

A RESEARCH ON FUNCTIONAL STATE OF NERVOUS SYSTEM OF SERVICEMEN WITH POST-CONCUSSION SYNDROME WITH USING SCREENING TESTS

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Abstracts

Analysis of servicemen participation in hostilities on the territory of the state has led to a significant increase in the number of personnel who have combat wounds, mutilations or injuries. Almost all participants in hostilities have health impairments, namely PCS, the prevalence of which is more than 70 % of the total number of injuries. This contingent of servicemen is important for the Ukrainian army, as their combat experience is a basis for the development and improvement of training of military specialists` training. However, their state of health can be an obstacle to the successful performance of their functional duties. **The Purpose of the Study** – to comprehensively investigate the functional state of the nervous system of servicemen who had PCS, using a battery of tests aimed at studying the psycho-emotional state. **Research Stuff and Methods** – 36 servicemen (average age 32,22±1,26 years) who had a history of concussion took part in the study. A set of tests included: tapping test, the Romberg test, finger-nose test, “Walking in a straight line with open and closed eyes” test, and the Yarotsky’s test. **Findings**. The tests used meet the basic requirements for screening, it means, they are simple, visual, economically feasible and allow obtaining sufficiently informative information about the health state of the participants. The absence of deep lesions of the nervous system was confirmed, that is, the testing proves the conclusions made regarding the pre-nosological nature of health disorders again.

Key words: military personnel, concussion, adaptation, physical training, screening test.

Артур Одеров, Сергій Романчук, Олег Небожук, Мар’яна Ріпак, Оксана Матвейко, Віктор Лашта, Володимир Климович, Олександр Тимочко. Дослідження функціонального стану нервової системи військовослужбовців, які мали контузію, шляхом використання скринінг-тестів. Аналіз участі військовослужбовців у бойових діях на території держави засвідчив значне зростання кількості тих із них, які мають бойові поранення, каліцтва або травми. Майже у всіх учасників бойових дій спостерігаємо порушення стану здоров’я, а саме контузію, поширеність котрої становить понад 70 % від загальної кількості травм. Цей контингент військовослужбовців є значущим для українського війська, оскільки бойовий досвід військових важливий як підґрунтя для розвитку та вдосконалення підготовки військових фахівців. Але стан їхнього здоров’я може виступати як перешкода для успішного виконання своїх функціональних обов’язків. **Мета дослідження** – комплексно дослідити функціональний стан нервової системи військовослужбовців, які мали контузію, за допомогою тестів, спрямованих на вивчення психоемоційного стану. **Матеріал і методи**. У дослідженні взяли участь 36 військовослужбовців (середній вік – 32,22±1,26 років) чоловічої статі, які мали в анамнезі контузію I та II ступенів. Використано тести, до складу яких входили теплінг-тест, координаційні проби Ромберга, пальцено-сова проба, тест «Хода по прямій з відкритими й закритими очима» та проба Яроцького, методи статистичної обробки даних **Висновки**. Використані тести відповідають основним вимогам до скринінгу, тобто є простими, наочними, економічно доцільними й дають змогу отримати достатньо інформативні відомості щодо стану здоров’я учасників. Підтверджено відсутність глибоких уражень нервової системи, тобто тестування ще раз доводить зроблені висновки щодо донозологічного характеру порушень здоров’я.

Ключові слова: військовослужбовці, контузія, адаптація, фізична підготовка, батареї тестів.

Statement of the Problem and Analysis of the Latest Research. Constant maintenance and provision of a high level of combat readiness of military personnel is a necessary condition for their successful performance of the task of protecting our state [2]. The activity of military personnel is characterized by constant increased physical and mental stress, the impact on the functional state and working capacity of military personnel, their performance of tasks in special conditions associated with risk to life and health [1, 5]. Physical training is not only an important factor on which the professional realization of servicemen depends, but also affects the performance of combat tasks.

Due to the fact that the Armed Forces of Ukraine take part in hostilities, the number of servicemen – veterans of hostilities has increased. Most of them have physical and psychological deviations in health and functional status [3, 4]. Against the background of the existing risk factors of the daily life of the participants, the adverse effect of the consequences of the concussion will intensify and gradually lead to the formation of pre-clinical conditions, which, in turn, can turn into pathology. Analysis of the nature of the complaints put forward by the respondents and self-assessments of well-being at the end of the working day and working week indicate deterioration of the regulation of the activity of the main organs and systems of the body, negative changes in the working capacity of servicemen, lack of opportunities for its recovery [6, 7]. All this is a sign of the formation of relevant pre-clinical health conditions. Thus, the purpose of our study is to conduct a study of the functional state of the nervous system of servicemen who had a concussion, using a battery of tests aimed at studying the psycho-emotional state.

The scientific research was carried out in accordance with the plan of scientific and scientific and technical activities of the Main Department of Training of the Armed Forces of Ukraine in accordance with the topic of the scientific research work “Justification of the norms of physical and psycho-emotional load of military personnel during combat operations” code “HARMONY” state registration number 0118U001599CA and the topic of the department’s GDR theories and methods of physical culture of the LDUFK for 2018–2021. “Theoretical and methodological aspects of optimizing the motor activity of various population groups” (protocol No. 4 dated November 17, 2017).

The Purpose of the Study. To comprehensively investigate the functional state of the nervous system of servicemen who had a concussion, using a battery of tests aimed at studying the psycho-emotional state.

Material and Methods. The research was conducted for 2 months at the training and field base of the National Academy of Land Forces named after Hetman Petro Sahaidachny. The research involved 36 male military servicemen who received first and second degree concussions while performing assigned tasks in combat areas. The average age of the subjects was $32,22 \pm 1,26$ years. The study of the functional state of the nervous system of the participants included conducting a battery of tests aimed at assessing the psycho-emotional state of military personnel.

All instrumental and laboratory studies were carried out with the help of equipment and instruments that passed the necessary metrological control. Obtaining indicators, on the basis of which the condition of the participants was assessed, was carried out using modern adequate methods, which allows us to consider the results of the study as objective.

In order to determine the properties of the nervous system based on psychomotor indicators, a functional tapping test was used. The following test material was used for the test: standard blanks, which were sheets of paper (203x283 mm), divided into 6 equal rectangles arranged in rows of 3 each. At the signal, the participants had to start putting dots in each rectangle of the form. During the allotted time (5 sec) for each rectangle, the participants had to put as many dots as possible in it. The transition from one rectangle to another was performed by the participants on command, without interrupting their work. All the time, the work was carried out at the maximum pace. The test was performed sequentially, first with a right hand, then with a left hand. The processing of the test results consisted in counting the number of dots in each rectangle. On the basis of the obtained results, a performance schedule was built, for which five-second time intervals were set on the abscissa axis and the number of dots in each rectangle on the ordinate axis. Based on the analysis of the shape of the curve, the strength of the nervous system was diagnosed.

We used Romberg’s coordination tests to determine imbalance in the standing position. Static coordination was assessed by the ability to maintain balance: “very good” if a person maintains balance (with feet together with arms stretched forward and eyes closed) for more than 15 seconds (absence of hand and eyelid tremors). If a tremor is registered, the test is evaluated as “satisfactory”. In other cases, static coordination was assessed as “unsatisfactory”. A simple test was feet together with arms stretched forward and eyes closed. Violation of the coordination function: swaying, loss of balance and (to a lesser extent) tremors of the fingers and toes. Complex test was standing on one leg with the heel of the other leg touching the knee joint of a supporting leg, arms stretched forward, and eyes closed. Evaluation: firm stability of the posture for more than 15 s in the absence of tremors of the fingers and eyelids was evaluated as “good”; swaying, slight tremor of the eyelids and fingers when holding the pose for 15 seconds – “satisfactory”; noticeable tremor of the eyelids and fingers when holding the pose for less than 15 seconds – “unsatisfactory”.

The finger-to-nose test was used to assess dynamic coordination. A participant was asked to touch a tip of a nose with their index finger with their eyes open and then with their eyes closed. A touch to a tip of the nose

was registered as normal. Brain injuries, neuroses (overtraining) and other functional disorders cause inaccuracy of movements, shaking (tremor) of hands.

To study the coordination of the respondents, we used the “walking in a straight line with open and closed eyes” test. The test required the use of special markings. Two straight parallel lines 5 m long were drawn with paint on the floor at a distance of 20 cm from each other. This “track” was used to quantify the kinetic stability. Deviation from a straight line while walking with eyes open and closed was measured in centimeters. The lateral deviation for healthy people while walking does not exceed 10–15 cm.

In order to assess the state of the vestibular apparatus, Yarotsky’s test was used. The examinee performed rotational movements of a head in one direction at a rate of two rotations per 1 second. A stopwatch was used to determine how long he kept his body balanced. Normally, this time is 28 seconds, a trained athlete performs this test for 90 seconds or more. A study of the somatic and vegetative response before and after the test was conducted.

All participants in our study gave their informed approval to participate in the experiment. The research was conducted and performed in accordance with the ethical standards of the Declaration of Helsinki.

Research Results and Their Discussion. The analysis of our previous studies and the review of scientific literature allowed us to conclude that military personnel who had a concussion have certain signs of nervous system disorders. Therefore, it is necessary to monitor the condition of servicemen of the specified category, identify risk factors and correct them in a timely manner with a help of complex measures aimed at adaptation to physical stress. Today, monitoring of physical condition and physical fitness is recognized as a main tool for monitoring physical health at a group and population level. An important part of monitoring a functional state is a use of so-called screening tests, which with a certain probability allow dividing the examined people into those with health abnormalities or without them. Results of such studies, as a rule, do not yet provide grounds for establishing a diagnosis, they only help to distinguish from a conditionally healthy contingent those people who are most likely to have a disease. The results of the tapping test are shown in the table 1.

Table 1

Tapping Test Results of Concussed Servicemen

A Subtest of the Tapping Test	Number of Touches, abs
1 Subtest, abs	33,24±3,32
2 Subtest, abs	42,56±4,87
3 Subtest, abs	47,44±5,07*
4 Subtest, abs	37,21±3,44
5 Subtest, abs	33,45±4,02
6 Subtest, abs	30,21±2,99
Sum of all Subtests, abs	224,11±14,87

* – differences with the results of subtest 1 are likely ($p < 0,05$).

The results shown in the table 1 indicate a certain stability of the test performance, which is proved by the absence of significant differences between the majority of average values of the subtests ($p > 0,05$). The exception is the results of subtest 3, which are significantly greater than the results of subtest 1. In our opinion, this may be an evidence of significant disorders absence in a nervous system.

At the same time, the graphic representation of the results shown in fig. 1 allows you to assess a strength of a nervous system.

As shown in the graph, the participants performed the first three subtests with an increase in a number of touches, and, as already noted, it was in the 3rd subtest that the highest test result was obtained. Starting with the fourth subtest, the number of touches decreased, although no significant differences were found. But such a direction of the graph allows us to conclude that the participants are characterized by a predominantly moderately weak type of nervous system, when after the first 2–3 subtests there is a decrease in performance.

The obtained results determined a need for an individual analysis of results of the tapping test. The strength of the nervous system was determined according to the following gradations: strong, stable, weak, medium, medium-strong and medium-weak, in accordance with the criteria given by Makarenko M. The following subdivision of participants was found: 5,56 % had a strong type, 30,56 % had a medium type, and 30,56 % had a weak type. 19,44 % and moderately weak – 44,44 %. For greater clarity, the obtained results are shown in fig. 2.

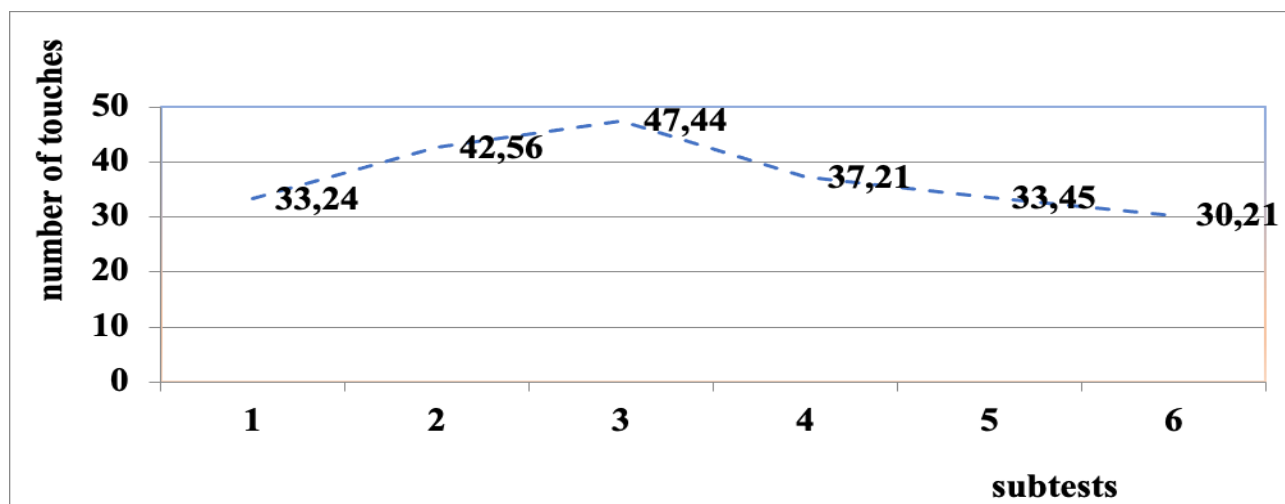


Fig. 1. *The Results of the Tapping Test of Servicemen Who Had a Concussion*

The results of fig. 2 prove the predominance among the participants of people with medium and moderately weak nervous system strength.

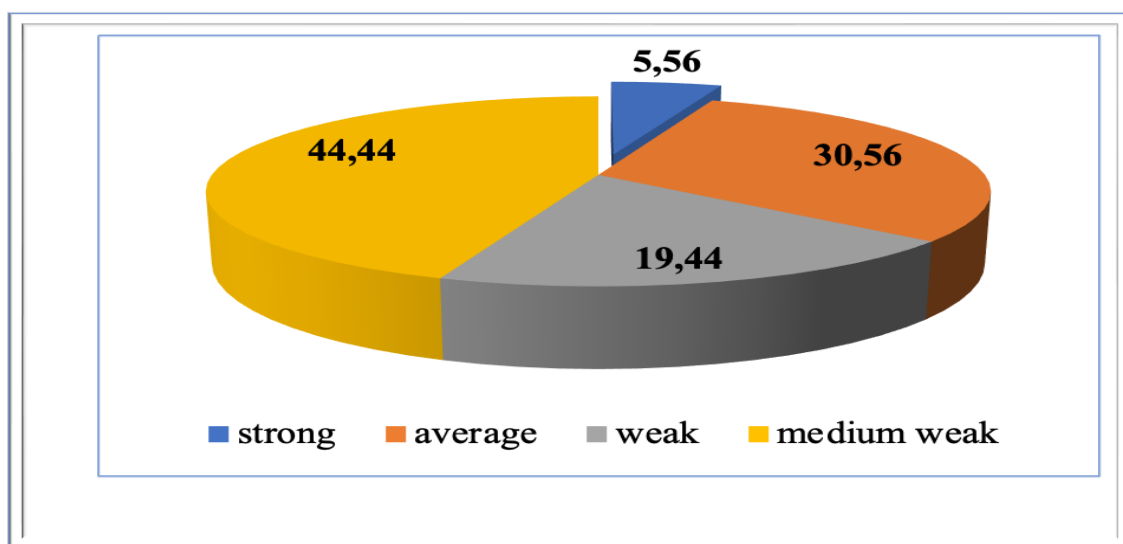


Fig. 2. *Distribution of Military Personnel According to a Strength of a Nervous System According to the Results of the Tapping Test, %.*

The fact that almost every fifth participant had a weak nervous system also attracts attention. The obtained results can be interpreted as evidence of deterioration of the strength of the nervous system of servicemen as a result of a concussion. However, this assumption still needs final proof, for which other tests were used.

The results of Romberg's test were quite interesting. The time to perform a simple Romberg pose was $11,01 \pm 2,78$ s on average for the group. That is, an average result for the group indicates the presence of certain violations of coordination in the participants, which is an unfavorable sign from the point of view of the forecast of the functional state and confirmation of the assumptions made earlier about disorders of a nervous system of military personnel.

At the same time, all participants were divided into two subgroups – those who completed the test and those who did not. The specific weight of servicemen assigned to the first subgroup amounted to 38,89 %, to the second – 61,11 %. When comparing the values of the subgroups, a tendency towards the probability of differences was established ($t=1,93$, $p<0,1$). The test execution time in the subgroups was $15,22 \pm 3,41$ s and $6,83 \pm 2,15$ s, respectively ($p<0,05$). A presence of differences both in a size of subgroups and in results of the test, in our opinion, should be interpreted as an illustration of certain coordination disorders in military

personnel. Considering the results, this is evidence for a gradual formation of disorders on a part of a nervous system as a result of a suffered concussion.

The results of Romberg's complicated pose also testify in favor of this assumption. The average value of the test results by group was $12,95 \pm 3,53$ s. The participants were divided into three subgroups: those who performed the test well, satisfactorily, and those who did not perform the test at all. The distribution of participants by subgroups is shown in fig. 3.

The specific weight of participants who completed the complicated Romberg test was 19,44 %, "satisfactory" – 16,67 %, and "unsatisfactory" – 63,89 %. A probable exaggeration of the number of servicemen with satisfactory and unsatisfactory results compared to the number of people who completed the test well, respectively ($t=4,66$, $p<0,05$) and ($t=4,28$, $p<0,05$), was revealed.

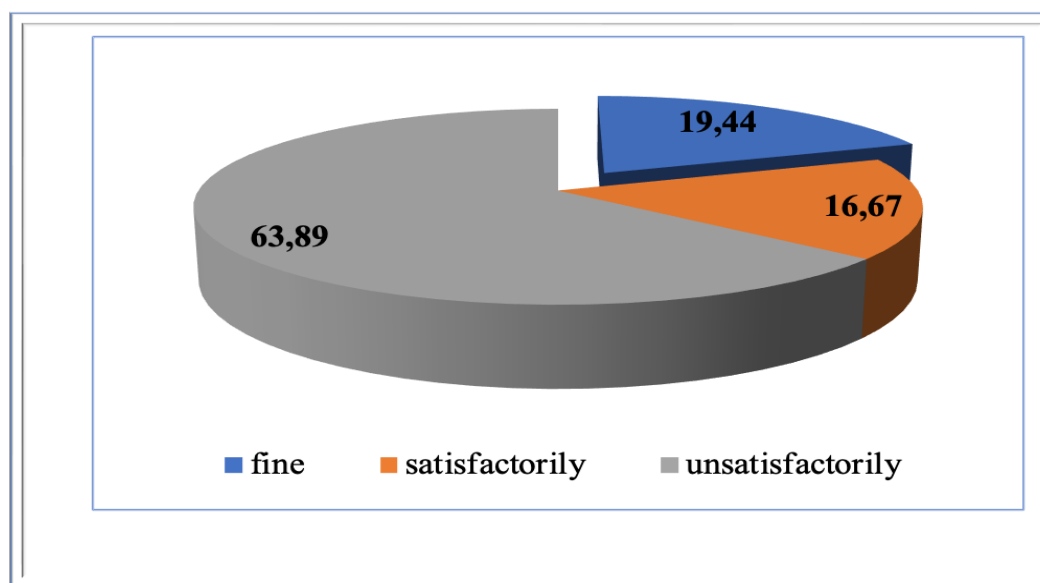


Fig. 3. *Subdivision of Servicemen According to the Results of the Complicated Romberg Test, %*

The test execution time in the subgroups was $16,11 \pm 23,23$ s, $15,57 \pm 4,33$ s, and $7,18 \pm 3,04$ s, respectively. Significant differences in test execution time between the first and third subgroups were confirmed ($t=2,01$, $p<0,05$). The given results allow us to conclude that a complication of the Romberg test conditions leads to a deterioration of the results. It should also be evaluated as a reflection of the presence of coordination disorders that appeared in the participants as a result of a concussion.

A comparison of the specific weight of the participants who completed the simple test and in the case of the complicated test received a "good" rating and allowed us to conclude that there were no significant differences. Also, no significant differences were found between the test execution time in the first and second subgroups when performing a complicated test. This can be explained by the fact that in both cases the time is at least 15 seconds. The grade "satisfactory" was given to those participants who had pronounced tremors of the eyelids and fingers while standing. Thus, the analysis of the results of Romberg's simple and complicated test allows us to conclude that there are coordination disorders in at least half of the examinees. In our opinion, this is another proof of the correctness of assumptions about consequences of a concussion as a basis for the formation of disorders of a nervous system.

The results of the finger-nose test are shown in fig. 4. They also testify a presence among the participants with disorders of dynamic coordination of movements.

A percentage of participants who could not touch a tip of a nose with a finger was 58,33 %, a number of participants who completed this test was 41,67% ($p>0,05$). In our opinion, a lack of significant differences in results of the finger-nose test is another evidence in favor of the previously made assumptions about the absence of serious disorders of a nervous system in servicemen who had a concussion. An insignificant difference between a number of participants who performed and did not perform the thumb-nose test, in our opinion, can be an evidence in favor of a pre-neurological disorders formation of a nervous system.

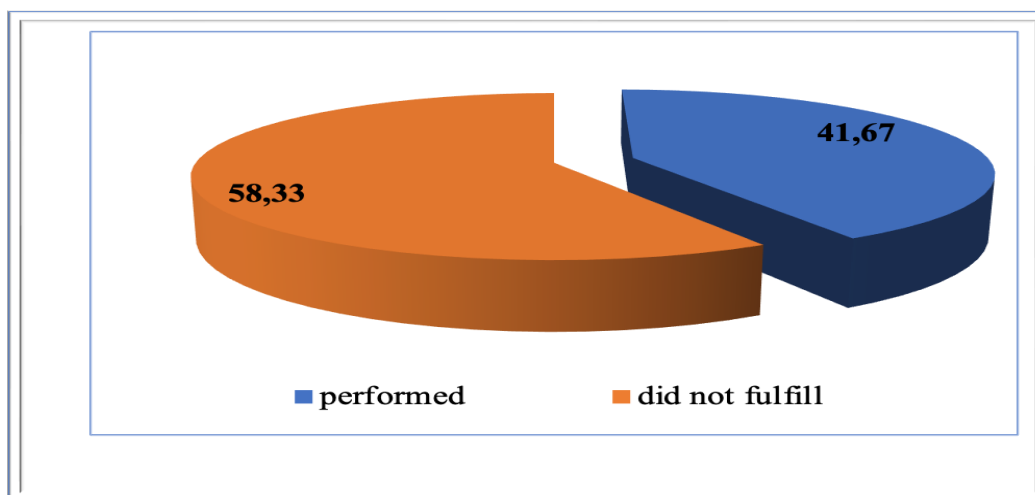


Fig. 4. Subdivision of Servicemen According to the Results of the Thumb-Nose Test, %

The results of the coordination study using the test “Walking in a straight line with open and closed eyes” are shown in table. 2.

Table 2

Results of the Test “Walking in a Straight Line with Open and Closed Eyes” of Servicemen Who Had a Concussion

Test score	Result
Deviation when walking with open eyes, see	13,25±4,18
Deviation when walking with closed eyes, see	18,47±3,26
A percentage of participants with a deviation of less than 15 cm when walking with open eyes, %	30,56*
A percentage of participants with a deviation of more than 15 cm when walking with open eyes, %	69,44
A percentage of participants with a deviation of less than 15 cm when walking with eyes closed, %	19,44*
A percentage of participants with a deviation of more than 15 cm when walking with eyes closed, %	80,56

* – differences with the specific gravity of individuals with a deviation of more than 15 cm are probable ($p < 0,05$).

The data given in table 2, testify an absence of sharp differences in the execution of test options. The average value of a deviation when performing the test with open eyes did not have significant differences from the result when performing the test with closed eyes ($t=0,98$, $p>0,05$). In our opinion, this should be evaluated as an evidence that the participants do not have significant coordination disorders, that is, there are no organic damage to a nervous system.

At the same time, in both versions of the test, a percentage of people who completed the test with an acceptable deviation was significantly less than a percentage of participants whose deviation was more than permissible. When performing the test with open eyes t equaled 3,58, $p < 0,05$, with closed eyes t equaled 6,55, $p < 0,05$). Moreover, the percentage of people who completed the test correctly or failed to do so did not have significant differences in both versions of the test. That is, the results of the specified sample also indicate a violation of the coordination of the participants, but at a level of a pre-clinical condition.

Yarotsky’s test is a simple and informative test that allows you to assess the condition of a vestibular apparatus. To analyze a performance of the test, it is necessary to determine the time of its performance and evaluate the dynamics of somatic and vegetative reactions. The obtained results are shown in table 3.

The results shown in table 3 indicate a presence of certain changes in the vestibular apparatus of the participants. The average time of Yarotsky’s test exceeds the 28 seconds norm set for an ordinary person, but is significantly less than the 90 seconds norm set for trained athletes. That is, these results should also be evaluated as evidence of certain pre-clinical conditions of a vestibular apparatus. The analysis of physiological indicators of a cardiovascular system allows us to draw a conclusion about a stress of its adaptive capabilities. This is evidenced by the presence of tachycardia and a tendency to a hypertensive reaction to the test. After the

test, this trend persists, although no significant changes were found in all physiological indicators. As with the analysis of the results of the previous tests, we conducted an individual analysis of the dynamics with a determination of a degree of reaction. There were no people with a zero degree at all, as the results of table 3 show, the vast majority of participants were characterized by a 2–3 degree of reaction, which should be evaluated as a satisfactory reaction to the load. A likely decrease in the specific gravity of individuals with a grade 1 reaction compared to the number of participants with a grade 3 reaction was found.

Table 3

The Results of Yarotsky's Test Servicemen Who Had a Concussion

Indicator	Result
Equilibrium time, p	36,81±9,19
Heart rate before the test, min^{-1}	82,33±9,12
Systolic pressure before the test, $mm\ Hg. Art.$	133,41±13,28
Diastolic pressure before the test, $mm\ Hg. Art.$	89,45±14,32
Heart rate after the test, s^{-1}	94,22±8,16
Systolic pressure after the test, $mm\ Hg. Art.$	147,34±15,23
Diastolic pressure after the test, $mm\ Hg. Art.$	97,48±18,33
Specific weight of people with 1 degree of reaction, %	13,89*
Specific weight of people with 2 degrees of reaction, %	55,56
Specific weight of people with 3rd degree of reaction, %	30,56*

* – differences with the specific gravity of people with 2 degrees of reaction are likely ($p < 0,05$).

The fact that almost every third participant had a grade 3 reaction, i. e. it was unsatisfactory, should be evaluated as a negative factor. The presence of the 3rd degree in athletes is associated with physical overstrain and exhaustion of adaptation capabilities. In the context under consideration, this should be evaluated as another evidence of the development of pre-clinical conditions characterized by disorders of a vestibular apparatus.

Conclusion and the Further Direction of Our Research. Thus, the results of our study allow us to draw the following conclusions. First, a pile of screening tests in our study can be used to analyze a functional state of concussed servicemen [8, 9, 10]. The specified tests meet basic requirements for screening and allow obtaining sufficiently informative information about the state of health of the participants. Secondly, the results indicate the absence of deep lesions of a nervous system, that is, the testing does not give grounds to classify the participants as people suffering from chronic diseases. Thirdly, the nature of changes and their expressiveness confirm that in servicemen who have had a concussion, the main signs of this condition are a deterioration of the strength of a nervous system according to the results of the tapping test, a violation of static and dynamic coordination of movements according to the results of the Romberg test and the finger-nose test, the growth specific gravity of people with coordination disorders and disorders of a vestibular apparatus. The analysis of the obtained results from a standpoint of pre-hospital diagnosis and taking into account the peculiarities of military work give reasons to believe that the participants have a sufficiently high risk of the transition of the stress of adaptation into its exhaustion and disruption with the subsequent formation [8, 11] of chronic pathology. This necessitates the justification, development and implementation of special programs aimed at correcting identified violations and the general improvement of servicemen of the specified category. In addition, the specifics of military work require research and assessment of servicemen physical fitness who have suffered from a concussion. This will make it possible to assess a physical health state and will be useful from the point of view of further analysis of established pre-clinical conditions. This is the goal and perspective of our further research.

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