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CORRELATION BETWEEN RESILIENCE AND COGNITIVE FUNCTIONING IN VETERANS WITH TRAUMATIC BRAIN INJURY

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Key words: *traumatic brain injury, cognitive functions, resilience, veterans*
Ключові слова: *черепно-мозкова травма, когнітивні функції, резилієнс, ветерани війни*

Abstract. Correlation between resilience and cognitive functioning in veterans with traumatic brain injury. Assonov D.O. *Resilience in veterans with brain trauma in remote period has received considerable attention over the past years. Cognitive functioning is described among factors that may influence resilience and included in the modern theoretical models of this positive psychology phenomenon. However, the characteristics of relationship between resilience and cognitive functioning in veterans with traumatic brain injury (TBI) in remote period was not studied* *empirically. Therefore, the purpose of this study was to gain better understanding of the possible association between resilience and cognitive functioning in Ukrainian war veterans with traumatic brain injury in remote period. This study included 146 veterans who were admitted to two clinical hospitals for war veterans. The Connor-Davidson Resilience Scale and Montreal Cognitive Assessment Scale were used. The present study shows that lower cognitive functioning in total and in several domains is associated with less effective resilience regardless of TBI clinical type (whether it is concussion or mild cerebral contusion). Moreover, such correlation was still present after excluding the effect of age, education and TBI characteristics like number of traumas and time since last TBI. Overall, we found empirical evidence that good cognitive functioning (especially executive functions, memory, attention, abstract thinking, and orientation) is essential for effective resilience in veterans with mild TBI even years after trauma and has more effect on ability to adapt than age, education, and trauma characteristics. Educating veterans to use their cognitive potential and to compensate the restrictions after mild TBI possibly may lead to better overcoming adversities and counteracting the risks of desadaptation and traumatic events. Therefore, psychological interventions for improving the ability to readapt and recover possibly should consider this relationship and include the component of educating veterans to use their cognitive reserve and compensate limitations to better adapt and thrive. Studies related to such interventions appear to be promising.*

Реферат. Взаємозв'язок між резилієнсом і когнітивними функціями у ветеранів з черепно-мозковою травмою. Ассонов Д.О. *Останніми роками велика увага приділяється резилієнсу ветеранів з черепно-мозковою травмою у віддаленому періоді. Когнітивне функціонування розглядається як один з факторів, які можуть впливати на резилієнс та є елементом сучасних теоретичних моделей цього концепту позитивної психології. Однак особливості взаємозв'язку резилієнсу та когнітивних функцій у ветеранів із черепно-мозковою травмою (ЧМТ) у віддаленому періоді емпірично не вивчалися. Тому метою цього дослідження було краще зрозуміти можливий зв'язок між резилієнсом та когнітивним функціонуванням українських ветеранів війни з черепно-мозковою травмою у віддаленому періоді. У дослідженні взяли участь 146 ветеранів, які були госпіталізовані до двох клінічних госпіталів для ветеранів війн. Для психодіагностичного обстеження було використано шкалу резилієнсу Коннора-Девідсона та Монреальську шкалу оцінки когнітивних функцій. Було виявлено, що погіршення когнітивного функціонування в цілому та в деяких когнітивних функціях зокрема пов'язане з менш ефективним резилієнсом незалежно від клінічного типу ЧМТ (струс мозку або забій головного мозку легкого ступеня). Більше того, така кореляція зберігалася і після врахування впливу віку, освіти та характеристик ЧМТ, таких як кількість травм та час, що минув з моменту останньої ЧМТ. Таким чином, виявлено емпіричні докази того, що добре когнітивне функціонування (виконавчі функції, пам'ять, увага, абстрактне мислення та орієнтування зокрема) навіть через роки після травми має важливе значення для ефективного резилієнсу ветеранів з легкою ЧМТ та більше впливає на здатність до адаптації, ніж вік, тривалість освіти чи особливості травми. Навчання ветеранів використання свого когнітивного потенціалу та компенсування обмежень після легкої ЧМТ, ймовірно, може покращити навички подолання негараздів та протидії ризикам травматичних подій та дезадаптації. Отже, психологічні інтервенції для покращення здатності до реадаптації та відновлення можуть враховувати цей взаємозв'язок та включати навчання ветеранів використання свого когнітивного резерву та компенсації обмежень для кращої адаптації та розвитку. Необхідні подальші дослідження подібних інтервенцій.*

Traumatic brain injury (TBI) is one of the conditions that has a significant negative impact on social reintegration and readaptation mechanisms in war veterans [1]. In the acute period symptoms of TBI are driven by different pathophysiological processes, while in the remote period the persistence of TBI symptoms is affected by psychological factors such as maladaptive behavior and cognitive patterns, that leads to chronic stress [2]. Thus, there is a need for improving rehabilitation of veterans with persistent consequences of TBI, and may be a path to the effective rehabilitation an impact on these psychological factors via behavioural interventions. Modern approaches to the rehabilitation of patients with TBI include the proposals to make a shift from problem-centered narratives to identification of strengths, development of flexibility and new cognitive patterns and behavior while accepting the limitations after TBI [3].

One of the important adaptation concepts in these approaches is resilience – a process that reflects the dynamic ability of a person to restore adaptive and effective psychosocial functioning and personal growth after a period of maladaptation, which occurred due to the disorganizing effect of traumatic factors [4]. It was reported that resilience negatively correlates with neurobehavioral symptoms of TBI even years after the brain injury [5]. Better resilience in veterans relates to less quantity of mental problems, good quality of life in both groups with and without TBI history [6, 7]. The other good side of resilience is that opposite to many stable personality traits, it is modifiable [8]. Thus, there is a need to study this phenomenon in the context of rehabilitation of veterans with TBI.

A processual model, proposed by Stainton et al., defines resilience as a process in which person interacts with present protective factors and utilizes them to overcome adversities and counteracts the risks and effects of desadaptation [9]. In a meaning-oriented model of resilience in TBI, suggested by Nalder et al., cognitive regulatory processes include controlling negative and ineffective thoughts by interacting with cognitive skills (awareness, memory, executive functions) as cognitive protective factors, and leading to resilience-related outcomes like re-engaging the valuable activities after the injury, disengaging from old life goals and identification of new priorities, learning to accept their limitations, re-evaluating what is most important [10]. Cognitive abilities, like memory, cognitive flexibility, switching attention, that are often declined after TBI, are accepted to play an important role in driving resilience and supposed to be crucial for successfully overcoming the desadaptation after stressful events [9]. However, despite the potential of these and other theoretical models to describe the nature of resilience, the authors recognize that further studies are needed to gain more evidence and isolate the factors linked to better resilience [9, 10].

Since cognitive functioning is indicated as one of the most important factors and processes of resilience in theoretical models of resilience in TBI, empirical examination of relationship between those two psychological phenomena seems to be promising. However, despite the clinical significance of such evidence, we did not find any studies that give a characteristic of this relationship in the population of veterans with TBI. Therefore, the purpose of the present study was to gain better understanding of the possible association between resilience and cognitive functioning in Ukrainian war veterans with brain trauma in remote period.

MATERIALS AND METHODS OF RESEARCH

The study has a cross-sectional design**.** A total of 146 Ukrainian veterans of Anti-Terrorist Operation/Joint Forces Operation in Ukraine with traumatic brain injury in the remote period (with ≥3 years after brain trauma event) were recruited in Hospital for War Veterans "Forest Glade" ("Lisova Poliana") of Ministry of Health of Ukraine and Kyiv City Clinical Hospital for War Veterans.

The enrollment was done in the period from 2019 to 2021. All participants were enrolled after giving the written informed consent. Participants' resilience was measured with the Connor-Davidson Resilience Scale (CD-RISC) [11] and cognitive functioning measured with the Montreal Cognitive Assessment Scale (MoCA) [12]. Connor-Davidson Resilience Scale (CD-RISC) developed by Connor, K.M., and Davidson, J.R.T. contains 25 statements, which patient should evaluate on a scale from 0 to 4, with higher total score, ranging from 0 to 100, connected with better resilience [11]. The CD-RISC scale is widely used valid, reliable, and consistent measure of resilience [11]. Montreal Cognitive Assessment Scale (MoCA) is a tool for assessment of mild cognitive impairment [12]. The total score ranges from 0 to 30 points, more than 26 points are interpretated as normal cognitive functioning. To assess different cognitive domains, we chose the method of differentiating scores on MoCA subscales: visual-spatial/executive abilities (up to 5 points), naming (up to 3 points), attention (up to 6 points), language (up to 5 points), abstraction (up to 2 points), delayed recall (up to 5 points), orientation (up to 6 points) [13].

The study was done according to principles of the Helsinki Declaration. Study's protocol was approved by the Committee of Bioethical Expertise and Ethics of Scientific Research of the Bogomolets National Medical University (protocol No. 127/02.12.2019) and a part of the research program "Dynamic biopsychosocial model of medical and psychological care (diagnosis, therapy, rehabilitation, prevention) of patients of multidisciplinary hospitals in a rapidly changing crisis-associated society" performed by the department of medical psychology, psychosomatic medicine, and psychotherapy (registration No. 0119U103910).

To check the assumption of normal distribution Shapiro-Wilk test was used. To assess relationships between different cognitive functions and resilience, Pearson and Spearman correlation coefficients were used (as applicable). P value less than 0,05 was interpreted as a statistically significant. The results are presented as a mean and standard deviation or median and interquartile range (as applicable). Correlation data are presented by indicating the coefficient and p level. Correlation between cognitive functioning and resilience with covariates of age, education, TBI clinical type, number and duration since last injury were tested using multivariate regression analysis as more flexible method allowing to model more than 1 independent variable to explain the dependent variable [14]. Storage of data was done in a licensed Microsoft 365 Excel (license by order No. 1212591279) and analysis was conducted in R programming language, using free statistical software EZR on R commander v 1.54 [15]. Data visualization was done in Python programming language using pandas, matplotlib and seaborn modules.

RESULTS AND DISCUSSION

Five of the participants (3.4%) were females, the rest were males. Eighty-three veterans (56.8%) lived with the spouse while sixty-three (43.1%) were single. The most frequent type of TBI in this sample was concussion, with eighty-three patients (56.8%) having a history of this clinical type of TBI. Sixty-three veterans (43.1%) were found to have a history of mild cerebral contusion. Patient characteristics and Shapiro-Wilk normality test results are shown in Table 1.

A significant positive correlation between CD-RISC score and MoCA total score ($r=0.413$, 95% CI 0.269-0.54, $t=5.44$, $p<0.001$) was found, as shown in the Figure 1. As it can be also seen, the correlation is relevant for both concussion (r=0.444, 95% CI 0.253-0.602, t=4.46, p<0.001) and mild cerebral contusion (r=0.393, 95% CI 0.161-0.584, t=3.34, p=0.001) clinical types.

Table 1

Patient demographic and clinical characteristics

	N	Mean	SD	Median	Q1-Q3	Min	Max	W	p
Age (years)	146	46.03	8.59	45.5	40.25–52	24	64	0.989	0.319
Education (years)	146	14.01	3.10	14	12-16	8	24	0.972	0.005
Time since injury (years)	146	5.44	1.24	6	5-6	3	7	0.882	0.001
Deployment duration	146	2.10	1.60	1	1-3	1	7	0.722	0.001
TBI number	146	1.21	0.55	1	1-1	1	4	0.436	0.001
Psychometric characteristics									
CD-RISC	146	62.17	13.08	63	53–71	22	100	0.993	0.772
MoCA total score	146	22.65	3.39	23	20.25–25	13	30	0.985	0.134
Executive function	146	3.49	0.94	4	3-4	2	5	0.868	0.001
Naming	146	2.92	0.26	3	3-3	2	3	0.289	0.001
Attention	146	4.34	1.06	4	4-5	2	6	0.899	0.001
Language	146	2.08	0.76	2	2-3	0	3	0.810	0.001
Abstraction	146	1.67	0.51	2	1-2	0	2	0.616	0.001
Delayed recall	146	2.66	1.17	3	2-3	0	5	0.928	0.001
Orientation	146	5.46	0.51	5	5-6	4	6	0.663	0.001

Results of further evaluation of the correlation between seven cognitive domains and resilience, as well as correlation between different cognitive functions are presented in the Figure 2. There were found statistically significant positive correlations between CD-RISC score and executive functions (p<0.001), attention (p<0.001), abstract thinking (p<0.001), memory (p<0.001) and orientation (p<0.001). No statistically significant correlations were found between resilience and naming MoCA subtest, as well as between resilience and language cognitive domain.

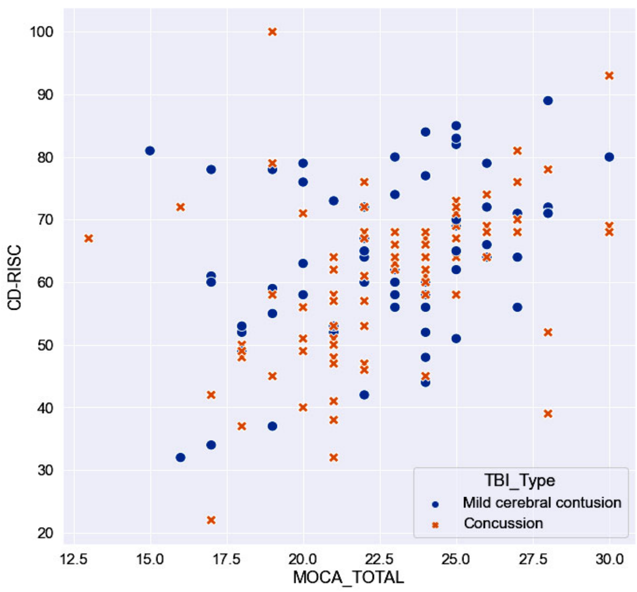

Fig. 1. Correlation of CD-RISC score and MoCA total score

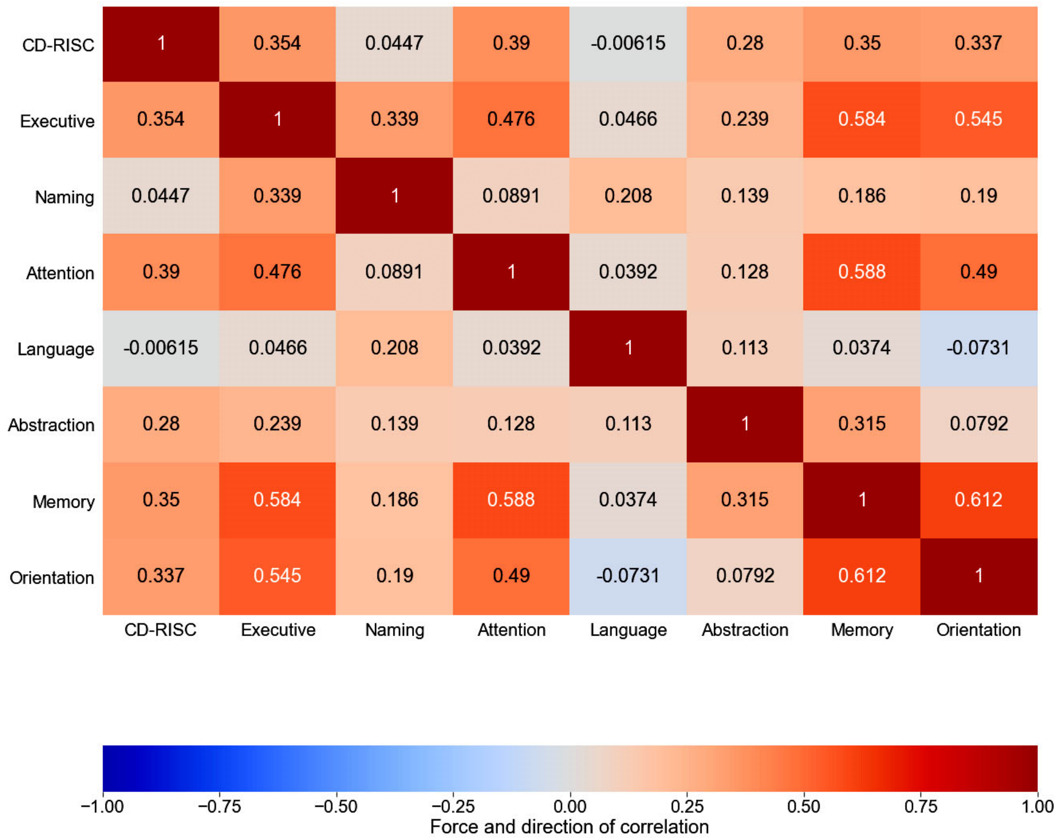

Fig. 2. Heatmap correlation matrix, representing force and direction of correlation between cognitive functions and resilience

Cognitive functioning significantly correlated with CD-RISC by multivariate regression analysis excluding the effect of age, education and TBI characteristics (clinical type, number of traumas and time since trauma), as seen in the Table 2. Multiple r^2 was 0.19, adjusted r^2 was 0.16 (p=0.001).

Table 2

Multivariate regression analysis

	B	St. β	S.E.	t	p
Intercept	**20.69**	**0**	**11.13**	**1.85**	**0.06**
MoCA Total score	**1.60**	**0.41**	**0.29**	**5.42**	**0.001**
Age	**0.07**	**0.04**	**0.11**	**0.64**	**0.52**
Education	**0.07**	**0.01**	**0.32**	**0.23**	**0.81**
TBI number	**1.09**	**0.04**	**1.80**	**0.60**	**0.54**
TBI type (1 – contusion)	**3.66**	**0.13**	**2.03**	**1.79**	**0.07**
Time since trauma	**-0.41**	**-0.03**	**0.81**	**-0.51**	**0.60**

Notes: MoCA – Montreal Cognitive Assessment; TBI – traumatic brain injury; B – regression coefficient; St. β – standardized regression coefficient; S.E. – standard error; t – Student's test value; p – type I error probability value.

As far as we know, this is the first study, in which such relationship is characterized in population of veterans with TBI in remote period. We found a positive relationship between resilience and such cognitive functions, as executive functions, memory, attention, abstract thinking, and orientation in veterans with brain trauma even years after traumatic event. Overall, these data show that lower cognitive functioning in total and in several domains particularly are associated with less effective resilience regardless of mild TBI clinical type (whether it was concussion or mild cerebral contusion). What we also find important is that such correlation was still present after excluding the effect of age, education and TBI characteristics like number of traumas and time since last TBI.

Our results provide some ground to certain theoretical models of resilience in TBI, discussed recently, where cognitive processes lie in the core of this phenomenon and are vital for effective readaptation and overcoming traumatic events [10].

Results presented in this paper were also concordant with findings of other studies. In a recent study of non-veteran population with remote TBI (2022) authors provided evidence that cognitive decline in 1 year after TBI was associated with greater psychological distress and lower satisfaction with life, while cognitive decline in remote period itself was predicted by preinjury depression (and, possibly, low resilience) [16].

Flora K. et al. (2018) also reported about moderate correlation between resilience and cognitive decline [17] in adult non-clinical population. Similar data with $r \approx 0.3$ was found in the study of Deng M. et al. (2018) [18] in population of patients with schizophrenia. A recent big study with a sample of 7535 elderly people (2021) with generalized linear model with adjustment to socio-demographic factors, comorbidities and lifestyle as a statistical method also shown that resilient participants had a significantly higher cognitive functioning, while participants with depression – lower ones [19].

In the study of Yao Z. and Hsieh S. (2019) they argue that cognitive flexibility is important for resilient overcoming the adversities and suggest, that cognitive training interventions may preserve the cognitive functioning that facilitates the resilient behavior [20]. Our findings in including cognitive training elements to psychotherapy of veterans with TBI (2021) gave the same results, adding evidence that enhancing cognitive functioning is vital for promotion of resilience [21]. Arici-Ozcan N. et al. (2019) found that people with higher cognitive functioning and flexibility also have less difficulties in emotional regulation, which, in its turn, leads to increase in resilience [22]. Considering the frequency of emotional regulation problems in veterans with TBI, this explanation of how cognitive flexibility related to resilience sounds possible.

Ziv Ben-Zion et al. (2018) found that cognitive flexibility is a significant predictor of PTSD symptom severity in survivors of traumatic events [23]. TBI and PTSD are highly comorbid in veterans [24], therefore, effective cognitive functioning may be the key target in future interventions for veterans with such comorbidity.

This allows to suggest that a common processes and mechanisms may underlie the cognitive decline and reduction in ability to adapt and recover in patients of different age and with different pathology. The role of cognitive domains like executive functions, memory, attention etc. in resilience of veterans with TBI in remote period now also have empirical evidence.

This study was subject to the several following limitations. First, correlation does not imply causation, so the results of this study need to be interpreted taking this into account when building factor models. Second, the study sample underrepresents the population of female veterans. Third, the data were taken only from veterans seeking help in Ukrainian hospitals. Fourth, only data from mild traumatic brain injury (concussion and mild cerebral contusion) were taken. Fifth, data was taken only from patients willing to participate in the study. Further studies may fill those gaps.

Our findings might become useful in creating more complex models, that include other potential factors and processes to predict the resilience of veterans with TBI and ability to adapt and thrive despite adverse situations. Another interesting possible implication of these findings may be in case of creating new psychological interventions to cultivate resilience in veterans with TBI in remote period. Including compensation of cognitive decline in such interventions and resilience development via targeting at different cognitive functions appear to be promising.

CONCLUSIONS

1. We found empirical evidence that good cognitive functioning is essential for effective resilience processes in veterans with mild traumatic brain injury even years after trauma and have more effect on ability to adapt than age, education, and trauma characteristics.
2. Better cognitive skills in such cognitive domains as executive functions, memory, attention, abstract thinking, and orientation may predict that veterans with traumatic brain injury will overcome the negative effects of stressogenic events or psychological traumas more successfully and may promote better readaptation, possibly via better understanding and controlling risk factors and how to effectively use all protective resources to overcome the adversities.
3. Compensating cognitive decline after trauma in veterans may lead to better ability of identifying priorities, re-evaluating the meaning, re-engaging the

valuable activities, building new life goals, and accepting own's limitations.

4. Training of veterans to use their cognitive potential and to compensate the restrictions after mild traumatic brain injury possibly may lead to better overcoming adversities and counteracting the risks of desadaptation and traumatic events. Therefore, psychological interventions for improving the ability to readapt and recover possibly should consider this relationship and include the component of training veterans to use their cognitive reserve and compensate limitations to better adapt and thrive. Studies related to such interventions appear to be promising.

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