

підготовки медичних фахівців. Наводяться результати емпіричного дослідження впливу симуляційних та психологічних тренінгів на психокорекцію і профілактику синдрому емоційного вигорання лікарів. Встановлено, що після зазначених тренінгів у лікарів значимо знижуються показники емоційного виснаження, деперсоналізації, поліпшується самопочуття і настрої. Рекомендовано проведення в системі симуляційного навчання різнопланових психологічних тренінгів та інших процедур психологічного супроводу та консалтингу.

**Ключові слова:** засоби медичної симуляції, симуляційний тренінг, психологічний тренінг, синдром емоційного вигорання, психокорекція та профілактика.

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**Ключевые слова:** средства медицинской симуляции, симуляционный тренинг, психологический тренинг, синдром эмоционального выгорания, психокоррекция и профилактика.

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## **BIOELECTRICAL IMPEDANCE DETERMINING BODY COMPOSITION AND HARDWARE-SOFTWARE RECORDING OF HEART RATE VARIABILITY DURING AN OBJECTIVE STRUCTURED CLINICAL EXAMINATION AS A DIAGNOSTIC TOOL**

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Practical issues of studying the role of electromagnetic phenomena of cardiac activity and impedance of body tissues in the diagnosis of the functional state of the human body are presented in the article. The purpose of the publication is to determine the clinical diagnostic potential and the appropriateness of applying the computerized methodology for a short record of heart rate variability and the body impedance measurement technique as an instrumental Objective Structured Clinical Examination. The article presents the results of a survey of functionally healthy people of different levels of fitness.

**Key words:** Non-communicable diseases, Objective Structured Clinical Examination.

*The work is a fragment of the research project "Development of algorithms and technology for introducing a healthy lifestyle in patients with non-communicable diseases based on the study of psycho-emotional status", state registration No. 0116U007798.*

Today, the concept of 4P-Medicine is one of the most promising models for modern Healthcare. Prediction, Prevention, Personalization, Participation - these are four basic principles of examination and treatment of patients according to modern approaches. Requirements for medical diagnostic procedures should increase. First of all, this applies directly to the communication between the doctor and the patient and the implementation of the Objective Structured Clinical Examination (OSCE) of the patient [6, 10, 14].

Therefore, the development of objective methods for diagnosing the functional state of the patient is extremely relevant. The current era of information technology and the computerization of the doctor's workplace has created technical capabilities for introducing fundamentally new computerized techniques for physical examination of patients during the initial examination of the patient and in the dynamics of treatment. The methodology of an OSCE of patients will comply with the principles of 4P-Medicine then to a greater extent [6,10,14]. Therefore, the issues of improving the diagnosis and management of patients with non-communicable diseases (NCDs) through the use of computerized methods of therapeutic examination and fundamentally new approaches to the study of electromagnetic phenomena in patients with NCDs are of interest for the further development of medicine and the practical part of healthcare.

We came to a preliminary conclusion in the course of a search study that it is electromagnetic oscillatory (wave) processes in the vascular system that are a synchronized indicator of the interaction between the central, autonomic nervous systems, humoral regulation and all organs, body tissues. It is necessary to consider cardiac activity as an integral electromagnetic wave cyclical phenomenon now. Thus, cardiac activity has a significantly greater diagnostic value in assessing the functional state of the body, and it is a source of complex parameters of the psychophysical potential, evaluating the prognostic value of the occurrence of adverse cardiovascular events. The method of assessing heart rate variability (HRV)

is considered by us as the most promising method for performing an OSCE in the 4P-Medicine Model. A short record of HRV (2-5 minutes) is an independent technique and it is characterized by non-invasiveness, simplicity and speed of execution. It allows you to assess the state of regulatory mechanisms in patients [3, 11, 12, 13].

A non-invasive method of monitoring the state of metabolism is necessary for working with patients according to the 4P-medicine model. Fat metabolism disorders play a key role in the pathogenesis of the onset and progression of NCDs. We suggest the use of Bioelectrical Impedance method (BIM) measurement with automatic of body composition calculation for this purpose [4,8,9].

Diagnostic equipment for HRV-short recording of and instruments for BIM determining body composition have been developed and certified in many countries of the world and in Ukraine. However, these methods are used very limited or not used at all in the practice of OSCE patients.

**The purpose** of the work was to determine the clinical diagnostic potential and the feasibility of OSCE patients of HRV-short recording of and BIM determining body composition as a tool procedure in functionally healthy individuals.

**Materials and methods.** An open, non-randomized, controlled study was performed at the Educational and practical Center of Biophotonics and Valeology of the Department of Internal Medicine and Emergency Medicine of the Ukrainian Medical Stomatological Academy (UMSA, Poltava, Ukraine). 82 functionally healthy individuals were recruited to participate in the present study. Following anamnesis, healthy individuals were familiarized with the experimental equipment and procedures. The functionally healthy football players of the teams of the main, additional, junior squads were examined during a routine medical examination (January 2020) of the Vorskla Football Club (Poltava, Ukraine) 60 people (median age – 20,5±4,7 years, men - 100%; Study Group 1 - persons engage in systematic sports at a professional level). Anamnesticly functionally healthy non-athletes - 23 post-graduate doctors (median age – 24,8±2,0 years, men - 78%; Study Group 2 - control) were examined for conducting the annual preventive training department strategy “Doctor in the fight against NCDs: start with yourself” (2020-2021). The study was approved by the Ethics Committee of the UMSA. It was carried out in compliance with all applicable ethical rules.

The formula of the methodology included the following methods of multiparameter diagnostics: 1) testing according to an adapted questionnaire with the determination of the psychological type of attitude towards a healthy lifestyle with the identification of predictors of the occurrence of NCDs; 2) BIM determining body composition; 3) HRV-short recording (background recording - 5 minutes and Orthostatic test - 3 minutes).

The formation of the healthy lifestyle components was calculated after testing according to the formula  $N\% = X \cdot 100 / 54$  (where X is the total number of points scored) and it had the following point estimate: 0-27 (0-50%) points - low (object-passive) level (neglect of one's health occurs in the respondent on the background of insufficient awareness of a healthy lifestyle) 28-45 (52-74%) - medium (objectively -active) level (the respondent has a sufficient level of awareness about the healthy lifestyle, but neglects his health) 45-54 (76-100%) - high (subjective) level (sufficient awareness coincides with the implementation of the health-saving activities of the respondent). Testing assessed the presence/absence of bad habits (drinking, smoking), the level of physical activity (morning exercises, regular exercise), proper nutrition [2].

BIM determining body composition was performed on a Body Composition Monitor (model HBF-500-E, Omron Healthcare, Japan) according to the recommended measurement technique. The BIM monitor automatically calculates the following indicators: body weight (kg), Body Mass Index (BMI), Body Fat Percentage (BFP) (5.0-60.0% in 0.1% increments), Visceral Fat Level (VFL) (at 30 levels in increments of 1 level), Skeletal Muscle Percentage (SMP) (5.0-50.0% in 0.1% increments), Resting Metabolism (RM) (385-5000 kcal) [4,9].

HRV was assessed using a complex (model Poly-Spectr, Neurosoft Company, Ivanovo, Russia). Technical requirements and commercial recommendations for the implementation of the research methodology were observed. Blood pressure was measured before and after recording HRV. The analysis of the results of HRV recording was carried out automatically by the hardware-software complex Poly-Spectr. Evaluated automatic conclusion, indicators of Variational Pulsometry and Spectral Analysis (Total power (TP,  $\text{mc}^2$ ); Very low frequency (VLF,  $\text{mc}^2$ ;) - 0,0033-0,04 Гц; Low Frequency power (LF,  $\text{mc}^2$ ) 0,04–0,15 Гц; High Frequency power (HF,  $\text{mc}^2$ ) - 0,15–0,4 Гц; a ratio of Low Frequency to High Frequency (LF/HF ratio) [1,3,5,11].

The study used certified medical equipment that has the appropriate metrological conclusions. The data obtained were analyzed by groups and by personnel. Statistical analysis was performed using the Prism

5.0 software package. The data obtained are presented as average values with their average error ( $M \pm m$ ). Mann-Whitney U-test was evaluated to determine the significance of differences between groups. Differences and correlations were considered significant at  $p < 0.05$ .

**Results of the study and their discussion.** A group analysis of indicators showed that respondents-athletes (group 1) have a higher level of psychological formation for a healthy lifestyle than non-athletes-young doctors (group 2). It was found that 47% of group 1 respondents have a high overall level of psychological type formation, 53% of the respondents have an average; 84% of the respondent of Group 2 have an average level, 4% of the respondent have a high level of formation of a healthy lifestyle. The following distribution of blocks takes place in Group 1: 1 block - 66% high level, 34% average level; 2 block - 57% high level, 40% average level, 3% low level; 3 block- 71% high level, 29% average level. The distribution of levels in Group 2 includes: 1 block - 26% high level, 61% average level, 13% low level; 2 block - 44% high level, 52% average level, 4% low level; 3 block - 87% average level, 13% high level of formation of a Healthy Lifestyle. The data obtained demonstrate greater awareness, awareness and implementation of health-preserving activities among athletes.

Understanding the importance and nature of health-preserving technology is a professional medical competency. The results obtained indicate a low level of these competencies among respondent doctors. The presence of respondents with bad habits, poor nutrition, and ignoring physical education in group 2 confirms this fact. So, 52% of respondents was drink strong alcoholic drinks, 65% of respondents was drink weak alcoholic drinks, 6% of respondents was drink energy drinks, 44% of respondents was smoke, 61% of respondents do not adhere to normotrophic nutrition, 35% of respondents consume more than 6 g of salt per day in group 1. These indicators are lower among respondents in group 2: 19%, 38%, 12%, 9%, 33% and 33%, respectively. Professional athletes accepted the group 1. 61% of the respondents do not exercise and 39% of the respondents never go in for sports in the control group. Significant changes in body composition were found in respondents of group 2. The averaged anthropometric data for the groups are given in Table 1.

Table 1

#### General Characteristics of the body composition

	Group 1 (n=60)	Group 2 (n=23)
Weight (kg)	73.54±9.22	74.48±12.07
Height (cm)	182±6.7	176.6±7.8
BMI	22.76±2.92	23.98±2.48
SMP (norm 42-54 %)	41.54±5.88	37.37±5.72*
BFP (norm 8-19.9%)	15.87±3.74	22.65±7.27*
VFL (norm 1-9 level)	4.27±1.10	6±2.42
RM	1742±67	1671±207

Note \* - the difference is reliable at  $p < 0.05$  between the characteristics Group 1. Group 2.

The obtained personified data made it possible to identify among the functionally healthy respondents such patients who need to correct their lifestyle and improve their health indicators clusters. 3 respondents had latent obesity with an increased BFP in group 1. We revealed obesity by BMI in 8 (33%) people, of which 5 (20%) of the respondents had a mild degree, 3 (13%) had a moderate degree in group 2. At the same time, obesity with an increase in BFP was detected in 11 (48%) of respondents: 4 (17%) of respondents had a high level of BFP, 7 (31%) of respondents had a very high level of BFP; 2 (8%) of respondents were diagnosed with visceral obesity.

The data obtained are a consequence of the presence of metabolic disturbances in these respondents and they are predictors of the occurrence of NCDs in the future in our opinion. A fundamentally important established fact is the presence of muscle mass deficiency in 16 (70%) of respondents in group 2. This confirms the fact of metabolic disturbance due to inactivity and this is another new early predictor of the occurrence of NCDs in the future, as we now believe. This fact is not accidental. As the results of a three-year retrospective analysis show, we recorded muscle deficit in more than half of the surveyed respondents (young doctor) annually, and we found that more than 30% of respondents (young doctor) showed impaired fat metabolism. 69 (54%) interns had impaired fat metabolism; BMI obesity was found in 31%, BFP obesity, was found in 17%, visceral obesity was found in 7% of people. 55 (93%) interns had a muscle deficit without gender differences [2,4].

We also believe that the levels of indicators of the electromagnetic activity of cardiac activity are another cluster that allows you to objectively assess the functional state of respondents and their level of fitness. Indicators of spectral characteristics of the electromagnetic parameters of cardiac activity and variational pulsometry are the most informative for assessing the functional state of respondents. Naturally, HRV is an individual diagnostic method that is sensitive to changes in neuro-humoral regulation and a

chronological change in indicators during the day according to the literature. At the same time, general patterns exist, which are also displayed in the averaged results by groups. Significant differences in the power of spectral characteristics for all indicators of the frequency spectrum were established by us (Table 2).

Table 2

**General indicators of Spectral Characteristics of the Heart Rate Variability**

	group 1 (n=60)		group 2 (n=23)	
	Background recording	Orthostatic test	Background recording	Orthostatic test
TP (mc <sup>2</sup> )	24173±71872	7333±11772	2918±2042*	2614±1955**
VLF (mc <sup>2</sup> )	8442±32908	3269±8946	935.5±858.2*	880.4±818.3**
LF (mc <sup>2</sup> )	7369±29211	2918±3429	1080±808.7*	1413±1218**
HF (mc <sup>2</sup> )	8362±14530	1146±2326	902.4±759.2*	320±251.7**
LF/HF ratio	1.024±1.071	6.656±5.078	1.433±0.925	6.003±5.591

Note \* - the difference is reliable at  $p < 0.0001$  between the indicators Background recording. \*\* the difference is reliable at  $p < 0.0001$  between the indicators Orthostatic test.

So, the spectral activity indices were significantly higher in the main group and they corresponded to the normal range. Apparently, these significant differences are due to a higher level of metabolism of substances and a higher energy status as a result of systematic sports. Spectral indicators were reduced and there was no balance in the control group, which a personalized analysis of the results shows clearly. Low and very low overall activity of regulatory mechanisms occurs in 12 (50%) respondents in the control group and average activity is recorded in 8 (32%) respondents in the control group, while activity is high and above average in 32 (65%) and 17 (29%) of the respondents of the main group, respectively. A low level of regulatory disruption was found in 40 (69%) respondents in the main group, an average level of regulatory disruption occurred in 14 (24%) respondents in the main group versus group 2, where high and medium levels of regulatory disruption occurred in 25% and 50% of respondents, respectively. This indicates the presence of higher functional reserves among the respondents of the main group as a result of physical fitness, proper metabolism and the corresponding general energy status of the body. Therefore, the spectral characteristics and functional state are better in the main group (athletes) than in the control group (not athletes).

Finally, the task to study the clinical effectiveness of the proposed method was successfully achieved. The results obtained are completely consistent with the data available in science regarding the fact that the power of the HRV frequency spectrum reflects the power of regulation [1,5,7,15]. Reliably large values in athletes demonstrate this clearly (Tabl.2). It is known that chronic distress with sympathetic hyperactivation is recorded in patients with NCDs according to HRV [1,5,15]. This was not registered in the control group, but a reduced spectrum power indicates a decreased regulation of systemic recovery mechanisms in the absence of systematic sports. And this refers the respondents of the control group to the risk group for the occurrence of NCDs in the future. This once again confirms the importance of regular sports for the prevention of NCDs. Our results supplemented the data available in science as well, since they proved the presence of significant differences in cardiac activity and metabolism in functionally healthy young people with different physical activities. They showed that promising predictors of the occurrence of NCDs (spectral changes in the activity of the heart, impaired body composition) can occur in functionally healthy people. The state of functional health in a patient in his youth does not guarantee the absence of a hidden pathology of metabolism and regulation of the body, which will be part of his cardiovascular continuum in the future.

The attitude of doctors to their health is of great importance. If the doctor does not adhere to the principles of a Healthy Lifestyle, then he will not be convinced of the promotion of a Healthy Lifestyle among his patients, and he will become ill with NCDs in the future [2]. This confirms the value and relevance of applying our proposed methodology additionally. There are practically no studies of the assessment of the Health Status of doctors in the scientific literature.

## Conclusions

1. A comprehensive study of the functional state of the body and assessment of respondents' lifestyle revealed that athletes have an objectively better functional state of the body, a better psychological type of attitude to a healthy lifestyle, a more correct Healthy Lifestyle than functionally healthy non-athletes.

2. It was found that tested and objective risk factors for the occurrence of NCDs and the formation of the preclinical phase of the disease occur in functionally healthy non-athletes. 3) New promising

predictors of the early occurrence of NCDs have been established: muscle deficiency, the phenomenon of a decrease in the spectral power of cardiac activity. 4) Instrumental impedance measurement and short recording of HRV methods have significant diagnostic potential and can be recommended for widespread use in the practice of OSCE patients. 5) The method of personalized diagnostics developed by us that determines the direction of correction of the way of life can be used to improve medical monitoring of patients, diagnostics, and it meets the main criteria of the 4P-medicine model.

*Prospects of further research lie in the fact that these research results are intermediate. A deeper study of the possibilities of the HRV method in the clinic of internal diseases is planned.*

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## Реферати

### БІОІМПЕДАНСНЕ ВИЗНАЧЕННЯ СКЛАДУ ТІЛА І АПАРАТНО-ПРОГРАМНИЙ ЗАПИС ВАРІАБЕЛЬНОСТІ РИТМУ СЕРЦЯ В СТРУКТУРІ ОБ'ЄКТИВНОГО КЛІНІЧНОГО ОБСТЕЖЕННЯ ЯК ДІАГНОСТИЧНИЙ ІНСТРУМЕНТ

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У статті розглянуті практичні питання дослідження електромагнітних феноменів серцевої діяльності та біоімпедансу тіла задля діагностиці функціонального стану людини. Мета публікація - визначення клінічного діагностичного потенціалу та доцільності застосування комп'ютеризованої методики короткого запису, варіабельності серцевого ритму та методики вимірювання імпедансу як доповнення до об'єктивного клінічного обстеження пацієнтів. У статті представлені результати обстеження функціонально здорових людей різних рівнів фізичної тренуваності.

**Ключові слова:** неінфекційні захворювання, клінічне об'єктивне обстеження.

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### БИОИМПЕДАНСНОЕ ОПРЕДЕЛЕНИЕ СОСТАВА ТЕЛА И АППАРАТНО-ПРОГРАММНАЯ ЗАПИСЬ ВАРИАБЕЛЬНОСТИ РИТМА СЕРДЦА В СТРУКТУРЕ ОБЪЕКТИВНОГО КЛИНИЧЕСКОГО ОБСЛЕДОВАНИЯ КАК ДИАГНОСТИЧЕСКИЙ ИНСТРУМЕНТ

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В статье представлены практические вопросы изучения роли электромагнитных феноменов сердечной деятельности и импеданса тела в диагностике функционального состояния организма человека. Целью публикации является определение клинического диагностического потенциала и целесообразности применения компьютеризированной методики короткой записи вариабельности сердечного ритма и методики измерения импеданса тела в качестве дополнения объективного клинического обследования пациента. В статье представлены результаты обследования функционально здоровых людей разного уровня физической подготовки.

**Ключевые слова:** неинфекционные заболевания, клиническое объективное обследование.

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