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Sequential transcranial electrical stimulation in patients with dyscirculatory encephalopathy associated with post-COVID syndrome

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ABSTRACT

BACKGROUND: The primary hypothesis for the use of sequential transcranial electrical stimulation therapy in the rehabilitation of patients with dyscirculatory encephalopathy associated with post-COVID syndrome is the potential synergistic effect on the central nervous system. Specifically, the method combines brain micropolarization — involving neocortex neurons and diencephalic brain stimulation — affecting limbic system structures. This synergy is expected to improve connections between cortical and subcortical structures, as well as neurohumoral regulation.

AIM: To study the effectiveness of complex medical rehabilitation involving sequential transcranial electrical stimulation therapy in patients with dyscirculatory encephalopathy associated with post-COVID syndrome.

MATERIALS AND METHODS: An open, prospective, randomized comparative study included 142 patients with dyscirculatory encephalopathy: 79 female (55.6%) and 63 male (44.4%) patients, aged 59 (45–69] years. The average disease duration was 8.4 years, with a period after coronavirus infection of 3.6 months. After randomization, patients in Group 1 (comparison group 1, *n*=48) received brain micropolarization; Group 2 (comparison group 2, *n*=46) received diencephalic brain stimulation; and Group 3 (main group, *n*=48) received both therapies sequentially. Treatment outcomes were evaluated based on changes in clinical symptoms over time and a battery of neuropsychological tests.

RESULTS: In Group 3, which received sequential transcranial electrical stimulation therapy, all symptoms of dyscirculatory encephalopathy showed a significant improvement (1.2–1.6 times) compared to baseline (p <0.05–0.001). For brain micropolarization alone (Group 1), there was an average reduction in the severity of symptoms such as cranialgia, memory and attention deficits, irritability, and sleep disturbances by 1.2–1.4 times. In Group 2, diencephalic brain stimulation resulted in an improvement in tinnitus, fatigue, work productivity, and dizziness by 1.3–1.4 times. In the main group, there was an overall alleviation of all psychophysiological issues (1.1–2.0 times; p <0.05–0.01); in comparison groups 1 and 2, improvement was 1.1–1.5 times and 1.2–1.8 times, respectively.

CONCLUSION: Medical rehabilitation using a combined approach (sequential application of brain micropolarization and diencephalic brain stimulation) alongside pharmacological support in patients with dyscirculatory encephalopathy associated with post-COVID syndrome is shown to be the most effective due to the pronounced neurotropic effect of the physical factors involved, allowing for the correction of a whole range of neurological, neuropsychological, and motor disorders.

Keywords: dyscirculatory encephalopathy; post-COVID syndrome; transcranial electrical stimulation; medical rehabilitation.

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Последовательная трансцеребральная электротерапия у больных дисциркуляторной энцефалопатией, ассоциированной с постковидным синдромом

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АННОТАЦИЯ

Обоснование. Основной гипотезой использования последовательной трансцеребральной электротерапии в восстановительном лечении дисциркуляторной энцефалопатии, ассоциированной с постковидным синдромом, является предположение о возможном синергическом действии на центральную нервную систему, а именно микрополяризации головного мозга — на нейроны неокортекса и диэнцефальной стимуляции головного мозга — на структуры лимбической системы, что, по-видимому, способствует полноценной коррекции корково-подкорковых связей и нейрогуморальной регуляции.

Цель исследования — оценить эффективность комплексной медицинской реабилитации с использованием последовательной трансцеребральной электротерапии у больных дисциркуляторной энцефалопатией, ассоциированной с постковидным синдромом.

Материалы и методы. В открытое проспективное рандомизированное сравнительное исследование включены 142 пациента с дисциркуляторной энцефалопатией, из них 79 (55,6%) женщин и 63 (44,4%) мужчины в возрасте 59 (45–69) лет. Средняя продолжительность заболевания составила 8,4 года, период после перенесённой коронавирусной инфекции — 3,6 месяца. После рандомизации пациенты группы 1 (сравнения 1, *n*=48) получали микрополяризацию головного мозга; в группе 2 (сравнения 2, *n*=46) — диэнцефальную стимуляцию головного мозга; в группе 3 (основная, *n*=48) — последовательное применение микрополяризации головного мозга и диэнцефальной стимуляции головного мозга. Результаты лечения оценивали по динамике клинических симптомов заболевания и блока нейропсихологических тестов.

Результаты. У пациентов группы 3, получавших последовательную трансцеребральную электротерапию, отмечена позитивная (в 1,2–1,6 раза) достоверная (p <0,05–0,001) динамика всех изученных симптомов дисциркуляторной энцефалопатии в сравнении с исходными значениями. При назначении микрополяризации головного мозга (группа 1) степень выраженности краниалгии, памяти и внимания, раздражительности и нарушения сна снизилась в среднем в 1,2–1,4 раза, а при использовании диэнцефальной стимуляции головного мозга (группа 2) уровень проявлений тиннитуса, утомляемости, работоспособности и головокружений уменьшился в 1,3–1,4 раза. В основной группе зарегистрировано нивелирование всех психофизиологических проблем в 1,1–2,0 раза (p <0,05–0,01), в группе сравнения 1 — в 1,1–1,5 раза, в группе сравнения 2 — в 1,2–1,8 раза.

Заключение. Медицинская реабилитация с использованием комбинированной технологии (последовательное применение микрополяризации головного мозга и диэнцефальной стимуляции головного мозга) на фоне медикаментозной поддержки у пациентов с дисциркуляторной энцефалопатией, ассоциированной с постковидным синдромом, является наиболее эффективной за счёт выраженного нейротропного действия физических факторов, обеспечивающего коррекцию целого комплекса неврологических, нейропсихологических и двигательных расстройств.

Ключевые слова: дисциркуляторная энцефалопатия; постковидный синдром; трансцеребральная электротерапия; медицинская реабилитация.

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循环障碍性脑病伴有新冠后综合征患者的序贯经脑电疗

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摘要

论证。在循环障碍性脑病伴有新冠后综合征的恢复性治疗中，使用序贯经脑电疗的主要假设，是其可能对中枢神经系统产生协同作用，即大脑微极化 — 新皮质神经元和间脑刺激 — 边缘系统结构，显然，有助于全面纠正皮质-皮质下连接和神经体液的调节。

研究目的 — 评估使用序贯经脑电疗对循环障碍性脑病伴有新冠后综合征患者进行综合医疗康复的疗效。

材料和方法。在这项开放前瞻性随机对比研究中，共纳入了142例循环障碍性脑病患者，其中女性79人（55.6%），男性63人（44.4%），年龄为59（45~69）岁。平均病程为8.4年，感染冠状病毒后的病程为3.6个月。随机分组后，第1组（对比1，n=48）的患者接受了大脑微极化；第2组（对比2，n=46）的患者接受了间脑刺激；第 3 组（主要组，n=48）的患者接受了大脑微极化和间脑刺激的序贯治疗。通过疾病临床症状的动态变化和成套神经心理测试来评估治疗结果。

结果。与初始值相比，接受序贯经脑电疗的第3组患者中，所有研究的循环障碍性脑病症状的动态变化均呈积极（1.2~1.6倍）和可靠（$p<0.05$~0.001）。使用大脑微极化时（第 1 组），头痛、记忆力、注意力、易怒性和睡眠障碍的程度平均降低了1.2~1.4倍，使用间脑刺激时（第2组），耳鸣表现、易疲劳性、工作能力和眩晕的程度降低了1.3~1.4倍。主要组的所有心理生理问题平均化（1.1~2.0倍；$p<0.05$~0.01）；对比组1为1.1~1.5 倍，对比组2为1.2~1.8倍。

结论。在药物支持的背景下，利用物理因素对神经有明显的促进作用，可确保总体纠正神经、神经心理和运动的障碍。对循环障碍性脑病伴有新冠后综合征的患者，采用组合技术（连续使用脑微极化和脑脊液脑刺激）进行医疗康复是最有效的。

关键词：循环障碍性脑病；新冠后综合征；经脑电疗；医疗康复。

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BACKGROUND

Chronic cerebrovascular insufficiency (discirculatory encephalopathy) is characterized by slowly progressive morphofunctional brain impairments and presents clinically with a pattern of neurological and neuropsychological disorders. The leading etiopathogenetic factors include microangiopathy, endothelial dysfunction, altered cerebral metabolism, and blood rheology, typically arising in the context of comorbid conditions [1–3]. Post-COVID syndrome is known to exacerbate anxiety, depression, and cognitive impairments [4–6], significantly worsening the clinical course of discirculatory encephalopathy by 1.3–2.2 times [7].

Therefore, medical rehabilitation for discirculatory encephalopathy associated with post-COVID syndrome should be comprehensive, integrating measures in accordance with clinical guidelines on cognitive impairment [8], rehabilitation for post-COVID syndrome [9], and the introduction of effective neurotropic medical technologies [10–12], such as transcranial electrical stimulation therapy. This approach may help prevent disease progression and address cognitive, emotional, and locomotor dysfunctions.

Despite the wide use of transcranial stimulation technologies in rehabilitation for discirculatory encephalopathy [13–16], their differentiated therapeutic effects and the potential for combined or simultaneous use remain unclear. The primary hypothesis underlying the use of sequential transcranial electrical stimulation therapy was the potential for a synergistic effect on the central nervous system: on one hand, through the predominant influence of transcranial micropolarization (TCMP) on neocortical neurons, and on the other, through diencephalic brain stimulation (DBS) targeting structures of the limbic system, which may contribute to the restoration of cortico-subcortical connectivity and neurohumoral regulation.

This study aimed to assess the effectiveness of complex medical rehabilitation involving sequential transcranial electrical stimulation therapy in patients with dyscirculatory encephalopathy associated with post-COVID syndrome.

METHODS

Study Design

It was an open-label, prospective, randomized comparative study in a day hospital setting in accordance with ethical standards (Helsinki Declaration, Fortaleza, Brazil, 2013).

Eligibility Criteria

Inclusion criteria: Patients diagnosed with stage I–II discirculatory encephalopathy associated with post-COVID syndrome, scoring 3 points on the rehabilitation routing scale, 3–4 months after COVID-19 infection; signed informed consent for participation and data processing.

Exclusion criteria: General contraindications to physiotherapy; history of inflammatory brain diseases, trauma, or tumors; psychiatric disorders; epilepsy; seizure syndrome; inflammatory eye diseases; grade III hypertension; ischemic heart disease with complex arrhythmias; pacemaker; individual intolerance to the prescribed medications or electrical stimulation.

Withdrawal criteria: Adverse reactions during the study; protocol violations; patient withdrawal of consent.

Study Setting

The study was conducted at the clinical base of the Department of Physical and Rehabilitation Medicine, Federal State Budgetary Educational Institution of Higher Education, Ural State Medical University, Ministry of Health of the Russian Federation, in the day hospital of Nizhnyaya Tura Central City Hospital.

Study Duration

The study was carried out from 2022 to 2023, with a follow-up period of 14 days per patient. Assessment and treatment were conducted before and after the rehabilitation course.

Intervention

The study enrolled 142 patients with discirculatory encephalopathy associated with post-COVID syndrome. Participants were randomized into three groups.

All patients received therapy consisting of a gentle training regimen and standard diet, daily group therapeutic breathing exercises (30 minutes), moderate-intensity walking (1500–2500 m), and general magnetic therapy (Kolibri-Expert device, Russia; Marketing Authorization No. FSR 2011/11030 (ФСР 2011/11030), issued on June 21, 2011) using a traveling pulsed magnetic field with 3.5 mT induction for 20 minutes daily over 10 sessions.

Pharmacologic therapy included the angioprotector pentoxifylline (200 mg three times daily); a cerebral circulation modulator, dry extract of Ginkgo biloba leaves (40 mg three times daily); the anticoagulant Xarelto (2.5 mg twice daily); and the metabolic agent Cytoflavin (2 tablets twice daily).

All three groups underwent sequential transcranial electrical stimulation therapy using the Magnon-2 device (Russia; Marketing Authorization No. RZN 2020/12308 (РЗН 2020/12308)), with variation in electrical pulse modalities:

Group 1 (reference group 1), which included 48 participants, received TCMP using the Magnon-2 device. The anode of the electrode-mask was placed on the forehead at the hairline, and the cathode was positioned in the retromastoid area. After selecting the channels using the current control buttons, a galvanic current of 0.3–0.5 mA was applied.

Group 2 (reference group 2), which included 46 participants, received DBS using the Magnon-2 device. The electrode mask was fixed to the skin of the eyelids and retromastoid area using a cross-polar configuration (two device channels) to produce signal interference. A bipolar current was applied with an initial pulse duration of 0.2 ms: during

the first five sessions, the stimulation frequencies were set at 1000 Hz in channel 1 and 990 Hz in channel 2 (interference frequency of 10 Hz). For the subsequent five sessions, the pulse duration was increased to 0.3–0.4 ms, with frequencies adjusted to 200 Hz in channel 1 and 190 Hz in channel 2 (interference frequency of 10 Hz). The current amplitude was increased until patients reported a mild vibration of moderate intensity beneath the electrodes and a more pronounced vibration of moderate strength within the head.

Group 3 (main group), consisting of 48 participants, received electroencephalic therapy using the Magnon-2 device in a sequential manner: first, TCMP was applied for 10–20 minutes, immediately followed by DBS for an additional 10–20 minutes, using the electrical parameters described above.

Sessions were administered daily, lasting 20–40 minutes (increased by 5 minutes each session), for a total of 10 sessions.

Outcomes Registration

Dynamic monitoring included clinical symptoms of discirculatory encephalopathy using a visual analog scale (VAS) from 0 (none) to 10 (maximal severity).

Neuropsychological testing was conducted to assess mental status using validated, high-sensitivity instruments: the Mini-Mental State Examination (MMSE), the Frontal Assessment Battery (FAB), the Clock Drawing and Number Search Tests (Schulte Tables, 1964), the 10 Words test by A.R. Luria (1962), the Hospital Anxiety and Depression Scale (HADS; S. Zigmond, R.P. Snaith, 1983), and the Spielberger State-Trait Anxiety Inventory (STAI, 1976).

Ethics Approval

The study was approved by the local Ethics Committee of the State Budgetary Healthcare Institution Nizhnyaya Tura Central City Hospital (protocol No. 2, dated February 7, 2022).

Statistical Analysis

Data were analyzed using SPSS 13.0 (Mathematica 5.1). Group equivalence was confirmed using the non-parametric Mann–Whitney U test. Quantitative data were compared using the Wilcoxon signed-rank test for paired samples, with a 95% confidence interval (95% CI). Results were considered statistically significant at $p < 0.05$.

RESULTS

Participants

The study involved 142 patients diagnosed with discirculatory encephalopathy associated with post-COVID syndrome who met the inclusion criteria. Among them, 79 were women (55.6%) and 63 were men (44.4%), with a median age of 59 years [95% CI, 45–69]. Disease duration averaged 8.4 years [95% CI, 3–10], and the post-COVID period was 3.6 months [95% CI, 3–4].

At baseline, participants reported the following symptoms: headache (127, 89.4%), tinnitus (122, 85.9%), impaired memory and attention (138, 97.2%), fatigue (95, 66.9%), reduced work capacity (95, 66.9%), irritability/emotional lability (80, 56.3%), depressive mood (56, 39.4%), nonspecific dizziness/unsteadiness (69, 48.6%), and sleep disturbances (127, 89.4%).

Neurological examination revealed focal symptoms such as pupillary light reflex attenuation (131, 92.3%), pathological reflexes (98, 69.0%), coordination disorders such as gait instability and reduced postural stability (99, 69.7%), nystagmus (70, 49.3%), flattened nasolabial folds (79, 55.6%), tongue deviation (63, 44.4%), and facial hypoesthesia/paresthesia (64, 45.0%).

Primary Results

The majority of patients (139/142, 97.9%) tolerated therapy well.

Significant intergroup differences were observed post-treatment (Table 1). In Group 3 (main group), which received combined transcranial electrical stimulation therapy using both methods sequentially (TCMP and DBS), a statistically significant improvement ($p < 0.05$) in all assessed symptoms of discirculatory encephalopathy was observed compared to baseline, with an increase of 1.2–1.6 times. In Group 1, which received only TCMP, there was a 1.2–1.4-fold reduction ($p < 0.05$) in the severity of cranialgia, memory and attention deficits, irritability, and sleep disturbances. In Group 2, which received DBS as monotherapy, a 1.3–1.4-fold decrease ($p < 0.05$) was observed in tinnitus, fatigue, reduced work capacity, and dizziness. All three groups reported decreased depressive symptoms (1.4–1.6 times; $p < 0.05$).

A comparative analysis of neuropsychological test scores in patients with discirculatory encephalopathy following COVID-19 revealed a similar pattern across the assessed parameters (Table 2). Group 3 demonstrated a reduction in all psychophysiological disturbances (by 1.1–2.0 times; $p < 0.05$); in Group 1, improvements were observed in the total MMSE score (by 1.1 times; $p < 0.05$), FAB score (by 1.1 times; $p < 0.05$), Schulte table performance (by 1.1 times; $p < 0.05$), and the 10 Words test (by 1.4 and 1.5 times for immediate and delayed recall, respectively; $p < 0.05$). In Group 2, a reduction in mental instability was noted based on Schulte tables (by 1.8 times; $p < 0.05$), anxiety and depression scores on the HADS (by 1.7 and 1.5 times, respectively; $p < 0.05$), and reactive and trait anxiety scores in the STAI (by 1.4 and 1.2 times, respectively; $p < 0.05$). Clock drawing scores improved significantly in all groups (1.3–1.5 times; $p < 0.05$).

Adverse Events

During the first DBS session, two patients in Group 2 and one in Group 3 reported discomfort (pressure around the eyes) and subsequently withdrew from the study. These cases were excluded from the statistical analysis.

Table 1. Clinical symptom dynamics with patients suffering from dyscirculatory encephalopathy after COVID-19

Clinical symptoms	T1/T2	Group		
		1 (*n*=48)	2 (*n*=46)	3 (*n*=48)
Cranialgia	*n*	43	41	46
	1	6.2 [3.7; 7.6]	5.9 [4.7; 7.3]	6.0 [3.5; 7.4]
	2	4.8 [3.1; 6.6]*	4.3 [3.3; 5.8]	3.8 [2.0; 5.4]*
Tinnitus	*n*	41	40	40
	1	4.9 [3.4; 6.3]	4.9 [3.1; 6.8]	5.2 [3.1; 7.2]
	2	4.0 [2.8; 5.6]	3.8 [2.6; 5.1]*	3.5 [2.6; 4.9]*
Cognitive impairments (memory, attention)	*n*	46	44	45
	1	5.1 [3.8; 6.4]	5.3 [4.0; 6.5]	5.4 [3.9; 6.8]
	2	4.4 [2.8; 5.9]*	4.0 [2.6; 5.9]	3.6 [2.3; 5.0]*
Reduced work capacity, fatigue	*n*	32	30	33
	1	6.8 [5.4; 8.1]	7.1 [5.6; 8.7]	7.0 [5.6; 8.4]
	2	6.2 [5.1; 7.3]	5.3 [4.2; 6.5]*	4.4 [3.8; 5.1]*, #
Irritability	*n*	28	25	27
	1	4.7 [3.0; 6.4]	4.5 [3.2; 5.9]	3.9 [3.3; 7.1]
	2	3.6 [2.5; 4.7]*	4.3 [2.9; 5.7]	3.3 [2.5; 5.7]*
Depressed mood	*n*	19	16	21
	1	4.8 [2.4; 7.1]	5.0 [2.6; 7.4]	5.2 [2.4; 7.1]
	2	3.5 [2.1; 5.0]*	3.6 [2.0; 5.3]*	3.2 [2.3; 4.1]*
Dizziness	*n*	25	22	22
	1	6.7 [5.3; 8.1]	6.5 [5.1; 7.9]	6.7 [5.6; 7.8]
	2	6.2 [4.8; 7.6]	5.1 [3.9; 6.4]*	4.3 [3.6; 5.1]*, #
Dissomnia	*n*	43	42	42
	1	5.2 [3.5; 6.9]	5.2 [3.3; 7.1]	5.0 [3.4; 6.7]
	2	4.1 [2.8; 5.4]*	4.7 [2.9; 6.4]	3.6 [2.3; 4.8]*

Note. * Significant differences in the pre-treatment and post-treatment group, p <0,05. T1/T2 — pre-/post-treatment.

DISCUSSION

Transcranial electrical stimulation therapy is a group of physiotherapeutic techniques aimed at restoring the functional state of the central nervous system [16, 17]. The therapeutic effects of this type of physiotherapy were identified by V.M. Bogolyubov and Z.S. Khostikoeva [18], who demonstrated that transcranial application of therapeutic physical factors induces generalized response patterns, subsequently activating the body's bioregulatory systems, particularly neurohumoral mechanisms.

The comparative analysis revealed significant differences in therapeutic outcomes among the three approaches to transcranial electrical stimulation therapy in patients with discirculatory encephalopathy associated with post-COVID syndrome. TCMP was most effective in reducing symptoms related to psychosomatic status (headache, impaired memory and attention, irritability, and sleep disturbances) and improving motor and cognitive functions (as assessed by MMSE, FAB, and the 10 Words test). This suggests TCMP may primarily facilitate the restoration of white matter connections between cortical/frontal and subcortical regions. In contrast, DBS proved more effective in addressing psychoneurotic symptoms, such as tinnitus, fatigue, reduced work capacity, and dizziness. These effects were reflected in improvements in HADS (anxiety and depression) and STAI (state and trait anxiety) scores. The deep stimulation produced by the interference of electrical currents in the diencephalic region—including the thalamus, hypothalamus, epithalamus, and subthalamus—appears to reduce the emotional and neurotic burden associated with somatic disorders. It is noteworthy that the combination of these

Table 2. Dynamics of neuropsychological test results with the patients suffering from dyscirculatory encephalopathy after COVID-19

Measure, Total Score		T1/T2	Group		
			1 (*n*=48)	2 (*n*=46)	3 (*n*=48)
MMSE		1	25 [23; 28]	26 [23; 29]	26 [24; 28]
		2	27 [25; 29]*	26 [24; 29]	28 [28; 29]*
FAB		1	15 [13; 17]	14 [12; 18]	14 [12; 16]
		2	16 [14; 18]*	14 [12; 18]	15 [14; 17]*
Schulte tables	Task efficiency	1	2 [1; 2]	2 [1; 2]	2 [1; 2]
		2	2 [1; 3]*	3 [1; 3]	3 [2; 3]*
	Mental stability	1	1.2 [0.8; 1.5]	1.3 [0.9; 1.4]	1.4 [0.9; 1.6]
		2	0.9 [0.6; 1.3]	0.7 [0.5; 1.0]*	0.7 [0.4; 1.1]*
10 Words test	Immediate recall	1	5 [5; 7]	5 [5; 7]	6 [5; 7]
		2	7 [6; 8]*	6 [5; 8]	7 [6; 8]*
	Delayed recall	1	4 [3; 6]	4 [3; 6]	5 [3; 7]
		2	6 [6; 7]*	4 [3; 7]	6 [6; 7]*
lock Drawing test		1	6 [5; 7]	6 [6; 7]	6 [5; 7]
		2	8 [7; 9]*	9 [7; 10]*	8 [7; 9]*
HADS	Anxiety	1	11 [8; 14]	12 [9; 13]	13 [10; 15]
		2	10 [8; 12]	7 [5; 9]*	8 [6; 10]*
	Depression	1	9 [6; 11]	9 [6; 12]	9 [6; 12]
		2	7 [4; 9]	6 [3; 8]*	6 [4; 8]*
Spielberger–State-Trait Anxiety Inventory (STAI)	Reactive anxiety	1	54 [46; 58]	52 [55; 60]	57 [50; 64]
		2	48 [44; 52]	36 [27; 46]*	40 [31; 48]*
	Trait anxiety	1	45 [29; 58]	41 [26; 59]	43 [28; 56]
		2	40 [30; 48]	33 [25; 44]*	32 [23; 42]*

Note. * Significant differences in the pre-treatment and post-treatment group. p <0.05. T1/T2 — pre-/post-treatment.

therapeutic modalities in the form of sequential transcranial electrical stimulation therapy (TCMP and DBS) produces pronounced positive clinical and neuropsychological shifts in patients with discirculatory encephalopathy associated with post-COVID syndrome, as confirmed by the comparative statistical analysis of the study outcomes.

The positive effects of transcranial electrical stimulation therapy have been supported by numerous studies conducted by both Russian and international researchers [19–21]. For instance, the regulatory effect of transcranial electrical stimulation therapy on central and peripheral pathogenetic mechanisms of gastroesophageal reflux disease was demonstrated by Sevostyanova et al. [19]. Research led by Shekelle [20] and Price [21] reported favorable outcomes of transcranial electrical stimulation in anxiety and depressive disorders.

Overall, sequential transcranial electrical stimulation therapy (TCMP and DBS) contributes to the reversal of all clinical symptoms and improves neuropsychological test scores by positively influencing cortico-subcortical connectivity in patients with discirculatory encephalopathy associated with post-COVID syndrome.

CONCLUSION

Thus, medical rehabilitation incorporating a combined approach—sequential application of TCMP and DBS—alongside pharmacologic support in patients with discirculatory encephalopathy associated with post-COVID syndrome proved more effective than monotherapy with either modality. This enhanced efficacy is attributed to the pronounced neurotropic action of transcranial electrical stimulation therapy, which enables correction of a broad spectrum of neurological, neuropsychological, and motor impairments.

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