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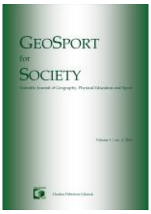

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Sensory, cognitive and motor disorders in patients with type 2 diabetes

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Abstract. **Background:** Neuropathy due to Type 2 diabetes causes sensory, cognitive and motor disorders. The present study was planned to examine sensory-cognitive and motor functions in patients with type 2 diabetes and to compare these results with healthy individuals. **Methods:** 20 healthy individuals and 20 patients with type 2 diabetes (19 females, 21 males), aged between 20 and 65 years were included in the study. Patients were separated as control and patient group. Sensory motor and cognitive functions were assessed by AYRES. Visual perception was analyzed with Space visualization test, Sensory integration test, Figure ground perception test and Position in space test, Somoto sensory perception was examined with Localization of the tactile stimulus test and Graphesthesia test, Motor performance was evaluated with Imitation of posture test. All the tests were applied to both groups. **Results:** There was a statistically significant difference between patients and healthy individuals in space visualization (p=0.001), sensory integration (p=0.001), figure ground perception (p=0.001) and position in space (p=0.001) tests of visual perception and posture imitation test (p = 0.001) of postural praxis and graphesthesia (p=0.001) of somatosensory test. But there was no significant difference in localization of the tactile stimulus test (p>0,05) between groups. **Conclusions:** Sensory, motor and cognitive problems affect daily living activities and these problems cause that patients to live dependently on others. So detailed assessment should be applied for a better plan of treatment.

Keywords: type 2 diabetes, Ayres, sensory, cognition, motor

Introduction

Diabetes is a systemic disease and it affects various body systems including cardiovascular, gastrointestinal, immune, and nervous systems. Certain kind of sensory input, such as vestibular input, influences the whole brain as well as other sensory systems (Hewston & Deshpande, 2016).

Adverse effects of diabetes on cognitive system and memory disorders have been noticed by researchers for a long while. Equally, dementia is one of the most disabling common health problems. It affects the quality of life of demented patients (Saedi et al., 2016). Both type 1 and type 2 diabetes mellitus have been associated with performance decreased on numerous domains of cognitive function. The exact pathophysiology of cognitive dysfunction in diabetes is not clear, but it is likely that hyperglycemia, vascular disease, hypoglycemia, and insulin resistance play significant roles (Kodl & Seaquist, 2008).

Neuropathy because of Type 2 diabetes causes sensory, cognitive, and motor disorders. Sensory integration dysfunction is a neurological disorder that includes impairment in processing data from the different senses (vision, auditory, touch, olfaction, and taste), the vestibular system (movement), and proprioception disorders are prevalent in children and adults. Skenazy and Bigler, (1984) declared neuropsychological impairment of diabetes with some tests. But in the literature, there are few studies that evaluate whole effects of diabetes (Skenazy & Bigler, 1985; Goldstein & Morewitz, 2011).

While chronic metabolic and vascular changes seem to play an important role in the treatment of diabetes and at present there are few leads for the targeted diagnostics and treatment of individual patients, diabetes is becoming more common, this study will be very important to shed light on the treatment.

This study was intended to be performed because there are rare studies evaluating the whole sensory-cognitive and motor functions of adult patients with type 2 diabetes in the literature. The present study was planned to examine sensory-cognitive and motor functions in patients with type 2 diabetes and to compare these results with healthy individuals.

Materials and methods

Subjects

The study was conducted at Mustafa Kemal University Hospital between 2014 November- 2015 April. We evaluated 20 patients with type 2 diabetes mellitus and 20 healthy people who volunteered to participate in the study. The participants are aged between 20 and 65 years. This study is based on a prospective analysis of sensory, motor, cognition problems of diabetes mellitus. The study was carried out after approval from the Ethics Committee of the Mustafa Kemal University and obtaining a signed informed consent from the patients who volunteered to participate in the study (no: 31/10/2014/192).

The inclusion criteria were:

- Aged between 20 and 65 years,
- Diagnosed with type 2 diabetes for the diabetic group,
- Independent in mobility,

- Have cognitive capacity to answer the questionnaire.

The Exclusion criteria were:

- Individuals who had a serious systemic disease other than diabetes,
- Had mental problems,
- Pregnancy.

Measurements

The demographic information of the individuals was questioned. Sensory motor and cognitive problems were evaluated with Southern California sensory integration test (AYRES). These tests were declared by Dr. A. Jean Ayres, a visionary occupational therapist and educational psychologist. Tests assess the sensory, cognitive and motor functions. These test are: motor-free visual perception tests (space visualization, sensory integration, figure ground, position in space), Somatosensory tests (kinesthesia, finger identification, manual form perception, graphesthesia, localization of tactile stimuli, double tactile stimuli perception), motor performance tests (imitation of postures, bilateral motor coordination, standing balance, motor accuracy) and right-left discrimination test, crossing mid-line of body test (Royeen et al., 1981; Mailloux, 1990; Spitzer & Smith Roley, 2001; Ayres, 2005; Miller et al.,2007; Roley et al., 2007).

We evaluated motor-free visual perception with space visualization, sensory integration, figure ground, position in space tests in both groups. Somatosensory problems were investigated with graphesthesia and localization of tactile stimuli tests and motor disorders were assessed with imitation of postures tests. All tests were applied to control group and to patients by the same physiotherapist.

The tests were performed as follows:

a. Space Visualization test: There were 30 different test form boards in the test booklet. We discontinued after the 5th error. Accuracy and time score were recorded (Ayres et al., 1989; Mailloux, 1990);

b. Sensory integration test: A form with 13 separate images were used for this test. Participants were asked to copy the same figure from the top lines by combining the points at the bottom of the page. The total score was calculated using a scoring system of 0-1-2 according to the accuracy of the lines (Ayres et al., 1989; Vargas & Camilli, 1998);

c. Figure Ground Perception Test: A test booklet was used for this test. There are 16 test steps in the booklet. The participants were asked to find three figures on the top page, from the six figures on the bottom page. The accuracy figure number is noted (Ayres et al., 1989);

d. Position in space test: The test assessed the perception of the same shape in different positions. We discontinued after the 5th error. The participants were shown the figure on the warning card and the figures in the book. Correct responses and time were recorded (Ayres et al., 1989);

e. Graphesthesia: In which the participant draws with a finger the same simple design the therapist drew on the back of the participant’s hand. Scored as 0, 1, 2 according to the similarity in the test booklet (Ayres et al., 1989);

f. Localization of tactile stimulus test: We used ball-point pen, centimeter ruler and shield. All tests were repeated on the other hand. Total right and left raw score were recorded (Ayres et al., 1989);

g. Imitation of postures: We did not need special material. The participant is asked to repeat the same 12 movements made with the hands and arms of the person standing in front of him in a swift manner. According to accuracy and quickness, scoring was done as 0, 1, 2 (Ayres et al., 1989).

Statistical analysis

For the statistical analysis, SPSS for Windows Release SPSS 22 was used. All data for normality was tested by using the Shapiro Wilk test. Test Differences between 2 groups were analyzed with parametric (Independent-Samples T test) and nonparametric tests (Mann-Whitney U). The characteristics of the study sample are described by mean and standard deviation for continuous variables, median, and minimum-maximum for ordinal variables.

Results

Twenty patients with type 2 diabetes and twenty healthy people who met the criteria, volunteered to participate and signed the informed consent included to study. 19 women (47,5%), aged between 20 and 65 years (46 years) and 21 men (52,5%), aged between 21 and 64 years (35 years) participated in the study.

We observed statistically significant difference in motor-free visual perception tests between groups. There was statistically significant difference between the patients with type 2 diabetes and the healthy individuals in space visualization total (p=0.001) and time (p=0.020) scores, sensory integration total and time scores (p=0.001), figure ground perception total score (p=0.001), position in space total and time scores (p=0.001), (table 1).

Table 1.Motor-Free Visual Perception Tests

Visual cognition tests	Tip 2 diabetes group X±SS	Healthy group X±SS	p	t	z
Space visualization - Total Score -Time	13.45±8.97 618.6±395.1	28.10±3,32 385.25±184.61	p=0.001* p=0.02*	- 6.849 2.393	
Sensory integration -Total score -Time	19.95±5.18 191.95±115.73	25.65±0.67 73.50±31.15	p=0.001* p=0.001*	- 4.875 4.420	
Figure ground perception -Total score -Time	27.1±5.06 417.5±174.85	39.5±4.39 344.3±173.16	p=0.001* p=0.19**	-7.96	-1.51
Position in space -Total score -Time	18.5±4.9 427.25±176.4	27.3±2.2 235.4±139.53	p=0.001** p=0.001**	3.81	-5.01

*: Independent Sample Tests

**: Mann-Whitney U test

We found statistically significant difference in graphesthesia both in right/left sides (p=0.001) while we couldn't found significant difference in tactile stimuli tests (p>0,05), (table 2).

Table 2. Somatosensory Tests

Somatosensory tests	Tip 2 diabetes group X±SS	Healthy group X±SS	p	t	z
Localization of tactile Stimuli	11.95±0.22	12±0.0	p=0.317**		-1.0
Graphesthesia Left Right	 8.35±2.49 7.75±2.51	 11.45±0.94 11±1.83	 p=0.001* p=0.001*	 -5.191 -4.674	

*: Independent Sample Tests
**: Mann-Whitney U test

Statistical significance difference was found in posture imitation (p=0.001) test in which motor performance was evaluated (table 3).

Table 3. Postural Praxis Test

Motor performance test	Tip 2 diabetes group X±SS	Healthy group X±SS	p	z
Imitation of posture	18.6±4.58	23.8±0.69	p=0.001*	-4.31

*: Mann-Whitney U Test

Discussion

The present study was planned to examine sensory-cognitive and motor functions in patients with type 2 diabetes and to compare these results with healthy individuals. We observed statistically significant difference in visual cognition (space visualization test, sensory integration test, figure ground test, position in space test), somatosensory tests (graphesthesia test) and motor performance (Imitation of posture test). The results of the study showed that Neuropathy due to Type 2 diabetes causes changes in sensory perception and motor function, and this cause limitation in learning functions and their independence in daily life living.

There were few study that assess whole sensory integration, motor and cognition problems in patient with type 2 diabetes. Our study is one of that rare studies that examined in type 2 diabetes patients so multiple parameters.

Hewston et al. declared latest evidence proposed that declines in sensory functions (somatosensory, visual and vestibular) in older adults with type 2 diabetes. Our results also showed somatosensory disorders in patient with type 2 diabetes (Hewston & Deshpande, 2016).

In our study there was significant difference in space visualization test between healthy and diabetic groups. Murray et al. used space visualization test in children with learning disability to assess motor dysfunction, sensory integration. They stated that coordination and perception might both showed the integration of the central nervous system and clumsiness seems to be related to some aspects of visual-perceptual ability (Murray et al., 1990).

There are different test to evaluate cognitive functions. Hazari et al. investigated cognitive functions in patients with type 2 diabetes with Mini-mental state examination test. They declared that patients with type 2 diabetes have decreased cognitive function which were more marked when the disease duration passed over 5 years and If in type 2 diabetes with hypertension, the cognitive impairment risks were increased too. We evaluated cognitive function with AYRES. We preferred this test because we couldn't find any test which assesses whole motor, cognitive, visual perception disorders. We found significant difference between two groups in sensory integration tests (Hazari et al., 2015).

Petersen et al. used AYRES in their study. They included 100 adult males in their study. Motor free visual perception was evaluated with figure ground position test like our study. They declared that it has some important advantages for assessing figure-ground perception in persons with motor impairment (Petersen & Wikoff, 1983).

Petersen et al. were assessed adult female performance on the AYRES Visual Figure Ground Perception Test (FGP) and to obtain an estimate of the test's reliability. They concluded that the FGP is a reliable assessment tool for use with adults (Petersen et al., 1985).

Our findings suggested that it is possible that metabolic imbalances and other factors could interact, either directly or indirectly and result in an altered central nervous system function and impaired cognition. There were a lot of studies about cognition disorders of diabetes but not sensory and motor disorders. So our study is important for evaluating whole diabetic neuropsychological complications and creating new treatments for adults and children (Strachan et al., 1997; Stewart & Liolitsa, 1999).

Andersen et al. examined Muscle Strength in Type 2 Diabetes. In 36 type 2 diabetic patients and in 36 control subjects matched for sex, age, weight, height, and physical activity, strength of flexors and extensors at elbow, wrist, knee, and ankle was assessed at isokinetic dynamometry. They found type 2 diabetic patients may have muscle weakness at the ankle and knee related to presence and severity of peripheral neuropathy. We found statistical significance difference in posture imitation ($p=0.001$) test in which motor performance was evaluated (Andersen et al., 2004).

Type 2 diabetes, has been found in the literature to impact dexterity and sensory function in the hands. Ochoa et al. evaluated the effects of tactile feedback on manual function in Type 2 diabetes patients. T2 diabetes patients and healthy controls underwent median nerve blocks at the wrist and elbow. All participants underwent traditional timed motor evaluations, force dynamometry, laboratory-based kinetic evaluations, and sensory evaluation. They found that mechanisms outside of tactile dysfunction play a significant role in motor dysfunction in Type 2 diabetes. The data presented in this study provide evidence to rule out tactile dysfunction as the sole contributor to manual dysfunction (Ochoa et al., 2016).

Metabolic control of diabetes mellitus as well as the duration of diabetes mellitus seem to be important disease variables in the impaired cognitive performance. Regular assessment of cognitive function suggested to performed as part of the routine review of diabetic patients (Van Harten et al., 2016).

We found that Motor-Free Visual Perception Tests scores of type 2 diabetes patients were worse than healthy group. Type 2 diabetes impact cognitive functions of those living with the disease.

We did not questioned duration of the disease, this was our limitation. Unfortunately the physiotherapist was not blind to disease of the patients and two groups were assessed by the same physiotherapist.

Conclusion

This study is important to take attention to the treatment of these functions, especially since changes in sensory perception and motor function in patients with Type 2 diabetes restrict individuals' learning functions and their independence in daily living activities. Not only for patients with type 2 diabetes even all metabolic disorders that affect the nervous system should be evaluated with tests to examine motor, sensorial and cognitive problems.

Sensory, motor and cognitive problems affect daily living activities and these problems cause that patients to live dependently on others. So detailed assessment should be applied for a better plan of treatment.

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