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NEUROPSYCHOLOGICAL COGNITIVE PERFORMANCE OF PATIENTS WITH TYPE-2 DIABETES

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ABSTRACT. The aim of this study was to assess the cognitive skills and visuo-motor performances of patients with type-2 diabetes. An ADL questionnaire, neurophysiological EEG recordings and a comprehensive battery of neuropsychological tests were administered to 33 type-2 diabetics and to 33 matched controls. Neither neuropsychological nor neurophysiological EEG findings differentiated type-2 diabetics as a group from their controls.

Key words: Diabetes, Type-2, neuropsychology

Diabetic patients frequently complain of loss of memory and of difficulty in concentration (13). However, there is very little objective data to substantiate or contradict the subjective feeling of lowered cognitive performance (1, 2, 6, 10, 12, 15, 16).

Miles & Root (13) examined 40 diabetics aged from 15 to 55 years, and 18 controls from members of staff, with memory span tests. They found some evidence of impaired intellectual functioning. Bale (2) examined type-1 diabetics, and the results suggested that mild dementia might be more common in diabetes than is usually supposed. Two recent investigations on type-1 diabetics did not reveal cognitive or memory deficiencies (15, 16), but diabetics displayed neuropsychological impairment on tasks that require visual and motor efficiency, and somatosensory discrimination (6, 15, 16). Very recently Lawson and his co-workers (10) failed to provide evidence of intellectual deterioration in a substantial group of type-1 diabetic patients with neuropathy. Meuter and his co-workers (12) showed that the speed of reaction of both type-1 and type-2 diabetics was significantly lower than that of controls who were matched for age, sex and level of education. Ability in memory-concentration tasks was also decreased in diabetics in general and particularly in type-2 diabetics.

Diabetes mellitus has been studied using multicausal interactive models. In particular, psychological factors in diabetes and in its treatment have been abundantly studied (for refs. see 5). The specific aim of this study is to delineate possible cognitive and visuo-motor deficiencies which may cause difficulties in the effective rehabilitation of type-2 diabetics. The study is part of a comprehensive rehabilitation research programme for the rehabilitation of type 2 diabetics.

SUBJECTS

Diabetics. The patients were selected from a large epidemiological and clinical study covering all 877 diabetics who were born and are living in the district of the Turku University Central Hospital, whose diabetes began at the age of 30 or later and had lasted 1–14 years, and who were 45–64 years old at the time of the study. The diagnosis of diabetes was based on the WHO criteria (two fasting whole venous blood glucose values equal to or above 7.0 mmol/l). The participation rate in the basic study was 73%. Forty-eight consecutive patients in the basic study meeting the following criteria were invited to participate in the present neurological and psychological study. The criteria were: (*a*) Diet or diet+oral hypoglycemic drugs (sulphonylureas and/or metphormin) as the treatment for diabetes, (*b*) no antihypertensive therapy and actual blood pressure below 160/95 mmHg, (*c*) no previous history of neurological or psychiatric diseases (except the possible diabetic neuropathy), (*d*) no medication for any other chronic diseases, (*e*) no chronic intake of alcohol, (*f*) no disability of the locomotor system making the ECG exercise test with bicycle impossible.

Thirty-three (69%) of the eligible patients gave their written consent to participate in the study. None of them had nephropathy, retinopathy, any marked visual impairment, angina pectoris or intermittent claudication. Some of the laboratory values in the basic study and the demographic characteristics of the selected diabetics are given in Table I.

Control subjects. The 900 control subjects were randomly selected from the population register in an age range of 45–64 years, born and living in the district of the Turku University Central Hospital, all non-diabetics. The participation rate in the basic study was 79%. From this group those who fulfilled the abovementioned criteria (*b*)–(*f*) were invited to participate in the present study

Table I. *Demographic and clinical characteristics of diabetic patients and control subjects at the time of the neuropsychological study (mean (median) ± SD)*

	Diabetics	Controls
Age (years)	56.3 (57)±5.2	55.9 (57)±5.4
Men (N)	22	22
Women (N)	11	11
Height (cm)	168 (170)±9	170 (171)±8
Weight (kg)	81 (79)±10	75 (74)±11
Subjects with at least complete elementary schooling (N)	29	32
Duration of diabetes (years)	7.3 (7)±3.7	–
Current blood pressure (mmHg)	138±18/82±9	134±14/82±9
Fasting plasma glucose (mmol/l)	10.3±3.2*	4.9±0.5
Glycosylated hemoglobin 1 (%)	9.3±1.8*	6.6±1.2
Peripheral neuropathy (N)	8**	2
Urinary infectous disease (N)	2	6
Gallbladder symptoms (N)	3	4
Intermittent infections (N)	1	2
Eye disease (refraction symptoms) (N)	1	2
Rheumatic disorders (N)	1	–
Asthma (N)	1	–
Paranoid psychosis (N)	–	1
Other chronic disease (N)	6	6

* Statistically significant difference is seen between the groups; $p<0.0001$ (t-test).
** Statistically almost significant difference is seen between the groups; $p=0.042$ (Chi-squared test) or $p=0.082$ (Fisher Exact Chi-squared test).

assuming that they could be matched for age and sex with the selected diabetics. Of the first forty-two eligible control subjects, 33 gave their written consent to be included in the present study. None of the controls had symptoms of angina pectoris or intermittent claudication. However, one control subject suffered from acute myocardiac infarction after the basic study. He was not excluded from the present study. The demographic characteristics of this group are given in Table I.

METHODS

Clinical neurological examination was performed for all patients and controls.

Activity of daily living (ADL): A self-report based rating scale was used to assess ADL of diabetics and their controls. It includes 32 items (0–3) which roughly characterize mobility, transfers, self-care and domestic activities.

Table II. *Statistically significant differences in ADL between diabetics (33) and normal controls (33)*

ADL	p
Lifting	0.0267
Running	0.0263
Airing carpets	0.0382
Bedmaking	0.0097
Vacuum cleaning	0.0447

Nonparametric Kruskal-Wallis and Mann-Whitney tests are performed for raw data, and significances are given as p-values.

Neurophysiological measures: EEG recordings were performed with Mingograf EEG-21 (Siemens-Elema). Photostimulation and hyperventilation were included in the examination. The analyses were performed blind, without diagnostic information about the subjects.

The alpha frequency was calculated manually from the 0_1 and 0_2 positions in the source derivation montage. The samples were obtained while the patient was alert. The mean frequency of five epochs containing ten alpha waves was calculated. The mean frequency obtained in this way correlates to the peak power in the alpha range of the power spectrum (unpublished results). The overall amount of theta and delta activity was estimated visually.

The EEG was scored on the basis of generalized slowing and focal abnormalities. The level of the patients' alertness was evaluated following Rechschaffen & Kales (14).

A detailed neuro- and psychophysiological assessment of peripheral or autonomic neuropathy will be published separately.

Neuropsychological tests: The following psychodiagnostic methods were used:

- Wechsler Memory Scale (WMS) (20)
- Wechsler Adult Intelligence Scale (WAIS) (21)
- Subtracting Serial Sevens Test (SSS) (17)
- Schultze Word Memory Test (19)
- Beck Depression Inventory (3)
- Symmetrical Drawing Leaf Test (22)

Table III. *EEG findings in type-2 diabetics and their controls*

	Diabetics (33)	Controls (33)
Awake (N)	28	31
Fluctuations in alertness (N)	5	2
Normal EEG (N)	28	32
Slight over-all disturbance (N)	3	1
Left intermittent disturbance (N)	2	0
Right intermittent disturbance (N)	0	0
Bilateral disturbance (N)	1	0
Left occipital alpha rhythm (mean ± SD)	10.2±1.2	9.8±0.8
Right occipital alpha rhythm (mean ± SD)	10.3±1.2	9.8±0.8

No statistically significant differences are observed between the groups (Mann-Whitney).

- NESI (EPI-C) (11)
- Benton's Visual Retention Test (4)
- Stroop Test (18)
- Trail-Making Test (TMT) (11)
- Rey-Osterrieth Complex Figure Test (11)

RESULTS

Neurological examination revealed peripheral neuropathy in 8 out of 33 diabetics and in 2 out of 33 controls (Table I).

Table IV. *Age-graded scores of the WAIS subtests, and the WAIS verbal and performance IQs for diabetics and controls*

	Diabetics (33) Mean SD	Controls (32) Mean SD
General information	11.1±2.2	10.7±2.1
General comprehension	11.6±3.0	11.8±3.2
Arithmetic	11.0±2.9	10.0±2.3
Similarities	11.6±2.5	11.8±2.5
Digit span	11.5±2.6	10.2±1.9
Vocabulary	10.9±2.5	10.2±2.6
Verbal IQ	105.5±13.0	102.6±10.1
Digit symbol	9.7±1.7	9.9±1.4
Picture completion	10.4±2.6	10.7±2.9
Block design	11.4±3.2	11.4±2.9
Picture arrangement	10.0±2.5	10.0±2.6
Objects assembly	9.9±3.3	10.4±3.0
Performance IQ	105.5±15.3	107.8±10.7

No statistically significant differences between the groups (Mann-Whitney).

Table V. *Verbal memory scores of diabetics and controls*

	Diabetics (33) Mean SD	Controls (32) Mean SD
WMS, logical memory	7.0±2.8	7.0±2.4
WMS, digit span	9.8±1.5	9.1±1.2
WMS, associative learning	15.5±2.9	14.9±2.7
WMS, logical memory retention	4.0±2.4	4.0±2.3
WMS, associative learning, retention	7.9±1.4	8.3±1.1
WMS, MQ	105.2±15.2	103.0±11.0
Schultze, memory span	72.0±13.1	72.8±12.5
Schultze, delayed recall	6.7±1.9	6.2±2.0

No statistically significant differences between the groups (Mann-Whitney).

ADL scores for diabetics were statistically significantly higher (worse) than those of the control subjects in a number on items (Table II).

EEG disturbances seemed to be more frequent in diabetics than in their controls, but this difference was not statistically significant (Table III).

None of the neuropsychological tests differentiated patients with diabetes from the control subjects (Tables IV–VII).

Beck's Depression Inventory revealed slightly more depressive features in patients with diabetes type-2 than in their control subjects (10.2±6.5 vs. 6.8±5.1; $p<0.05$; Mann-Whitney).

DISCUSSION

The present data do not substantiate earlier assumptions about the impairment of higher neurop-

Table VI. *Visual memory scores of diabetics and controls*

	Diabetics (33) Mean SD	Controls (32) Mean SD
WMS, visual retention	8.9±2.8	8.6±2.5
Benton, difference right	0.9±1.5	1.3±1.2
Benton, difference errrors	3.9±3.5	3.8±2.3
Rey-Osterrieth, difference copying-memory	16.6±4.5	17.1±6.2
Leaf, errors	19.7±9.9	18.5±9.0
Leaf, reversions	9.0±6.1	8.4±6.1

No statistically significant differences between the groups (Mann-Whitney).

Table VII. *Visual perception cognitive control and motor dexterity of diabetics and controls*

	Diabetics (33)	Controls (32)
	Mean SD	Mean SD
Stroop, *x*-errors	0.2±0.4	0.3±0.7
Stroop, Word-errors	1.3±1.5	1.8±3.2
Trail-Making test, A, time	50.6±26.1	50.5±16.6
Trail-Making test, B, time	151.6±61.5	155.6±63.7

No statistically significant differences between the groups (Mann-Whitney).

sychological performances in patients with diabetes type-2. The present results are in variance with the observations of Miles & Root (13) and of Meuter et al. (12). The selection procedure used in these investigations differed from ours, i.e. such complications of diabetes as cerebral vascular diseases had not been excluded (12). At least some of the previous observations could be due to peripheral rather than central nervous deficiencies (10). However, the cognitive status of the type-1 diabetics with neuropathy did not differ from age-matched controls (10). The speed of reaction, a factor from principal component analysis of psychological variables, was reduced in diabetics when compared with their matched controls (12). There is also a group of type-2 diabetics with decreased performance in memory-concentration (12). There were somewhat more ADL problems in our group of diabetics than in the matched control group. The difference can be explained by the relatively high incidence of peripheral neuropathy observable among the diabetic patients of this study.

Arterial hypertension is commonly associated with type-2 diabetes. Sixty percent of diabetics belonging to the basic population of our study had antihypertensive treatment and/or actual blood pressure over or equal to 160/90. The corresponding observation in non-diabetics was 30%. Because chronic hypertension, together with antihypertensive agents, seems to be related to neuropsychological impairment (12), it is important to exclude hypertensive subjects from a study designed to clarify the relationship between diabetes and neuropsychological performance. Subjects with arterial hypertension were not included in our study. The EEG findings did not differentiate the diabetics as a group from their controls. This observation also supports our opinion about the relatively normal higher nervous functions and performances in patients with diabetes type-2 and without significant vascular complications.

It is known that where a chronic disease is present, depression may coexist with it (9). The psychological impacts of diabetes are no exceptions to this rule (5). The present study showed statistically significantly more depressive attitudes in patients with diabetes than in those without diabetes.

Diabetics—even those who demonstrate no complications and whose illness is under control—have been regarded as vocationally handicapped primarily by the potential hazards to health or difficulties of control (7). Persons with severe diabetes, however, need to be considered separately when defining realistic criteria for control and rehabilitation (8).

We would like to underline that cognitive performance does not place any restrictions upon the rehabilitation and counseling of patients with type-2 diabetes without complications.

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