

The results of the corrective rehabilitation program on the gait of amateur athletes with long-term consequences of brain injury

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ABSTRACT

Aim: To study the results of the quality of life, the state of vestibular disorders and the nature of walking of amateur athletes with the consequences of a combat craniocerebral injury after rehabilitation treatment according to a correctional program.

Materials and Methods: The study was conducted on the basis of the Ukrainian Scientific Research Institute of Prosthetics in Kharkov. Under observation were 38 men aged 25–42 years with long-term consequences of a closed craniocerebral injury in the late long-term period. In all patients, complications after TBI were persistent headache, decreased muscle strength in the lower extremities, impaired coordination and balance, and walking patterns. All patients were involved in amateur sports before injury. The following research methods were used during the examination: visual analogue pain scale (VAS), Lovett manual muscle test, Bohannon test, «Timed Up and Go test».

Results: All patients were randomly divided into two groups. Patients Gr.1 (n=20) were trained according to the developed program, which included training according to the PNF method, kinesiotherapy, classes on the C-mill sensory treadmill and the Hunova computer device, segmental reflex massage. Patients Gr. 2 (n=18) underwent a course of physical rehabilitation according to the generally accepted methodology of the Ministry of Health of Ukraine. After working with patients according to the developed correction and rehabilitation program, the following dynamics were observed: the quality of life on the VAS scale in Gr.1 patients had a statistically significant difference ($p<0.05$) compared to the primary indicator. The dynamics of the Lovett manual muscle test indicated an increase in the muscle strength of the extensor and flexor muscle groups of the lower extremities, the dynamics of the balance indicator in the standing position behind Bohannon in all Gr.1 patients and acquired statistical significance ($p<0.05$). According to the test «Timed Up and Go» patients Gr.1 approached the standard value ($p<0.05$). In all patients of Gr. 2, the studied characteristics had a positive trend ($p>0.05$).

Conclusions: Individual selection of physical exercises, development of correctional and rehabilitation programs, multidisciplinary approach has a positive impact on changes in the functional state of amateur athletes, quality of life and contributes to the return to an active social life.

KEY WORDS: amateur athletes, traumatic brain injury, correctional rehabilitation program

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INTRODUCTION

Today, a full-scale invasion of the aggressor country continues on the territory of our state, which has changed the lives of many Ukrainians. Many athletes defend their hometowns in the ranks of the territorial defense and the Armed Forces of Ukraine. Everyone has faith in victory and dreams of returning to normal life. Unfortunately, not everyone returns without being wounded in the war. However, everything will end and amateur athletes will return to their real lives.

Among the combatants in the East of Ukraine since 2014, the second place among all the injuries received was occupied by damage to the central nervous system, which were caused by the blast wave [1, 2]. An integral part of all barotraumas is a true concussion due to the action of an air wave, resembling a short massive impact

with a wide dense surface [3–5]. It is known that 73% of cases of combat injuries are accompanied by brain concussion, which occurs three times more often than other injuries. However, most often the military do not recognize this injury as severe and do not seek medical help [1]. The main problem of closed craniocerebral injury (CTBI) is that complications appear after some time. However, the consequences of CTBI are very significant and can cover disorders not only from the side of the physical state, but also from the side of the psychosomatic sphere. This problem is also gaining urgency from an economic point of view, because in most cases, CTBI during the hostilities will be received by people of working age, who eventually receive the status of disabled people. CTBI, obtained during the period of combat operations, is a complex of structural and functional changes in the

Table 1. The interpretation of the assessment of muscle strength according to the Lovett test

Score	Description of the value
0	This is the absence of pain, a person does not feel it at all
1	Discomfort is extremely mild
2	Unpleasant sensations are mild
3	The pain disturbs regularly, the patient is constantly distracted by it.
4	Moderate pain
5	Pain is moderately intense
6	Pain is still moderate
7	Pain is heavy. She literally subjugates all other sensations
8	Feelings are intense. Physical activity is extremely limited
9	Pain is very severe
10	Pain is unbearable. The patient is bedridden, he often dreams

Table 2. The interpretation of the evaluation of muscle strength according to the Lovett test, ball

Score, ball	Description of the value
0	complete absence of muscle tension
1	weak muscle contraction
2	expressive muscle tension and the ability to perform movements in an incomplete volume
3	full range of motion without additional resistance
4	full range of motion with medium resistance over the entire range
5	full amplitude with maximum resistance

nervous system of an adaptive plan, which is a dynamic, multi-level process. The degree of expression and dynamics of clinical manifestations of structural and functional disorders of the main pathogenetic processes directly depends on the severity of the injury [3-8]. Local disorders are detected only after a few days through disorders of the functions of the cranial nerves; paralysis and paresis of the limbs; disorders of coordination and balance; convulsions, etc. [9, 10].

The question of the renewal of amateur athletes with the help of individual selection of correctional and rehabilitation programs remains open. Indeed, in the scientific literature almost no attention is paid to the problem of the physical rehabilitation of such patients, as well as the restoration of amateur athletes who participated in hostilities. Movement disorders after blast injury are the most common complication. The recovery of such patients is possible only with a timely and comprehensive approach using the selection of methods and means of physical rehabilitation. The selection of correctional and rehabilitation programs aimed at restoring the balance and walking pattern will improve the quality of life and the ability to return to amateur sports.

AIM

To study the results of the quality of life, the state of vestibular disorders and the nature of walking of amateur

athletes with the consequences of a combat craniocerebral injury after rehabilitation treatment according to a correctional program.

MATERIALS AND METHODS

The study was conducted on the basis of the Ukrainian Scientific Research Institute of Prosthetics in Kharkov. The organization of the study was based on the provisions of the Helsinki Declaration of the World Medical Association. All patients provided written informed consent to participate in the study. Under observation were 38 men aged 25-42 years with long-term consequences of a closed craniocerebral injury in the late long-term period.

The duration of the post-traumatic period is from six months. The cause of disability was wounds and contusions associated with military operations. In all patients, complications after TBI were persistent headache, decreased muscle strength in the lower extremities, impaired coordination and balance, and walking pattern. All patients were involved in amateur sports before the injury.

During the examination, the following research methods were used:

1. Visual analogue pain scale (VAS). VAS is a horizontal 10 cm line with "no pain" written on one end and "worst pain imaginable" on the other end, from 0 to 10. The analysis of the results is given in Table 1 [11]:

Table 3. The interpretation of the balance assessment in a standing position according to the Bohannon test, ball

Score, ball	Description of the value
0	Can't stand
1	Can balance for less than 30 seconds with feet shoulder-width apart
2	Can balance for more than 30 seconds with feet shoulder-width apart
3	In S.P. feet together, stand for less than 30 seconds
4	In S.P. standing, feet together, stand for 30 seconds or more

Table 4. The indicator of quality of life index of patients in Group 1 (n=20) and Group 2 (n=18), cm

Group	Before the program, cm	After the program, cm	Difference, cm	p
Gr. 1 (n=20)	8,37±2,4	5,24±1,6	3,16±0,8	<0,05
Gr. 2 (n=18)	8,37±2,4	7,10±0,8	1,27±1,6	>0,05

Table 5. The indicator of muscle strength of patients in Group 1 (n=20) and Group 2 (n=18), ball

Lovett's muscle strength rating scale	Gr. 1 (n=20), ball		Gr. 2 (n=18), ball	
	Before rehabilitation M±m	After rehabilitation M±m	Before rehabilitation M±m	After rehabilitation M±m
Abdominal muscles	3,2±0,24	4,1±0,28*	3,2±0,24	3,6±0,7
Spinal extensor muscles	3,1±0,17	4,2±0,12*	3,1±0,17	3,3±0,4
Square muscle of the lower back	3,4±0,14	4,2±0,18*	3,4±0,14	3,7±0,12
Iliopsoas muscle	2,4±0,25	3,8±0,34*	2,4±0,25	2,9±0,12
Adductor thigh muscles	3,2±0,12	4,3±0,15*	3,2±0,12	3,6±0,11
Quadriceps femoris	2,2±0,16	3,5±0,18*	2,2±0,16	2,7±0,13
Tibialis anterior	2,5±0,14	3,6±0,12*	2,5±0,14	3,1±0,11
Triceps muscle of the leg	2,1±0,17	3,5±0,14*	2,1±0,17	2,6±0,12
Biceps femoris	2,3±0,15	3,4±0,17*	2,3±0,15	2,8±0,14
Gluteus medius thigh	2,2±0,13	4,2±0,12*	2,2±0,13	2,6±0,15
Gluteus maximus muscle	2,3±0,17	3,6±0,14*	2,3±0,17	2,9±0,12

* p<0.05 (statistically significant difference)

1. *Lovett test* – a special test for manual determination of the strength of the patient's muscles. The abdominal muscles, spinal extensors, quadratus lumborum, iliopsoas, and hip adductors were assessed; quadriceps femoris; anterior tibial (when the foot is extended at the ankle joint); three-headed shins (when the foot is bent at the ankle joint); biceps femoris; middle sciatic muscle of the thigh; large ischial. The assessment of muscle strength according to the Lovett test is presented in Table 2 [10, 11]:
2. The assessment of balance in the standing position was performed using the *Bohannon test* [10, 1] (Table 3).
3. *Test "Timed Up and Go" (TUG)*. Assesses functional mobility, balance, walking ability and determines the risk of falling. It is an easy-to-survey test that is both sensitive and specific about the likelihood of a fall. To conduct the test, you must prepare a chair with an armrest, a stopwatch and mark the distance of 3 meters. The patient sits on a chair, follows the command, gets up, reaches the 3-meter mark, comes back and sits down. Fall risk score for vestibular disorders – >11 seconds.
4. *Pedagogical experiment*. In order to test the effectiveness of the developed correctional and rehabilitation program, a pedagogical experiment was conducted, which included ascertaining and forming stages. The ascertaining stage of the pedagogical experiment made it possible to find out the current state of the study of the problem of physical rehabilitation of patients and, on the basis of the primary examination (conversations, observations, functional testing), to determine the problems of patients with the consequences of post-traumatic brain injury and form homogeneous groups. The formative stage of the pedagogical experiment involved the implementation of the developed program and verification of its effectiveness by comparing the studied indicators in patients of both groups.

Table 6. The indicator of balance in the standing position behind in patients Gr. 1 (n=20) and Gr.2 (n=18), in points

Group	Before the program	After the program	difference	p
Gr. 1 (n=20)	1,8±0,9	3,1±0,7	1,9±0,2	<0,05
Gr. 2 (n=18)	1,8±0,9	2,1±0,8	0,2±0,9	>0,05

METHODS OF MATHEMATICAL STATISTICS

Statistical data processing was carried out using the statistical package STATISTICA 13.0 (StatSoft). The arithmetic mean value was calculated – M ; standard deviation – δ ; dispersion – D ; the error of the arithmetic mean is $\pm m$. Verification of the conformity of the distribution of the sample population to the normal law was carried out using the Shapiro-Wilk test. To determine significant differences, Student's parametric test (t) was used; differences were considered statistically significant at $p < 0,05$.

When building a correctional rehabilitation program, the principles of physical rehabilitation and pedagogical interaction were followed, namely, accessibility, complexity and multidisciplinary [3, 12-23]. All patients were randomly divided into two groups.

Patients Gr.1 (n=20) were trained according to the developed correctional rehabilitation program. The developed correction and rehabilitation program included training according to the PNF method, kinesiotherapy, classes on the C-mill sensory treadmill and the Hunova computer device, and segmental reflex massage. The course of physical therapy lasted 24 days. Classes were held 6 times a week, in the morning with a physical therapist, every day except Sunday. Group 2 patients (n=18) underwent a course of physical rehabilitation according to the generally accepted methodology of the Ministry of Health of Ukraine.

A PNF training method based on neurophysiological mechanisms that improve muscle responses to their active contraction through stimulation of spinal motoneurons with impulses in response to proprioceptive stimulation from the periphery. This is achieved through special models of spiral-diagonal movements, actively performed by the patient with the help of the hands of a specialist in physical rehabilitation with a dosed counter resistance. [2].

Kinesiotherapy. Active movements in the joints of the extremities were prescribed with full amplitude and multiple repetitions with and without additional weights. The exercises included coordination exercises (a combination of simple and then more complex movements in all joints of the limbs), development of the amplitude and accuracy of active movements. Exercises were used in the starting position standing, sitting and lying down. Patients necessarily performed relaxation exercises in combination with breathing ex-

ercises. With the help of special exercises, the sensory support of motor acts was improved (proprioceptive, visual, verbal, tactile control) [15, 22-25].

Classes on the C-mill sensory treadmill with built-in power platforms and biofeedback. The technique is used for diagnosing and training walking, provides gradual progress and a high level of patient motivation throughout the rehabilitation process, gradually returning the patient to a natural walking style.

The HUNOVA device is an automated rehabilitation process that improves the sense of balance and balance while walking. It also allows, thanks to the automation of the rehabilitation process, to increase the intensity of rehabilitation programs and evaluate the patient's capabilities in terms of movement, speed, strength and other derived parameters.

To activate physiological and trophic processes in the tissues of the lower extremities, *segmental-reflex massage* was performed, namely, massage of the paravertebral zones of the spinal segments of the lumbosacral spine, from which the innervation of the lower extremities is carried out. The purpose of the massage was to apply mechanical stimulation to the root of the spinal nerves at the points of their exit from the spinal column. This contributed to the provision of a stimulating effect on tissue and physiological processes in the reflex-related tissues of the lower extremities. This procedure was carried out in the initial position of the massaged person lying on his stomach, under which a small massage roller was placed. After stroking the massaged area, connective tissue massage was performed sequentially. The exit points of the spinal nerve roots were studied. Then the "Rhombus of Michaelis" zone was rubbed in different directions, paying special attention to the lower borders of the sacrum [4, 5]. In conclusion, continuous vibration of the paravertebral zones of the massaged area was carried out. The duration of the procedure is 10-12 minutes.

ETHICAL APPROVAL

The research related to human use has been complied with all the relevant national regulations and institutional policies, principles of the Helsinki Declaration, adopted by the General Assembly of the World Medical Association (1964-2000), the Council of Europe Convention on Human Rights and Biomedicine (1997).

INFORMED CONSENT

Informed consent has been obtained from all individuals included in this study.

RESULTS

The clinical picture of all patients was almost the same. All the subjects had the main neurological syndromes that limited their vital activity: vegetative disorders and discoordination of the vestibular genesis.

At the level of the structure and function of the ICF, mono- or hemiparesis of the lower extremities was observed in all patients. Loss of sensation below the neurological level. Violation of proprioceptive sensitivity in the feet and toes. Limitation of the range of motion in the joints of the lower extremities.

At the ICF activity level, all self-care patients were independent of outside help.

At the ICF participation level: all patients complained of being able to walk non-stop only for a distance of less than a kilometer. Not an opportunity to return to amateur sports.

Personal factors: purposeful and motivated return to amateur sports.

After working with patients, the following dynamics was observed behind the developed correctional and rehabilitation program. Thus, when assessing the quality of life according to the VAS scale, the dynamics of pain syndrome parameters in Gr. 1 patients had a statistically significant difference ($p < 0,05$) compared with the primary indicator. However, in patients Gr. 2 showed positive dynamics, but it did not acquire statistical significance ($p > 0,05$) (Table 4).

When testing on the Lovett scale, the study of simple movements performed in one plane was carried out. According to the Lovett Manual Muscle Test (MMT), during the initial examination, signs of loss of muscle strength of the extensor and flexor muscle groups of the lower extremities were observed in all patients. It was found that the MMT indices of both the anterior and posterior thigh muscle groups tended to a statistically significant decrease, i.e., lower back. The assessment of muscle strength according to the Lovett test in patients indicated a decrease in the strength of all studied muscle groups (Table 5).

After a course of rehabilitation in patients Gr. 2 observed a trend towards improvement in all indicators according to the Lovett test ($p > 0,05$). Patients Gr.1 showed statistically significant dynamics of all studied parameters ($p < 0,05$). Thus, the indicators of the abdominal muscles increased by 0,9 points, the extensor muscles of the spine by 1,1 points, the square muscle of the lower back by 0,8 points, the iliopsoas muscle by

1,4 points, adductor muscles of the thigh by 1,1 points, quadriceps femoris by 1,3 points, anterior tibial muscle by 1,2 points, triceps muscle of the lower leg by 1,4 points, biceps femoris by 1,1 points, gluteus medius femoris by 2 points and the gluteus maximus muscle by 1,3 points, which was statistically confirmed ($p < 0,05$).

The average balance in the standing position according to Bohann was $1,8 \pm 0,9$ points in the initial study, which indicated instability to more maintain one's standing position, independently on both legs. After working on the program in patients Gr. 1 determined a statistically significant positive trend ($p < 0,05$) in patients Gr. 2 positive changes were observed but did not acquire statistical significance ($p > 0,05$). The dynamics of balance indicators is presented in Table 6.

In the primary study of testing vestibular coordination and pattern walking, the indicator in all patients indicated a statistically significant decrease in the obtained data compared to the standard indicator ($p < 0,05$). The average execution time was 20 seconds or more. When observing patients during the test, attention was paid to walking, during which 13 patients lost their balance; 14 had short steps; in 12 people, a small arm swing was observed. After rehabilitation according to the developed program, patients Gr. 1 on average passed the test in 12-14 seconds and almost approached the standard value (11 seconds).

DISCUSSION

Thus, the results of the study indicated that in amateur athletes in the late long-term period, the complications of TBI were a decrease in muscle strength in the lower extremities, impaired coordination and balance, a walking pattern, and a decrease in the quality of life. All of the above confirmed the opinions of some scientists that after TBI of an explosive genesis, local disturbances are detected only after a few days in the form of disorders of the functions of the cranial nerves; paralysis and paresis of the limbs; disorders of coordination and balance; convulsions, etc. [5, 9, 25-27].

We agree with the opinion of A. Matveiko et al. (2019) that in order to stimulate new neural pathways after brain contusion, it is necessary to develop correctional and rehabilitation programs, the main tool of which is kinesiotherapy [1].

The conclusions of Voronova V. Ya., Lazareva O. B., Kovelskaya A. V. and Kobinsky O.V. (2021) were confirmed, indicating that in order to restore walking in patients with TBI, it is necessary to form an examination and intervention plan based on SMART -objectives, which are to get an idea of the needs and potential of the patient, allow you to choose the intervention that best meets the patient's main problem [13, 18, 20, 21].

Based on the findings of many scientists, we have determined that it is the individual selection of physical exercises, the development of correctional and rehabilitation programs, the multidisciplinary approach that positively affects the changes in the functional state of amateur athletes, the quality of life and contributes to the return to an active social life. [10, 21-24].

LIMITATIONS

The study presented has some limitations. Firstly, the small number of patients who were involved in the study, limiting the ability to generalize to other populations. Secondly, the study was conducted only within the framework of one social sphere; it may be a limitation for summarizing the results.




CONCLUSIONS













In amateur athletes with TBI in the late recovery period, at the level of structure and function according to the ICF, there is a violation of proprioceptive sensitivity in the feet and toes. At the level of participation, accord-

ing to the ICF, there are complaints about not being able to return to amateur sports. After the course of rehabilitation according to the author's program, patients of Group 1 observed a statistically significant improvement of all studied indicators, namely, the quality-of-life indicator according to the VASH improved by 3.16 points; according to the scale of the Lovett test, an increase in muscle strength of both the front ($p < 0.05$) and the back group of the thigh and lower back muscles ($p < 0.05$). The balance score according to the Bohannon test in Gr.1 patients increased by 1.9 ± 0.2 points ($p < 0.05$). Test for "Timed Up and Go" patients Gr. 1 on average passed the test in 12-14 seconds ($p < 0.05$). In Gr.2 patients, a tendency to improvement was observed for all the above-mentioned indicators, but they did not reach statistical significance ($p > 0.05$).

Prospects for further research involve the development of a correctional rehabilitation program for amateur athletes with the consequences of brain contusion and a violation of the walking pattern for a complete recovery of physical condition and return to sports activities.

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CONFLICT OF INTEREST

The Authors declare no conflict of interest

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