral nerves damage.The study was conducted at the Military Medical Hospital in Kyiv. The patients were arbitrarily divided into 2 groups: the main group (38 people) and the control group (38 people).The duration after the combat trauma was from 4 to 6 months. The age of the surveyed ranged from 18 to 52 years, averaging 33.8 ± 6.7 years. 82.3% of patients had a partial lesion of the peripheral nerves, 17.7% of the persons had a complete lesion.According to the age,the number, the character of trauma, and the character of peripheral nerve damage, the main and control groups of men were homogeneous (Table 1).

Table 1. Distribution of patients by clinical manifestations

Clinical syndromes	Groups of surveyed	
	MG, n=38	CG, n=38
	Abs. units / %	Abs. units / %
Isolated forearm injuries	12 (31,58)	13 (34,21)
Brush injuries isolated	7 (18,42)	6 (15,79)
Multiple injuries of the forearm	36 (94,74)	34 (89,47)
Multiple brush injuries	21 (55,26)	22 (57,89)
In combination with damage to the ulnar nerve	11 (28,95)	10 (26,32)
In combination with radiation nerve damage	9 (23,68)	11 (28,95)
Combined with damage to the median nerve	12 (31,58)	10 (26,32)
Combined with damage to the median and elbow nerves	6 (15,79)	7 (18,42)

Research methods: In order to evaluate and summarize the initial and repeated anthropometric and neurological parameters, the men were examined prior to the use of physical therapy (primary examination) and 6 months after the implementation of the comprehensive physical therapy program (re-examination). We used the following research methods: analysis and synthesis of data from literature sources, anamnesis collection, neurological examination, goniometry to determine the amplitude of movements in the wrist and elbow joints using goniometer, wrist dynamometer to determine the strength of the muscles of the brush muscle ((Belova, A.N., Schepetova, O.N., 2002). For the Syndrome Ratio, we were able to obtain a visual analog pain scale (VAS) and DN 4 (Masur, H., Papke, K., Althoff, S., et al., 2004;Bouhassira, D., et al., 2005). Exposed pain syndrome ranged from 1 to 3 points - low intensity pain, 4-6 points - moderate intensity, up to 7-9 points - intense, unbearable pain.

Neurological deficit was assessed according to the movable and sensual functions of the nerve(Bismak, O.V., 2019). To assess the state of impaired nerve function and restore it after surgery, as well as to study sensitivity disorders, we used the conventional scheme of English surgeons by R. B. Zachary; W. Holmes, an Austrian surgeon H Millesi, modified by the Leningrad Research Institute of Neurosurgery (Grigorovich, K.A., 1981; Belova, A.N., 2014). On the aforementioned scale, the motor function is evaluated by the contractile muscle capacity of M0-M5 and the sensitivity S0-S5 (Table 2).

Table 2. Diagram of muscle strength and sensitivity assessment

Indicator	Meaning
Diagram of muscle strength assessment	
M0	no muscle contraction (complete paralysis)
M1	weak and infrequent contractions of the muscles without signs of movement in the joints
M2	movements when turning off limb weight
M3	movements to overcome limb weight
M4	movements with overcoming resistance
M5	normal force, complete clinical recovery
Scheme of sensitivity assessment	
S0	anesthesia in the autonomous zone of innervation
S1	vague pain
S2	hyperpathy
S3	hypesthesia with reduction of hyperpathy
S4	moderate hypesthesia without hyperpathy
S5	normal pain sensitivity

The research design.For men of the main group, a comprehensive program of physical therapy after surgical treatment of firearm wounds of the forearm and brush, combined with trauma to the peripheral nerves of the upper limb,which was developed and implemented, which included the use of kinesitherapy, elements of reflexology (method of application, MG massage, 1997) by Efimenko, PB (2013); manual therapy procedures by VP Gubenko (2006) and mechanotherapy by Popadyukha, Yu.A. (2018).

Kinesiotherapy is the form of therapeutic exercises for upper extremity helped to strengthen the muscles of the upper extremity affected, to increase the amplitude of movements, and to increase endurance. Used passive and active exercises for injured and healthy limbs, isometric exercises, exercises with objects. Efimenko massage, P.B. used to eliminate pain, improve blood circulation, activate proprioceptive sensitivity, increase muscle tone, increase range of active movements in the affected upper extremity

Methods of influence applications by Lyapko Lyapko, M.G. are to stimulate the main as well as specific reflex points on the surface of the human body. They are based on the impact on the skin of applique devices. Glue of different area, the needles of which are fixed on an elastic rubber base and consist of several metals (iron, copper, zinc, nickel, silver)

The influence of a large number of needles on the skin with the activation of the receptor apparatus causes a corresponding reaction in the form of activation of circulation, release into the subcutaneous tissue of biologically active substances, mediators (cytokines, endorphins, serotonin, histamine, etc.), which have a common, local influence. on the body.

Conducting manual therapy procedures allowed to reduce pain, eliminate swelling, improve trophic processes in the affected area.Mechanotherapy was used to increase flexibility and amplitude of movements, improve coordination of movements, increase sensory-motor control and proprioceptive sensitivity, increase muscle strength.

Statistical analysis. Generalization of the studied characteristics was assessed by mean arithmetic valueand standard deviation. Confidence of differences between mean values was stated by Student's t-criterion. Assessment of statistical hypothesizes based on 5% significance level. For statistical processing of data we used licensed program Microsoft Excel (2010). Statistical analysis of the received results was conducted, considering recommendations on the Microsoft Excel tables usage for computer data analysis.

Results of the study and their discussion.

Assessing the severity of VAS and DN4 pain, we noted that in the primary examination in patients in the primary and control groups, your VAS was above average (6.32 ± 1.12 and 6.48 ± 0.18 points, respectively). The DN4 questionnaire was also above average, indicating that all patients had neuropathic pain in the affected limb. There were no significant differences between the groups (p> 0.05) (Table 3).

Table 3. Indicators of the severity of pain in the examined patients before the course of rehabilitation

Level of the pain(points)	Main group (n=38)	Control group (n=38)	t-criterion of Student	p
	$\bar{x}$±S	$\bar{x}$±S		
On a scale VASH	6,32±1,12	6,48±1,18	0,14	p>0,05
Behind the questionnaire DN4	6,72±1,15	6,82±1,22	0,89	p>0,05

From the anthropometric parameters in the examined patients of the main and control groups, we determined the amplitude of the active movements in the wrist and elbow joints, the strength of the muscles of the injured limb and determined the force index.

The data on the deficiency of active movements in altered-sacral joint development after goniometric study before the course of physical therapy, note art pathology in the use of both groups, as possible coincidence with the present movements (flexion / extension, absent / reduction) .

The average forces of motion amplitude at change-delay of joints in different groups of the group of the group: active starry - 19,57 ± 1,94 °, active expansion - 18,55 ± 1,84 °, active ultrasonic removal - 15.03 ± 1.64 °, active discharge radiation 4.05 ± 1.54 °.

In the past control group, cuts and discrepancies, deviations and representations were made at the same level as the main group (Table 4).

Table 4. Indicators of goniometry in the wrist and elbow joints in the examined patients before the beginning of the rehabilitation course

Test movement, degrees	groups of surveyed			t-criterion of Student	p
	Normal	Main group, (n=38)	Control group, (n=38)		
		$\bar{x}$±S	$\bar{x}$±S		
Radial wrist					
Active flexion / extension	75 65	19,57±1,94 18,55±1,84	19,43±2,06 18,79±2,01	0,31 054	p>0,05 p>0,05
Active ulnar / radial diversion	40 20	15,03±1,64 4,05±1,54	15,34±1,85 4,36±1,71	0,78 0,82	p>0,05 p>0,05
Elbow joint					
Active flexion / extension	40 180	22,41±2,65 92,54±2,47	23,37±1,97 92,98±1,89	0,95 0,87	p>0,05 p>0,05
Active pronation / supination	90 90	45,11±8,23 41,42±8,22	46,48±8,96 42,83±8,64	0,69 0,73	p>0,05 p>0,05

In the elbow of the wounded limb, there were also significant deviations from the rate of active flexion-extension and pronation-supination (Table 4). The effects of gunshot injuries on the forearm and arm, combined with peripheral nerve injuries, are not only a decrease in the amplitude of joint movements, but also a decrease in muscle strength of the injured hand.

In the initial examination by dynamometer results, we found that the average strength of the injured right hand in patients in the main group was 23.80 ± 1.91 kg, the left - 18.76 ± 1.88 kg, which is significantly lower than the average strength of the healthy hand and norms: right arm - 42.43 ± 2.14 kg, left arm - 32.81 ± 1.91 kg. In the control group, patients also showed reduced rates of wounded limb strength during wrist dynamometry. The decrease in the strength of the injured arm in patients in both groups is confirmed by the low indexes of the force index in both the main and control groups. No significant difference between the studied indicators was observed (p> 0.05) (Table 5).

Table 5. Indicators of wound and healthy limb dynamometry in the examined patients before the course of rehabilitation

Indicators	Normal	groups of surveyed		t-criterion of Student	p
		Main group, (n=38)	Control group, (n=38)		
		$\bar{x}$±S	$\bar{x}$±S		
Injured arm, straight, kg	35	23,80±1,91	23,81±1,89	0,02	p>0,05
Healthy arm, right, kg	50	42,43±2,14	41,84±1,99	1,23	p>0,05
Injured arm, left, kg	30	18,76±1,88	18,89±1,91	0,28	p>0,05
Healthy arm, left, kg	45	32,81±1,91	32,77±1,98	0,07	p>0,05
Wounded arm, strength index %	60	33,57±2,76	32,48±2,53	0,86	p>0,05
Healthy hand , strength index %	70	44,28±3,54	43,63±2,92	0,92	p>0,05

Injury of peripheral nerves in gunshot wounds of the upper limb significantly affects movable function of the limb and sensitivity in the affected segment, requires additional surgery, helps to increase the duration of treatment and rehabilitation, increase the number of patients with poor results (Revskoy, A.K., Lufing, A.A., 2007).In the initial examination we found that in most patients of the major and control groups movement disorders on a 6-point scale were at the level of M1-M2 - weak and rare muscle contractions without signs of movement in the joints and movements with exclusion of limb weight and M3 - movements with overcoming limb weight. No significant difference between the studied indicators was found (p> 0.05) (Table 6).

Table 6. Indicators of movable disorders in the surveyed manufacturers before the course of rehabilitation

Indicators	Main group (n=38)		Control group (n=38)	
	Abs. units	%	Abs. units	%
No muscle contraction (complete paralysis)(M0)	3	7,89	2	5,26
Weak and rare muscle contractions with no signs of movement in the joints(M1)	7	18,42	8	21,05
Movements when turning off limb weight(M2)	11	28,95	10	26,32
Movements to overcome limb weight (M3)	9	23,68	11	28,95
Movements to overcome resistance (M4)	8	21,05	7	18,42
Normal force, complete clinical recovery (M5)	0	0	0	0

According to Tsymbalyuk VI, Tretyak IB, Luzan BM (2016), with firearm wounds of the peripheral nerves of the upper limb, sensitivity disorders are expressed in the appearance of zones with complete or partial loss of sensitivity, but along with this possible phenomena of nerve irritation - hyperesthesia, paresthesia. In the primary examination, hyperpathy (S2), 9 (23.68%) patients in the main group and 8 (21.05%) patients in the control group could not determine the nature of the pain in 11 patients (28.95%). (S1), 8 (21.05%) and 9 (23.68) subjects, respectively, of the main and control group (S3) complained of hypesthesia. No significant difference between the studied indicators was observed (p> 0.05) (Table 7).

Table 7. Indicators of sensitive disorders in the examined patients before the course of rehabilitation

Indicators	Main group (n=38)		Control group (n=38)	
	Abs. units	%	Abs. units	%
Anesthesia in the autonomous zone of innervation	1	2,63	2	5,26
Unspecified pain(S1)	9	23,68	8	21,05
Hyperpathy(S2)	11	28,95	11	28,95
Hypesthesia with reduction of hyperpathy(S3)	8	21,05	9	23,68
Moderate hypoesthesia without hyperpathy (S4)	7	18,42	6	23,68
Normal pain sensitivity (S5)	2	5,26	2	5,26

All of the above symptoms indicate that patients with firearms breaks of the bones of the forearm and hand bones had manifestations of traumatic peripheral nerve damage, which significantly impeded the restoration of function in the victims. The re-examination was performed after 6 months, usually using a physical therapy program. First of all, there has always been a regression of pain in the manufacturers surveyed.

Analyzing the severity of pain syndrome on the VASH scale and the DN4 questionnaire after rehabilitation, we noted a significant reduction in pain in both the main and control groups, indicating a positive effect of massage and other physical therapy on this indicator (p <0.001; p <0.05). (Table 8). However, in the

main group, the number of positive answers to the question about the presence of different manifestations of pain syndromeand the DN4 significantly decreased compared to the control group (p <0.001) (Table 8).

Table 8. Dynamics of indicators of the severity of pain in the examined patients at the primary and re-examination ($\bar{x} \pm S$)

Indicators	Group	Before experiment $\bar{x}\pm S$	After experiment $\bar{x}\pm S$	t-criterion of Student	p
On a scale VASH	Main	6,32±1,12	3,01±1,12	4,22	p<0,001
	Control	6,48±1,18	4,32±1,21	3,11	p<0,05
Behind the questionnaire DN4	Main	6,72±1,15	4,42±1,18	4,01	p<0,001
	Control	6,82±1,22	5,82±1,17	3,02	p<0,05

However, comparing the severity indicators of pain severity in the examined patients, we concluded that they were significantly better in the main group than in the control group, which showed the effectiveness of the author's physical therapy program (p <0.001) (Table 9).

Table 9. Comparative characteristics of the degree of severity of pain in the examined patients at repeated examination ($\bar{x} \pm S$)

Level of the pain(points)	Main group (n=37)	Control group (n=36)	t-criterion of Student	p
	$\bar{x}\pm S$	$\bar{x}\pm S$		
On a scale VASH	3,01±1,12	4,32±1,21	3,59	p<0,001
According to the DN4 questionnaire	4,42±1,18	5,82±1,17	4,93	p<0,001

After the course of rehabilitation after 6 months, most patients had positive results in the form of increased strength and volume of limb movements, improvement of sensitive and vegetative-trophic disorders

Concentrated active physical true and mechanical actions helped to achieve the amplitude of the transitions in the transition-part to the lowest and highest levels. Thus, the bending of an inclined arm in the wrist-accuracy has increased to 68.36 ± 1.72 °, extension - to 58.05 ± 0.68 °, radial and ulnar from exceptionally few reliable landscapes - at the initial and repeated examination 17, 11 ± 1.37 ° and 35.42 ± 1.36 ° (p <0.001).In the control group, we also obtained a significant change in the amplitude of the movements at the change-wrist joint for the processing of the ends: the flexion increased from 19.43 ± 2.06 ° to 58.09 ± 1.92 °, extension - 18.79 ± 2,01 to 49.32 ± 0.97 (p<0.05). A similar improvement was immediately reduced in the case of radial and ultraar distal injuries (Table 10).In the elbow joint of the wounded limb of both groups of patients there was a similar dynamic: significantly significant changes occurred in all test movements (flexion-extension, pronation-supination).

Table 10. Dynamics of the movable amplitude indices in the wrist and elbow joints at re-examination

Indicators	Group	Before experiment $\bar{x}\pm S$	After experiment $\bar{x}\pm S$	t-criterion of Student	p
Radial wrist joint					
Bending	Main	19,57±1,94	68,36±1,72	0,31	p<0,001
	Control	19,43±2,06	58,09±1,92	0,65	p<0,05
Extension	Main	18,55±1,84	58,05±0,68	0,54	p<0,001
	Control	18,79±2,01	49,32±0,97	0,98	p<0,05
Radial diversion	Main	4,05±1,54	17,11±1,37	0,82	p<0,001
	Control	4,36±1,71	10,13±1,76	0,93	p<0,05
Ulnar assignation	Main	15,03±1,64	35,42±1,3627,72±	0,78	<0,001
	Control	15,34±1,85	1,31	0,64	p<0,05
Elbow joint					
Bending	Main	22,41±2,65	35,53±2,42	0,95	p<0,001
	Control	23,37±1,97	28,24±1,85	1,12	p<0,05
Extension	Main	92,54±2,47	145,27±2,53	0,87	p<0,001
	Control	92.98±1,89	131,34±2,32	1,03	p<0,05
Pronation	Main	45,11±8,23	82,58±3,36	0,69	p<0,001
	Control	46,48±8,96	64,26±3,87	0,72	p<0,05
Supination	Main	41,42±8,22	79,84±4,08	0,73	p<0,001
	Control	42,83±8,64	63,35±3,78	0,86	p<0,05

The physical therapy program in the patients of the main group included a large number of isometric exercises, weight training on special training machines for the upper limb Artromot and XTrainer Thera-Band contributed to the change of the muscles of the injured limb, as evidenced by a significant increase in dynamometry and power index <0.001). Men of the control group also experienced significant changes in muscle strength of the injured limb (p <0.001) (Table 11).

Table 11. Dynamics of dynamometry results in study groups with repeated examination

Indicators	Group	Before experiment $\overline{X} \pm S$	After experiment $\overline{X} \pm S$	t-criterion of Student	p
Wounded arm strength, kg (left)	Main Control	18,76±1,8818,89±1,91	27,07±0,73 23,43±1,02	0,28 0,32	p<0,001 p<0,05
Injured arm strength, kg (right)	Main Control	23,80±1,9123,81±1,89	32,11±0,94 27,42±0,94	0,02 0.12	p<0,001 p<0,05
Healthy arm strength, kg (left)	Main Control	32,81±1,9132,77±1,98	41,07±0,83 35,11±0,96	0,07 0,14	p<0,001 p<0,05
Healthy arm strength, kg (right)	Main Control	42,43±2,14 41,84±1,99	49,03±0,94 45,14±0,84	1,23 1,38	p<0,001 p<0,05
Wounded Force Index, %	Main Control	33,57±2.76 32,48±2,53	37,94±0,87 34,11±0,96	0,86 0,98	p<0,001 p<0,05
Healthy arm strength index , %	Main Control	44,28±3,54 43,63±2,92	56,32±1,24 48,27±1,27	0,92 1,14	p<0,001 p<0,05

Restoration of movable function of the injured limb on a 6-point scale to the level of M4-M5 was evaluated as a good result, which was in 21 (55.26%) patients in the main group and in 17 (44.74%) patients in the control group.A satisfactory result to the level of M3 (functional recovery) was observed in 11 (28.95) men of the main group and control group and to M1-2 (a small improvement, but functionally insufficient recovery) in 5 (13.16%) patients of the main group and in 9 (23.68%) men in the control group.Without significant positive changes (no effect) of movable messages (M0) were left for 1 (2.63%) who were registered in the main and control group. Analyzing the dynamics of motor function improvement in the examined groups, it should be noted that in the main groups they were more pronounced (Table 12).

Table 12. Indicators of dynamics of the movement disorders in the examined patients after the course of rehabilitation

Indicators	Main group (n=38)		Control group (n=38)	
	Beforethecourse ofrehabilitation	After the course of rehabilitation	Before the course of rehabilitation	After the corse of rehabilitation
	(abs. units/%)	(abs. units/%)	(abs.units/%)	(abs.units/%)
No muscle contraction (complete paralysis)(M0)	3 (7,89)	1 (2,63)	2 (5,26)	1 (2,63)
Weak and rare muscle contractions with no signs of movement in the joints(M1)	7 (18,42)	2 (5,26)	8 (21,05)	4 (10,53)
Movements when turning off limb weight (M2)	11 (28,95)	3 (7,89)	10 (26,32)	5 (13,16)
Movements to overcome limb weight (M3)	9 (23,68)	11 (28,95)	11 (28,95)	11 (28,95)
Resistance Movements (M4)	8 (21,05)	14 (36,84)	7 (18,42)	12 (31,58)
Normal force, complete clinical recovery (M5)	0	7 (18,42)	0	5 (13,16)

During the re- examination, we observed an improvement in the sensory function of the injured limb in men of both groups: at S4 level, the sensitivity recovered in 12 (31.58%) patients of the main group, which was 7.90% higher than the control group (9 (23.68%)), improvement to the S3 level was observed in the same number of patients in the main and control group - 10 people (26.32%). As can be seen from Table 15, in both groups the number of patients with hyperpathy and with vague pain was decreased(Table 13).

Table 13. Dynamics of indicators of sensitive disorders in the examined patients before the course of rehabilitation

Indicators	Main group (n=38)		Control group (n=38)	
	Beforethecourseofrehabilitation	After the course of rehabilitation	Before the course of rehabilitation	After the course of rehabilitation
	Abs. units	%	Abs. units	%
Anesthesia in the autonomous zone of innervation (S0)	2 (5,26)	1 (2,63)	2 (5,26)	1 (2,63)
Unspecified painful actions (S1)	9 (23,68)	5 (13,16)	8 (21,05)	6 (15,79)
Hyperpathy(S2)	11 (28,95)	8 (21,05)	12 (31,58)	11 (28,95)
Hypesthesia with reduction of hyperpathy (S3)	8 (21,05)	10 (26,32)	9 (23,68)	10 (26,32)
Moderate hypoesthesia without hyperpathy (S4)	8 (21,05)	12 (31,58)	7 (18,42)	9 (23,68)
Normal pain sensitivity (S5)	0	2 (5,26)	0	1 (2,63)

Discussions

Among the rehabilitated contingents in all highly developed countries, the special position is occupied by combatants. This is due to the influence on them of a number of extreme factors arising in the conditions of war, the first of all - firearms, and the need for further measures to restore the health, combat actions and overall activities of all war veterans and invalids(Akimova, T.N., Savchenko, V.V., Gladkova, E.V., 2009).

In the works by Bilyy, V.Ya. (2004), Kapustin, R.F., Gombalevsky, D.V. (2004) noted that gunshot wounds of the forearm and brush formed a special group due to their size (up to 15-20% among combat injuries of the limbs), the complexity of the anatomical structure and the functional significance of the hand as a part of the body.

The gunshot wounds of the upper limb are accompanied not only by bone defects, but also by damage to the neuromuscular, capsule, and blood vessels(Rolik, O.V., Ganich, T.S., Kolisnik, G.I., 2004).The forced immobility of damaged joints quickly leads to wrinkling of the articular capsule and the appearance of contracture. Nerve damage often leads to the denervation of the relevant skeletal muscles, impaired their trophic function and the main function(Tatarchuk, N.M., 2015;Covery, D.C., Born, C.T., 2010).

Gunshot wounds, namely gunshot fractures - mechanical traumas caused by the small size and mass of the wounded projectile.Wounds in gunshot fractures always have a very complex structure . As a result of the wound, the dense structure of the diaphysis collapses with the formation of a large number of bone fragments, which have received impetus from the wound projectile and have acquired some speed, which has transformed them into secondary early projectiles causing additional injury to the soft tissues with the formation of secondary canals (Rhee, P.M., Moore, E.E., Joseph, B., Tang, A., Pandit, V., 2016). The depth of soft tissue damage depends on the strength of the mechanical action, its direction, the nature of the wound projectile, and the location of the wound. Particularly significant disorders occur in the muscles. Defects in them due to the reduction of individual beams increase, resulting in the formation of cavities and pockets(Revskoy, A.K., Lufing, A.A., 2007; Alekseev, V.V., Barinov, A.N., 2010).According to various authors, the overall incidence of peripheral nerve damage is 15 to 20% among all wounded with surgical trauma. Nerve damage significantly affects the functional outcome of wounds, performance and quality of life of combatants (Sakovets, T.G., Bogdanov, E.I. (2013), Shapovalov, V.M., Gladkov, R.V. (2014).

According to the results of research, the means of physical therapy in the complex restorative treatment of people with inflammatory fractures of the upper extremity in combination with traumas of the peripheral nerves prevented more intensive restoration of the damaged functions of the upper extremity and increased results of motor therapy. According to the results of research, the means of physical therapy in the complex restorative treatment of people with the firearm beaks of the bones of the upper limb in combination with traumas of the peripheral nerves prevented more intensive restoration of the damaged functions of the upper limb and increased results of motor therapy. The data of literature show that the most effective for this category of patients are the following exercises: gentle flexion and extension of the injured hand in the joint itself; circular rotation (for this the hands need to be bent at the elbows and rotate them in different directions) rotation with a brush, which can initially be supported by a healthy limb, stretching the fingers, exercises with the support on the table: extending the hand, lifting the forearm, squeezing the fingers in the lock. In the case of flexion and extrusion contractures in the joints of the fingers, passive movements in the direction opposite to the formation of the contracture are recommended.When forming bending contracts in the early stages, it is necessary to use passive flexion carefully, and when forming extensors - passive flexion, and massage (Mateev, I., Bankova, S., 1987;Stepashko, M.V., 2010).

Further study of this problem and generalization of scientific experience described in the literature can be a prerequisite for the formation of a clear and universal protocol for the establishment of rehabilitation diagnosis, prognosis, definition of rehabilitation interventions and the most informative and effective criteria for evaluating the performed restoration of impaired functions.

Conclusions

Despite the general recognition of the originality and severity of fire arm brush injuries, there is no work on the subject in recent years. The concept of one of the most relevant pathologies of gunshot wounds and wound rehabilitation is based on the experience of World War II and is occasionally supplemented by medical statistics after military conflicts.

In Ukraine, as a result of increased military action, there is a need to develop a comprehensive program of physical therapy, in particular after gunshot wounds to the forearm and arm, combined with damage to the peripheral nerves of the upper limb.

In connection with the above, we have developed and implemented a physical therapy program that included kinesitherapy (passive, active, active-passive exercises, isometric and strength exercises for injured and healthy upper extremity), elements of reflexology (Lyapko, M.G., 1997, 2005), massage by the method Efimenko, PB (2013); procedures of manual therapy by the method of Gubenko VP (2006) and mechanotherapy by the method of Popadyukha, Yu.A. (2018).

In the primary study of anthropometric parameters in men of both groups (amplitude of movements in joints of the injured limb, muscle strength and force index) and neurological examination of the injured limb

(pain syndrome, motor and sensory function) revealed pathological abnormalities, revealing pathologic disorders in the upper limb. The differences in the studied parameters between the patients in the main and control groups were statistically insignificant. The initial study revealed a decrease in the amplitude of the movements in the wrist and elbow joints of the wounded limb, a decrease in muscle strength, impaired innervation, manifested by the presence of severe pain, motor and sensitive deficits.

Our implementations to the physical therapy program we have developed in this pathology has contributed to the positive changes in the studied parameters. There was a regression of pain in patients examined on the VASH scale and the DN4 questionnaire.

In the both groups, the amplitude of the movements and the muscle strength of the injured limb brush increased.At the neurological examination after the course of rehabilitation we noticed the improvement of the movable and sensitive function of the wounded limb: restoration of the movable function on a 6-point scale to the level M4-M5 was observed in 21 (55.26%) patients of the main group and in 17 (44.74%) patients in the control group, sensitivity at S4 level was restored in 12 (31.58%) patients in the main group, which is 7.90% higher than the control group (9 (23.68%)) , improvement to S3 level was observed in the same number of patients in the main and control group - 10 people (26.32%).In the main group,

the most of the anthropometric and neurological parameters were studied significantly better ($p < 0.001$), which tested the effectiveness of our physical therapy program.

Conflict of Interests. The authors declare that there is no conflict of interests.

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