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DEVELOPMENT OF METHODOLOGIES OF PSYCHOPHYSIOLOGY TESTING AND ITS PROSPECTS IN REHABILITATION

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Psychophysiology testing (PPT) is tool to estimate psychophysiological important features (PIF). Today several hundreds of various PIF are known, but relationship between the rehabilitation diagnose and tests is absent. Aim of work is development of the PPT method for patients under rehabilitation. For that it is needed to determine the most relevant PIFs, to select the set of tests for each PIF, and to find relation between rehabilitation diagnose and tests.

16 most important PIFs and 19 tests are selected from which 8 are known, 5 are modified and 6 are novel developed by authors. During PPT, patient is exposed by tests, the speed and errors are registered, and integral index are calculated. Software-hardware complex "Psycholot-1" is used, in which all calculations are performed in computer with visualization on the monitor. Functional reserve (FR) is measured by ECG device, which allows to estimate the state of vegetative nervous system by HRV and the state of heart by ECG.

General methodology of the PPT based on the estimation of PIFs are proposed. It was obtained that complex "Psycholot-1" is suitable for assessing and monitoring the current state of patients under rehabilitation. Method of rehabilitation based on biofeedback is proposed, in which above device is used in the trainer mode with visual presentation of tests to the patient in real time. To verify decision-making rules, it is necessary to monitor a group of patients undergoing rehabilitation, as well as to determine the effectiveness of rehabilitation.

Also, technology of determining the FR during PPT and examples of its use are described. Registration of ECG was conducted three times within 3 minutes: 1) at rest before the test, 2) during the PPT, and 3) after finishing PPT at rest. Indicators for the first and last observations were compared between each other, which allow analyze the functional state after the action of psycho-emotional factor, i.e. PPT. Total 50 persons (38 men and 12 women) were observed.

Approach based on PPT intended for monitoring of rehabilitation process is developed. 16 PIFs and 19 tests were selected for estimation of effectiveness of rehabilitation. Tests are based on registration of speed and errors, and calculation of integral index. Procedure simplifies and reduces in price PPT, promotes reliability of estimation of positive effect of rehabilitation for given patient. Also, method for determining FR during PPT is proposed.

Keywords*: psychophysiology testing, functional reserve, rehabilitation, estimation of patient state, biological feedback*

Introduction. With the help of psychophysiology testing (PPT) such psychophysiological important features (PIF) are estimated: aggressiveness, memory, attention (sustainability, distribution, switching, volume, concentration), functional mobility of nervous processes, psychomotor qualities, balance of nervous processes, orientation in space, orientation in closed space, spatial and temporal extrapolation, reserves of vegetative functions, sustainability to impact of stresses; sustainability to monotony of the work, responsibility, predisposition to risk and others. In total there are several hundreds of various PIF and different approaches of PPT for various types of danger works [1], but for today the general methodology of PPT, which would take into account the correspondence between the type of pathology, i.e. rehabilitation diagnose and set and sequence of tests with simultaneous consideration of the functional reserve, is absent.

Aim of study. Aim of the work is the development of the general methodology of PPT for patients under rehabilitation on the basis of estimation of the level of development of PIF, which should determine the set and sequence of psychophysiological (PP) tests, registration of indicators of the speed and correctness of execution of tasks by the surveyed patient, registration of errors made by the patient, calculation of the integral indicator, estimation of conformity of the level of development of PIF to the requirements of rehabilitation process. For that it is necessary to perform such tasks:

1) determine PIF, which are the most relevant for

rehabilitation;

2) select the set of tests, which are the most suitable for estimation of the selected PIFs;

3) find relation between given rehabilitation diagnose and the set and sequence of tests.

4) Development of method for estimation of functional reserve during PPT.

Materials and methods.

1. Correspondence between the type of PIFs and tests. By the results of long-term researches, 16 most important PIF, which are presented in the Table 1, are selected by us. The set of tests, which are the most suitable for estimation of level of development of each

Table 1. List of the most important PIF and corresponding tests

PIF Code	Name of PIF	Test Code	Name of test
1	Attention	1	Table (modified test «Arrangement of numbers»)
		2	Switching of attention (modified test «Finding numbers with switching»)
2	Spatial orientation	3	Clocks
3	Spatial orientation in the closed space	4	Closed space
4	Balance of nervous processes	5	Balance wheel (modified test «Reaction to the moving object
5	Psychomotor qualities	6	Simple visual and motor reaction (SVMR) (variant of test of determination of latent periods of SVMR)
		7	Complex visual and motor reaction (CVMR) (variant of test of determination of latent periods of CVMR with the choice)
6	Memory	8	Memory (Visual memory on the figures)
7	Visual and motor coordination	9	Visual and motor coordination
8	Functional mobility of nervous processes	10	Functional mobility of nervous processes»
9	Spatial and temporal extrapolation	11	Forecasting of movements
10	Resistance to monotony	12	CVMR in terms of continuous presentation of irritants
11	Aggressiveness	13	Portrait samples (modified test Sondi)
12	Stress resistance	14	Individual sense of time
		15	Extreme conditions (modified test «Establishment of regularities» in stress conditions)
		18	Formalized estimations of observation and interview
13	Predisposition to risk	16	Individual strategym
14	Reserves of vegetative functions	17	Variation pulsometry
		18	Formalized estimations of observation and interview
15	Responsibility	18	Formalized estimationsof observation and interview, complex indicator byseparate results of objective tests (determination of latent periods of SVMR, determination of latent periods of CVMR with the choice, Table)
16	Operative thinking	19	Scale of progressive Raven matrices

type of PIF, is also selected and formed.

From 19 proposed tests 6 are new (code 9,11,12,15,16,18), 5 are modified by authors (code 1,2,4,5,13) and 8 are known (code 3,6-8,10,14,17,19). The essence of many of them is shortly disclosed in the patent UA 83618 [2]. According to Ukrainian regulations, 17 kinds of danger works are selected and 19 batteries of tests are determined early for each of them [3].

2. Procedure of testing for rehabilitation. Procedure includes such steps.

1) type of disease needed rehabilitation treatment, i.e. rehabilitation diagnose is selected.

2) PIFs, which are necessary for selected rehabilitation diagnose are determined. For example, for stroke it is needed to estimate PIF No. 5 "Psychomotor qualities", No. 7 "Visual and motor coordination", and No. 8 "Functional mobility of nervous processes".

3) sets and sequence (battery) of tests, which are necessary for estimation of selected PIF are determined. In our case (for PIFs No. 5,7 and 8) tests in such sequence should be conducted according to the Tbl. 1: No. 6, 7. 9, 10.

4) indicators of speed and correctness of execution of tasks by the tested patient and mistakes, made by him (her), are registered.

5) quantitative indicators of the level of development of PIF are calculated and after they recalculated in T-scores. T-scores (mean – 50 units, standard deviation (SD) – 10 units) is one of the well-known scales, which allows standardize heterogeneous parameters in the same units, which are incomparable in own units of measurement [4].

6) integral indicator (general T-score) of the level of development of PIF,

7) generalized conclusion on state of the patient, which reflects effectiveness of rehabilitation, is formulated.

8) Results of PPT are printed out and provided to the medical doctor.

3. Method for estimation of functional reserve. We consider that vegetative reserve is the synonym of functional reserve (FR) or measure of the functional state (FS). FS of the organism is the integral characteristics of health, which displays the level of functional reserve, which can be spent on adaptation [5]. FS is the question of branch of diagnostic medicine called donozological diagnostics. It is the survey of patients under rehabilitation or practically healthy persons with the aim of detection of effectivenes of rehabilitation process, risk factors, latent and unidentified cases of diseases.

Thereby, the detection of FR during PPT is per se the variant of donozological diagnostics. PPT is the provoking factor, which causes stress and psychic load in the person. Of course, determination of FR during PPT should provide physiologically important information, which should be received online, within a few minutes.

In our opinion, the survey of cardiovascular system with the help of portable ECG device meets these requirements. Cardiovascular system occupies the central place in maintenance of homeostasis, registration and analysis of ECG is quite easy to implement. Diagnostic parameters include 3 groups: 1) heart rate variability (HRV), 2) analysis of amplitude-temporal ECG indicators, 3) violations of the heart rhythm. In addition to the analysis of ECG it is expedient to estimate the arterial pressure and frequency of respiratory movements. Concerning the problem of interpretation of the obtained results, we consider establish 4 grades, which correspond to the logic of determination of the level of FS according to theory of donozological diagnostics [6].

- State of health with sufficient functional (adaptive) capabilities of organism;
- Donozological states, in which optimal adaptive capabilities are provided with higher (than in norm) tension of regulatory systems, which leads to the increased consumption of FR of organism;
- Premorbid states, which are characterized by the decreasing functional capabilities of organism and are detected in the form of two stages:

a) with predominance of non-specific changes by preservation of homeostasis of basic vitally important systems of organism, including cardiovascular system,

b) with predominance of specific changes on the part of certain organs and systems, homeostasis of which is violated, but due to compensation mechanisms symptom of disease may be unexpressed or to be in the initial phase and have the compensatory character;

- State of disruption of adaptation (pathology) with the sharp decline of functional capabilities of organism due to violation of compensation mechanisms. As a rule, in this state various diseases are observed at the stage of sub- or decompensation.

Therefore, these gradations reflect decreasing of the FR. Principles of classification of results of the research to each gradation are discussed in detail in [7]. More specific criteria of interpretation of the state of patient during PPT and practical recommendations, depending on rehabilitation diagnose, will be produced in the course of experimental researches.

Results.

1. Determination of FR in the course of PPT. The example of practical use of the above described technology is estimation of FR of candidates for police service. Work of the policeman is associated with significant mental, emotional and physical load, his training requires considerable financial costs and time. PPT is the part of medical examinations and is defined as the complex of measures, aimed at carrying out of professional selection of the policeman by his professionally important PIF.

Correspondence of revealed PIF in the candidate for policeman to these criteria determines «fit» or «unfit for employment» during passing selection. Candidates pass the military and medical commission, in which, except for psychologists and psychiatrists, participate doctors-therapists, surgeons and other specialists are taking part on the base of Central Polyclinic of Ministry of Internal Affairs. However, as the practice shows, exactly indicators, obtained during researches with functional

loads, which partially model complex conditions of further professional activity, give the opportunity to estimate additionally FR of organism and the ability to adaptation. Therefore, it is necessary to supplement the procedure of PPT with technology of estimation of FR and take into consideration vegetative reactions of the human organism in response to the emotional load during PPT.

PPT was conducted at Center of Psychiatric Aid and Professional Psychophysiological Selection of MIA with the help of software and hardware complex «Forecast». Research consisted of estimation of separate PIF, namely: SVMR, power of nervous system (Tepping test), estimation of distribution of attention and speed of its switching (Grunbaum test), reaction to the moving object (RMO), lability of visual analyzer by means of test of critical frequency of light flashing (CFLF), analysis of heart rate in response to information load. For passing each testpoints are accrued, which are formed in the integral indicator in the form of estimation from -1 to +1 in the conclusion.

The candidate is considered unfit under conditions, if the general estimation is 0 and lower, or under conditions, if by one of the tests the point does not exceed the preset threshold value. Depending on the position, for which the candidate claims, batteries of tests were formed, which include 3 or 4 indicated tests. Two groups of candidates were covered by us: to the patrol police and operational subdivisions. Candidates to the patrol police passed SVMR, Tepping-test, Grunbaum test and RMO, candidates to operational subdivisions – CFLF, Tepping-test and heart rate analysis respectively.

Determination of FR was conducted by means of ECG device, created in the Glushkov Institute of Cybernetics. The device allows to estimate the state of vegetative nervous system by analysis of HRV and the state of heart muscle by means of ECG from limbs. The analysis of some aspects of HRV, responsible for the psychoemotional state, was conducted separately. By means of functional scaling the interval scale from 0 to 100 points was created. The closer results to the middle of the interval of population norm – the more points are provided. By means of this scale the state of HRV, myocardium (M) and psychoemotional state (PS) were estimated. In addition, the integral indicator of FS, was calculated (Tabl. 2).

Registration of ECG was conducted three times: 1) in the state of rest before the beginning of testing within 3 minutes, 2) continuously during the whole PPT, and 3) after the end of PPT within 3 minutes at rest. Indicators for the first and the last 3-minute intervals were compared between each other, which allow analyze the work of functional systems at rest and during the period of recovery after the action of the psychoemotional irritant. Total 50 candidates (38 men and 12 women) were surveyed.

By the results of the survey, before the beginning of testing in the general group of surveyed the value of the average integral indicator in the state of rest was 63.92 points. After recovery this indicator increase to 66.62 points. All 3 components are increased, but PS demonstates the greatest degree (from 61.94 to 67.54). SD demonstrates the opposite tendence: decreasing R (from 8.300 to 6.545) and increasing PS (from 11.829 to 15.206).

By the individual data analysis there are clearly distinguished 3 groups (clusters) of the surveyed, in which after PPT physiological indicators: 1) changed less than 10% (32 persons), 2) significantly deteriorated (4 persons), and 3) improved (14 persons) [7].

2. Using PPT to assess the state of patients and their rehabilitation. Today, in the field of rehabilitation, it is important to interpret the results of the diagnosis of the patient's state and formulate a rehabilitation diagnosis in order to justify certain interventions or adjust the individual rehabilitation treatment program [8]. The use of device "Psycholot-1" for the implementation of the diagnostic component of medical rehabilitation allows you to assess violations of psychological and PP homeostasis using quantitative metrics.

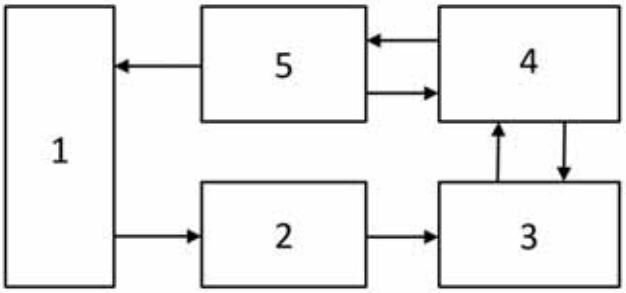

Fig. 1. The scheme of training with use of "Psycholot-1": 1 - the patient; 2 - specialized keyboard; 3 - PC or laptop; 4 - software, 5 – monitor

Table 2. Results of estimation of functional reserve under the PPT

Indicator	Before testing		Recovery after testing	
	Average	SD	Average	SD
Integral	63.920	5.841	66.620	6.108
R (regulation))	75.740	8.300	75.680	6.545
M (myocardium)	54.300	9.197	56.700	9.078
PS (psychophysiological state)	61.940	11.829	67.540	15.206

There is a method of biological feedback (BF), which consists in the use of unconscious processes and control of physiological processes, first by controlling external signals, and then by consciously regulating the internal physiological state. According to the classical model of BF information about the state of the physiological target system, which becomes available to the patient, exacerbates the perception of symptoms of dysfunction and allows the patient to control the work performed, to form a behavioral strategy suitable for eliminating these symptoms. In this context, complex "Psycholot-1" should be used in the training mode. In Fig. 1 shows an idea of the method of PP functional correction of the human state and the diagnosis of changes due to correction using the said device.

The essense of this approach is to visually present PP tests to patient in real time. At the same time, the patient repeatedly performs tests by hand by pressing the appropriate buttons on a specialized keyboard in training mode, analyzes their grades, tries (learns) to reduce the number of errors and increase the speed of tests. This unconsciously improves his PIF, in particular, psychomotor skills, cognitive abilities, reaction speed. Such training with the use of BF stimulates the nervous system and reduces the level and severity of existing disorders.

To objectively diagnose the changes, first, before training, testing is carried out in the exam mode, quantitative indicators of the patient's condition are determined. Then, after training (BF correction), repeat the test and compare the results of the two tests. As a result, it allows quantify the improvement of both the patient's condition as a whole on the basis of the integrated indicator, as changes in the level of 11 of the most important PIF out of 16 listed in Table. 1 (exept of PIFs No. 2,3,9,11,13,16).

Certain disadvantage is the need to work with a laptop, which imposes restrictions on the conditions of BF sessions and makes it difficult or even impossible to combine BF sessions with active (physical) load on the body. But at the same time passive loading in the form of light and sound, thermal, electromagnetic or other stimulation is possible or even expedient. It can also be promising to use therapies that do not require special technical means, and can be implemented only with a laptop. For example, it may be music therapy, which is known to stimulate the nervous processes.

Discussion. Originality of the developed methodology consists in:

1) implementation the set of 19 tests, except for 8 known tests, 5 modified and 6 new tests;

2) selection of the set of tests for the certain pathology;

3) presentation to the surveyed patient of the corresponding set of tests in the specially established sequence for each type of pathology;

4) recalculation of indicators of tests in T-scores (wide range and high fractionality of estimations of the T-scale allow to conductthe detailed differentiation of persons);

5) calculation of the general quantitative indicator of current state of the patient;

6) estimation of the functional reserve based on the ECG and HRV indicators.

Advantages of suggested approach lie in:

1) reduction of time, and therefore, cheapening (reduction of the total number of tests);

2) increase of reliability of its results (application of T-scores and integral indicator);

3) increase of objectiveness of the conclusion (application of computer and device "Psycholot", which provide automation of testing and formulation of conclusion);

4) increase effectiveness of rehabilitation labor safety in the industry (based on increasing reliability and objectiveness of estimation of state of patient based on results of PPT).

For implementation of methodology it is provided the application of the software and hardware complex for PPT «Psycholot», according to UA 83361 [9], in which calculation of indicators, determination of the level of PIF are performed in automatic mode with data visualization on the computer monitor. Modified and novel test methodics are realized in device «Psycholot-1», which is certified and introduced into production by Science and Production Enterprise «Metecol» (Nizhyn, Chernihiv region) [10].

The experience of authors is based on conduction of PPT in the «Expert-Training Center» Ltd during last year, serves as confirmation of the fact that the proposed set of tests and their sequence is the most suitable for revealing of degradation of PIFs.

Conclusions. The developed approach refers to differential psychophysiology and is intended for monitoring of rehabilitation process. The patient is exposed by tests, the number and sequence of which are determined by pathology. Tests are selected from 19 tests, from which 8 are known, 5 are modified and 6 are developed by authors. During PPT the speed and correctness of execution and errors are registered, and integral indicators of the PIF level are calculated. Procedure simplifies, shortens the time and cheapens PPT, increases reliability and objectiveness of conclusion on effectiveness of rehabilitation. Further we consider study of relations between the level of functional reserve and the level of development of PIF on the basis of analysis of obtained estimations during PPT.

Study of PPT tools was conducted on the basis of the software and hardware complex "Psycholot-1". This complex is suitable for assessing and monitoring the current condition of patients undergoing rehabilitation. Method of rehabilitation based on biofeedback and using the specified complex is proposed, in which above device is used in the trainer mode with visual presentation of tests to the patient in real time. To verify decision-making rules, it is necessary to monitor a group of patients undergoing rehabilitation, as well as to determine the effectiveness of rehabilitation with the use of the complex "Psycholot-1".

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РОЗРОБЛЕННЯ МЕТОДИК ПСИХОФІЗІОЛОГІЧНОГО ТЕСТУВАННЯ ТА ЇХ ПЕРСПЕКТИВИ В РЕАБІЛІТАЦІЇ

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Запропоновано загальну методику психофізіологічного тестування (ПФТ) на основі оцінки рівня розвитку психофізіологічно важливих якостей. Визначено набір та послідовність тестів для оцінки стану пацієнта під час реабілітації. Використовується 19 тестів, з яких 8 відомих, 5 модифікованих та 6 нових, розроблених авторами. Оцінку проводять на основі реєстрації швидкості та правильності виконання завдань, обчислення інтегрального показника. Методика спрощує та здешевлює ПФТ, підвищує достовірність та об'єктивність висновку щодо стану пацієнта під час реабілітації, що у підсумку підвищує ефективність реабілітації. Описана технологія визначення функціонального резерву в процесі ПФТ та приклади її використання.

Проведено дослідження засобів ПФТ на основі програмно-апаратного комплексу «Психолот-1». Такий комплекс придатний для оцінки та контролю поточного стану пацієнтів, які проходять реабілітацію. Запропоновано спосіб реабілітації на основі біологічного зворотного зв'язку, в якому цей комплекс застосовується у режимі тренажера із візуальним поданням пацієнтові тестів у реальному часі. Для перевірки вирішувальних правил потрібно провести моніторинг групи пацієнтів, які проходять реабілітацію, а також визначення ефективності реабілітації із застотосуванням комплексу «Психолот-1».

Ключові слова: *психофізіологічне тестування, функціональний резерв, реабілітація, оцінка стану пацієнта, біологічний зворотний зв'язок.*