Клинические, образовательные и социальные аспекты психологии здоровья

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Research article

Long-term neuropsychological and pathopsychological consequences associated with COVID-19

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Abstract

Introduction. Long-term consequences associated with COVID-19 have a significant impact on people's health. The most common symptoms observed in the post-COVID period include disorders of the nervous system (21.7 %). However, data on the mental structure of the consequences induced by SARS-CoV-2 is still lacking. The purpose of this study was therefore to assess the structure and nature of health complaints as well as neuropsychological and pathopsychological disorders in people in the post-COVID period.

Materials and Methods. This article presents the results of an extensive survey involving 1,200 respondents, which aimed to identify the main general somatic, mental and neurological consequences that developed from four weeks to twelve months after COVID-19 infection. Another part of the described results comes from an experimental psychological examination of 47 respondents randomly selected from the main study group (n = 1,200), which included an assessment of the overall state of cognitive functions, memory, attention, gnosis, praxis and the severity of psychopathological symptoms.

Results. A total of seven subphenotypes of disorders were identified in the post-COVID period, among them anxiety and related phenomena (1), neuromuscular disorders associated with pain syndrome (2), disorders of respiratory, cardiovascular and autonomic systems (3), asthenic phenomena (4), disorders of cognitive functions (5), depressive phenomena (6) and disorders of sensory organs (7). The experimental psychological examination revealed the following mental disorders: a decline in logical and mechanical long-term memory, a decrease in mental stability, difficulties in spatial gnostic and praxic orientations, the severity of anxious and depressive tendencies and a proclivity for obsessive phenomena.

Conclusions. Rehabilitation of persons with a history of COVID-19 infection requires a comprehensive neuropsychological correction program rooted in a multidisciplinary approach. The identified subphenotypes and mental disorders of the post-COVID period can be used as corrective targets in rehabilitation.

Keywords: new coronavirus infection (NCI), cognitive impairment, COVID-19, post-COVID syndrome, central nervous system damage, mental disorders

Научная статья

Отсроченные нейропсихологические и патопсихологические последствия, ассоциированные с COVID-19

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Аннотация

Введение. Отсроченные последствия, ассоциированные с COVID-19, оказывают значимое влияние на состояние здоровья населения. Лидирующие позиции среди симптомов постковидного периода занимают нарушения со стороны нервной системы (21,7 %). При этом данных о психической структуре последствий SARS-CoV-2 на сегодняшний день недостаточно. В связи с этим целью исследования была оценка структуры и характера жалоб на состояние здоровья, а также нейропсихологических и патопсихологических нарушений у людей в постковидный период.

Материалы и методы. В статье приводятся результаты расширенного анкетирования 1200 респондентов, которое было направленно на выявление основных общесоматических, психических и неврологических последствий, развившихся в период от 4 недель до 12 месяцев после перенесенного COVID-19. Другая часть описываемых результатов относится к экспериментально-психологическому обследованию 47 респондентов, случайным образом отобранных из основной группы исследования (n = 1200), включавшему оценку общего состояния когнитивных функций, памяти, внимания, гнозиса, праксиса, а также выраженности психопатологической симптоматики.

Результаты исследования. С повышением возраста увеличивалась тяжесть протекания как острой фазы, так и отсроченных последствий перенесенной новой коронавирусной инфекции. Было выявлено семь субфенотипов нарушений в постковидном периоде, включающих в себя тревожные и сопряженные подобные явления (1), нервно-мышечные нарушения, сопряженные с болевым синдромом (2), нарушения дыхательной, сердечно-сосудистой и вегетативной систем (3), астенические явления (4), нарушения со стороны когнитивных функций (5), депрессивные явления (6), нарушения со стороны органов чувств (7). В рамках экспериментально-психологического обследования были выявлены следующие психические нарушения: снижение логической и механической долговременной памяти, снижение психической устойчивости, трудности пространственных гностических и праксических ориентировок, выраженность тревожных и депрессивных тенденций, склонность к навязчивым явлениям и выраженному дискомфорту от наличных соматических симптомов.

Заключение. Реабилитация лиц после перенесенного COVID-19 требует проведения комплексной программы нейропсихологической коррекции в рамках мультидисциплинарного подхода. Выявленные субфенотипы проявлений постковидного периода, а также нейропсихологические и патопсихологические нарушения могут быть использованы в качестве коррекционных мишеней при ее разработке.

Ключевые слова: новая коронавирусная инфекция (НКИ), когнитивные нарушения, COVID-19, постковидный синдром, поражение центральной нервной системы (ЦНС), психические расстройства

Introduction

To this day, the SARS-CoV-2 (COVID-19) pandemic continues to produce a significant impact on public health through its long-term effects, collectively termed 'post-COVID syndrome' (PCS). Research carried out in Russia as well as in other countries indicates that this condition encompasses a broad array of somatic, neurological and mental impairments, represented by polymorphic and diffuse disorders affecting various body systems (Belyakov et al. 2023; Bogolepova et al. 2021; Petrova et al. 2022; Zhang et al. 2023).

The imperative of clinical and psychological research into post-COVID state is due not merely to a paucity of data on its psychological profile, but also to a high prevalence of neurological disorders (21.7%) and their protracted nature (10 to 12 months) after the initial infection (Yarmukhamedova, Uzakova 2023; Orrù et al. 2021).

A notable trend has emerged with a shift towards a multidisciplinary and personalized approach to post-COVID rehabilitation. Pioneering protocols have been produced to guide interdisciplinary teams comprising physicians, clinical psychologists and occupational and physical therapists among others (Kupferschmitt et al. 2022). Experimental neuropsychological rehabilitation programs have also been launched (Harenwall et al. 2021) and clinical outcomes published for individuals with post-COVID syndrome, which underscore the high efficacy of professional teams operating within a biopsychosocial model (Maltseva, Shmonin 2023).

Extensive research (Gutova et al. 2021; Evstifeeva et al. 2022; Polidanov et al. 2022; Usov, Yushkov 2021; Filippchenkova et al. 2022) has identified a range of psychological sequelae associated with COVID-19 infection. These include marked anxiety and depressive symptoms, a significantly diminished quality of life, asthenic conditions, impaired attention and memory functions, dissatisfaction with personal health status among respondents and a demonstrated correlation between the severity of post-COVID outcomes and an individual's stress resilience, coping strategies and degree of alexithymia. Despite these findings, there is limited data on the neuropsychological and pathopsychological impairments that characterize the full spectrum of long-term sequelae. Consequently, the precise delineation of targets and the content of clinical-psychological rehabilitation programs continue to present a challenge for practitioners.

The present study therefore aims to assess the structure and nature of health complaints, alongside neuropsychological and pathopsychological impairments in a post-COVID cohort.

Materials and Methods

Data collection and participant examination took place at the clinical facilities of the Saint Petersburg Pasteur Institute of the Federal Service for the Oversight of Consumer Protection and Welfare of the Russian Federation and Pavlov University of the Ministry of Healthcare of the Russian Federation. The work was supported by a grant from the Russian Science Foundation (No. 23–45–10017) as part of Russian-Belarusian cooperation.

This paper seeks to provide a more detailed description and interpretation of results obtained during the initial phase of the comprehensive study funded by the aforementioned grant and conducted throughout 2023 (Belyakov et al. 2023). It also aims to integrate a clinical-psychological component into the analysis and explanation of the complaints, difficulties and impairments associated with the post-COVID condition.

The study was approved for conduct by the Ethics Committee of the Saint Petersburg Pasteur Institute (Approval No. 84 dated 16 February 2023). The participants with a history of COVID-19 infection provided voluntary informed consent for participation and the processing of their personal data prior to enrolment.

Inclusion criteria were defined as:

1) age from 18 to 60;
2) a confirmed history of COVID-19 infection, verified by a positive polymerase chain reaction (PCR) test for SARS-CoV-2.

The study employed a two-phase design: phase 1 consisted of a systematic regional clinical-epidemiological investigation into the consequences of COVID-19 infection; phase 2 involved an experimental psychological assessment of the patients.

As part of the first phase, a specialized questionnaire was developed to retrospectively obtain the following data: basic demographic details, information regarding the participant's COVID-19 infection history and vaccination status, physical and mental well-being before and after the illness and ongoing symptoms that impacted daily functioning at the time of the survey. The questionnaire included self-assessment based on 38 symptoms (anxiety related to health, work or the loved ones, dyspnea, dizziness, hair loss, etc.). Participants were supposed to rate the severity of each symptom on a scale including 'not bothersome', 'mild', 'moderate' and 'extremely severe'. Phase 1 collected data from 1,200 respondents who had a history of COVID-19 infection within six preceding months.

Phase 2 involved experimental psychological assessment of a random sample of 47 patients drawn from the main cohort (n = 1,200). All selected patients had contracted COVID-19 within the previous six months. A clinical-psychological interview was conducted to document baseline complaints, chronic medical conditions and other factors. The assessment focused on the following key domains:

1) short- and long-term mechanical memory;
2) short- and long-term logical memory;
3) psychomotor speed, along with attention stability and efficiency;
4) dynamic, kinesthetic and spatial praxis;
5) visual-object and visual-spatial gnosis, auditory gnosis and body schema orientation;
6) screening for the severity of anxiety and depressive tendencies, psychopathological symptomatology and the degree of cognitive impairment.

The neuropsychological and pathopsychological assessment of individuals with post-COVID syndrome employed the following methods: Luria's 10 Words Test; Schulte Tables; the Logical Memory subtest from the Wechsler Memory Scale; specific neuropsychological probes to evaluate praxis (e.g. the Fist-Edge-Palm task, Finger Position Praxis Test, Head's Test); tests for gnostic functions, such as Incomplete Pictures Test, Clock Reading Test, auditory tests and body schema orientation tests; The Hospital Anxiety and Depression Scale (HADS); The Montreal Cognitive Assessment (MoCA); and The Symptom Checklist-90-Revised (SCL-90-R).

Statistical data analysis was performed using MS Excel 2010 and STATISTICA 10 software. The statistical approach included: distribution normality testing using the Shapiro-Wilk test; Spearman rank correlation; factor analysis conducted via Principal Component Analysis (PCA) and Varimax rotation with Kaiser normalization. Descriptive statistics methods were also applied in data analysis. A p-value of less than 0.05 (5% error probability) was used for statistical significance.

Results

The study cohort consisted of 1,200 respondents with confirmed COVID-19 infections occurring between 2019 and 2023. Participants had a mean age of 40 ± 11.9 years, with a gender distribution of 71.1% females and 28.9% males. The majority (72.3%) belonged to the working-age population. Most respondents (76.6%) had experienced an acute COVID-19 infection of moderate severity. The average number of confirmed COVID-19 episodes was 1.35 ± 0.6 cases. Vaccination was reported in 743 patients (61.9%).

A correlation analysis examining the relationship between respondent age and health characteristics before and after COVID-19 infection (n = 1,200) further revealed that older age showed positive correlations with acute-phase COVID-19 symptoms, including measured oxygen saturation reduced to 95–94% ($p<0.0001$), measured oxygen saturation reduced to 93% or lower ($p < 0.0001$) and impaired consciousness ($p < 0.05$). Notably, symptoms including fever above 38°C, exertional dyspnea and low blood pressure below 90/60 mm Hg demonstrated no significant age correlation, suggesting non-specificity of these symptoms across various age groups (Fig. 1).

Advanced age was associated with more severe disease manifestations, including increased hospitalization cases ($p < 0.0001$), higher intensive care unit admission rates ($p < 0.05$), greater need for oxygen support ($p < 0.0001$) and elevated pneumonia incidence during acute infection ($p < 0.0001$).

Data on stress levels during acute infection revealed significantly higher levels among older respondents, with particularly pronounced stress intensity reported in the year preceding COVID-19 infection ($p < 0.0001$). Overall, general somatic, neurological and mental complaint severity demonstrated positive correlation with increasing age.

Factor analysis (Table 1) identified seven principal factors representing the most closely related health complaints in the post-COVID period. The list of 38 complaints used in the survey was developed through a multidisciplinary team's discussions focusing on general metabolic symptoms that could subsequently facilitate the identification of specific groups of COVID-19 sequelae.

The experimental psychological study involved 47 respondents, comprising 40 women (85.1%) and 7 men (14.9%) with a mean age of 37.2 ± 13.9 years. The majority (72.2%) were actively employed, while the remaining participants included students (13.9%), retirees (2.8%) and unemployed individuals (11.1%). A significant proportion of participants reported experiencing varying degrees of stress during the acute phase of COVID-19: mild (33.4%), moderate (25%) and severe (22.2%), with only 19.4% reporting no such stress.

Participants mentioned the following premorbid psychoneurological difficulties prior to the COVID-19 infection:

1) one-third indicated pre-existing sleep disturbances;
2) half of the respondents reported experiencing periods of low mood lasting more than two weeks, along with memory and attention deficits before the infection;

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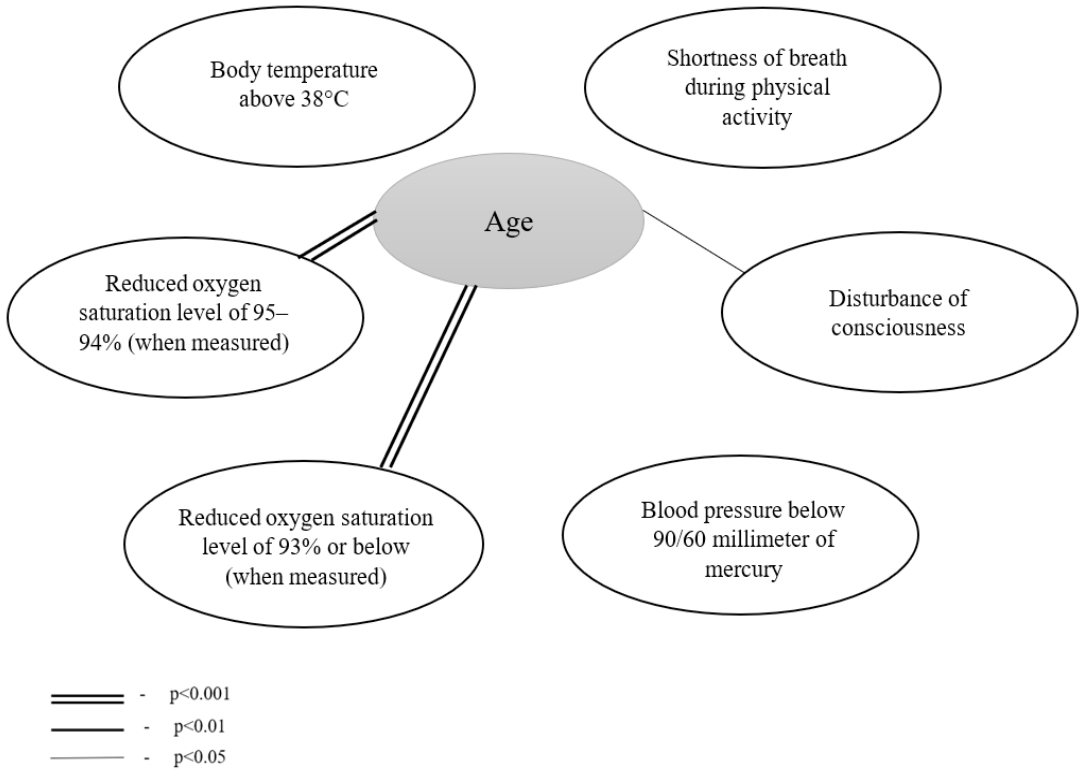

Fig. 1. Correlation galaxy of relationships between age and symptoms in the acute phase of COVID-19, n = 1,200

Рис. 1. Корреляционная плеяда взаимосвязей возраста и симптомов острой фазы COVID-19, n = 1200

Table 1. Results of the factor analysis of complaints about respondents' health in the post-COVID period, n = 1,200

Factors	Health complaints	Factor loading on a trait	Dispersion load
Factor 1	Obsessive thoughts / movements / fears	0.66	4.13
	Health anxiety	0.66	
	Work anxiety	0.65	
	Panic attacks	0.59	
	Anxiety for the loved ones	0.56	
	Nightmares	0.51	
	Insomnia	0.42	
Factor 2	Burning sensation in the limbs	0.69	3.97
	Feeling of numbness in the limbs	0.62	
	Gait disorders	0.61	
	Common muscle pain	0.60	
	Urinary disorders	0.59	
	Decrease in material income due to the illness	0.48	
	Severe pain in the spine	0.45	
	Pain in different parts of the abdomen	0.35	
Factor 3	Chest pain	0.74	3.88
	Feeling of heaviness in the chest	0.74	
	Dyspnea	0.72	
	Irregularities in the heartbeat	0.64	
	Fluctuations in blood pressure	0.51	
	Dizziness	0.46	
Factor 4	Fast fatiguability	0.66	3.60
	Weakness, powerlessness	0.62	
	General malaise	0.57	
	Low activity	0.56	
	Excessive muscle fatigue	0.52	
	Daytime sleepiness	0.51	
	Headache	0.43	
Factor 5	Concentration problems	0.77	2.84
	Lethargy, slow thinking	0.76	
	Bad memory	0.75	
Factor 6	Reluctance to take care of one's appearance	0.60	2.61
	Hair loss	0.58	
	Decreased / increased appetite	0.57	
	Inability to cope with household stress	0.48	
	Bad mood	0.46	
Factor 7	Absence / change / distortion of odors	0.83	1.97

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Табл. 1. Результаты факторного анализа жалоб на здоровье респондентов в постковидном периоде, n = 1200

Факторы	Жалобы на здоровье	Факторная нагрузка на признак	Дисперсионная нагрузка
Фактор 1	Навязчивые мысли / движения / страхи	0,66	4,13
	Тревога за здоровье	0,66	
	Тревога за работу	0,65	
	Панические атаки	0,59	
	Тревога за близких	0,56	
	Ночные кошмары	0,51	
	Бессонница	0,42	
Фактор 2	Ощущение жжения в конечностях	0,69	3,97
	Ощущение онемения конечностей	0,62	
	Нарушения походки	0,61	
	Распространенные мышечные боли	0,60	
	Нарушения мочеиспускания	0,59	
	Снижение материального достатка из-за болезни	0,48	
	Выраженные боли в позвоночнике	0,45	
	Боли в разных отделах живота	0,35	
Фактор 3	Боли в грудной клетке	0,74	3,88
	Чувство тяжести в грудной клетке	0,74	
	Одышка	0,72	
	Перебои в работе сердца	0,64	
	Колебания артериального давления	0,51	
	Головокружения	0,46	
Фактор 4	Быстрая утомляемость	0,66	3,60
	Слабость, бессилие	0,62	
	Общее недомогание	0,57	
	Низкая активность	0,56	
	Чрезмерная мышечная утомляемость	0,52	
	Сонливость днем	0,51	
	Головные боли	0,43	
Фактор 5	Нарушения концентрации внимания	0,77	2,84
	Заторможенность, замедленность мышления	0,76	
	Плохая память	0,75	
Фактор 6	Нежелание следить за своим внешним видом	0,60	2,61
	Выпадение волос	0,58	
	Снижение / усиление аппетита	0,57	
	Неспособность справляться с бытовой нагрузкой	0,48	
	Плохое настроение	0,46	
Фактор 7	Отсутствие / изменение / искажение запахов	0,83	1,97

3) all the examined individuals reported obsessive phenomena (thoughts, movements or fears) that interfered with their daily functioning before the infection.

Evaluation of mnestic functions revealed that the most significant challenges in the post-COVID period were associated with long-term mechanical (impaired in 31.9% of participants) and logical memory. Assessment of the latter showed notable weakness in forming associations when memorizing logically cohesive material: immediately after presentation, participants recalled only 9.6 ± 3.2 out of 24 possible information units (short-term logical memory), declining to 7.7 ± 3.9 after a delay (long-term logical memory).

One-third of respondents also demonstrated insufficient memorization capacity, manifested as difficulties retaining the learned material. Short-term mechanical memory remained within standard ranges (5.9 ± 1.6).

The memory function study identified reduced mental stability in 41.3% participants, although other metrics from the Schulte Tables test fell within normal parameters: psychomotor speed (35.7 ± 6.4) and work warming-up (0.98 ± 0.14). Active attention capacity was also within normal limits (5.9 ± 1.6). Notably, most respondents (69.5%) exhibited a hypersthenic type of attention exhaustion, suggesting mild impairment of this mental function, most likely accompanied by asthenic manifestations, which were experienced by 59.6% participants as reported during interviews.

Gnostic assessment revealed significant difficulties observed in visual-spatial orientation during the Clock Reading Test, with only 6.5% participants completing the task error-free. Only 15.2% respondents fully succeeded in the visual-object gnosis test. No significant auditory gnosis impairments were detected, although 13% participants made occasional errors in recognizing object and musical sounds.

The results of the praxis assessment tests in the post-COVID phase are summarized in Table 2. It shows that the greatest challenges were observed in spatial praxis, which governs spatially oriented actions, hand movement coordination, etc. No impairments in body schema orientation were identified, with 97.8% respondents successfully completing the relevant test.

Table 2. Results of tests assessing the state of various types of praxis in persons in the post-COVID period, n = 47

Parameters	Successful execution	Single errors	Multiple errors	Sample failed
Dynamic praxis (right hand)	73.9%	17.4%	8.7%	–
Dynamic praxis (left hand)	69.5%	19.6%	10.9%	–
Spatial praxis	56.7%	32.6%	6.5%	2.2%
Finger praxis (right hand)	80.4%	19.6%	–	–
Finger praxis (left hand)	76.1%	21.7%	2.2%	–

Табл. 2. Результаты выполнения проб на оценку состояния различных видов праксиса лиц в постковидном периоде, n = 47

Параметры	Успешное выполнение	Единичные ошибки	Множественные ошибки	Проба не выполнена
Динамический праксис (правая рука)	73,9%	17,4%	8,7%	–
Динамический праксис (левая рука)	69,5%	19,6%	10,9%	–
Пространственный праксис	56,7%	32,6%	6,5%	2,2%
Пальцевой праксис (правая рука)	80,4%	19,6%	–	–
Пальцевой праксис (левая рука)	76,1%	21,7%	2,2%	–

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According to the MoCA assessment of the general cognitive status, significant cognitive impairments (scores below 26) were detected in 15.4% respondents. The greatest difficulties with task performance emerged in the Delayed Recall subtest, which evaluates long-term mechanical memory (Table 3).

The Hospital Anxiety and Depression Scale (HADS) revealed that half of the participants exhibited signs of anxiety and depressive phenomena at either subclinical or clinical levels (Fig. 2).

Evaluation of psychopathological symptom severity in the post-COVID period using the Symptom Checklist SLR-90 revealed significant elevations on specific scales, particularly Somatization (1.34 ± 0.76) and Obsessive-Compulsive symptoms (1.4 ± 0.8). The Global Severity Index (0.92 ± 0.49) and the Positive Symptom Distress Index (1.44 ± 0.76), which reflect the severity and intensity of distressing symptoms, remained within standard ranges, albeit approaching borderline levels (Table 4).

Discussion

The identified correlation between advancing age and an increased number of factors mediating severe acute COVID-19 manifestations, combined with the propensity for experiencing more intense stress both throughout life and during illness, underscores the need for special attention to post-COVID symptoms in older populations. This also necessitates the development of medical and psychological rehabilitation programs specifically tailored to the above-mentioned challenges.

The data obtained by the factor analysis of respondents' post-COVID health complaints can be interpreted as follows:

1. *Factor 1: obsessive phenomena, anxiety related to health, work or the loved ones, panic attacks, nightmares and insomnia.* These complaints represent a group of *anxiety and related phenomena* encompassing anxiety itself, sleep disturbances, panic attacks, uncontrolled fear episodes and others.

Table 3. Results of assessing the general state of cognitive functions using the MoCA method, n = 47

MoCA subtest	Mean (M)	Standard deviation (SD)	Normative values
Visual-constructive skills	4.45	0.74	5
Naming	3.00	0.00	3
Attention	5.91	0.29	6
Speech	2.73	0.46	3
Abstraction	1.86	0.35	2
Delayed playback	3.45	1.01	5
Orientation	5.95	0.21	6
Total points	27.08	1.96	≥ 26

Табл. 3. Результаты оценки общего состояния когнитивных функций по методике «МоСА», n = 47

Субтест МоСА	Средние значения (М)	Стандартное отклонение (SD)	Нормативные значения
Зрительно-конструктивные навыки	4,45	0,74	5
Называние	3,00	0,00	3
Внимание	5,91	0,29	6
Речь	2,73	0,46	3
Абстракция	1,86	0,35	2
Отсроченное воспроизведение	3,45	1,01	5
Ориентация	5,95	0,21	6
Общая сумма баллов	27,08	1,96	≥ 26

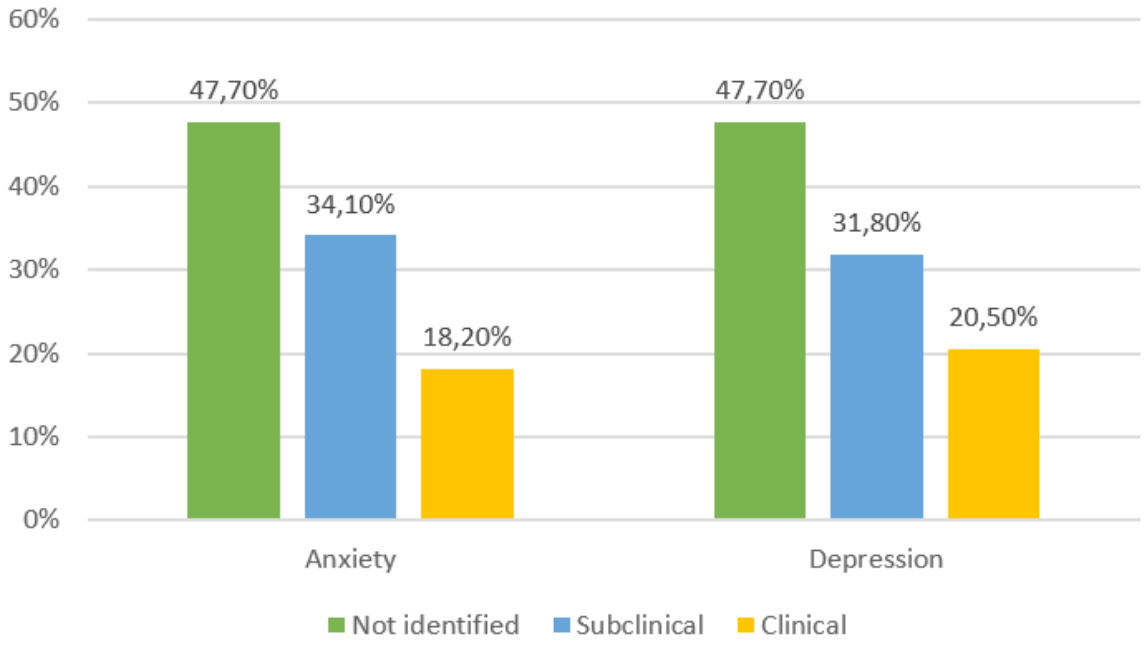

Fig. 2. Results of assessing the severity of anxiety and depressive phenomena using the HADS method, n = 47

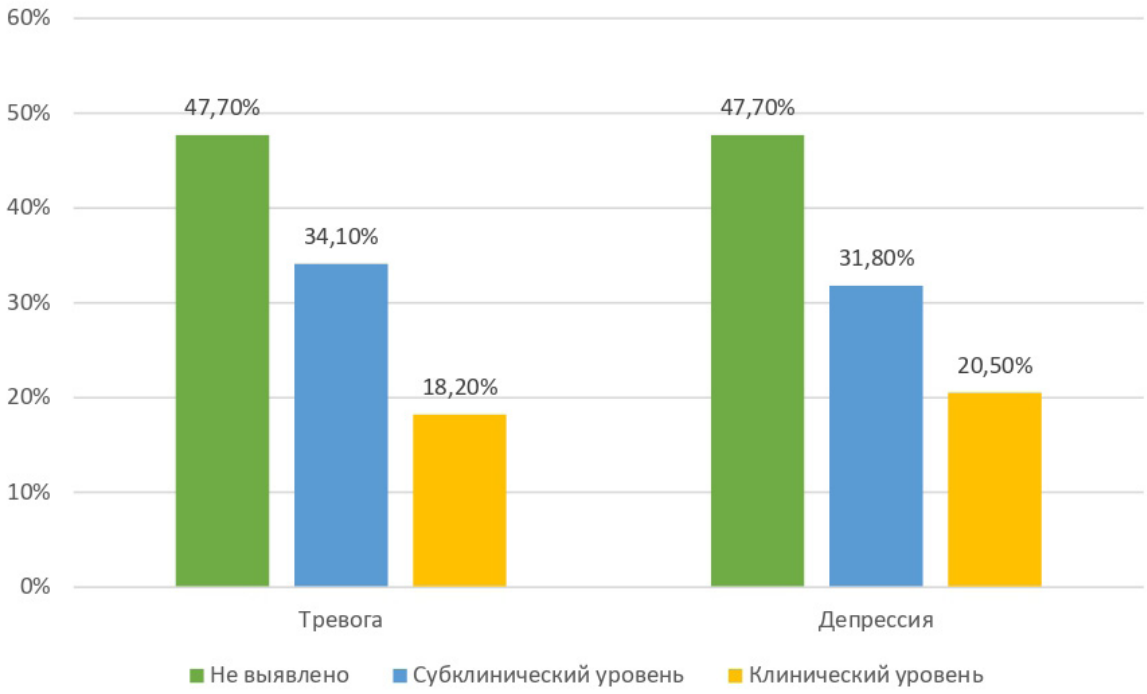

Рис. 2. Результаты оценки выраженности тревожных и депрессивных явлений по методике HADS, n = 47

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Table 4. Results of assessing the severity of psychopathological symptoms using the SLR-90 method, n = 47

SLR-90 scale	Mean values (M)	Standard deviation (SD)	Standard values
Somatization	1.34	0.76	≤ 1
Obsessive-compulsive	1.40	0.80	≤ 1.3
Interpersonal sensitivity	0.84	0.62	≤ 1.6
Depression	1.18	0.72	≤ 1.3
Anxiety	0.91	0.59	≤ 1.1
Hostility	0.63	0.46	≤ 1.4
Phobic anxiety	0.50	0.60	≤ 0.7
Paranoid tendencies	0.56	0.51	≤ 1.3
Psychoticism	0.38	0.34	≤ 0.9
Overall Symptom Severity Index	0.92	0.49	≤ 1.1
Present Symptom Distress Index	1.44	0.76	≤ 1.8

Табл. 4. Результаты оценки выраженности психопатологической симптоматики по методике «SLR-90», n = 47

Шкала SLR-90	Средние значения (M)	Стандартное отклонение (SD)	Нормативные значения
Соматизация	1,34	0,76	≤ 1
Обсессивность-компульсивность	1,40	0,80	≤ 1,3
Межличностная сензитивность	0,84	0,62	≤ 1,6
Депрессия	1,18	0,72	≤ 1,3
Тревожность	0,91	0,59	≤ 1,1
Враждебность	0,63	0,46	≤ 1,4
Фобическая тревожность	0,50	0,60	≤ 0,7
Паранойяльные тенденции	0,56	0,51	≤ 1,3
Психотизм	0,38	0,34	≤ 0,9
Общий индекс тяжести симптомов	0,92	0,49	≤ 1,1
Индекс наличного симптоматического дистресса	1,44	0,76	≤ 1,8

2. *Factor 2: burning sensations and numbness in the limbs, gait disorders, widespread myalgia, urinary disorders, severe spinal pain, pain in various parts of the abdomen and disease-related income loss.* These manifestations may be collectively classified as *neuromuscular disorders associated with pain syndrome* in various body parts. They may be attributed to damage not only to skeletal muscles but also to internal muscle layers of the body, as suggested by an association with such complaints as stomach aches and urinary dysfunction. There is also a particularly noticeable correlation with financial strain caused by COVID-19. This socially critical post-COVID sequela is thus specifically linked to motor disorders, which limit one's activeness and working capacity. This necessitates the involvement of physical therapists, rehabilitation specialists, manual therapists and other relevant professionals in post-COVID rehabilitation.
3. *Factor 3: chest pains, chest heaviness, dyspnea, irregular heartbeat, blood pressure fluctuations and dizziness.* They are typical of *disorders of respiratory, cardiovascular and autonomic systems*, in which irregular heartbeat and dizziness result from oxygen transport deficiencies affecting multiple body systems.
4. *Factor 4: rapid fatigability, weakness, debility, general malaise, low activity, excessive muscle fatigue, daytime sleepiness and headaches.* Such symptoms can be attributed to the group of *asthenic phenomena* associated with general tone reduction, manifestations of 'irritable weakness' and reduced activity and working capacity.

5. *Factor 5: concentration problems, lethargy, slow thinking and bad memory.* Associated difficulties can be described as *disorders of cognitive functions* affecting three fundamental cognitive mental processes: attention, memory and thinking.
6. *Factor 6: neglect of one's personal appearance, hair loss, decreased/increased appetite, inability to cope with household stress and bad mood.* These complaints are largely characteristic of *depressive phenomena*, manifested as symptoms of hypothymia, reduced motor activity and slowed thought processes. It is worth noting that hair loss is specifically associated with this group of symptoms, which may explain the multifactorial nature of this condition following a COVID-19 infection. Depressive experiences linked to overall body stress and related immune responses disrupting healthy hair growth, on one hand, and the specific impact of SARS-CoV-2 on the body's metabolism, on the other, may collectively serve as factors mediating active hair loss in the post-COVID period.
7. *Factor 7: smell and taste absence/change/distortion.* Such complaints can be attributed to *disorders of sensory organs*, which take various forms of distorted taste and smell.

The experimental psychological study revealed a pattern of mnestic impairments, with particularly vulnerable long-term mechanical and logical memory functions. Our findings are consistent with a neurophysiological understanding of SARS-CoV-2 impact on brain structures (Crivelli et al. 2022; Jamilloux et al. 2020), in particular the activation of inflammation and neuronal death processes around the hippocampus, which is responsible for memory consolidation.

Also worthy of attention are the obsessive symptoms reported in the post-COVID period, including life-impeding thoughts, movements and fears. According to our findings, such symptoms pre-existed in all the respondents who took part in the psychological assessment. The assessment findings showed elevated scores on the Obsessive-Compulsive scale. This raises questions about the significance of the premorbid background behind not only somatic disorders but psychological ones as well for assessing risks and taking these described characteristics into account during rehabilitation. Clarifying the influence of individuals' premorbid health status on the post-COVID period could be a promising area for further research.

Importantly, we also observed neuropsychological impairments in the respondents, which manifested themselves as mild cognitive complications, focused on a decreased ability for spatial orientation, affecting both gnostic and praxic aspects of mental activity. Given the portion of our sample (15.4%) which did show more pronounced cognitive disorders and the findings of other studies (Belyakov et al. 2023; Lauria et al. 2023; Herrera et al. 2023; Zhang et al. 2023), a strong case can be made for more detailed scientific evaluation of post-COVID patients using brain magnetic resonance imaging alongside other neurological and neuropsychological diagnostic methods.

Conclusions

Advanced age increases the severity of both acute phase and long-term sequelae of COVID-19 infection. Identification of this risk group justifies long-term multidisciplinary monitoring for older populations during and after the COVID-19 infection, given somatic, neurological and mental challenges. Our study discovered seven subphenotypes of post-COVID impairments:

1) anxiety and related phenomena;
2) neuromuscular disorders associated with pain syndrome;
3) disorders of respiratory, cardiovascular and autonomic systems;
4) asthenic phenomena;
5) disorders of cognitive functions;
6) depressive phenomena;
7) disorders of sensory organs.

Some of the promising areas of future research may include discussing the identified manifestations of post-COVID changes, describing other criteria for their identification and grouping, determining the areas of rehabilitation, recovery, monitoring duration, etc. They may ultimately produce specific practical recommendations concerning post-COVID care.

The neuropsychological assessment revealed long-term logical and mechanical memory impairment, reduced mental stability, spatial gnostic and praxic orientation difficulties, marked anxiety and depressive tendencies, proclivity for obsessive phenomena and marked discomfort induced by somatic complications.

Consequently, effective post-COVID recovery and rehabilitation require comprehensive neuropsychological correction provided within a multidisciplinary framework. The described impairments may serve as correction targets for its development. Further pathopsychological and neuropsychological research in this field seems to be of high value to both scientists and practitioners.

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Conflict of Interest

The authors declare that there is no conflict of interest, either existing or potential.

Конфликт интересов

Авторы заявляют об отсутствии потенциального или явного конфликта интересов.

Ethics Approval

The research programme and its protocol were approved by the Ethics Committee of the Pasteur Research Institute of Epidemiology and Microbiology No. 84 dated February 16, 2023.

Соответствие принципам этики

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Data Availability Statement

Data are available upon request to the corresponding author.

Заявление о доступности данных

Данные доступны по запросу, адресованному автору-корреспонденту.

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