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# Analysis of Neurophysiological Parameters in Patients with Acute Psychotic Disorder with Symptoms of Schizophrenia

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**Abstract**

The paper analyzes physiological parameters reflecting the function of motor imagination in patients with acute psychotic disorder with symptoms of schizophrenia and acute psychotic disorder without symptoms of schizophrenia in comparison with a control group of healthy subjects. The study involved 44 patients with acute psychotic disorder with symptoms of schizophrenia, 33 patients with acute psychotic disorder without symptoms of schizophrenia, and 77 healthy subjects. We analyzed vegetative (galvanic skin response, heart rate) and electrophysiological (spectral power of the μ-rhythm and its asymmetry) indicators in the state of calm wakefulness and their change during motor imagination. The found experimental data show common features and differences in physiological reactions during motor imagination in patients with the first psychotic episodes. In patients with acute psychotic disorder with symptoms of schizophrenia, the change in galvanic skin response is excessively expressed and the suppression of the μ rhythm is reduced. In patients with acute psychotic disorder without symptoms of schizophrenia, there were no differences from healthy subjects in autonomic shifts and electrophysiological changes, except for suppression of the μ rhythm in the right frontal region, which exceeded the corresponding changes in both patients with acute psychotic disorder with symptoms of schizophrenia and healthy subjects.

**Keywords:** first psychotic episode, motor imagination, μ-rhythm of electroencephalogram, cutaneous conduction, heart rate.

## INTRODUCTION

Research aimed at differentiated assessment of neurophysiological processes in acute psychotic disorder without symptoms of schizophrenia and acute psychotic disorder with symptoms of schizophrenia are becoming more and more relevant [1]. At the same time, data from neurophysiological studies demonstrate a similar cognitive profile with patients who underwent a psychotic episode [3]. The proportion of works devoted to the neuronal mechanisms of cognitive disorders in acute psychotic disorders without symptoms of schizophrenia and acute psychotic disorders with symptoms of schizophrenia is small, although the search for biological markers within the dimensional approach to the consideration of mental disorders, in which biological correlates are of particular importance, is becoming increasingly important [2.4]. One of the cognitive-perceptual processes is motor imagination, in which the mental performance of a movement is not accompanied by any peripheral activity [5]. A kinetic sensation arises when imagining movement from the first person perspective. This type of task is widely used in neurology and neurorehabilitation for training purposeful movements [6]. The neurophysiological mechanisms of motor imagery can be investigated by analyzing the suppression of the μ rhythm

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of the electroencephalogram. It is believed that the μ-rhythm with an oscillation frequency of 8-13 Hz reflects the work of the sensorimotor cortex. Synchronous mu waves are recorded at rest, and their desynchronization occurs when performing motor activity, observing movement or imagining movement. Studies of the μ-rhythm are most often limited to the analysis of its suppression in the sensorimotor areas (C3, C4, Cz). The study of the activity of neural ensembles of the frontal cortical zones (F3, F4, Fz) is found in only a few works. Neuroimaging methods show that in the process of motor imagination, neural ensembles of the fronto-parietal network are activated [7], which at the same time is very sensitive to cognitive and affective influences. It is also known that any mental activity causes shifts in the autonomic nervous system. In this regard, the study of the autonomic characteristics of motor imagination is relevant. In the physiology of sports, electrodermal and cardiovascular reactions of the body during the imagination of movement are actively studied. Vegetative responses are interesting in that they reflect top-down regulation, which is based on the activation of procedural memory mechanisms. In schizophrenia, motor dysfunctions are often found, often referred to as “mild neurological signs” [8]. The presence of motor disorders in patients along the entire continuum of the disease, as well as their manifestation in the relatives of patients, allows considering these disorders as a potential biological marker [9, 10]. However, in patients with schizophrenic spectrum disorders, motor functions are less impaired and are probably determined by other neuronal mechanisms. Also, in patients with acute psychotic disorder with symptoms of schizophrenia, the autonomic components of emotional response have been well studied [11, 12], but there are no studies of autonomic changes accompanying cognitive activity. Neurophysiological studies of motor imagination in combination with autonomic indicators can help in studying the brain mechanisms for creating an internal representation and self-control of purposeful action, identifying similarities and differences in patients with acute psychotic disorder without symptoms of schizophrenia and acute psychotic disorder with symptoms of schizophrenia and the potential release of biological markers.

The aim of this work is to study physiological parameters reflecting the function of motor imagination in patients with acute psychotic disorder without symptoms of schizophrenia and acute psychotic disorder with symptoms of schizophrenia in comparison with a control group of healthy subjects.

## MATERIALS AND METHODS

This work was carried out as part of a comprehensive study on the basis of the City Clinical Psychiatric Hospital, Tashkent city. The study was approved by the ethics committee. In the present study, two groups of patients with a diagnosis of acute psychotic disorder with symptoms of schizophrenia were examined: (group I, n = 44) and acute psychotic disorder without symptoms of schizophrenia (group II, n = 33). The clinical picture of the group of patients was characterized by hallucinatory-delusional symptoms in the form of verbal hallucinations, delusions of influence and various kinds of automatisms. In some patients, the seizures were of an affective-delusional character, where sensual delusions, delusions of meaning or intermetamorphosis coexisted with pathologically altered affect. All patients received therapy with atypical antipsychotics from the moment of admission to the clinic for 3–20 days before the electroencephalographic examination, which is a limitation of the present study. They had not received antipsychotic therapy prior to admission to the clinic. Diagnostics was carried out in accordance with international psychiatric standards according to the criteria of the International

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Classification of Diseases-10. A control group of subjects (n = 77) was formed, with the research data of which the physiological indicators of the motor imagination of patients in two groups were compared. Socio-demographic characteristics of the studied groups are given in table. 1. A total of 154 people were examined. Socio-demographic parameters were compared using the median $\chi 2$ test. The study included somatically healthy right-handers both in the control group and in the patient group. There were no statistically significant differences in gender, age and educational level between the studied groups ($p> 0.10$). The experimental task included a mental representation of one's own movement. In the instructions, the subject was asked to imagine how he was walking along a well-known road (for 2 minutes). The presentation of the test was accompanied by the subsequent control of the results obtained in the form of a self-report of the subject. The vegetative and electrophysiological parameters were recorded simultaneously in the state of calm wakefulness (background) and in the process of performing the experimental task (test) with eyes closed. During the study, subjects sat in a chair in a darkened room. The galvanic skin response was recorded in the case of skin conduction.

**Table 1. Socio-demographic characteristics of the studied groups**

| **Groups** | **Numberofsubjects** | **Sex** | **Sex (in %)** | **Average age (in years)** | **Age (years)** | **Education (years)** |
|---|---|---|---|---|---|---|
| I group | 44 | 25 men | 56,8% | 27,55±1,36 | 18–54 | 13,23±0,25 |
| | | 19women | 43,2% | | | |
| II group | 33 | 18 men | 54,5% | 27,61±1,34 | 18–54 | 13,45±0,33 |
| | | 15 women | 45,5% | | | |
| Control group | 77 | 43 men | 55,8% | 27,09±0,92 | 17–57 | 13,97±0,24 |
| | | 34 women | 44,2% | | | |

Notes: age - $\chi 2 = 0.239$, df = 2, p = 0.89; education - $\chi 2 = 4.107$, df = 2, p = 0.13; floor - 2 = 0.040, df = 2, p = 0.98.

The electrodes were placed on the palmar side of the index and middle fingers of the left hand. The galvanic skin response was recorded at a constant current of 1.5 mcA. Galvanic skin reactions were calculated as the average value of the modulus of deviation from the baseline, which was taken as the average of the entire record (arbitrary units). The number of heartbeats was recorded using an electrode located on the left forearm. The reference electrode for recording the number of heartbeats was the ground electrode. Vegetative indicators were recorded in 70 people in the control group, 33 people in group I and 26 people in group II. Values of galvanic skin response and the number of heartbeats had a normal distribution for each group of subjects (Kolmogorov-Smirnov test: $p> 0.1$). Intergroup differences in three groups of subjects were

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analyzed using analysis of variance (One-way ANOVA) for the categorical factor "group", which had three levels: control, I and II groups of subjects. The Fisher LSD test was used as a posteriori analysis. An intergroup comparison was made of changes in galvanic skin response parameters and the number of heart contractions in motor imagery compared to the background (the difference in values in the background and in the presentation of movement). An electroencephalogram was recorded from 19 leads located according to the international scheme 10–20%: Fp1, Fp2, F3, F4, F7, F8, C3, C4, T3, T4, T5, T6, P3, P4, O1, O2, Fz, Cz and Pz on a setup consisting of a 19-channel amplifier and a personal computer. The recording is monopolar. Reference electrodes are ear electrodes. An electroencephalogram was recorded for 120 seconds in each functional state. When calculating the spectral parameters, we averaged the analysis data for 10–15 epochs with a duration of 5 seconds. The μ-rhythm of the electroencephalogram was isolated using a special program [13] based on the spatial-frequency filtering of the electroencephalogram and the characteristic response to opening the eyes. The method for isolating the mu rhythm is described in detail in [14]. The suppression of the spectral power of the mu rhythm was analyzed in the frontal leads F3, F4, Fz and in the projections of the sensorimotor cortex - C3, C4, and Cz. The index of suppression of μ-rhythm was calculated as the difference in spectral power in the presentation of movement and at rest in the corresponding cortical zones. The natural logarithm of the spectral power was used to normalize the data. Intergroup differences in changes in the spectral power of the μ-rhythm during motor imagery were determined using ANOVA: main repeated effects with the categorical factor “group”. For lateral electrodes (F3, F4, C3, C4), the factors “area” (frontal and central) and “hemisphere” (left and right) were included. For centerline electrodes (Fz, Cz) - only the “area” factor. A posteriori analysis was carried out using the Fisher LSD test in the presence of significant intergroup differences ($p < 0.05$) or tendencies ($p < 0.1$).Correlation analysis was used to investigate the conjugation of changes in vegetative and electrophysiological (suppression of the spectral power of the μ rhythm) characteristics in three groups of subjects. Statistical processing of the obtained indicators was carried out using the STATISTICA 6.0 software package.

## RESULTS

Comparative analysis of vegetative indicators in the background and during the task. In all groups of subjects, the values of vegetative characteristics increased during imagination of movement compared to the background. An analysis of variance ANOVA revealed intergroup differences in changes in galvanic skin responses during the test compared with the background at the tendency level ($F(2.126) = 2.42$, $p = 0.09$). A posteriori analysis showed that these characteristics were higher in group I of subjects compared with the control group ($p < 0.05$). There were no intergroup differences in the rate of change in the number of heart contractions in motor imagination compared to the background: $F(2.126) = 0.55$, $p = 0.58$. Thus, the change in galvanic skin reactions was most pronounced in patients of group I, while the change in the number of heart contractions between the groups did not differ. Suppression of μ-rhythm when presenting own motion. All subjects showed desynchronization of the μ-rhythm when performing a task on motor imagination. Intergroup differences in suppression of the μ-rhythm were found for the lateral areas, the "group" effect is significant: $F(2.151) = 4.24$, $p = 0.016$. Suppression of μ-rhythm in the control group is greater than in group I of subjects in leads F3 ($p < 0.05$), F4 ($p < 0.01$), C3 ($p < 0.05$) and C4 ($p < 0.05$), but less than in group II in F4 at the tendency level ($p < 0.06$). There were also differences in this indicator in groups I and II. Suppression of μ-rhythm

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was more pronounced in group II than in group I in the right frontal area F4 ($p < 0.001$), and in the left central area (C3) it differed at the level of tendency ($p < 0.07$). The index of suppression of μ-rhythm for electrodes along the midline (Fz, Cz) did not have intergroup differences: $F (2.125) = 2.62$, $p = 0.201$. Consequently, the suppression of the μ rhythm is more pronounced in the control group than in patients of group I. In patients of group II in the right frontal region, the suppression of the μ-rhythm is greater than in the other two groups of subjects.

The conjugation of autonomic and electrophysiological parameters with motor imagination took place only in the control and II groups of subjects. In the control group, the change in galvanic skin reactions was associated with a change in the power of the μ-rhythm in the right frontal area F4 ($r = -0.31$, $p < 0.05$). In group II of subjects, the change in the number of heart contractions was associated with a change in the power of the μ-rhythm in the right central region of C4 ($r = -0.39$, $p < 0.05$). In subjects of groups I and II, no significant correlation coefficients of autonomic characteristics were revealed, while electrophysiological indicators of motor imagination were associated with the sum of positive and negative symptoms. In group II, on the contrary, there were correlations between the suppression of the μ rhythm and the sum of positive symptoms: the correlation coefficients with the sum of positive symptoms were significant for the suppression of the mu rhythm in the frontal (F4, $r = 0.39$, $p < 0.05$) and central (C4, $r = 0.39$, $p < 0.05$) leads of the right hemisphere. The conjugation of changes in autonomic and neurophysiological characteristics during the imagination of movement was found only in healthy subjects.

## DISCUSSION

In the present complex study, the autonomic and neurophysiological characteristics of motor imagination in healthy subjects and patients have been analyzed. Our data have shown that the presentation of self-movement is accompanied by reactions of the autonomic and central nervous system, manifested in an increase in cutaneous conduction and heart rate and suppression of the μ-rhythm of the electroencephalogram during motor imagination as compared with the state of calm wakefulness. These reactions are characteristic of both healthy subjects and patients with acute polymorphic psychotic disorder with symptoms of schizophrenia and acute polymorphic psychotic disorder without symptoms of schizophrenia. However, the severity of such reactions in the subjects of the three groups is different. Vegetative shifts in motor imagination have been well studied in a cohort of healthy subjects [15]. Significant reactions are shown, manifested in a decrease in skin resistance (in our case, an increase in skin conduction) and an increase in the number of heart contractions. These characteristics did not differ in healthy subjects and patients in group II. However, patients of group I had an excessive change in galvanic skin reactions. This may indicate a reduced ability for motor imagination, since the mental "effort" required to solve a cognitive task is also associated with tonic sympathetic innervation [16]. A similar sensitivity of the autonomic nervous system with a simultaneous decrease in the activation of the medial prefrontal cortex in patients of group I occurs during the processing of emotional-affective information (fear, threat), studied using a combination of magnetic resonance imaging methods and recording galvanic skin reactions. We have shown that a decrease in the power of the mu rhythm in the frontal and central cortical zones during motor imagery is observed in all patients, but the severity of this reaction is noticeably lower than in the norm, only in patients of group I. A decreased index of mu rhythm suppression in the parietal cortex may be associated with a decrease in motor control during motor imagination and attention to the cognitive task being performed [17]. In patients of group II, on the contrary, there were no differences from the norm in the suppression of the mu rhythm in all the studied cortical zones, excluding the right frontal region, in which there was an increased activation during imagination of movement. Perhaps this is due to the presence of a stress component in such patients. Some authors note that increased activation of the right frontal region is associated with certain affective symptoms, in particular with anxiety. A certain interaction of neurophysiological and peripheral manifestations is observed in any cognitive activity, including motor imagination [18, 19]. In our work, it was shown that during imagination of movement in healthy subjects, oscillatory activation is associated with the reactivity of tonic galvanic skin reactions, in patients of group II - with reactivity of the number of heart contractions, and in patients of group I there are no correlations between central and peripheral responses of the body. However, for an adequate interpretation, the obtained facts require further research. Until now, the neuronal mechanisms of the imagination of movement in the primary psychotic episode have been studied very little and the results obtained are contradictory. In scientific works, in patients with the first psychotic episode, a reduced suppression of the μ rhythm was found in comparison with healthy subjects [20]. In chronic patients in remission, no differences in this indicator from healthy subjects were found. However, L.M. McCormick and co-authors, when studying the suppression of the μ-rhythm in chronic patients in an acute psychotic state, found an increased reactivity of this indicator in comparison with healthy subjects when observing the movement of the experimenter's hand [21]. It can be assumed that the reactivity of the μ rhythm in patients of both groups is associated with the clinical picture and stage of the disease. We are the first to obtain data on the relationship between the reactivity of the μ rhythm and positive symptoms. The discovered experimental facts may indicate differences in the physiological reactions of the body during motor imagination in patients with the first psychotic episodes. Motor imagination, which includes the functions of attention and memory, requires an optimal balance of reactions of the central and peripheral nervous systems.

## CONCLUSION

1. With motor imagination in patients with acute polymorphic psychotic disorder with symptoms of schizophrenia, there is a mismatch of autonomic and neurophysiological reactions. Decreased in comparison with healthy subjects, indicators of μ-rhythm reactivity of the electroencephalogram are accompanied by excessive peripheral activation in terms of cutaneous conduction, which may indicate the difficulty of performing this type of cognitive activity.

2. In patients with acute polymorphic psychotic disorder without symptoms of schizophrenia, there are fewer differences from healthy subjects in the neurophysiological and autonomic reactions of the body when imagining their own movement. However, the increased activation of the right frontal region when performing the task compared to other groups of subjects may be associated with affective manifestations in the clinical picture.

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## CONFLICT OF INTEREST

The authors declare that they have no competing interests.

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