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Modern Techniques in Cognitive Rehabilitation in Patients with Type 1 Diabetes Mellitus

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Resume: Type 1 diabetes mellitus (DM) is considered to be a metabolic disorder leading to a multifactorial negative effect on target organs, at the same time, it is an important risk factor in the development of cognitive impairment, the problem of prevention and treatment of which currently occupies one of the central places in modern endocrinology and neurology. Objective: to evaluate modern methods of rehabilitation in the correction of cognitive impairment in patients with DM type 1. 50 patients with DM type 1 18 to 45 years old were examined, and all patients were measured the levels of fasting glycemic, glycated hemoglobin (HbA1c). Randomization was carried out: patients of the 1st group underwent cognitive training using the computerized Happy Neuron Pro program 2 times a week for 45 minutes; group 2 was engaged in physical therapy on the basis of the sports and recreation complex of Siberian State Medical University 2 times a week for 60 minutes. When assessing the level of HbA1c, a greater decrease was observed in group 1 compared with group 2 (0.7% and 0.3%, respectively). Cognitive functions improved in both rehabilitation groups, an average of 2 points. Using motor and computer rehabilitation techniques improves cognitive function in patients with DM type 1. Computerized training leads to a significant improvement in carbohydrate metabolism.

According to modern concepts, type 1 diabetes affects the processes of neuroplasticity, the dynamics of which is reflected in cognitive functions. Thus, a meta-analysis of 59 original studies showed that both in pediatric practice and in adult patients with type 1 diabetes, there is an increased level of cognitive impairment [1, 2]. In addition, cognitive functions such as memory and attention are most often affected [3].Therefore, strategies for the prevention and timely correction of cognitive impairment in patients with type 1 diabetes are of great importance for reducing the burden of dementia on the individual and the health care system both today and in the future.

One of the approaches to the correction of cognitive It has been demonstrated that physical therapy (exercise therapy) using structured exercises lasting from 3 to 6 months improves glycemic control, as well as metabolic, inflammatory and vascular profiles in people with diabetes [4]. In experimental models, it has been shown that motor exercises improve the processes of angiogenesis, neurogenesis and synaptic plasticity [5]. However, a meta-analysis of the assessment of the role of exercise therapy in Alzheimer's disease showed no effect of exercise on the size of the hippocampus [6]. Another modern and highly effective technology for the correction of cognitive disorders can be computerized training, which is actively used with positive results in various neurodegenerative diseases [7, 8, 9].

The development of measures specifically designed to improve cognitive functions in patients with type 1 diabetes at a young age may be particularly useful [10]. Thus, the use of innovative web technologies and multicomponent interventions in adolescents with poorly controlled type 1 diabetes led to an improvement in HbA1c due to improved cognitive functions [11].

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In this regard, **the purpose** of this study was to evaluate the role of computerized training in the correction of cognitive impairment compared with motor rehabilitation in patients with type 1 diabetes.

Materials and methods. All patients underwent anamnestic and general clinical examination. To analyze the parameters of carbohydrate metabolism, the glucose level was used, which was studied by the glucose oxidase method on the Biosen analyzer, as well as the HbA1c content, which was evaluated on the Hitachi-911 automatic clinical chemical analyzer (Germany, 1996). To register the level of cognitive functions, the Montreal Scale was used, including an assessment of attention, memory, executive functions, concentration, speech, visual-constructive skills, numeracy, abstract thinking and orientation. The normal level is considered to be at a score of 26-30 points, if there are 25 points or less, cognitive dysfunction is diagnosed.

The study included 49 patients with type 1 diabetes aged 18-45 years with different levels of disease compensation. All patients were divided into 2 groups depending on the type of cognitive rehabilitation: Group 1 – took classes in computerized training (Scientific brain training program, HAPPYNEURONPRO) 2 times a week for 45 minutes, group 2 - physical therapy classes at the sports and recreation complex 2 times a week for 60 minutes. The study lasted 6 months. During the study, 10 people dropped out, mainly from group 2, due to the complexity of the work schedule and low compliance, and therefore these patients were excluded from the sample and the calculation of the results.

The computerized training based on the SCIENTIFIC BRAIN TRAINING program, HAPPYNEURONPRO, included 8 exercises for verbal, visual and spatial memory; information processing speed; executive functions; auditory perception; language skills and vocabulary; as well as visual attention. The exercises "Verbal memory" and "Language skills and vocabulary" train memorization of a list of words. Visual Memory uses abstract symbols and exotic characters to develop patients' ability to pay attention to visual details, and the Spatial Memory exercise teaches them to memorize the location of objects using certain methods and techniques.

Physical therapy classes were held 2 times a week, the duration of one lesson was 60 minutes. Physical therapy classes were conducted in accordance with the general principles of physical therapy: individual approach, cyclicity, systematicity, gradualness, alternation, diversity, visibility, accessibility, complexity [12]. Each therapeutic gymnastics lesson included three sections: introductory (warm–up) - general developmental, breathing exercises from the initial standing positions; The main one was special exercises alternating with restorative ones, taking into account the dispersion of the load, aimed at forming muscle strength, coordination abilities, dexterity, balance from the starting positions of standing, lying, knee-wrist using gymnastic sticks, fitballs, dumbbells; the final one included exercises for flexibility, balance, breathing exercises. The exercises were performed at a slow, medium pace. The intensity and dosage of physical exercises took into account the individual characteristics of the patient, the course of the underlying disease, the functional state, and the level of physical fitness.

The complex of therapeutic gymnastics included special exercises aimed at developing coordination abilities, dexterity, balance, attention, general endurance and muscle strength. In the course of classes, exercises with dumbbells, gymnastic sticks, and fitball exercises were used. A complex of morning hygienic gymnastics, exercises for self-study (coordination exercises, attention exercises) were recommended daily.

The sample size was measured using the formula for calculating the minimum volume of groups to compare the indicator in two independent groups. Statistical processing of the research data was carried out in the IBM SPSS Statistics19.0.0 Russian version (IBM SPSS Inc). The Shapiro–Wilk W-test made it possible to determine the normality of the distribution. In the descriptive analysis, the

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arithmetic mean (X) and the error of the mean (m) were calculated for a normal distribution, and the quartiles (Me, Q1–Q3) were calculated for an abnormal distribution. For comparative analysis, the Student's t-test for normal and the Mann-Whitney Z–test for abnormal distribution were used. The Wilcoxon criterion was used for dependent data. The significance level was critical at a level of 0.05. Qualitative data were evaluated using frequency analysis. To determine the validity of the differences, Pearson's $\chi 2$ was determined.The Spearman coefficient was used in the correlation analysis.

RESULTS AND THEIR DISCUSSIONS

Table 1 shows the characteristics of patients with type 1 diabetes, from which it can be seen that they were comparable in gender and age.

Table No. 1. Characteristics of patients with type 1 diabetes mellitus

	1-st group	2-st group
Age, years	29,8 (25,3–30,0)	33,0±8,9
Duration of SD, years	13,7±5,8	11,2±5,9
Gender, m/w, % (n)	58,0 (11)/42,1 (8)	70,0 (14)/30,0 (6)

An assessment of the parameters of carbohydrate metabolism showed that both groups of patients did not reach the Hba1c targets of 7.9%, the average fasting glycemia index of 9.6 and 8.0 mmol/l corresponds. When analyzing the dynamics of HbA1c changes after 6 months, its greatest decrease occurred in group 1 by 0.7%, compared with group 2 by 0.3% (t=3.6, p=0.002; t=3.2, p=0.005) (Table 2).

Table No. 2 Characteristics of carbohydrate metabolism in patients with type 1 diabetes mellitus before and 6 months after rehabilitation

Parameters	1-st group	2-st group
The average level of HbA1c, mmol/l	**7,9±1,5**	**7,9±1,3**
(before rehabilitation)	**9,6 (7,4-10,6)**	**8,0±2,1**
Average glycemic level,	**7,2±0,1**	**7,6±1,1**
mmol/l (before rehabilitation)	**8,0±1,4**	**7,7±1,7**

When analyzing cognitive functions in patients of the 1st and 2nd groups, a decrease in the overall score of less than 26 was noted before any type of intervention, which corresponds to the diagnosis of "cognitive dysfunction". At the same time, the most reduced indicators of the scale are "Attention and memory" (U=142.5, p=0.04; U=38.0, p=0.000002) (Table 3).

Table No. 3 Results of the Montreal Scale of Cognitive Dysfunction in patients with type 1 diabetes mellitus before rehabilitation

	1-st group	**2-st group**
Total score	**25,2 (23,5–27,5)**	**22,3±3,1**
Visual-constructive skills	**3,7 (3,0–4,5)**	**3,5 (3,0–4,0)**
Calling	**3,0 (3,0–3,0)**	**3,0 (3,0–3,0)**
Attention	**5,6 (6,0–6,0)**	**4,7 (4,0–6,0)**
Speech	**2,1 (2,0–3,0)**	**1,6 (1,0–2,0)**
Abstraction	**1,5 (1,0–2,0)**	**1,3 (1,0–2,0)**
Memory	**3,3±1,3**	**2,4±1,3**
Orientation	**6,0 (6,0–6,0)**	**6,0 (6,0–6,0)**

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months after cognitive rehabilitation, it was found that both types improved cognitive functions equally in patients with type 1 diabetes by almost 2 points overall (Table 4).

Table No. 4 Results of the Montreal Scale of Cognitive Dysfunction in patients with type 1 diabetes mellitus after 6 months of rehabilitation

	1-st group	2-st group
Total score	27,0±1,4	24,2±2,1
Visually constructive skills	4,3 (4,0–5,0)	4,0 (3,8–4,3)
Calling	3,0 (3,0–3,0)	3,0 (3,0–3,0)
Attention	5,6 (6,0–6,0)	4,8 (4,0–6,0)
Speech	2,5 (2,0–3,0)	2,4 (2,0–3,0)
Abstraction	2,0 (2,0–2,0)	1,5 (1,0–2,0)
Memory	3,7 (3,0–4,0)	2,6±1,4
Orientation	6,0 (6,0–6,0)	6,0 (6,0–6,0)

During the correlation analysis, it was revealed that the result of performing the task "Visual attention and auditory perception" is influenced by the cognitive function of memory (R=0.5, p =0.03; R=0.54, p =0.02).

After the rehabilitation, all patients were asked about the comfort of the rehabilitation process itself and the desire to continue the recommended interventions. In group 1, 90% of patients were satisfied with their work in the computerized program and were ready to continue their studies, while only 50% of people from group 2 noted their interest and desire to study. At the same time, the remaining patients were asked about the reasons for refusing further physical therapy classes. Most often, patients noted a lack of time (8 people), the rest – the difficulty of performing exercises (2 people).

During the correlation analysis, it was revealed that the result of performing the task "Visual attention and auditory perception" is influenced by the cognitive function of memory (R=0.5, p =0.03; R=0.54, p =0.02).

Patients with type 1 diabetes have cognitive decline compared to those without diabetes, which can be associated with both hypoglycemia and hyperglycemia [13]. In the conducted study, patients with elevated HbA1c levels showed a decrease in MoCA test scores. This complication can be prevented or delayed by intensive glycemic control, as well as effective programs to improve disease management, knowledge, skills and motivation of patients, which leads to a significant improvement in outcomes [14].

As therapeutic measures, one of the methods is motor rehabilitation, which improves memory, attention and executive functions by influencing neurochemical processes in experimental models [15]. Also, the examined patients registered an increase in the number of points in the test for cognitive impairment. In addition, one of the modern approaches to rehabilitation is the use of Internet technologies, especially taking into account the young age of patients with type 1 diabetes. The study shows the high effectiveness of this approach in terms of correcting both cognitive impairment and carbohydrate metabolism, as well as a higher commitment to the implementation of recommendations in this group of patients. The limitation of the study is a small sample due to the difficulty of recruiting a large number of patients for physical therapy.

CONCLUSION. Patients with type 1 diabetes have cognitive impairments that are associated with dysglycemia. The use of motor and computer rehabilitation methods with the same result improves cognitive functions in patients with type 1 diabetes. Additionally, as a result of the computerized training, patients registered a significant decrease in HbA1c, which is associated with better compliance when using this method of rehabilitation, when 90% of patients are satisfied with the

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technique and are ready to follow the recommendations.

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