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EXECUTIVE FUNCTIONS IN PERSONS WITH METABOLIC SYNDROME

Abstract: Modern man lyfestyle contributes to the increasing incidence of metabolic syndrome in the developed world. Prevalence of the metabolic syndrome in adults ranges from 20 to 25%, and it tends to increase. Each year, 3.2 million people around the world die from complications associated with this syndrome. Treatment involves cooperation of medical doctors of various specialties, but the decisive factor is patient motivation, given that the treatment requires significant lifestyle changes. Our hypothesis is that metabolic syndrome patients have reduced ability to plan, convert plan into action and effectivly implement planned activities, showing signs of dysexecutive syndrome. The term executive functions comes from the english word "executive", which also means the controlling, in neuropsychology reserved for high-level abilities that influence more basic abilities such as attention, perception, memory, thinking and speaking. The main objective of this study was to determine characteristics of executive functioning in patients with metabolic syndrome. The sample consisted of 61 subjects of both sexes, aged 20 to 60 years, divided into two groups - those with a diagnosis of metabolic syndrome and those without this diagnosis. The results suggest that people with metabolic syndrome showed significantly poorer performance in almost all indicators of executive functions, represented by Wisconsin Card Sorting Test (Wisconsin Card Sorting Test) variables.

Key words: executive functions, metabolic syndrome, Wisconsin Card Sorting Test (WCST)

Introduction
The concept and definition of the metabolic syndrome

Metabolic syndrome is a cluster of conditions that includes abdominal (central) obesity, increased blood pressure, increased triglycerides (fats), decreased "good"

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HDL cholesterol, insulin resistance. People suffering from this syndrome are at increased risk of developing diabetes type II, blood vessel and heart disease. Despite the existence of multiple definitions and diagnostic criteria for the metabolic syndrome, perhaps the most frequently used and cited is the NCEP ATP III definition (Third Adult Treatment Panel) (1). According to the NCEP ATP III definition, metabolic syndrome is present if three or more of the following five criteria are met:

- waist circumference over 102 cm (men) or 88 cm (women)
- fasting triglyceride (TG) level over 1.7 mmol / l
- fasting high-density lipoprotein (HDL) cholesterol level less 1.04 mmol / l (men) or 1.3 mmol / l (women)
- blood pressure over 130/85 mmHg
- fasting blood sugar over 5.6 mmol / l

Metabolic syndrome is usually caused by an unhealthy *lifestyle*. There is scientific evidence that both genetics and lifestyle factors play important roles in the development of metabolic syndrome. Lifestyle factors include overweight, physical inactivity, lack of sleep and very high intakes of carbohydrate (more than 60%). The detailed architecture of *genetic* risk factors has not yet been *precisely defined.* Stress is also considered one of the causes as it disturbs the hormonal balance, increasing abdominal fat. Modern man lifestyle contributes to the increasing incidence of metabolic syndrome in the developed world. Prevalence of the metabolic syndrome in adults ranges from 20 to 25% (2,3), and it tends to increase. Each year, 3.2 million people around the world die from complications associated with this syndrome (2). *Recent research shows connection between metabolic syndrome and mental disorders such as depression, tension and aggression.* Raikkonen et al. (4) showed that depressive symptoms, stress, frequent and intense feelings of anger and tension are associated with the risk for developing the metabolic syndrome. The pathogenesis of the metabolic syndrome is multiple and treatment requires addressing several directions. It is necessary to treat each of the components of the metabolic syndrome using optimal modern method or medication. Treatment involves cooperation of medical doctors of various specialties, but the decisive factor is patient motivation, given that the treatment requires significant lifestyle changes (5, 6), focusing primarily on behavioral changes such as smoking cessation, increased physical activity, weight reduction and diet. To achieve an optimal level of performance, relevant institutions often create special programs that involve a number of structured and clearly defined multidisciplinary therapeutic and rehabilitation contents and procedures (7, 8), which require a high level of commitment.

The concept of executive functions

The term executive functions comes from the English word “executive”, which also means the controlling, in neuropsychology reserved for high-level abilities that

influence more basic abilities such as attention, perception, memory, thinking and speaking. "Executive functions" is an umbrella term for functions that are involved in goal-oriented behavior. In general, executive functions include a number of complex skills represented in different cognitive domains and modalities, which manifest themselves in all aspects of behavior. Lezak (9) proposed a four-component executive function model:

- Volition - the process of determining goals, desires and needs and their conceptual realization. It includes the ability of voluntary, intentional action and behavior. In other words, it is the process of formulation of intention in accordance with one's needs and desires and their realization in the future.
- Planning - identification and organization of the steps and elements needed to carry out an intention or achieve a goal. Planning includes the ability to refine a strategy which will be used to carry an intention or achieve a goal, realizing the difference between desires and actual circumstances, and anticipation of the future by weighing of options and alternatives.
- Purposive action - transition of a plan into productive activity that requires the actor to initiate and maintain action as long as necessary, switch or stop it according to circumstances or goal
- Effective performance - ability to monitor, self-correct, and regulate the intensity, tempo and other qualitative aspects of delivery. Dysfunction of this component is estimated by analyzing the nature of errors, ability of insight, response to errors and compensatory efforts used to overcome them.

Dysexecutive syndrome is currently the most popular psychological construct related to frontal lesions. The term dysexecutive syndrome first appeared in Baddeley's description of cognitive and *behavioral* problems in patients with impaired executive functions (10). Various types of attention disorders are described in the context of frontal lobe dysfunction: difficulties in maintaining and focusing attention, vulnerability to interference, disorder of selective attention, unilateral neglect, disorder of visual fixation, disorder of eye movements, impaired vigilance, etc. In addition, numerous studies have shown that frontal lesions cause a range of thinking disorders (11,12): disorder of abstract reasoning, problems of sorting, planning difficulties, disorders of creating and testing a hypothesis, reduction of divergent thinking (fluency, shapes and gestures) and difficulty in practical problem solving (difficulty in organizing behaviors).

Objective

Our hypothesis is that metabolic syndrome patients have reduced ability to plan, convert plan into action and effectively implement planned activities, showing signs of

dysexecutive syndrome. In this context, the main objective of this study was to determine characteristics of executive functioning in patients with metabolic syndrome.

Method

The research was conducted from October 2012 to June 2013 in Belgrade, at the Institute of Endocrinology, Diabetes and Metabolic Diseases KCS. The sample consisted of 61 subjects of both sexes, aged 20 to 60 years, divided into two groups - those with a diagnosis of metabolic syndrome and those without this diagnosis. All of subjects were previously assessed as of average cognitive abilities. Group with metabolic syndrome consisted of 31 individuals who attended the diagnostic procedure in the Institute for Endocrinology, Diabetes and Metabolic Diseases KCS. Control group consisted of 30 people without metabolic syndrome, selected randomly, matched according to age, sex and education with the group with metabolic syndrome (Table 1).

Table 1: Sample structure according to age, sex and education

	Subject categories					
	With metabolic syndrome			*Without metabolic syndrome*		
Age (years)	AS 37.06	SD 12.987		AS 37.27	SD 10.379	
Sex	**male**	**female**		**male**	**female**	
N (%)	**10 (16.7%)**	**21 (34.4%)**		**11 (18%)**	**19 (31.1%)**	
Education	**secondary school**	**higher ed.**	**college**	**secondary school**	**higher ed.**	**college**
N (%)	**17 (27.9%)**	**6 (9.8%)**	**8 (13.1%)**	**15 (24.6%)**	**6 (9.8%)**	**9 (14.8%)**
Total N (%)	**31 (51.7%)**			**30 (48.3%)**		

In this study, we used Wisconsin Card Sorting Test (Wisconsin card sorting test - WCST), which is considered one of the most popular tests for assessment of perseveration and abstract thinking. In addition, it is also a good indicator of executive functions, due to its reported sensitivity to frontal lobe dysfunction. WCST test allows the assessment of the subject's strategic planning, visual organization and search, ability to utilize environmental feedback to shift cognitive sets and to direct behavior toward achieving a goal, as well as to modulate impulsive responding (13). To enable faster and easier test application and data processing, we used a computerized version of the WCST test authored by colleague Natasa Bajic (The Wisconsin Card Sorting

Test, Jugoslovenska Aplikacija Testa, YU-WCST). In comparison with manual administration, computerized version testing is not ended after six correct categories were achieved, but is continued until all cards were sorted, and the feedback is provided by computer not examiner. In this way, without direct instruction, respondent is directed to sort cards by the principle of color, form and finally the number. A *change* in principle follows *10* consecutive correct responses. Data were analyzed using SPSS version 20 software, using descriptive statistical methods and T test.

Results

Table 2: Descriptive statistics for the standard WCST scores for both groups

WCST scores	*Metabolic syndrome*	*Control group*	t	Sig.
Correct responses	79.97	101.80	4.656	0.000
Errors	48.03	26.20	-4.656	0.000
Categories Completed	5.19	8.03	4.453	0.000
Perseverative Responses	11.32	1.40	-4.562	0.000
Perseverative Errors	9.81	1.30	-4.648	0.000
Nonperseverative Errors	38.23	24.90	-3.941	0.000
Failure to Maintain Set	2.72	0.05	-4.218	0.000
% Concept Level Responses	40.09	59.83	4.846	0.000
Trials to 1st Category	15.45	12.30	-1.216	0.229

Comparing the means shows statistically significant differences in almost all standard scores of WCST test (Table 2) between persons with metabolic syndrome and the control group. Average of correct responses in metabolic syndrome group was significantly lower than in the control group ($t = 4.656$, $p < 0.001$) which is correspondent with categories completed since these two measures are highly correlated. The main reasons for such difference are preservative responses and perseverative errors. Significantly higher values of average number of perseverative responses ($t = -4.562$, $p < 0.001$) and perseverative errors ($t = -4.648$, $p < 0.001$) in subjects with metabolic syndrome than in the control group indicate difficulty in shifting cognitive set and mental rigidity. Additionally, significantly higher scores in failure to maintain set in people with metabolic syndrome than in the control group ($t = -4.218$, $p < 0.001$) is indicator of difficulties in maintaining the optimal level of attention and concentration. Since the significant difference was found regarding % concept level responses ($t = 4.846$, $p < 0.001$), it can be assumed that there is a tendency of prolon-

ged problems with attention and concentration maintenance in people with metabolic syndrome compared to the control group, i.e. they need more time to change wrong classification criterion. Although there are no significant differences in the context of attention and concentration level during initial steps of the task, which is illustrated with no significant difference between the groups in trials to 1st category scores ($t = -1.216$, $p = 0.229$), it is obvious that considerable difficulties arise after first errors in subjects with metabolic syndrome. These results are consistent with other studies (14,15,16,17,18,19) in suggesting that people with metabolic syndrome show poorer performance in indicators of executive functions compared to the population without metabolic syndrome.

Conclusion

As previously noted, treatment of metabolic syndrome involves cooperation of medical doctors of various specialties, but the decisive factor is patient motivation. One of the most important tasks for people suffering from metabolic syndrome represents significant lifestyle changes (5, 6), which can only be achieved with great effort and perseverance. Our hypothesis is that metabolic syndrome patients have reduced ability to plan, convert plan into action and effectively implement planned activities, showing signs of dysexecutive syndrome. Various studies have confirmed that people with metabolic syndrome have difficulties with executive functioning (14,15,16,17,18,19), which is affecting consistent implementation of treatment plan. As in other recent studies (16), our research has shown that people with metabolic syndrome show significant difficulties in the domain of attention, with focus on sustained attention difficulties. Results also suggests that people with metabolic syndrome show significantly lower capacity to adjust actions based on feedback, demonstrating inability to adopt a new strategy that may be more appropriate in achieving a goal. In light of growing evidence that people with metabolic syndrome show difficulties with executive functioning, results indicate the need for treatment modifications and change in treatment planning. Based on research results, *some practical recommendations include* interventions aimed at developing better focus on treatment, better understanding of feedback received and their more consistent and successful implementation, strengthening and reinforcing new patterns of behavior consistent with the treatment, and at the same time discharging previously fixed and harmful behavior patterns.

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