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DOI: <https://doi.org/10.22141/2224-0713.21.1.2025.1147>V.I. Horoshko¹ , T.M. Pavlova² , O.V. Markovska² , H.P. Samoilo² , M.S. Cherniaiev² ,
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Possibility of rehabilitation of patients with cognitive dysfunction and impairment of critical thinking in mild traumatic brain injuries

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Abstract. Background. Studying the impact of mild traumatic brain injury (TBI) on cognitive functions and critical thinking is an important task in modern neurology and rehabilitation medicine. The aim of this study is to analyze the impact of mild TBI on cognitive functions and critical thinking, and to evaluate the possibilities of rehabilitation to restore these functions. **Materials and methods.** Clinical, neuropsychological and instrumental methods were used for assessing the state of cognitive functions in mild TBI. The study involved 36 patients aged 28 to 35 years, including 20 men (55.56 %) and 16 (44.44 %) women, maintaining gender equality. They had a diagnosis of mild TBI according to the International Statistical Classification of Diseases and Related Health Problems (10th revision) under the code S06.9X9, confirmed by medical documents. **Results.** The study showed that 29 people (80 %) with mild TBI had memory and attention impairments, which manifested themselves through a decrease in the ability to remember new information and concentrate. Patients with severe cognitive impairments were found to have structural changes in the brain on magnetic resonance imaging, such as hippocampal atrophy and enlargement of the cerebral ventricles. In 15 of 36 patients, these changes correlated with worse results on all neuropsychological tests (significance level $p < 0.01$). **Conclusions.** 1. Cognitive impairment: 29 patients (80 %) with mild TBI demonstrate significant memory and attention impairment, as evidenced by a 15% decrease on Wechsler Memory Scale scores compared to the control group ($p < 0.05$). 2. Slowed information processing: 23 patients (63.8 %) have a slow speed of information processing, as indicated by a 20% increase in the time to complete tasks of the Trail Making Test compared to the control group ($p < 0.01$). 3. Impaired critical thinking: 26 patients (72 %) with mild TBI demonstrated difficulties in critical thinking and executive functions, as evidenced by an 18% increase in the number of errors on the Wisconsin Card Sorting Test compared to the control group ($p < 0.01$). 4. Gender differences: women have more cognitive impairment than men, including a 12 % lower average score on the Wechsler Memory Scale ($p < 0.05$). 5. Age differences: older patients (32–35 years) show more significant cognitive deficits than younger ones (28–31 years), in particular, the average time to complete the Trail Making Test was 25 % longer in older individuals ($p < 0.01$). 6. Neuroimaging findings: 15 of 36 patients had structural brain changes on magnetic resonance imaging, such as hippocampal atrophy and enlargement of the cerebral ventricles, correlating with worse results of neuropsychological tests ($p < 0.01$). 7. Multidisciplinary approach combining cognitive rehabilitation, physical activity, potential pharmacological treatments, and psychological support offers promising opportunities for restoring cognitive functions and critical thinking abilities in individuals with mild traumatic brain injuries.

Keywords: mild traumatic brain injury; neuropsychological tests; critical thinking; cognitive dysfunction; rehabilitation



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Introduction

Mild traumatic brain injury (TBI) is a common form of traumatic brain injury that can have a significant impact on cognitive function and critical thinking. According to the World Health Organization (WHO), approximately 69 million cases of traumatic brain injury are registered worldwide each year, of which up to 80 % are mild TBI. In European countries, the incidence of mild TBI is approximately 250–300 cases per 100,000 population. According to the Ministry of Health, in Ukraine, the annual incidence of TBI in different regions ranges from 2.3 to 6 cases (on average 4–4.2) per 1,000 population. Every year, 10–11 thousand citizens die from TBI in Ukraine, i.e. the mortality rate is 2.4 cases per 10,000 population (in the USA, 1.8–2.2). However, due to the war, these figures in Ukraine are rapidly increasing [1–3].

Mild TBI is frequently overlooked because of its seemingly minor severity, yet its long-term effects can greatly impact the victims' quality of life. Memory, attention, executive functions, and critical thinking are often impaired. This can lead to decreased professional productivity and social adaptation, which in turn affects a person's overall well-being. Research shows that the effects of mild TBI can persist for several months or even years after the trauma. Thus, in the United States, approximately 15–30 % of patients with mild TBI experience long-term cognitive impairment that affects their daily life [1].

Similar results have been obtained in studies in Europe, which demonstrated that mild TBI can lead to significant impairments in cognitive functions and critical thinking [2, 3]. Australian studies have also confirmed that mild TBI can cause difficulties in managing emotions and critical thinking. In addition, repeated mild TBIs can lead to cumulative effects, which increases the risk of developing chronic neurodegenerative diseases, such as chronic traumatic encephalopathy [4].

Recent updates to the WHO, the American Congress of Rehabilitation Medicine (ACRM) criteria and approaches to diagnosing mild TBI reflect significant advances in understanding and treating the problem. The WHO has updated its guidelines for the management of traumatic brain injury, including new monitoring and diagnostic methods to help more accurately identify and treat mild TBI, in 2021. These guidelines emphasize the importance of early diagnosis and intervention to help reduce the risk of long-term cognitive impairment and improve patients' quality of life. The ACRM has also published updated criteria for diagnosing mild TBI, considering new scientific advances and practical considerations. These criteria include the use of modern neuropsychological tests and neuroimaging tools, such as magnetic resonance imaging (MRI), to assess the extent of brain tissue damage (ACRM, 2022) [5–7].

Thus, studying the effect of mild TBI on cognitive functions and critical thinking is an important task of modern neurology and rehabilitation medicine. The development of effective rehabilitation methods and the introduction of preventive measures can significantly improve the quality of life of victims and reduce the risks of long-term negative consequences.

The purpose of the study. To analyze the impact of mild TBI on cognitive functions and critical thinking, and to evaluate the possibilities of rehabilitation to restore these functions.

Materials and methods

The study used clinical, neuropsychological and instrumental methods to assess the state of cognitive functions in patients with mild TBI. The study involved 36 patients aged 28 to 35 years, 20 men (55.56 %) and 16 women (44.44 %), maintaining gender equality. They had a diagnosis of mild TBI according to the International Statistical Classification of Diseases and Related Health Problems (10th revision) under the code S06.9X9, confirmed by medical documents. The study included patients who had suffered a mild TBI 6 months ago.

The control group included 36 healthy individuals without a history of mild TBI, who were selected considering age and gender equality, to ensure comparison with the main group. Patients with chronic diseases that could affect cognitive functions were excluded. The study was conducted for 3 months at the CE "City Clinical Hospital 3 of Poltava City Council" in 2024.

Patients' condition was assessed upon admission to the hospital and at the end of hospitalization. Clinical methods included medical examinations and history taking with an emphasis on the details of the injury and its symptoms. The purpose was to determine the general health of patients and identify possible comorbidities that could affect the results of the study. Instrumental methods included the use of neuroimaging technologies, such as MRI, to assess structural changes in the brain after mild TBI [5].

Neuropsychological methods included the use of standardized tests, such as the Wechsler Memory Scale to assess patients' short-term and long-term memory [8], the Trail Making Test to determine the speed of cognitive processes and executive functions [9], and the Wisconsin Card Sorting Test to assess the ability to plan, organize, and flexibly think [10].

The data obtained from the testing were processed using statistical methods like analysis of variance to compare averages between groups and regression analysis to determine relationships between variables. The t-test and chi-squared test were used to compare the results between the study and control groups. Student's t-test was used to evaluate the averages between two independent groups. It determines if there are statistically significant differences between the average values of cognitive indicators in patients with mild TBI and healthy individuals from the control group. T-tests were applied for each individual neuropsychological test (Wechsler Memory Scale, Trail Making Test, Wisconsin Card Sorting Test) to assess the significance of differences in results between the groups.

The chi-squared test was used to assess associations between categorical variables, such as the presence or absence of cognitive impairment in different groups. It determines if there is a statistically significant difference in the distribution of cognitive impairment between patients with mild TBI and the control group. The chi-squared test helps assess whether

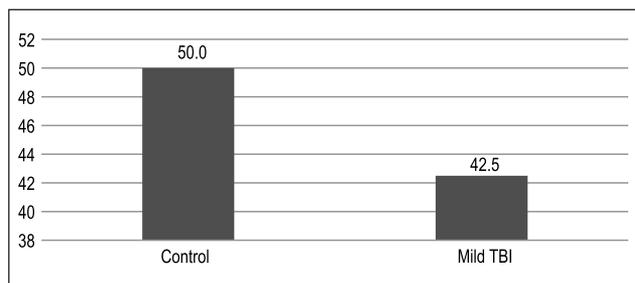


Figure 1. Average score on the Wechsler Memory Scale

there is a relationship between the results and factors that may affect cognitive functions.

The obtained *p*-values (significance level) were used to determine the statistical significance of the results. $p < 0.05$ was considered statistically significant, indicating that the differences between the groups are not random and have a high probability of existing in the general population.

In addition, Cronbach's alpha values were calculated to assess the internal consistency and reliability of the results. This detailed approach to statistical analysis ensured the reliability and validity of the findings obtained as a result of the study on the effect of mild TBI on cognitive functions and critical thinking.

Results

The study showed that 29 patients (80 %) with mild TBI had memory and attention impairment, which manifested itself in the form of a decrease in the ability to remember new information and concentrate attention. In particular, there was a decrease in the score on the Wechsler Memory Scale by 15 % compared to the control group. The average score in patients with mild TBI was 42.5, while in the control group, this figure was 50 that indicates a statistically significant difference ($p < 0.05$) (Fig. 1).

Patients with mild TBI demonstrated a decrease in cognitive functions, especially short- and long-term memory. These memory deficits affected their ability to assimilate and reproduce new information, which was confirmed by lower scores on the Wechsler Memory Scale. In 23 individuals (63.8 %), a slowdown in information processing speed was observed, which negatively affected the ability to make decisions.

In the Trail Making Test, these patients showed significantly longer task completion time. The average time to complete task A in the control group was 29 seconds, while in patients with mild TBI, this figure was 35 seconds, which is 20 % longer ($p < 0.01$). For task B, the average completion time in the control group was 75 seconds, while in patients with mild TBI — 90 seconds, which also showed an increase of 20 % ($p < 0.01$). These results indicate a significant slowing in cognitive processes in mild TBI, which negatively affects the ability to make quick decisions and process information (Fig. 2).

Impaired critical thinking manifested itself in the appearance of difficulty when analyzing and synthesizing information, impulsiveness in making decisions, and dif-

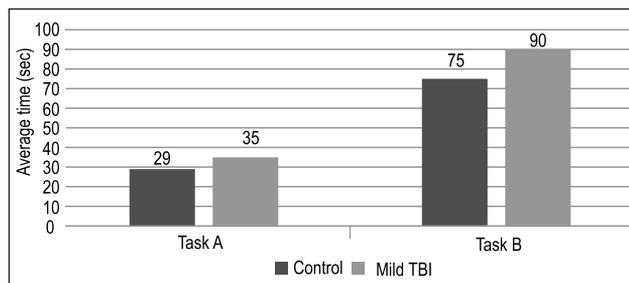


Figure 2. Results of the Trail Making Test

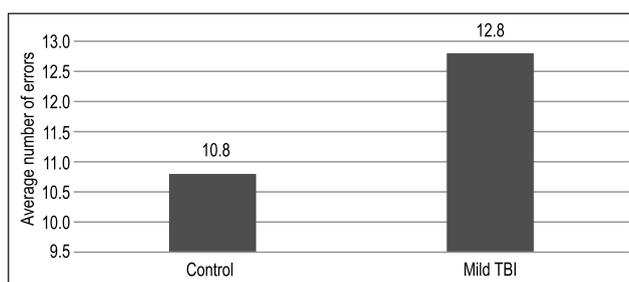


Figure 3. Score on the Wisconsin Card Sorting Test

iculty in searching for alternative options for action. In the Wisconsin Card Sorting Test, 26 of 36 patients demonstrated a decreased performance. The average number of errors in patients with mild TBI was 12.8, which is 18 % higher than in the control group (10.8 errors, $p < 0.01$) (Fig. 3). Patients with mild TBI have little difficulty adapting to changes in card sorting rules, which indicates a deficit in cognitive ability and a decrease in the effectiveness of cognitive functions.

The study also included a subgroup analysis based on age, gender, and injury severity. It was found that cognitive impairment (mostly of short-term memory) was observed more often in women than in men. The average score of women on the Wechsler Memory Scale was 12 % lower than that of men ($p < 0.05$). Older patients (32–35 years) showed more significant cognitive deficits than younger ones (28–31 years), and the average time to complete the Trail Making Test was 25 % longer in older individuals ($p < 0.01$).

Structural changes in the brain were detected by MRI in patients with the most severe cognitive impairment, such as hippocampal atrophy and enlargement of the cerebral ventricles. Fifteen of 36 patients showed these changes, which correlated with worse performance on all neuropsychological tests ($p < 0.01$).

These results confirm that mild TBI can have long-lasting and significant effects on cognitive function and critical thinking. The impairments identified suggest the need to develop effective rehabilitation and prevention methods to improve the quality of life of victims.

Discussion

The results of the study indicate that mild closed head injuries (mild TBI) have a significant impact on the cognitive functions of patients, as confirmed by the results of neuropsychological tests. However, it should be noted that

the findings also highlight an important aspect in the impact of mild TBI on critical thinking, which is key to everyday functioning and social integration of patients.

First of all, impaired critical thinking after mild TBI can affect the ability to analyze situations, formulate reasonable conclusions and make rational decisions. This is especially important in the context of professional activities and interpersonal interactions, where high quality of cognitive processes is a prerequisite for success and harmonious relationships [1, 2, 7].

The study showed that critical thinking impairment in mild TBI manifests itself in the form of difficulties when analyzing and synthesizing information, as confirmed by the results of the Wisconsin Card Sorting Test. Patients demonstrated significantly worse results compared to the control group, indicating a deficit in cognitive flexibility and a decrease in the efficiency of executive functions.

This is consistent with the data of studies by other authors, in particular, Smith et al. (2018) who found that 15–30 % of patients with mild TBI in the United States experience long-term cognitive impairment, including problems with critical thinking. In addition, it should be noted that impairments in critical thinking can have long-term consequences for patients' social and professional adjustment [1, 4]. The loss of the ability to effectively plan, analyze, and make decisions can lead to problems in work and personal life, which in turn can affect overall well-being. For example, according to studies by Jones et al. (2017) and Müller et al. (2019), individuals with mild TBI experience significant difficulties in completing complex tasks and making informed decisions, which negatively affects their professional functioning and interpersonal interactions [2, 3].

In the rehabilitation of patients with mild TBI, it is important to pay special attention to restoring critical thinking and executive functions. Rehabilitation programs should include exercises to improve memory and attention, and special training aimed at developing skills in analysis, synthesis of information, and decision-making.

Interventions, such as problem-solving therapy and cognitive-behavioral therapy, have been shown to reduce residual symptoms and improve psychological functioning in mild TBI patients [11]. Additionally, specialized cognitive training programs have demonstrated positive effects on occupational performance and client factors, contributing to overall rehabilitation success [12].

Physical exercise plays a crucial role in cognitive recovery after mild TBI. Aerobic exercises, such as walking and swimming, have been associated with improvements in attention and memory. Moreover, neuromodulation techniques like transcranial magnetic stimulation and transcranial direct-current stimulation are emerging as potential interventions to enhance cognitive functions, though further research is needed to establish their efficacy. Addressing emotional and psychological aspects is vital, as cognitive impairments often coexist with conditions like depression and anxiety. Cognitive-behavioral therapy and psychoeducation have been effective in improving outcomes for mild TBI patients, aiding in their adaptation to cognitive changes [13].

We believe that a multidisciplinary approach combining cognitive rehabilitation, physical activity, potential pharmacological treatments, and psychological support offers promising opportunities for restoring cognitive functions and critical thinking abilities in individuals with mild traumatic brain injuries.

Finally, it is important to note that further research should be aimed at developing and implementing new methods for assessment and rehabilitation of patients with mild TBI that consider all aspects of cognitive impairment, including critical thinking. It helps increase the effectiveness of treatment and improve the quality of victims' life.

Conclusions

The results of the study highlight the importance of further research and development of new approaches to rehabilitation of patients with mild closed craniocerebral injuries (mild TBI). Given the significant impact of mild TBI on cognitive functions and critical thinking, development prospects may include several key areas: new rehabilitation programs, innovative technologies in rehabilitation, neuroplasticity research, prevention of repeated injuries, interdisciplinary approach, and longitudinal studies. Thus, the development prospects in the field of research and rehabilitation of patients with mild TBI are multifaceted and include both innovative treatment methods and preventive measures. An integrated approach to the study and treatment of mild TBI will help reduce its negative impact on cognitive functions and critical thinking, thereby improving the quality of life of victims.

1. Cognitive impairment. 29 patients (80 %) with mild TBI demonstrate significant memory and attention impairment, as evidenced by a 15% decrease in Wechsler Memory Scale scores compared to the control group ($p < 0.05$).

2. Slowed information processing. 23 patients (63.8 %) have a slowed information processing speed, which is manifested itself in an increase in the time to complete tasks on the Trail Making Test by 20 % compared to the control group ($p < 0.01$).

3. Critical thinking impairment. 26 mild TBI patients (72 %) demonstrated difficulties in critical thinking and executive functions, as evidenced by an 18% increase in errors on the Wisconsin Card Sorting Test compared to controls ($p < 0.01$).

4. Gender differences. Women have more cognitive impairments than men, including average scores on the Wechsler Memory Scale that are 12 % lower ($p < 0.05$).

5. Age differences. Older patients (32–35 years) demonstrated more significant cognitive deficits compared to younger ones (28–31 years), in particular the average time to complete the Trail Making Test was 25 % longer in older individuals ($p < 0.01$).

6. Neuroimaging findings. 15 of 36 patients showed structural changes in the brain on MRI, such as hippocampal atrophy and enlargement of the brain ventricles, correlating with worse performance on neuropsychological tests ($p < 0.01$).

7. Multidisciplinary approach combining cognitive rehabilitation, physical activity, potential pharmacological

treatments, and psychological support offers promising opportunities for restoring cognitive functions and critical thinking abilities in individuals with mild traumatic brain injuries.

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Ethical norms. This study was conducted in accordance with the ethical standards set forth in the Declaration of Helsinki and with adherence to ethical principles.

Informed consent. We obtained written and oral informed consent of the patients for this investigation.

Data availability statement. This article presents details of clinical episodes; data sharing is not applicable.

Authors' contribution. V.I. Horoshko — concept and design of the study, acquisition of data, analysis and interpretation of data, drafting the article, final approval; T.M. Pavlova, O.V. Markovska — concept and design of the study, acquisition of data, analysis and interpretation of data, critical revising, final approval; H.P. Samoiloiva — concept and design of the study, analysis and interpretation of data, drafting the article, critical revising, final approval; M.S. Cherniaiev — concept and design of the study, analysis and interpretation of data, final approval; A.S. Shapkin — concept and design of the study, analysis and interpretation of data, drafting the article, final approval.

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Можливості реабілітації пацієнтів із когнітивною дисфункцією та порушенням критичного мислення при легких черепно-мозкових травмах

Резюме. Актуальність. Вивчення впливу черепно-мозкової травми (ЧМТ) легкого ступеня на когнітивні функції та кри-

тичне мислення є актуальним завданням сучасної неврології і реабілітаційної медицини. **Мета:** аналіз впливу легкої ЧМТ

на когнітивні функції та критичне мислення, а також оцінка можливостей реабілітації для відновлення цих функцій. **Матеріали та методи.** Використовували клінічні, нейропсихологічні й інструментальні методи оцінки стану когнітивних функцій при ЧМТ легкого ступеня. У дослідженні взяли участь 36 пацієнтів віком від 28 до 35 років — 20 чоловіків (55,56 %) та 16 (44,44 %) жінок, яким встановлено діагноз легкої ЧМТ згідно з 10-м переглядом Міжнародної статистичної класифікації хвороб і проблем, пов'язаних зі здоров'ям, під кодом S06.9X9, що підтверджується медичними документами. **Результати.** Дослідження показало, що у 29 осіб (80 %) із ЧМТ легкого ступеня спостерігалися порушення пам'яті та уваги, які проявлялися зниженням здатності запам'ятовувати нову інформацію та концентрувати увагу. У пацієнтів із серйозними когнітивними розладами за допомогою магнітно-резонансної томографії виявлено структурні зміни в головному мозку, як-от атрофія гіпокампа та збільшення шлуночків. У 15 із 36 осіб ці зміни корелювали з гіршими результатами всіх нейропсихологічних тестів (рівень значущості $p < 0,01$). **Висновки.** 1. Когнітивні порушення: у 29 хворих (80 %) із легкою ЧМТ значно погіршені пам'ять та увага, про що свідчить зниження оцінки за шкалою пам'яті Векслера на 15 % порівняно з контрольною групою ($p < 0,05$). 2. Уповільнена обробка інформації: 23 пацієнти (63,8 %) мають повільну швидкість обробки інформації — час на виконання завдань тесту про-

кладання маршруту збільшується на 20 % порівняно з контрольною групою ($p < 0,01$). 3. Порушення критичного мислення: 26 осіб (72 %) із легкою ЧМТ демонструють труднощі з критичним мисленням і виконавчими функціями, про що свідчить збільшення на 18 % кількості помилок у Віконсинському тесті сортування карток порівняно з контрольною групою ($p < 0,01$). 4. Гендерні відмінності: жінки мають більше когнітивних розладів, ніж чоловіки, включаючи нижчий на 12 % середній бал за шкалою пам'яті Векслера ($p < 0,05$). 5. Вікові відмінності: у хворих старшого віку (32–35 років) когнітивний дефіцит більш значний, ніж в осіб молодшого віку (28–31 рік): зокрема, середній час виконання тесту прокладання маршруту був на 25 % довшим у старших пацієнтів ($p < 0,01$). 6. Результати нейровізуалізації: 15 із 36 пацієнтів мали структурні зміни мозку за результатами магнітно-резонансної томографії, як-от атрофія гіпокампа і збільшення шлуночків, що корелює з гіршими результатами нейропсихологічних тестів ($p < 0,01$). 7. Мультидисциплінарний підхід, який поєднує когнітивну реабілітацію, фізичну активність, потенційне фармакологічне лікування й психологічну підтримку, пропонує багатообіцяючі можливості для відновлення когнітивних функцій і здібностей критичного мислення в осіб із легкими черепно-мозковими травмами.

Ключові слова: черепно-мозкова травма легкого ступеня; нейропсихологічні тести; критичне мислення; когнітивна дисфункція; реабілітація