UDC 616-004:616.89-008.45/.48:616.8-008.6]-07-047.37
DOI https://doi.org/10.32782/2226-2008-2025-1-10

D. I. Andreichenko https://orcid.org/0000-0002-4804-0891
O. I. Kalbus https://orcid.org/0000-0003-0796-4825
Yu. I. Hudaryan https://orcid.org/0009-0007-9718-4721
T. V. Yudina https://orcid.org/0000-0002-5860-1728
S. O. Makarov https://orcid.org/0000-0002-3106-9727
O. V. Makarenko https://orcid.org/0000-0001-8730-1081

THE RELATIONSHIP BETWEEN COGNITIVE IMPAIRMENT AND THE LEVEL OF NEUROLOGICAL DEFICIT IN PATIENTS WITH RRMS

Dnipro State Medical University, Dnipro, Ukraine

UDC 616-004:616.89-008.45/.48:616.8-008.6]-07-047.37

D. I. Andreichenko, O. I. Kalbus, Yu. I. Hudaryan, T. V. Yudina, S. O. Makarov, O. V. Makarenko

THE RELATIONSHIP BETWEEN COGNITIVE IMPAIRMENT AND THE LEVEL OF NEUROLOGICAL DEFICIT IN PATIENTS WITH RRMS

Dnipro State Medical University, Dnipro, Ukraine

Multiple sclerosis (MS) is a severe chronic disease with a complex pathogenesis characterized by a wide range of clinical manifestations, among which cognitive and motor disorders are especially pronounced.

The aim of the present article is to study the relationship between the degree of neurological deficit and cognitive functions in patients with relapsing multiple sclerosis. The Expanded Disability Status Scale (EDSS) was used to assess neurological deficit, and cognitive functions were analyzed through the Schulte test and the Luria test "Memorizing 10 words".

The study included 93 patients with RRMS, who were divided into two groups depending on the level of EDSS (group 1: EDSS < 3 points – 43 patients; group 2: EDSS ≥ 3 points – 50 patients).

The research findings uncovered major disparities amongst the clusters. Individuals with an EDSS score ≥ 3 points demonstrated notably weaker outcomes in cognitive evaluations compared to individuals with less severe neurological conditions. The velocity of the Schulte test was significantly slowed down in this cluster, reflecting the exhaustion of cognitive resources. Furthermore, recall assessments indicated troubles in keeping facts within short-term memory, predominantly under the conditions of repetitious tasks. These cognitive deficits showed interrelation with the level of neurological impairment and the advancement of the illness.

Conclusions: The study proves that the level of neurological impairment strongly influences the cognitive status of MS patients. Those with a higher EDSS score demonstrate significantly poorer performance on tests measuring attention, memory, and processing speed. Such an effect is particularly evident in test situations that require high concentrations and repetitions of tasks. The findings underscore the urgent need to integrate cognitive assessments into routine monitoring of MS patients.

Keywords: multiple sclerosis, cognitive function, EDSS, Schulte test Luria, test short-term memory.

УДК 616-004:616.89-008.45/.48:616.8-008.6]-07-047.37

Д. І. Андрейченко, О. І. Кальбус, Ю. І. Гударя'н, Т. В. Юдіна, С. О. Макаров, О. В. Макаренко

ВЗАЄМОЗВ'ЯЗКИ МІЖ КОГНІТИВНИМИ ПОРУШЕННЯМИ ТА РІВНЕМ НЕВРОЛОГІЧНОГО ДЕФІЦИТУ У ХВОРИХ НА РРРС

Дніпровський державний медичний університет, м. Дніпро, Україна

Мета: дослідити взаємозв'язок між ступенем неврологічного дефіциту та когнітивними функціями у пацієнтів із рецидивуючо-ремітуючою формою РС. Оцінка неврологічного дефіциту здійснювалась за розширеною шкалою стану інвалідності EDSS, когнітивні функції аналізували за допомогою тестів Шульте та тесту Лурія «Запам'ятовування 10 слів».

Дослідження включало 93 пацієнти з РРРС, яких поділили на дві групи залежно від рівня EDSS (1 група EDSS < 3 бали – 43 пацієти, 2 група EDSS ≥ 3 бали – 50 пацієнтів).

Результати дослідження виявили, що пацієнти з показником EDSS ≥ 3 бали мали нижчі результати у когнітивних тестах у порівнянні з групою з менш вираженим неврологічним дефіцитом. Зазначені когнітивні порушення корелювали зі ступенем неврологічного дефіциту та прогресуванням захворювання.

Ключові слова: розсіяний склероз, шкала EDSS, тест Шульте, тест Лурія, короткочасна пам'ять.

Introduction. Multiple sclerosis (MS) is a complex chronic autoimmune disease that causes demyelination, axonal loss, and progressive damage to the central nervous system (CNS). A key characteristic of MS is its predominance in young adults between the ages of 20 and 40, making it the leading cause of neurological disability in this age group. The vast majority of patients (80–85%) suffer from relapsing-remitting MS (RRMS), which is characterized by alternating periods of exacerbation and remission. In addition to motor disorders, this form of the disease is accompanied by cognitive impairments such as impaired attention, reduced processing speed, memory impairment, and emotional difficulties including anxiety and depression [1–3].

Human movement relies on the fusion of many systems, which are motor functions, balance, and cognitive control all

coming together under the central nervous system (CNS). In patients with multiple sclerosis (MS), demyelination and axonal degeneration disturb this synergy and present difficulties in simultaneous applications of cognitive and motor tasks. For instance, sometimes even simply walking and talking at the same time is hard because of the scarcity of cognitive resources. On top of that, motor impairments, such as limb weakness, coordination problems, and balance disorder, make mobility very difficult and are usually the first sign of how far MS has progressed. These combined with chronic fatigue severely compromise the functional ability of patients and thus their quality of life [4, 5].

Progressive cognitive dysfunction of the gradual type, in particular, appears to be highly correlated with motor dysfunction, accompanied by increasing severity over time within a characteristic clinical pattern. The demyelination process affecting both white and gray matter reduces the efficiency of neural connections required for advanced, complicated cognitive and motor tasks. This patient population exhibits more pronounced difficulties with attention and quick information processing, making the integration of new environments exceedingly challenging [6]. Emotional disorders enhance the impact of cognitive problems in multiple sclerosis, with depression and anxiety being the primary variants. For instance, highly anxious patients may find themselves struggling with attention on an occasional basis as well as organization of thinking. In turn, cognitive impairment seems to exacerbate emotional distress, thus creating a vicious cycle with worsening outcomes for patients [7–9].

In multiple sclerosis, knowledge of the interplay between motor and cognitive impairments contributes to the formulation of an integrated treatment plan. Using rehab approaches that are multidisciplinary, interventions have been able to yield better results in patients. For instance, cognitive therapy on the domains of attention, memory, and executive functions, together with rehabilitation in the motor aspects, can really enhance the adaptability of patients.

Moreover, testing of thinking skills can show how a sickness is getting worse and whether a treatment is working. People with higher EDSS scores need extra care because they have a greater chance of having thinking skill problems.

The study was aimed at assessing the dynamics of cognitive tests (Schulte test and Luria ten-word test) in patients with multiple sclerosis depending on the level of neurological deficit EDSS to determine the characteristics of disorders and changes in cognitive functions.

Materials and research methods. The study included 93 patients with a confirmed diagnosis of relapsing-remitting multiple sclerosis (MS), who were treated in the neurological department No. 1 of the Dnipropetrovsk Regional Clinical Hospital named after I.I. Mechnikov of the Dnipropetrovsk Regional Council from 2021 to 2023.

Among the patients, there were 56 women (60.2%) and 37 men (39.8%). The patients' age ranged from 19 to 65 years, and the median age was 37.0 years [32.0; 42.0]. The largest proportion of patients belonged to the age group of 18-40 years (62.3%). The gender structure was dominated by women aged 30-39 – 38 people (40.9%). The ratio of women to men in the entire sample was 1.5:1, with the largest ratio noted in the age group of 50+ (2:1). Differences in age between sexes were not statistically significant (p=0.67). The study was approved by the Bioethics Commission of the Dnipro State Medical University of the Ministry of Health of Ukraine (protocol No. 76 dated October 25, 2021) and was performed in accordance with the requirements of the Declaration of Helsinki.

Statistical data processing was performed using the software packages LibreOffice and R (version 4.4.0) [10]. The Shapiro-Wilk test was applied to check the type of distribution of quantitative data. Since the distribution of quantitative data in the study was non-parametric, non-parametric statistical methods were used. Quantitative data were presented as median with 25th and 75th percentiles (Me [25%; 75%]). The Mann-Whitney test was used to compare quantitative data between groups. The Jonkheer-Terpstra test was used to analyze trends in quantitative indicators when comparing three or more groups. Qualitative data were presented as n (%), and the Pearson Chi-square test without Yates's correction for continuity was used for comparison between groups.

A linear mixed-effects model with random effects on intercept and slope was used to examine the relationship between patient group EDSS scores, Schulte and Luria test attempt order, and test results [11]. The fixed effects were EDSS group and test attempt order, while the random effects were the test results for each patient. Since the software used to calculate the mixed-effects model does not provide p-values for the model coefficients, the statistical significance of the coefficients was assessed by t-value: $t > 1.96$ corresponded to a significance level of <0.05, and $t > 2.6$ indicated $p<0.01$. Comparisons of linear mixed-effects models were performed using ANOVA.

The critical p-value for hypothesis testing was set at <0.05.

All study participants assessed neurological deficits using the EDSS (Expanded Disability Status Scale). Attention and memory impairments were assessed using validated psychodiagnostic methods: the Schulte Table Attention Test and the O. R. Luria 10-Word Memory Test.

All participants were divided into two groups – Group 1 and Group 2 – depending on their EDSS scores. Patients with EDSS scores < 3 were assigned to Group 1, and patients with EDSS ≥ 3 were included in Group 2. The number of participants in Group 1 was 43 (46.2%), Group 2 included 50 patients (53.8%).

The EDSS (Expanded Disability Status Scale) is a measure of the level of neurological deficit and physical activity in patients with multiple sclerosis. It was developed by John Kurtzke as one of the standardized methods that quantifies the status of the patient on a scale from 0 to 10. The EDSS has been used as the primary scale for follow-up assessments of disease progression and effectiveness of treatment in clinical trials. This gives the possibility for quantitative evaluation of the neurologic status of patients in a number of functional systems (FS) including vision, coordination, motor functions, sensation, bladder, cerebellar and brainstem functions.

The final score is arrived at by adding up the scores of all the systems that are functioning and assessing mobility.

Schulte attention test: This helps to measure attention, sensorimotor reaction speed, and mental performance. There are five tables containing numbers from 1 to 25 arranged in random order. The patient names these numbers in order, saying them aloud. The time taken to complete each table normal is 30-40 seconds and the number of errors made is noted down. Decreased speed or increased errors indicate decreased performance or concentration.

"Memory for 10 words" by O. R. Luria: It is a test of verbal memory. A list of 10 words, neutral from an emotional point of view, is read to the patient at intervals of 1 second. The patient is asked to repeat the list up to five times until he/she can remember it fully. Recall after 50–60 minutes, unannounced, tests long-term memory for delayed recall.

Results and discussion. The study of the dynamics of cognitive tests depending on the EDSS score revealed a number of important patterns that confirm the close relationship between the level of neurological deficit and cognitive abilities of patients with multiple sclerosis.

As shown in Figure 1, there was a tendency that with each subsequent attempt to perform the Schulte test, the test time generally increased in most patients. An increase in the Schulte test time was observed in both groups, taking into account the EDSS score. However, when studying this trend, it became clear that the rate of increase in the Schulte test time in patients with EDSS ≥ 3.0 was higher than in patients with EDSS < 3.0. This indicates a progressive depletion of cognitive resources during repeated attempts to perform tasks that require attention and speed of sensorimotor reaction.

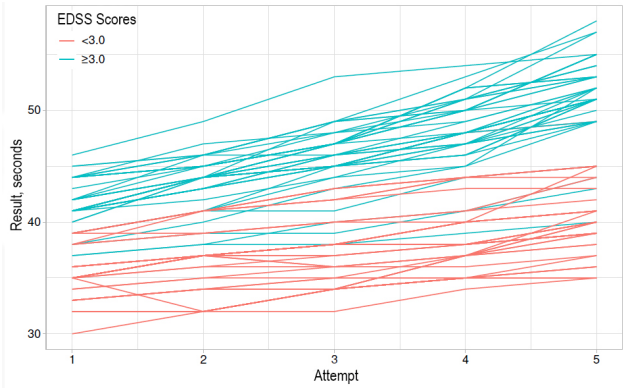

Fig. 1. Results of 5 Schulte test attempts depending on EDSS score

The medians and 25th and 75th percentiles of the Schulte test scores rose with each next attempt, confirming the progressive decline in cognitive abilities. (Figure 2). The rise in the interquartile percentiles (25th and 75th) indicates that the variability of results among patients had also increased, underscoring individual differences in the progression of cognitive decline.

A statistically significant difference was found between the results of all attempts at the Schulte test in both EDSS subgroups ($p < 0.01$). In addition, a statistically significant increase in scores on the Schulte test was noted with every attempt in both EDSS subgroups; this was confirmed by the Jonkher-Terpstra test. ($p < 0.01$).

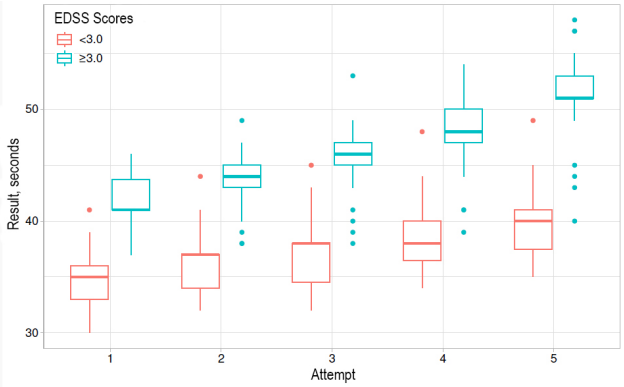

Fig. 2. Medians with 25th and 75th percentiles of the results of 5 Schulte test attempts depending on the EDSS score

Patients with an EDSS score ≥ 3.0 had an average of 4.83 seconds higher Schulte test result. Each subsequent attempt was associated with an average increase in Schulte test result of 1.12 seconds. The increase in Schulte test result with each attempt in patients with an EDSS score ≥ 3.0 was on average 1.29 seconds higher than in patients with an EDSS score < 3.0. The t-values for all of the above indicators were > 2.6, thus they were considered statistically significant at a significance level of $p < 0.01$ (Table 1).

Table 1

Results of a linear mixed-effects model examining the influence of EDSS score and Schulte test attempt number on test results

Parameter	Regression coefficient	Standard error	t-value
Intercept	34.11	0.35	96.91
EDSS score ≥3.0 (yes/no)	4.83	0.48	10.06
Attempt	1.12	0.08	14.56
EDSS score ≥3.0 (yes/no):Trial (interaction)	1.29	0.11	12.20

The increase in the time to complete the Schulte test with each subsequent attempt indicates the depletion of cognitive resources, especially if the task is repeated. The more pronounced rate of increase in time in the group with EDSS ≥ 3.0 confirms that the higher level of neurological deficit is associated with a limitation of attentional reserves and cognitive flexibility.

Patients with higher EDSS scores had a slower pace of task completion, which indicates a violation of the speed of information processing and sensorimotor coordination. The Schulte test was sensitive to changes in the cognitive status of patients with MS and can be used to monitor the progression of cognitive impairment associated with neurological deficit.

Analysis of the results of the 10-word Luria test in patients with MS revealed significant differences in cognitive functions depending on the level of neurological deficit on the EDSS scale.

When evaluating Figure 3 with the results of 6 attempts of the 10-word Luria test depending on the EDSS score, dependencies were observed (Figure 3). The presence of

the results of the attempt after 1 hour created a nonlinear relationship between the result and the ordinal number of the attempt. With each subsequent attempt, the difference in the median test results between the groups decreased. For patients with an EDSS score ≥ 3.0, the decrease in the median test results after 1 hour was more significant than for patients with an EDSS < 3.0. The median results for patients with an EDSS ≥ 3.0 were higher than in the comparison group. The differences in the medians between the groups were statistically significantly lower ($p < 0.01$). After excluding the test attempt after 1 hour, the Jonkheer-Terpstra test showed a statistically significant increase in the medians with each subsequent attempt in both groups ($p < 0.01$).

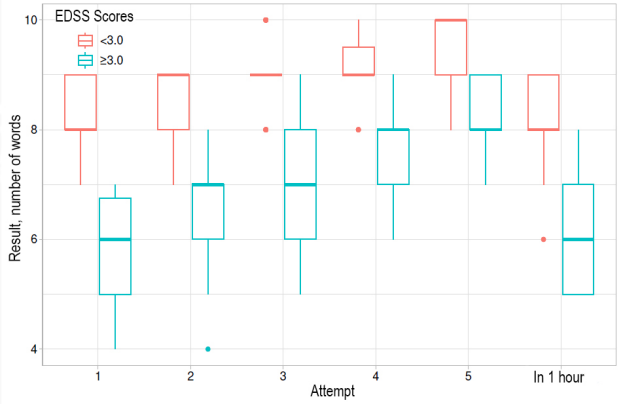

Fig. 3. Medians with 25th and 75th percentiles of the results of 6 attempts of the Luria 10-word test depending on the presence of mild dementia

Patients with an EDSS score ≥ 3.0 recalled an average of 2.72 fewer words on the 10-word Luria test compared with patients with an EDSS score < 3.0. This suggests that patients with less neurological deficits retain the best cognitive reserves. Each subsequent attempt was associated with an increase in test score of an average of 0.35 more words recalled for patients in both groups. The increase in Luria 10-word test score with each attempt for patients with an EDSS score ≥ 3.0 was an average of 0.26 more words recalled than for patients with an EDSS score < 3.0, indicating the ability to learn even in the presence of cognitive deficits. The t-value for all the indicators listed above was > 2.6, meaning that they were considered statistically significant with a significance level of $p < 0.01$ (Table 2).

Patients with higher EDSS scores have marked difficulty in acquiring new information. This is reflected in both fewer words recalled on the first attempt and a limited ability to benefit from repeated attempts. Patients with more pronounced neurological disabilities tend to exhibit greater loss of information over time, which suggests an impairment in the maintenance of verbal memory.

Table 2

Results of a linear mixed-effects model examining the influence of EDSS score and ordinal number of attempts on the Luria 10-word test test results

Parameter	Regression coefficient	Standard error	t-value
Intercept	7.88	0.17	46.55
EDSS score ≥3.0 (yes/no)	-2.72	0.23	-11.79
Attempt	0.35	0.03	12.34
EDSS score ≥3.0 (yes/no):Trial (interaction)	0.26	0.04	6.72

The Luria 10-Word Memory Test has been sensitive to changes in cognitive status, most of all in patients who manifest more severe neurological deficits. It may indicate that the patient is experiencing cognitive decline.

Both tests, Schulte and Luria, are effective in monitoring the progression of cognitive impairment among patients with multiple sclerosis, particularly when the degree of neurological deficit is substantial. For this reason, they can be recommended for monitoring purposes regarding cognitive dysfunction.

The results can also be applied to create individualized cognitive rehabilitation programs that consider the degree of cognitive impairment, as well as brain plasticity. In addition, these data may serve as a prognostic tool for the early identification of patients who are at high risk for marked cognitive decline, a possibility that would allow for much needed intervention.

Results were statistically significant ($p<0.01$), which means that facts can neither be denied nor questioned and further research is needed to find out how the level of EDSS affects the cognitive function of patients with multiple sclerosis.

Discussion. Ttherefore, the results of the study of the dynamics of cognitive tests with regard to EDSS scores are in line with previous studies asserting that there exists a close relationship between the degree of neurological deficit and the cognitive abilities of patients with MS. Specifically, increased EDSS– Schulte test completion time characterizes higher-grade patients who may be confirmed by other authors as those in whom cognitive resources become progressively depleted with increasing grades of neurological deficit. Similar findings have been reported in studies that highlight heightened sensitivity to attentional demands and slowing of information processing speed under long or repetitive task conditions [12–14].

Results of the Luria 10-word memory test also corroborated the association between the extent of cognitive depletion and the degree of neurological deficit. Patients with higher EDSS scores exhibited significantly lower performance, in other studies verifiably consistent with the decline in MS patients' verbal memory and learning ability. On the other hand, the capacity to partially enhance performance (in patients with higher EDSS scores) by increasing the number of words recalled on repeated attempts suggests that some level of cognitive plasticity is preserved even in the face of considerable deficits.

In addition, statistically significant differences between EDSS groups in Schulte test time and Luria word recall ($p<0.01$) emphasize the importance of taking into account the level of neurological deficit when assessing the cognitive status of patients with multiple sclerosis. These results also support the findings of other studies on the importance of sensitive tests that can detect early signs of cognitive decline [15, 16].

For the diagnosis of cognitive impairments in patients with multiple sclerosis (MS), neuropsychological tests such as the Brief Repeatable Battery of Neuropsycho-

logical (BRB-N) and the Minimal Assessment of Cognitive Function in MS (MACFIMS) are traditionally used. However, these tests have several drawbacks: their administration requires a significant amount of time (BRB-N – 45 minutes, MACFIMS – 90 minutes), and they are quite complex and exhausting for patients. Some authors use the Mini-Mental State Examination (MMSE), but this test does not assess executive and attentional functions, making it less suitable for MS patients [17, 18].

Thus, it is preferable to use rapid, accessible, and reliable methods, such as the Clock-Drawing Test, which evaluates visuospatial skills, planning, and organization of actions, as well as the Five-Word Test, which examines memory impairments (both short-term and long-term) and learning ability [19, 20].

However, it should be noted that the Luria and Schulte tests proposed in the study are more informative for assessing cognitive status in MS patients. These tests allow for a more detailed and in-depth evaluation of cognitive deficits, particularly attention and information processing speed, identifying impairments at early stages and being more sensitive to the dynamics of changes in these parameters.

Conclusions. Result analysis of the Schulte and Luria cognitive tests proved that the degree of neurological deficit, measured by EDSS, is a decisive factor influencing the cognitive activity of multiple sclerosis patients. Those with higher EDSS scores demonstrated graver deficits in attention, cognitive endurance, and memory functions – a finding that indicates a progressively depleting cognitive reserve.

These findings emphasize the need to screen the cognitive status of multiple sclerosis patients on a regular basis so that any impairment can be detected early and specific cognitive rehabilitation programs can be formulated.

BIBLIOGRAPHY

1. Cuerda-Ballester M, Martínez-Rubio D, García-Pardo MP, et al. Relationship of Motor Impairment with Cognitive and Emotional Alterations in Patients with Multiple Sclerosis. *Int J Environ Res Public Health*. 2023; 20(2):1387. Published 2023 Jan 12. doi:10.3390/ijerph20021387
2. Garg N, Smith TW. An update on immunopathogenesis, diagnosis, and treatment of multiple sclerosis. *Brain Behav*. 2015;5(9):e00362. doi:10.1002/brb3.362
3. Silveira SL, Cederberg KLJ, Jeng B, et al. Symptom clusters and quality of life in persons with multiple sclerosis across the lifespan. *Qual Life Res*. 2021;30(4):1061-1071. doi:10.1007/s11136-020-02689-x
4. Eshaghi A, Prados F, Brownlee WJ, et al. Deep gray matter volume loss drives disability worsening in multiple sclerosis. *Ann Neurol*. 2018;83(2):210-222. doi:10.1002/ana.25145
5. Storm FA, Nair KPS, Clarke AJ, Van der Meulen JM, Mazzà C. Free-living and laboratory gait characteristics in patients with multiple sclerosis. *PLoS One*. 2018;13(5):e0196463. Published 2018 May 1. doi:10.1371/journal.pone.0196463
6. Radetz A, Mladenova K, Ciolac D, et al. Linking Microstructural Integrity and Motor Cortex Excitability in Multiple Sclerosis. *Front Immunol*. 2021;12:748357. Published 2021 Oct 12. doi:10.3389/fimmu.2021.748357
7. Matias-Guiu JA, Cortés-Martínez A, Valles-Salgado M, et al. Functional Components of Cognitive Impairment in Multiple Sclerosis: A Cross-Sectional Investigation. *Front Neurol*. 2017;8:643. Published 2017 Nov 28. doi:10.3389/fneur.2017.00643
8. Hankomäki E, Multanen J, Kinnunen E, Hämäläinen P. The progress of cognitive decline in newly diagnosed MS patients. *Acta Neurol Scand*. 2014;129(3):184-191. doi:10.1111/ane.12161
9. Yigit P, Acikgoz A, Mehdiyev Z, Dayi A, Ozakbas S. The relationship between cognition, depression, fatigue, and disability in patients with multiple sclerosis. *Ir J Med Sci*. 2021;190(3):1129-1136. doi:10.1007/s11845-020-02377-2
10. Core R Team. A Language and Environment for Statistical Computing. Vienna: Foundation for Statistical Computing; 2024. Available from: https://www.R-project.org.
11. Bates D, Mächler M, Bolker B, Walker S. Fitting Linear Mixed-Effects Models Using lme4. *Journal of Statistical Software*. 2015;67(1):1-48. DOI: doi.org/10.18637/jss.v067.i01.
12. Spivak Y. Neurodegeneration and Cognitive Dysfunction in Multiple Sclerosis. *Reports of Vinnytsia National Medical University*, 2024;*28*(3):550-561. doi: 10.31393/reports-vnmedical-2024-28(3)-29
13. Gudzhenko GV. Cognitive impairments in multiple sclerosis. Ukrains′kyi Nevrologichnyi Zhurnal. 2020;4:37-42. doi: 10.30978/UNJ2020-4-37. (In Ukrainian).
14. Teslenko O, Tovazhnianska O. Clinical features of cognitive dysfunction in patients with relapsing-remitting multiple sclerosis. Visnyk Kharkivs′koho Natsional′noho Universytetu imeni VN Karazina. Seriia Medytsyna. 2024;32(1(48):28-39. doi: 10.26565/2313-6693-2024-48-03. (In Ukrainian).
15. Odintsova TA. Features of cognitive impairments in multiple sclerosis patients depending on various risk factors. Psykhiatriia, Nevrolohiia ta Medychna Psykholohiia. 2021;18:39-48. doi: 10.26565/2312-5675-2021-18-03. (In Ukrainian).
16. Achiron A, Chapman J, Magalashvili D, et al. Modeling of cognitive impairment by disease duration in multiple sclerosis: a cross-sectional study. *PLoS One*. 2013;8(8):e71058. doi:10.1371/journal.pone.0071058
17. Kalb R, Beier M, Benedict RH, Charvet L, Costello K, Feinstein A, et al. Recommendations for cognitive screening and management in multiple sclerosis care. *Mult Scler*. 2018;24(13):1665-1680. doi:10.1177/1352458518803785
18. Sehanovic A, Smajlovic D, Tupkovic E, et al. Cognitive Disorders in Patients with Multiple Sclerosis. *Mater Sociomed*. 2020;32(3):191-195. doi:10.5455/msm.2020.32.191-195
19. Potapov O, Kmyta O, Tsyndrenko O, Makeyenk I, Sumtsova K, Nikolaenko Y. Peculiarities of the course, diagnosis, and treatment of multiple sclerosis. *Eastern Ukrainian Medical Journal*. 2022;10(4):389-398. doi.org/10.21272/eumj.2022;10(4):389-398
20. Shulga OD. Structural changes in the brain in patients with early multiple sclerosis. *Odesa Medical Journal.* 2019;2-3:35-39. Available at:https://files.odmu.edu.ua/journal/OMJ_2019.0203/m192-3_35.pdf

Надійшла до редакції 13.11.2024 р.
Прийнята до друку 27.03.2025 р.
Електронна адреса для листування dima.andr2016@gmail.com