

## Original Article

# Cognitive dysfunction in military personnel – combatants with metabolic syndrome

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### Abstract

Cognitive dysfunction is a frequent yet underrecognized complication of metabolic syndrome (MS), with important medical and social implications. Impairment of cognitive abilities in these patients can reduce quality of life and increase the long-term risk of dementia and social maladaptation. This study evaluated the prevalence and clinical features of cognitive disorders (CDs) in military personnel—combatants—diagnosed with MS. Eighty-two patients with MS (main group) and 40 patients with arterial hypertension (AH) without MS (control group) underwent comprehensive assessment, including neuropsychological testing, biochemical analysis (lipid profile, glucose), blood pressure measurement, and statistical evaluation. Absence of cognitive impairment was significantly more frequent in the control group ( $\chi^2=11.7$ ,  $p<0.01$ ), whereas moderate CDs predominated in the MS group ( $\chi^2=4.2$ ,  $p<0.05$ ). The MS group demonstrated significantly lower performance across most neuropsychological measures, including screening scales, auditory-verbal memory, attention, processing speed, speech, and spatial orientation. Depression and anxiety scores correlated negatively with MMSE ( $r=-0.3$ ,  $p<0.05$ ) and positively with deficits in word memorization, naming, and attention tasks. Elevated triglycerides were associated with poorer attention and delayed recall ( $p<0.05$ ), while low high-density lipoprotein (HDL) levels correlated with more errors in delayed reproduction ( $p<0.05$ ). Findings indicate that in military personnel with MS, CDs are predominantly neurodynamic and, at present, do not result in complete social or domestic maladaptation. However, affected individuals remain at elevated risk for progression to severe cognitive impairment and dementia, underscoring the need for early detection and targeted preventive interventions.

**Keywords:** metabolic syndrome, cognitive disorders, metabolic disorders, hypertriglyceridemia, military personnel, combatants

### Introduction

Stress factors in the combat environment impair the ability of military personnel to perform their duties due to cognitive function deterioration. In addition to stress factors caused by the combat situation, somatic diseases also have a depressing effect on cognitive functions.

Over the last decade, researchers have been drawn to the importance of metabolic syndrome (MS) as a risk factor not only for cardiovascular diseases and type 2 diabetes mellitus, but also for cognitive disor-

ders (CDs), as well as accelerated cognitive aging [1–3]. The significance of CDs in MS is determined, on the one hand, by their psychosocial consequences and, on the other hand, by the negative impact on patients' adherence to drug and non-drug therapy [4, 5].

It has been established that MS is associated with impairments in memory, visual-spatial gnosis, executive functions and reaction speed [3, 6]. Patients with MS have a higher risk of developing severe CDs in old age, including vascular dementia and dementia due to Alzheimer's disease [7, 8]. Pointing to the close connection and presence of common pathogenetic links



between cardiometabolic and CDs, several authors suggest using the term "metabolic-cognitive syndrome" and focus on its holistic study [2].

Various models describing the influence of MS on cognitive activity have been substantiated. In particular, among them, there are those suggesting the leading importance of micro- and macrovascular changes, genetic factors, oxidative stress, neuroinflammatory factors, and disorders of lipid and glucose metabolism in the brain [3, 6]. However, a unified approach and general understanding of the interaction and mutual influence of these pathogenic factors have not yet been developed. There is no unambiguous answer to the question of whether the adverse effects of MS are a simple sum of the effects of its components, or whether MS has an independent significance in the development of CDs [9, 10].

In recent years, the results of research in this area have become increasingly controversial. In particular, several studies have not found a correlation between MS and CDs, including dementia, despite CDs being associated with individual components of MS [11, 12]. MS has prognostic significance about CDs only if it is stable, that is, in the absence of positive dynamics of cardiometabolic parameters [13].

Thus, a detailed study of the clinical and neuropsychological patterns of development of non-dementia CDs in MS among military personnel who participated in combat operations seems to be an important and relevant scientific problem of military medicine.

The aim of our work is to determine the prevalence and clinical characteristics of CDs in military personnel, combatants with MS.

## Material and methods

In total, the study included 127 military personnel – participants in the Russian-Ukrainian war (99 men, 28 women) aged from 25 to 60 years (average age –  $50.6 \pm 5.4$  years), who were hospitalized in the cardiology clinic of the Military Medical Clinical Center of the Western Region (MMCC WR) (Lviv). The study was approved by the local ethics committee of the MMCC WR. The main group consisted of 82 patients with MS, the control group consisted of 40 patients with arterial hypertension (AH), but without indications of MS during an objective examination. The socio-demographic characteristics of the subjects are presented in Table 1.

The age of the majority of those examined was between 40 and 60 years. The subjects also differed in

marital status – most patients were married. The examination assessed blood pressure (BP), anthropometric characteristics, serum glucose levels, lipid levels, and cognitive functions. BP measurements were taken while sitting, after a 5-minute rest, on the right arm, three times, with calculation of the average of the last two measurements. Waist circumference was measured with a measuring tape while standing at the end of exhalation. The tape was positioned strictly horizontally, parallel to the floor, at the level of the crista iliaca. Blood was collected from the vein on an empty stomach in the morning. Serum glucose and lipid levels were determined using the "HUMASTAR 300" device (Germany).

When assessing the severity of MS components, the criteria proposed by the International Diabetes Federation, the National Heart, Lung, and Blood Institute, the World Heart Federation, the International Atherosclerosis Society, and the American Heart Association:

- Waist circumference  $\geq 94$  cm for men and  $\geq 80$  cm for women;
- Triglyceride level  $\geq 1.7$  mmol/l or taking lipid-lowering therapy;
- High-density lipoprotein (HDL) levels  $< 1.0$  mmol/L in men and  $< 1.3$  mmol/L in women;
- Blood plasma glucose level  $\geq 5.6$  mmol/l or taking hypoglycemic therapy;
- BP  $\geq 130/85$  mmHg or regular use of antihypertensive therapy.

All patients underwent an extensive neuropsychological examination, with both qualitative and quantitative assessments of the results obtained. The following methods were used: Mini-Mental State Examination (MMSE, Folstein M. *et al.*, 1975), Clock drawing test (CDT, Lovestone S. *et al.*, 2001), Verbal association test (Borkowski J. *et al.*, 1976), Digit span test (Wechsler D., 1945), Boston naming test (BNT, Kaplan J. *et al.*, 1978), Schulte test (Bleicher V.M., 2002), study of visual memory (Luria A.R., 1969), Wisconsin card sorting test (WCST, Berg E. *et al.*, 1948), Line orientation test (Benton A., 1975), memorisation of 10 words (Rosen W. *et al.*, 1984) [14–18].

The following were used to assess the emotional state of the patients: Beck depression inventory (Beck A.T., 1961), Spielberger state anxiety scale (Spielberger C.D., 1970).

Methods of statistical analysis of the data included standard descriptive statistics (frequencies, mean, and standard error of the mean). The conformity of the distribution of indicators to normality was assessed using

Table 1: Main socio-demographic characteristics of patients in the study groups.

Socio-demographic characteristics		The main group (n=82)	The control group (n=40)
Age	≤40 years	32 (39%)	17 (42.5%)
	>40 years	50 (61%)	23 (57.5%)
Education	Secondary (special)	48 (58.5%)	24 (60%)
	Higher	34 (41.5%)	16 (40%)
Marital status	Never been married	6 (7.3%)	4 (10%)
	Divorced	10 (12.2%)	5 (12.5%)
	Married	66 (80.5%)	31 (77.5%)

the Kolmogorov-Smirnov criterion. When comparing subgroups by qualitative indicators, the Chi-square test and Fisher's exact test were employed. For comparing quantitative indicators within subgroups, the Student's t-test and the Mann-Whitney U-criterion were used. Statistical analysis of the data was carried out using the IBM SPSS Statistics 19.0 program.

## Results

The structure of MS is dominated by elevated BP, hyperglycemia, hypertriglyceridemia, reduced HDL levels, and central obesity (Table 2).

When comparing the severity of CDs in patients of the studied groups, it was found that the absence of cognitive functions ( $\chi^2=11.7$ ,  $p<0.01$ ) was significant-

ly more common in patients of the control group. In contrast, patients in the main group had moderate CDs ( $\chi^2=4.2$ ,  $p<0.05$ ). There was no significant difference in the frequency of mild CDs between the groups ( $\chi^2=1.8$ ,  $p>0.05$ ) (Table 3).

When comparing cognitive functions, patients in the main group showed lower results in most of the neuropsychological tests used than the control group. The differences were statistically significant in both the screening scales of the MMSE and the Clock drawing test, as well as in the indicators of auditory-verbal memory, attention and concentration, speed of completing neuropsychological tests, speech production, and spatial orientation. Especially significant were the differences on the scales assessing the functions of the frontal lobes of the brain, including the learning and consolidation of the action program, the ability to

Table 2: Components of MS in patients of the study groups.

Cardiometabolic parameters	The main group (n=82)	The control group (n=40)	p
Waist circumference, cm	96.9±3.5	88.7±2.2	<0.05
Triglyceride level, mmol/l	1.9±0.6	1.4±0.4	<0.05
High-density lipoprotein level, mmol/l	1.1±0.4	1.5±0.3	<0.05
Blood plasma glucose level, mmol/l	5.9±0.5	5.5±0.3	<0.05
Systolic BP, mmHg	154.9±3.7	146.0±2.0	<0.05
Diastolic BP, mmHg	88.0±2.5	84.1±1.6	>0.05

Table 3: Frequency of CDs in patients of the study groups.

Degree of severity of CDs	The main group (n=82)	The control group (n=40)
Lack of CDs	14 (17.1%)	12 (30%)
Mild CDs	46 (56.1%)	21 (52.5%)
Moderate CDs	22 (26.8%)	7 (17.5%)

Table 4: Comparison of cognitive function indicators in patients of the study groups.

Neuropsychological tests	The main group (n=82)	The control group (n=40)	p
MMSE	26.0±0.4	26.9±0.2	<0.05
Auditory-verbal memory, memorisation of 10 words	3.5±0.4	2.1±0.3	<0.01
Correct answers, Boston naming test	40.8±2.4	46.6±1.6	<0.05
Semantic clues	10.1±1.2	6.3±0.8	<0.01
Phonetic clues	7.9±1.3	4.9±0.7	<0.05
Wrong answers, Boston naming test	2.1±0.7	1.2±0.3	>0.05
Line orientation test	21.7±4.2	24.1±2.4	>0.05
Schulte test	48.4±2.1	41.5±1.5	<0.01
Clock drawing test	8.2±0.3	9.0±0.2	<0.05
Litteral associations, Verbal association test	8.8±1.5	11.6±0.8	<0.05
Categorical associations, Verbal association test	11.0±1.6	14.7±0.9	<0.05
Repetition of numbers, direct order	6.0±0.8	6.8±0.5	>0.05
Repeating numbers, reverse order	3.9±0.6	4.7±0.7	>0.05
Wrong answers, Wisconsin test	34.5±3.3	24.2±2.1	<0.01
Number of categories, Wisconsin test	5.3±1.1	8.0±0.8	<0.05
Number of unfinished categories, Wisconsin test	2.4±0.5	1.3±0.2	<0.05
Assimilation, Wisconsin test	19.3±2.3	12.2±1.4	<0.01
Chaotic answers, Wisconsin test	0.7±0.2	0.25±0.1	<0.05
Perseverations, Wisconsin test	12.1±1.9	6.7±0.8	<0.01
Conceptualisation, Wisconsin test, %	86.2±1.1	92.2±2.0	<0.01

generalise and analyse, conceptualisation, the number of perseverations, and chaotic answers (Table 4).

Analysis of the nature of CDs in patients with MS has shown that they affect to a greater or lesser extent all spheres of cognitive activity, but to a greater extent, neurodynamic indicators of cognitive functions (speech activity, ability to concentrate attention, speed of psychomotor processes). None of these patients had primary and pronounced hippocampal-type memory disorders. It should be noted that the patients included in the study were predominantly middle-aged, in whom the development of degenerative brain damage (Alzheimer's disease) is relatively rare. However, it can-

not be excluded that in the future (especially in the absence of adequate treatment) they may also develop amnesic disorders.

In the group of patients with MS, a significantly higher level of depression and personal anxiety was diagnosed when compared with the control group (Table 5).

Emotional disorders were detected in 51 (62.2%) patients with MS and were characterised by the presence of mild depression and moderately expressed constitutional and situational anxiety. Combined anxiety-depressive disorders were observed in the majority of cases, 26 (31.7%) patients.

Table 5: Comparison of emotional state indicators in patients of the studied groups.

Scales	The main group (n=82)	The control group (n=40)	p
Depression	13.8±0.7	10.8±1.3	<0.05
Situational anxiety	40.3±2.6	38.0±3.5	>0.05
Personality anxiety	46.2±1.9	40.1±2.3	<0.05

Emotional disturbances had an impact on patients' cognitive functions. A correlation was found between the index of depression, anxiety, and scores on the MMSE ( $r=-0.3$ ,  $p<0.05$ ), memorization of 10 words ( $r=0.3$ ,  $p<0.05$ ), the Boston Naming Test ( $r=0.4$ ,  $p<0.05$ ), and the Schulte test ( $r=0.3$ ,  $p<0.05$ ). Differential diagnosis of CDs and emotional disorders is not always possible due to their frequent combination. Gauthier S. and Touchon J. even distinguish a special "dysthymic" type of moderate CDs, in which cognitive deficit is combined with moderately expressed but persistent depressive syndromes.

The component of MS most closely associated with cognitive dysfunction was hypertriglyceridemia (in 41.5% as opposed to 17.1% in the control group;  $p<0.05$ ). Correlations were found between lipid metabolism indices and success on tests to assess attention and memory (delayed replay): elevated triglycerides were more likely to result in decreased concentration of attention (in 66.1% as opposed to 36.6% with values of control group;  $p<0.05$ ), as well as decreased memory (in 89% as opposed to 48.9%;  $p<0.05$ ). More frequent errors in the delayed reproduction task were noted with reduced levels of HDL (in 74.4% of participants, as opposed to 46.3% in the control group;  $p<0.05$ ).

## Discussion

The present study was aimed at assessing the role of MS and its components in the formation of the risk of CDs in combatants, who are young and middle-aged individuals. Despite the wide representation of works confirming the association between MS and an increased risk of CDs, some studies indicate an ambiguous nature of this relationship [19–23].

The data we obtained are consistent with that part of the studies that indicate a greater vulnerability of the cognitive sphere in patients with MS [23, 24]. For example, in a prospective study of 993 individuals with an observation period of 16 years, it was found that the presence of MS and the number of MS components are associated with a deterioration of memory and executive cognitive functions (cognitive control functions) [23]. In a cross-sectional study including 1898 respondents aged 18 to 86 years, the presence of MS and insulin resistance was found to be associated with impaired executive cognitive function [24].

The present study established the leading importance of hypertriglyceridaemia as the component of MS most closely associated with cognitive dysfunction.

The obtained results are consistent with those of the Three-City Study [25], which established the key prognostic roles of hypertriglyceridemia and low HDL in cognitive decline. Similarly, other authors have noted an increased risk of CDs associated with elevated levels of total cholesterol and triglycerides [26], although the results of these studies are contradictory [27, 28].

The only component of MS not associated with cognitive dysfunction in the present study was elevated plasma glucose levels. This is an unexpected result, given the widespread evidence in the scientific literature of the negative effect of hyperglycaemia on cognitive performance [29]. However, this result is not unique. The prospective studies PROSPER and Rotterdam Study did not reveal the prognostic significance of glucose level and insulin resistance in the formation of the risk of CDs in individuals without diabetes mellitus [30]. The effects of hyperglycemia could be identified by choosing a different threshold value for the plasma glucose level. It can also be assumed that the relationship between glycaemia and cognitive functions is non-linear, which requires additional research.

The study showed a high frequency and complex genesis of CDs in patients with MS. In most cases, CDs are neurodynamic and do not cause social and everyday maladaptation, but patients with CDs are at risk of developing a more severe cognitive defect and dementia.

## Conclusion

In young and middle-aged military personnel with metabolic syndrome, a decline in cognitive performance is evident, primarily affecting executive functions, auditory-verbal memory, spatial gnosis, perception, attention, concentration, and psychomotor speed. These impairments are most often mild or moderate in severity, with 56.1% and 26.8% of cases, respectively. More than half of the affected individuals also exhibit emotional disturbances—predominantly mild or moderate anxiety and anxiety–depressive states—which further compromise cognitive functioning. Patients with metabolic syndrome, particularly those with hypertriglyceridemia, should therefore be regarded as a high-risk group for the development of cognitive dysfunction. Regular assessment of cognitive status in these individuals is recommended, with the Mini-Mental State Examination (MMSE) and the Clock Drawing Test serving as effective initial screening tools. A reduction of 1–2 points on these assessments should prompt comprehensive neuropsychological

testing, including evaluations of attention, concentration, speech activity, verbal association, and psychomotor performance, such as the Schulte test. Early detection and monitoring in this population are crucial for preventing progression toward clinically significant cognitive impairment.

## Conflict of interest

The authors declare no conflict of interest.

## Ethics approval

The approval for this study was obtained from the Ethics Committee of the Danylo Halytsky Lviv National Medical University (Approval ID: 347).

## Consent to participate

Written informed consent was obtained from all the participants.

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