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ORIGINAL RESEARCH

Prior Diagnosis of Diabetes but Not Its Control is Associated with Higher Depression Score Among Older Individuals

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Purpose: The study assessed the relationship between prior diagnosis of diabetes and its control with depression score, differences in socioeconomic, lifestyle, health characteristics and diabetes control by adherence to treatment in population-based sample of older individuals.

Patients and Methods: The analysis of the sub-sample of Polish cohort of the HAPIEE (Health, Alcohol, and Psychosocial Factors in Eastern Europe) study was conducted; 464 participants were interviewed and random first 360 (78%) underwent physical examination and blood sample tests. Depressive symptoms were assessed using the Center for Epidemiological Studies Depression Scale. The robust regression method was applied to assess the association between depression score and diabetes diagnosis as well as diabetes control.

Results: There were 97 participants (21.0%) at mean age of 73.6 years (SD=6.31 years) with prior diagnosis of diabetes. Mean HbA1c concentration was 6.65% (SD=1.0) The majority of patients (55.7%) used oral medication with diet. Nearly 20% declared the use of oral treatment alone, and 10.3% used combined treatment of oral medications, insulin, and diet. In this study, 86.6% of the participants with diabetes confirmed self-monitoring of blood glucose levels and 58.8% were on high-quality diet. No differences in socio-economic, lifestyle, health characteristics or control of diabetes by adherence to diabetes treatment were found. After adjustment for age and gender, diagnosis of diabetes was associated with greater depressive score by about 2 points (β=2.02, 95% CI=0.16;3.88). However, no significant association between depression score and any indicator of diabetes control was found.

Conclusion: In older individuals with diabetes, depression score was higher compared to those without diabetes, but it was not related to poorer diabetes control. No differences in socioeconomic, lifestyle, health characteristics and control of diabetes by adherence to diabetes treatment may suggest that in this age group some other, less known factors are substantial for achievement of treatment targets.

Keywords: diabetes, depression, older adults, control

Introduction

Diabetes is a growing public health problem, and its prevalence is projected to increase globally by 25% over the next 10 years.[1] In large Polish studies, the prevalence of diabetes in the adult population varied between 7% and 9% in men and 6% and 8% in women.[2] According to the Multicenter National Population Health Examination Survey (WOBASZ study), which included a sample from the general Polish population, the prevalence of diabetes increased by approximately 2% during the decade 2003 to 2014 and reached more than 8%. The prevalence of diabetes increases with age, and the disease is the most prevalent (27%) in the age group 65–74 years. It is also known that the prevalence of depression is twice to more than three times higher in people with diabetes.[3]

The use of pharmacotherapy in patients diagnosed with diabetes in Poland appears to be high (92% in the WOBASZ II study). However, in the group of high cardiovascular risk patients, in the EUROASPIRE V study, only 75%

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participants diagnosed with diabetes declared using pharmacotherapy.[4,5] According to the data of National Health Fund, in 2019, 2.8 million people in Poland were taking antidiabetic drugs and this number increased, compared to 2015.[5] However, despite the high number of treated people, the proportion of patients who reach treatment targets, recommended by international and national expert committees, remains unsatisfactory.[6–8] In the review by Aschner et al, it was found that in developing countries glycemic control in individuals with type 2 diabetes remained suboptimal and has even worsened in recent years.[9] In the developed countries, control of diabetes remains also below expectations. In the large study in the American population, conducted between 1999 and 2010, the proportion of patients with diabetes who reached the treatment target, defined as HbA1c level <7.0%, was between 48% and 56%.[10] A smaller study indicated that in some populations the proportion of patients with poorly controlled diabetes might be even higher.[11]

There is no information from the recent nationwide studies on diabetes control, measured by the HbA1c target, for the general population of Poland. Data from the National Health Fund indicate that in 2018, small proportion of patients with diabetes had examined HbA1c levels in the previous 12 months.[5,6]

There are several factors associated with nonadherence to therapy. In addition to these related to the health care system, the relationship between the patient and the provider and medication, the most important are the characteristics of the patients such as age, gender, education, or physical and mental status.[12] Depression is a significant comorbid condition in diabetes.[13] The guidelines of scientific societies indicate that a substantial proportion of patients have a diagnosis of a psychiatric disorder. Therefore, physicians should be equally attentive to somatic and emotional causes of symptoms, as well as potential causes of nonadherence resulting from psychiatric disorders.[14] There is evidence supporting bidirectional association between diabetes and depression. Diabetes increases the risk of depression by 15–28%. On the other hand, depression was confirmed as a risk factor for diabetes in non-diabetic individuals (34% and 60% risk increase). In addition, depression accelerates the occurrence of complications and appears to hinder diabetes-specific care.[15,16]

Given that the prevalence of both diabetes and depression is increasing in the older age group, special attention should be directed toward the elderly. This is particularly important because of the predicted increase in older people, the population with particularly high prevalence of diabetes and other comorbidities such as cognitive impairment.[12,17,18]

Findings from the recent Polish studies confirm that in patients with diabetes, depression is more common in older age groups with longer diabetes duration, lower awareness, and greater severity of microvascular disease complications.[19] Because not all relationships observed in the general population could be simply transferred to old individuals, there is a strong need to address these issues in research among older age groups. There is evidence that comorbid depression and diabetes in older individuals increased the risk of cognitive impairment and that the effect of depression on mortality in people with diabetes is strongest in older age groups.[13,20]

Our study addresses the need to quantify the association between the prior diagnosis of diabetes and the depression score in older adults and to assess the determinants of possible nonadherence to diabetes treatment in a population-based sample in the urban population of Central Europe.

The study assessed 1) the relationship between prior diagnosis of diabetes and its control with depression score and 2) the differences in socioeconomic, lifestyle, health characteristics and control of diabetes by adherence to treatment in population-based sample of older individuals.

Materials and Methods

The analysis of the Polish subsample of the HAPIEE (Health, Alcohol, and Psychosocial Factors in Eastern Europe) study was conducted. The HAPIEE study is the longest on-going cohort study to investigate the effect of classical and non-conventional risk factors of cardiovascular and other non-communicable diseases in Eastern Europe.[21] The third reexamination of the cohort started in December 2019 and was continued until March 2020. Within this period, 930 eligible participants were contacted and 464 (50%) responded to the invitation. Participants were interviewed at home by trained nurses. An extensive standard questionnaire was administered using computer-assisted personal interviewing (CAPI). The entire cohort was planned to be examined in the clinic; however, due to the COVID pandemic, the study was halted after examining 464 random participants of whom first 360 (78%) were random and able to undergo physical examination and blood sample drawing for biochemical tests.

Diabetes

The diabetes interview began with a basic question as to whether the participant had ever been diagnosed with diabetes. Participants who answered yes, received a series of further questions referring to 1) age at the first diagnosis, 2) treatment used (diet, tablets, insulin, other injectable preparations, no treatment, do not know); 3) self-monitoring of blood glucose levels; 4) use of continuous glucose monitors; 5) forgetting medicine (no if never forgets vs yes if forgets at least a few times a year); and 6) changing of medicine with no medical consultation (no for never changed vs yes if changed a few times or more in the last year). Non-adherence to the diabetes treatment was defined as either unsupervised change or forgetting medications.

Venous blood was collected using vacuum tubes after overnight fasting. Hemoglobin A1C was determined in a whole blood sample by HPLC (ion-exchange high performance liquid chromatography). Blood samples for the determination of glucose concentrations were centrifuged within 4 hours of venipuncture. Serum glucose was determined in serum using enzymatic methods. All analyses were carried out on the same day in one laboratory. Control of diabetes was defined as reaching the treatment target for HbA1c below 7%.[7,22]

Depression

Depressive symptoms were assessed using Center for Epidemiological Studies Depression Scale (CES-D) by L. Radloff.[23] The scale consists of 20 items referring to symptoms occurring during the past week, ranked on a 4-point scale. The total score range was from 0 (lowest depression score) to 60 (highest depression score). Calculation of the final score allowed for a maximum of four missing answers; in those who gave between 16 and 19 responses, the answers were inputted using the average score. The CES-D scale was previously validated in the Polish population.[24]

Socioeconomic and Lifestyle Characteristics

Socioeconomic and lifestyle characteristics were assessed during interview and included: education (university vs lower), smoking status (ever smoked vs never smoked), self-rated sleep quality (very good and good vs lower). Leisure time physical activity was assessed as an average number of hours (for winter and summer periods separately) spent on walking, sports, and other physical activities such as housework. A diet index was derived from information on products consumed such as fruits and vegetables, red or highly processed meat, poultry, fish, corn or wheat bread, cheese, butter, sweets and chocolates, sodas, sugar, or junk food. If the participant declared the consumption according to the diabetes recommendations, he got 1 point for each product; maximum possible score was 16. Individuals who obtained a score of seven (the median value) or more points were classified as those with high-quality diet, while others were classified as being on low-quality diet.[25,26] Perceived control over life was assessed by a standardized scale adapted from the Whitehall II Study and the MacArthur Foundation Program on Midlife Development. Participants were asked to indicate to what extent they agreed or disagreed with 11 statements referring to their perceived control over life. The score ranged from 0 to 55 points, with higher scores indicating higher perceived control.[27–29]

Health

Information on self-rated health (very good and good vs lower), diagnosis of hypertension, and hypercholesterolemia were used. Body mass index (BMI) was calculated as kg/m^2 based on weight and height measured in the clinic.

Statistical Analysis

The distribution of categorical variables was presented as number and percentage. Continuous variables' mean (SD) or median (interquartile range) were presented. Chi^2 test, the independent sample *t*-test or the Mann–Whitney *U* test were used to compare the distributions by diagnosis of diabetes and adherence to treatment. The robust regression method was applied to assess the association between depressive symptoms and diabetes diagnosis as well as diabetes control. Models included CES-D score as an outcome and diagnosis of diabetes or diabetes control variables with age and gender as predictors. Statistical analysis was done in *R* Studio. The p value <0.05 was accepted to be significant.

The HAPIEE study complies with the Declaration of Helsinki, and it was approved by The Jagiellonian University Bioethics Committee. All participants gave their written consent to participate in the study after being informed of the purpose and procedures of the study.

Results

The sample studied included 464 respondents aged between 63 and 87 years (x = 72.7 years; SD = 6.38). Of them, 97 (21.0%) had a prior diagnosis of diabetes. The distributions of health, socioeconomic and lifestyle characteristics are presented in Table 1 for the whole sample and by diagnosis of diabetes. Diabetes was more frequent in men than in women (p = 0.036). Depression score was higher in patients with diabetes, compared to those without the diagnosis (10.7 vs 12.6, p = 0.021).

Characteristics related to diabetes treatment and control in participants diagnosed with diabetes are presented in Table 2. The average age at first diagnosis of diabetes was 60.03 years (SD = 12.5). The vast majority of participants were on treatment and 58.8% were on high-quality diet. There were only three individuals who declared no treatment at all, and other five reported diet as the only treatment. The majority of participants (55.7%) used oral medication with diet. Up to 18.6% declared the use of oral treatment only, and 10.3% used combined treatment of oral medications, insulin, and diet. There were six individuals who used insulin as the only pharmacological treatment, and of them two participants declared not being on the diet.

Nearly 90% of the participants with prior diagnosis of diabetes confirmed self-monitoring of blood glucose levels and about 16% used continuous glucose monitors.

There were 67.5% of the participants with diabetes who declared that they never forgot to take glucose-lowering tablets or insulin over the past year. However, 16.7% declared changing the dose of the drug or insulin without consultation with a doctor.

In the subsample of participants with diabetes whose blood samples were analyzed, mean HbA1c was 6.65% (SD = 1) and mean glucose concentration was 7.13 mmol/l (SD = 1.94). There were 70% of the respondents who achieved the recommended HbA1c treatment target 7.0% or less and 60% who had fasting blood glucose level below 7 mmol/l.

The distribution of socioeconomic, health, lifestyle characteristics, control of blood glucose and HbA1c by adherence to diabetes treatment is presented in Table 3. Adherence to treatment was not significantly related to any characteristic studied, including the mean glucose and HbA1c and the proportion of the patient who achieved the target of treatment. In

Table 1 The Distribution of Socioeconomic, Lifestyle and Health Characteristics in the Whole Sample and by Diagnosis of Diabetes

	Total		**Prior Diagnosis of Diabetes**		**No Diagnosis of Diabetes**		***p***
	N=464		**n=97**		**n=367**		
Age [years] (x, sd)	72.70	6.376	73.58	6.31	72.38	6.37	0.078
Gender (woman, n,%)	240	51.7	41.00	42.3	198	54.3	0.036
Education (university, n,%)	216	46.7	48	49.5	167	45.8	0.513
Self-rated health (good and very good, n,%)	244	48.3	29	29.9	195	53.4	<0.001
Self-rated sleep (good and very good, n,%)	250	54.1	45	46.4	205	56.2	0.086
Smoking (ever used, n,%)	255	55.2	56	57.7	199	54.5	0.572
Leisure physical activity (hours, x, sd)	21.1	17.60	16.53	14.01	22.34	18.25	0.001
Perceived control (x, sd)	38.70	7.64	37.45	7.72	39.09	7.59	0.058
Depression (CES-D score, x, sd)	10.70	7.86	12.56	8.89	10.49	7.05	0.021
			n=60		n=260		
BMI [kg/m^2] (x, sd)	28.26	4.64	29.75	5.40	27.92	4.39	0.006

Note: N=464.

Table 2 Treatment of Diabetes and Proportion of Patients Reaching the Treatment Targets

	N=97	
Age of diagnosis (years, x, sd)	60.03	12.5
Diabetes Treatment		
Diet only (n,%)	5	5.2
Oral medication only (n,%)	18	18.6
Insulin only (n,%)	2	2.0
Diet + oral medication (n,%)	54	55.7
Diet + insulin (n,%)	4	4.1
Oral medication + insulin (n, %)	1	1.0
Diet + oral medication + insulin (n,%)	10	10.3
No treatment (n,%)	3	3.09
Blood glucose monitoring		
Self-monitoring of blood glucose (n,%)	84	86.6
Self-monitoring of blood glucose (twice a day or more, n,%)	35	36.1
Continuous glucose monitoring (n,%)	16	16.5
Adherence to treatment		
Forgetting about medicine (never, n,%)	65	67.5
Unsupervised change of dose (never, n,%)	80	83.3
High-quality diet (n,%)	57	58.8
	N=60	
Diabetes control		
HbA1c % (x, sd)	6.65	1.00
HbA1c below 7% (n,%)	42	70.0
Glucose mmol/l (x, sd)	7.13	1.94
Glucose below 7 mmol/l (n,%)	36	60.0

participants who did not adhere to treatment, the proportion of self-rated health was lower than in those who adhered to treatment (22% vs 39%, p = 0.072). However, the difference was not significant.

There was a significant relationship between diabetes diagnosis and depression scores. After adjustment for age and gender, the diagnosis of diabetes was associated with greater depressive score by about 2 points (β = 2.02, 95% CI = 0.16;3.88). However, in participants with diabetes, there was no significant association between depressive symptoms and any indicators of diabetes control (Figure 1).

Discussion

In this study of older individuals, 21% had prior diagnosis of diabetes and out of them 70% achieved the main treatment target. The results obtained confirm that the previous diagnosis of diabetes was associated with a higher depression score. However, neither adherence to treatment nor control of diabetes was related to depression score.

The relationship between diabetes and depression score was in agreement with previously published studies that reported that depression may be related to various chronic diseases, including diabetes. The meta-analysis which covered studies on diabetic patients from older population, showed that diabetes is related to the higher level of depression.[3,30] The results of the studies varied from no effect to medium effect size, which might suggest that other factors could mediate this relationship. Furthermore, the relationship between depression and diabetes can be bidirectional. On the one hand, chronic diseases such as diabetes can cause depression; on the other hand, depression itself can interact with

Table 3 Distribution of Socioeconomic, Lifestyle, Health Characteristics and Control of Diabetes by Adherence to Diabetes Treatment

	Adheres to Treatment n=38[a]		Does Not Adhere to Treatment n=58[b]		p
Age [years] (x, sd)	73.16	6.89	74.02	5.86	0.411
Gender (woman, n,%)	13	34.2	28	48.3	0.173
Education (university, n,%)	20	52.6	27	46.6	0.560
Self-rated health (good and very good, n,%)	15	39.5	13	22.4	0.072
Self-rated sleep (good and very good, n,%)	17	44.7	27	46.6	0.861
Smoking (ever used, n,%)	24	63.2	31	53.5	0.347
Leisure physical activity (hours, x, sd)	16.18	13.82	16.82	14.37	0.893
Perceived control (x, sd)	37.09	7.95	37.56	7.66	0.776
Depression (CES-D score, x, sd)	12.32	8.99	12.82	8.95	0.775
	n=26[a]		n=33[b]		
BMI [kg/m^2] (x, sd)	29.21	5.10	30.59	5.90	0.350
HbA1c % (x, sd)	6.77	1.14	6.56	0.90	0.541
HbA1c below 7% (n,%)	17	65.4	25	75.8	0.382
Glucose mmol/l (x, sd)	7.37	2.08	6.97	1.85	0.572
Glucose below 7 mmol/l (n,%)	14	53.9	21	63.6	0.447

Notes: [a]Forgets medications or changes medication dosage by him/her-self. [b]Adheres to recommendation.

diabetes.[31] Due to the observational, cross-sectional study design, our research cannot detect a causative relationship, but supports that awareness of the disease, more than the disease itself is related to higher scores of the depression scale.

In this study, diabetes control was assessed using biochemical parameters that were not associated with depression. Previous research on this problem, however, is inconclusive. There are studies that showed that there is a relation between glycemic control and depressive symptoms, at least in some patients.[32,33] The fact that diabetes control was not related to depression score may be surprising but still is consistent with some other research in this field. However, a lack of significant association in our study may also be the result of the relatively small sample studied. Moreover, although randomly selected, the group is not fully representative of the general population as the study participants were found to

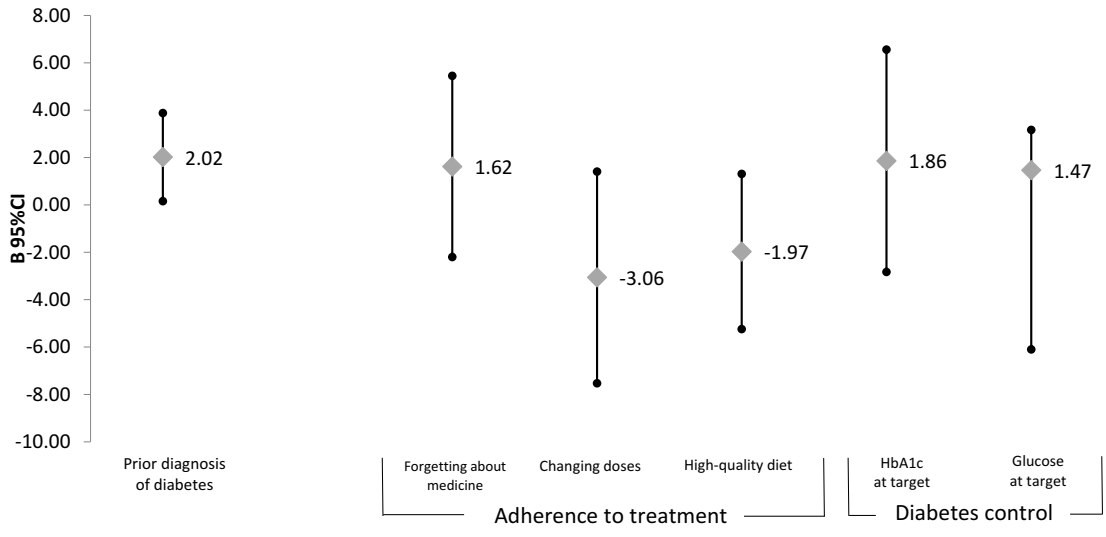

Figure 1 Relationship between depression score and diabetes diagnosis, and characteristic of adherence to treatment and diabetes control. Each model was adjusted for age and gender.

be the healthier part of the general population. Additionally, respondents were examined in earlier phases of the study to have been better informed about their health and, in general, more compliant.[34,35]

Only 3% of the respondents in our study indicated that they had not received any anti-diabetic treatment and 5% would remain on the diet only. These proportions agreed with the other study in the Polish population. However, no specific information on diabetics over 65 years old was provided in that study.[4] A high proportion of participants declared that they monitored their blood glucose concentration (87%). Compared to the study by Kotseva[36] that was carried out on patients with congenital heart defects, in our study people with diabetes were more likely to achieve the target of HbA1c treatment. This confirms that the sample in our study consisted of healthier or at least more obedient individuals, compared to other Polish studies.[5] In our sample, nearly 70% declared that they never forget to take their medication. However, the diet index indicated that a high proportion of people do not follow the recommendations of the diabetes societies, which was a similar finding to other studies in diabetic patients, which indicated unhealthy dietary habits.[37,38] Unsatisfying compliance with the dietary recommendations may be the effect of insufficient knowledge on the importance of diet, and the relation between diet and disease control in patients. In the WOBASZ study, more than three-quarters of participants were characterized by unsatisfactory level of knowledge about diabetes prevention, or about the consequences of untreated diabetes.[39]

Limitations and Strengths of the Study

There are several limitations of our study. First, it included a small sample surveyed what is partially related to the COVID-19 pandemic. The analysis of the blood samples was carried out only for 78% of the participants, which restricted the power of the analysis. Furthermore, all participants with diabetes, regardless of type of diabetes, were included in the study. However, the age at diagnosis suggests that the vast majority of them had type 2 diabetes. Respondents included in this analysis participated in previous studies and, if necessary, were instructed to contact the doctor. This could explain that diabetes control in our sample was better than average and that only two new diabetes cases were detected during the present survey. Furthermore, the assessment of adherence to diabetes treatment was based only on self-declaration and might explain the lack of association with socioeconomic, lifestyle, and health characteristics with diabetes control. The diet index used is not a standard tool for assessing nutrition in people with diabetes. Finally, the conclusions from this study are limited to the populations of patients with similar clinical characteristics, including satisfactory glycemic control in general.

However, there are some strengths of the study, and the most important seems to be a focus on the older part of the general population. To date, knowledge about adherence to recommendations is limited to the percentages of people who adhere to treatment, and results are reported for a wider age range of the population.[4] In our study, detailed information was obtained not only about achieving the treatment target for glucose levels but also about self-monitoring and adherence to medications, dose changes and diet quality, as well as the achievement of the treatment target for HbA1c. Finally, we focus on the older population in which the prevalence of type 2 diabetes is the highest, as is the risk of complications of the disease.

Conclusion

In older individuals with diabetes, depression score was higher than in participants with no diabetes, but neither adherence to treatment nor control of diabetes was related to depression score. No differences in socioeconomic, lifestyle, health characteristics and control of diabetes by adherence to diabetes treatment may suggest that in this age group, some other less known factors are substantial for achievement of treatment targets.

Policy and Practical Implications of the Study

The results of our study confirm that in older individuals with diabetes, depression is an important co-occurring condition that can impact a patient's overall health and wellbeing. However, diabetes control does not seem to be a sufficient means to raise the mood of patients with diabetes, as well as the presence of depression does not explain the poorer control of diabetes. Healthcare resources should be directed towards factors that are known to have a greater impact on diabetes control.

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Disclosure

The authors report no conflicts of interest in this work.

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