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ORIGINAL RESEARCH

Relations of Well-Being, Coping Styles, Perception of Self-Influence on the Diabetes Course and Sociodemographic Characteristics with HbA1c and BMI Among People with Advanced Type 2 Diabetes Mellitus

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Purpose: Assessment of the relationship between psychological and sociodemographic factors with the levels of glycated hemoglobin (HbA1c) and Body Mass Index (BMI) among people with advanced type 2 diabetes mellitus (T2DM).

Patients and Methods: A total of 2574 persons, among them 1381 (53.7%) women, with type 2 diabetes, during the period of switching from biphasic mixtures of human insulin to insulin analogues. The age of participants ranged from 22 to 94 years (M = 63.5; SD = 9.58), and their treatment period was in the time frame from 2 years to 43 years (M = 10.2; SD = 6.1). Participants filled out a Scale for Perception of Self-Influence on the Diabetes Course, Well-Being Index WHO-5, two questions from the Brief Method of Evaluating Coping with a Disease.

Results: Statistically significant correlations were found between the HbA1c levels and (1) disease duration (r_s=0.067; $p < 0.001$); (2) number of complications ($r_s = 0.191$, $p < 0.001$) (3) the perception of self-influence on the diabetes course (r_s=- 0.16; $p < 0.001$); (4) well-being (risk of depression) (r_s=- 0.10; $p < 0.001$). The regression analysis showed that 7% of HbA1c variability is explained by age, a perception of self-influence on the diabetes course, the number of complications, place of residence, education, BMI. The most important findings concerning BMI were found in regression analysis, which indicated a week relationship between BMI and a number of complications, perception of self-influence on the diabetes course and coping styles (3% of the resultes' variability). The group at high risk of depression had the highest levels of HbA1c.

Conclusion: Sociodemographic and psychological factors show weak but statistically significant relationships with the current levels of HbA1c and BMI.

Keywords: type 2 diabetes mellitus, glycemic control, psychosocial factors, HbA1C, BMI, depression

Introduction

Optimal management of type 2 diabetes is a challenge for modern medicine as the consequences of pathological blood glucose levels often lead to serious complications and premature death. Improper adherence to medical recommendations for disease management is also common among patients with this disease. To improve this situation, research into the psychosocial aspects of diabetes is ongoing and its

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results lead to conclusions that are contained in treatment guidelines.[1,2] The bidirectional relationship between depression and type 2 diabetes is best documented. The results of a recent meta-analysis of longitudinal studies indicate that the baseline level of depression is much more associated with the risk of increased levels of glycated hemoglobin (HbA1c) than vice versa.[3] The results for other psychological and social factors are not as well documented. Two large international studies Diabetes, Attitudes, Wishes and Needs (DAWN)[4] and the Second DAWN study/DAWN2[5] did not take into consideration a level of HbA1c, that reflects the average blood glucose concentration at approximately 3 months before the test, with the majority (about 60%) of HbA1c being formed in the last month before the test.

Achieving and maintaining normal levels of glucose remains a challenge for many persons with diabetes. Only 25.5% of patients had adequate glycemic control in a study conducted in 7 European countries.[6] Surveys from other countries reported that 60.5% to 78.2% of patients had poor glycemic control.[7–9] Meta-analysis of 23 studies reported the average HbA1c of 8.4%.[10] A systematic review and meta-analysis show limited associations between HbA1c and mental state.[11] Psychosocial interventions improved HbA1c to a small but significant extent (unified mean difference of 20.29%) and had some effect on mental status. Meta-analysis indicated that psychological interventions for adults with T2DM have minimal clinical benefits in improving glycemic control.[12] Data obtained from 23 studies on 3818 patients indicates that psychoeducational interventions significantly reduced HbA1c levels when compared to controls with a significantly weighted difference (WMD) of −0.279 (95% CI = −0.480, 0.079, $p = 0.006$).[10] There were no significant differences between different types of interventions.

It is stressed that treatment targets and strategies should be individualized, which leads to four-time larger reduction in HbA1c comparing to interventions that do not use individualized goal settings.[13]

The Body Mass Index (BMI), which reaches the degree of obesity, is an important risk factor for type 2 diabetes, due to its' relations with the development of insulin resistance.[14] Weight control is one of the targets of diabetes management. In addition to the diabetogenic effect, obesity and the distribution of adipose tissue are also associated with inflammation, dyslipidemia, and cardiovascular complications.[15]

There is no systematic review and meta-analysis of the relationship between BMI and glycemic control as measured by HbA1C levels and the number of complications. Research results indicate weak correlations between HbA1c levels and BMI.[16] In the DINAMIC II study, the percentages of people with impaired glycemic control (HbA1c >7) differed slightly in the groups with a BMI below or equal 25; from 25 to 30; and above 30. They were respectively 49.33%; 46.87%; 49.48%.[17] More pronounced differences in BMI were found in groups that differed in the level of HbA1c in the study of people without diagnosed diabetes. In the group with the HbA1c level of 5.6% or less, the average BMI was 26.3, in the group with the HbA1c level of 5.7% −6.4% the average BMI was 29.1, and in the group with the HbA1c level higher than 6.5% the average BMI was 30.8.[18]

Recommendations of the American Diabetes Association (ADA) are based mainly on research conducted in English-speaking countries. However, the results of the Second Diabetes Attitudes Wishes and Needs (DAWN2) study on the correlation of psychosocial and psychological outcomes in people with diabetes, show significant differences found in the 17 countries that participated in the study.[5,19] There are only a few psychosocial aspects of diabetes assessed in large samples of patients with advanced disease, including the assessment of HbA1c.

The analysis of literature, on the basis of which the Psychodiabetic Kit was constructed, leads to the conclusion that the assessment of coping styles, perception of self-influence on the diabetes course and the levels of anxiety and depression are the most important in the management of people with diabetes during regular medical visits.[20]

Aims

Having access to observational and cross-sectional data from large populations of patients with advanced type 2 diabetes, the study was dedicated to access the relationships between sociodemographic, clinical and psychological factors with:

1. level of glycated hemoglobin (HbA1c);
2. body mass index (BMI).

Materials and Methods

Participants

The observational study included outpatients, with type 2 diabetes, diagnosed according to the ICD-10 classification.[21] Patients were treated only with mixtures of human insulins (Mixtard 30, 40, 50, Humulin M3, Insuman Comb 25,

Gensulin M10-50, Polhumin Mix 2–5) and mixtures of human insulins with short-acting insulin preparations (ActRapid, Humulin R, Insuman Rapid, Gensulin R, Polhumin R).

Inclusion criteria were the following: adults with type 2 diabetes, as part of outpatient treatment, 1–61 days after switching from human insulin to insulin analogues and the availability of the HbA1c measurement result. The study was conducted from day 1 to day 61 after the initiation of insulin analogues, as it was possible to assume with high probability that the HbA1c result reported was derived from the treatment period with mixtures of human insulins. Based on these criteria, a database was created which was the basis for the publication about problems with adherence after switching from human insulin to insulin analogues,[22] that presented only correlations of studied factors with treatment adherence. The presented work is an additional analysis of that study database, on the relationship of sociodemographic, clinical and psychological factors with HbA1c and BMI. For this reason, the inclusion criteria include the time from treatment changeover, which is not a variable taken into account in the goals and calculations presented in this paper, and was the subject of an earlier analysis.

The exclusion criterion were cognitive dysfunctions that made the understanding of the used research methods impossible.

Research Procedure

The study was approved by the Bioethics Committee of the Medical University of Warsaw and was conducted in accordance with the Declaration of Helsinki. Data was collected by 343 professionals (from all over Poland) who acted as interviewers, treated outpatients with type 2 diabetes and who switched patients' treatment from biphasic human insulins to biphasic insulin analogues. Each investigator enrolled patients who met the inclusion criteria. The patients read the study information and signed the informed consent to participate in the study.

Assessments

All patients were assessed during a regular visit. Due to this abbreviated measures of the Psychodiabetic Kit[20] were applied. This set consists of questionnaires that were originally created in Polish and then translated into English versions. They are used to assess psychological variables: coping with the disease styles, the perception of self-influence on the disease course, the severity of depression and anxiety symptoms. They have proven psychometric properties.

Participants of the study completed the following assessments during their visit (completed by the physician and/or the patient):

1) Data from physician's questionnaire – developed for the purpose of the study. It contained data on the scope of the study (date of the study, patient's data: initials, age, sex, height and weight (BMI was later established), duration of type 2 diabetes, place of residence, education, HbA1c level, presence and type of diabetes complications, previous treatment with human insulin, duration of treatment, current treatment with insulin analogues, date of switchover). The data were assessed by the treating physician based on the patient's medical records. The above included:

- BMI (Body Mass Index, kg/m2) - the ratio of body weight in kilograms to the square of the height in meters, which is important in assessing the risk of obesity-related diseases and overweight. The groups were divided according to the BMI category into groups with normal body weight (BMI = 18.50–24.99), overweight (BMI $\geq$ 25) and obesity (BMI $\geq$ 30).
- HbA1c reflects the average blood glucose concentration for approximately 3 months before the test, with the majority (about 60%) of HbA1c being formed in the last month before the measurement. According to the 2020 ADA recommendations, nonpregnant adults without significant hypoglycemia should achieve a level of A1c < 7%. In patients not achieving treatment goals and in those, whose treatment modalities are changed, HBA1c tests should be performed at least quarterly, and as needed.[1]

The following self-report questionnaires, which are part of the Psychodiabetic Kit, were used to assess psychological variables:

1) Brief Method of Evaluating Coping with Disease (2 questions).[20,23]

The short coping assessment method contains descriptions of four stressful situations and four possible behaviors in every one of them. The behaviors, given as answer options, are characteristic of the four styles of coping with stress, i.e. oriented on: avoidance, emotions, task and best solution. The full version of the tool has relatively good psychometric properties for such a short questionnaire, in

both male and female versions. Reliability for individual styles of coping with stress, measured by the Cronbach's coefficient, in the version for men is: α = 0.67 for the avoidance-oriented style; 0.68 for emotions-oriented style; 0.75 for task-oriented style; 0.59 for best solution-oriented style. In the version for women, these values are respectively: 0.65; 0.67; 0.71; 0.55.

In order to shorten the time of the study for its participants, based on the analysis of the psychometric properties of the original tool[17] and for the purpose of this research, two items with the strongest correlation with the result of the entire questionnaire were distinguished and used. Two selected questions concern the attitude towards health and social problems. In some of the analyzes, responses to questions were aggregated, distinguishing between adaptive (task-oriented and best solution-oriented) and maladaptive (avoidance-oriented and emotion-oriented) and mixed styles.

2) Scale for Perception of Self-Influence on the Diabetes Course.[20,24]

The feeling of having an influence on the source of stress is one of the most important psychological factors that play a role in choosing a style of coping with stress. A perception of high self-influence on the course of the disease facilitates compliance with medical recommendations and solving related problems. The assessment of the perception of self-influence on the course of the diabetes was performed by physician on the Likert scale, used in the creation of the Brief Measure to Assess the Perception of Self-Influence on the Disease Course - version for diabetes.[24] The physicians' evaluation score based on the clinical knowledge of the patient and could range between 0 and 4. A score of 0 represents the lowest possible perception of self-influence (no influence); a score of 4 the highest possible perception of self-influence on the course of the disease.

3) WHO-5 Well-Being Index (5 questions).[25]

The WHO-5 questionnaire was used instead of the Brief Self-Rating Scale of Depression and Anxiety (which was a part of the Psychodiabeic Kit)[20] due to the very limited time of examination. The tool has adequate internal and external reliability (Cronbach's α = 0.88) for the Polish translation.[26] According to WHO data, the score below 13 points on this scale is an indication for a thorough examination for depression. The sensitivity of this scale for depression screening is 93% and specificity is 64%.[27] In more recent studies, a score below 7 is considered a high probability of depression.[28] The following groups of the risk of depression were established:

- No risk of depression: 13 or more points in the WHO-5 questionnaire
- Requiring clinical verification of depression: 8–13 points in the WHO-5 questionnaire or if the patient selected an answer to one of the five questions giving 0 or 1 point.
- High probability of depression: ≤7 score on the WHO-5 questionnaire

Statistical Analyzes

The statistical analyzes were carried out using SPSS version 27 for Windows. Statistical significance for all of the conducted analyzes was established at $p < 0.05$.

HbA1c and Sociodemographic, Clinical and Psychological Characteristics

The normality of the distribution of HbA1c variable was tested using the Kolmogorov–Smirnov test. The results of K–S tests for the whole group and in each compared subgroup are available in Table S1 and S2.

As the data were not normally distributed, nonparametric tests were applied. The Kruskal–Wallis *H*-tests were used to verify differences in the HbA1c levels according to sociodemographic, clinical and psychological categorical variables: education level, place of residence, BMI and the style of coping with stress related to the disease. Post-hoc tests with a Bonferroni-adjusted alpha level were then performed to compare all pairs of groups. The Mann–Whitney *U*-test was used to compare HbA1c levels between men and women, maladaptive and adaptive categories of coping styles.

The Spearman rank-order correlation coefficient was used to test the strength and direction of association between HbA1c and continuous variables: age, the perception of self-influence on the course of diabetes and depression (WHO-5), number of complications and duration of the disease.

The main analyzes were performed using multiple regression analyzes to identify significant sociodemographic, clinical and psychological predictors of the HbA1c levels, with the effect of other predictors statistically eliminated. A bootstrap method was applied, with bias-corrected and accelerated (BCa) bootstrap confidence intervals to deal with non-normality of data.[29] To obtain

sufficiently accurate 95-percent BCa, the number of bootstrap samples was on the order of 5000.[30,31]

The variables measured on the ordinal scale were recoded using the Dummy Coding method (coded variables: 0 = no, 1 = yes). The variance inflation factors (VIFs) were also calculated. This statistic provides a measure of multicollinearity between predictors in multiple regression analysis by estimating artificial inflation of the variance of a regression coefficient. A general guideline is that a VIF of higher than 10 indicates a high correlation with other predictors.[32,33] However, according to more restrictive criteria from literature,[33] there is a potential multicollinearity problem when the VIF value is greater than 3 or 5. To test whether the assumption of independent errors is tenable, the Durbin-Watson statistic test was estimated. The value of this statistic can vary between 0 and 4. Field[34] suggests that values of less than 1 or greater than 3 indicate problems with meeting the assumption of independent errors.

BMI and Sociodemographic, Clinical and Psychological Characteristics

The normality of the distribution of variables in each BMI category was tested using the Kolmogorov–Smirnov test. The results of K–S tests for continuous variables in the whole sample and each BMI's subgroup are available in Table S2 and S3. A Kruskal–Wallis test was applied to estimate differences in the age, disease duration, perception of self-influence on the course of diabetes, number of complications and well-being - a risk of depression according to the category of BMI (normal, overweight, obese). A chi-square test of independence was performed to examine the relationships between BMI categories and categorical variables (gender, education level, place of residence, styles of coping with stress). For each pair of columns, the column proportions were compared using a *z*-test. Our primary purpose was to check whether sociodemographic, clinical and psychological characteristics were significant predictors of BMI above norm, employing a multiple logistic regression with bootstrapping. The participants were divided according to BMI values to normal weight (0) and above normal weight (1). To deal with non-normally-distributed data, the 95% BCa confidence intervals from 5000 bootstrap replicates were estimated.[29] To assess whether the estimated multiple logistic models fitted the data, the Hosmer and Lemeshow goodness of fit test was employed.[35] For significant predictors of BMI, odd ratios with 95% confidence intervals (CI) were calculated as estimates of relative risk.

Results

Sociodemographic, Clinical and Psychological Characteristics of the Study Sample

The observational study included 2574 outpatients with type 2 diabetes, diagnosed according to the ICD-10 classification.[21] The sample consisted of 1381; (53.7%) women and 1171 (45.5%) men, treated from 2 years to 43 years (M = 10.24; SD = 6.10) (percentages do not add up to 100 due to lack of data 0.8%). The age of the respondents ranged from 22 to 94 years (M = 63.58; SD = 9.58). Descriptive statistics of the studied population are presented in Table 1.

Comparisons and Relationships of HbA1c with Sociodemographic, Clinical and Psychological Characteristics

The basic intergroup comparisons in HbA1c levels according to categorical variables and correlations analysis between HbA1c and continuous variables are presented in Table S4 and S5. The levels of HbA1c varied across the level of education, place of residence, BMI categories, styles of coping (see Table S4). A weak but significant positive correlation between duration of the disease and HbA1c levels was found (r_s = 0.07; p < 0.001). The longer the duration of diabetes, the higher HbA1c. The perception of self-influence on the course of diabetes was weakly and negatively associated with HbA1c level. It means that the lower the degree of a perception of the self-influence, the worse the glycemic control is (r_s = −0.16; p < 0.001). Statistically significant, though weak, correlations between the level of HbA1c and the number of complications (r_s = 0.191, p < 0.001) and WHO-5 score (risk of depression) were also found (r_s= - 0.10; p < 0.001) (see Table S5).

Sociodemographic, Clinical and Psychological Predictors of the HbA1c Level

The multiple regression analysis concerning the levels of HbA1c and the analyzed predictors, led to the construction of a model that explains 7% variation in HbA1c results

Table 1 Sociodemographic, Clinical and Psychological Characteristics of the Study Sample (*N* = 2574)

Sociodemographic Characteristics				
	Mean (SD)	**Median**	**Quartiles (Q1, Q3)**	**Min-Max**
Age	63.58 (9.58)	64	58, 70	<22; 94>
Sex	**Category** Female Male		**Frequencies (%)** 1381 (53.7%) 1171 (45.5%)	
Education	Primary Secondary Higher		884 (34.3%) 1333 (51.8%) 340 (13.2%)	
Residence	Rural City Big city		651 (25.3%) 998 (38.8%) 902 (35%)	
Clinical characteristics				
Duration of diabetes [years]	Mean (SD) 10.24 (6.10)	Median 10	Quartiles (Q1, Q3) 6, 13	Min-Max <0.3; 74>
BMI [kg/m2]	29.69 (4.41)	29.23	26.89, 32.01	<16.18; 56.19>
	Category Underweight Normal Overweight Obese Class I Obese Class II Obese Class III		**Frequencies (%)** 5 (0.2%) 285 (11.1%) 1160 (45.1%) 794 (30.8%) 223 (8.7%) 54 (2.1%)	
HbA1c	Mean (SD) 7.99 (1.11)	Median 7.90	Quartiles (Q1, Q3) 7.30, 8.50	Min-Max <4.10; 15.0>
	Category ≤7 >7		**Frequencies (%)** 419 (16.3%) 2155 (83.7%)	
Number of diabetes complications	Mean (SD) 1.16 (1.06)	Median 1.00	Quartiles (Q1, Q3) 0, 2	Min-Max <0; 4>
	Category Macroangiopathy Retinopathy Nephropathy Neuropathy Macroangiopathy		**Frequencies (%)** 1150 (44.7%) 859 (33.4%) 270 (10.5%) 717 (27.9%) 1150 (44.7%)	
Psychological characteristics				
Coping style	**Category** Avoidance-oriented Task-oriented Best solution-oriented Emotion-oriented		**Frequencies (%)** 300 (12.2%) 367 (14.9%) 248 (10.1%) 206 (8.4%)	
WHO-5	Mean (SD) 15.36 (4.65)	Median 15.00	Quartiles (Q1, Q3) 12.25, 18.75	Min-Max <0; 25>

(*Continued*)

Table 1 (Continued).

	Mean (SD) Psycological Characteristics	Median	Quartiles (Q1, Q3)	Min-Max
	Category		**Frequencies (%)**	
	No risk of depression		1775 (69%)	
	Medium risk		582 (22.6%)	
	High risk of depression		166 (6.4%)	
	Mean (SD)	Median	Quartiles (Q1, Q3)	Min-Max
Perception of self-influence on the diabetes course	2.56 (0.96)	3.0	2.0, 3.0	<0; 4>

Notes: The percentages do not sum up to 100, since the respondents could choose more than one answer or none/missing data. BMI categories criteria: underweight <18.4; normal 18.5-24.9; overweight 25-29.9; obese class I 30-34.9; obese class II 35-39.9; obese class III >40.
Abbreviations: HbA1c, glycated hemoglobin; BMI, body mass index.

(R^2_{adj} = 0.07; $F(15, 2244) = 12.37$; $p < 0.001$). In this study, the VIF values ranged from 1.05 to 2.18, indicating no multicollinearity (see the value in Table 2). The Durbin-Watson statistic informs whether the assumption of independent errors is tenable. The closer to 2 the value is, the better, and for these data the value of 1.938 was so close to 2, that the assumption has almost certainly been met.

As presented in Table 2, significant variables in the model were: age, secondary and higher education, living in a big city, BMI, number of complications and the perception of self-influence on the course of diabetes. For this model, older age (β = −0.11; 95% Bca CI: −0.02 – −0.007) and perception of self-influence on the course of diabetes, (β = −0.09; 95% Bca CI: −0.16 – −0.04) were significant predictors of lower HbA1c levels. The patients living

Table 2 Summary of the Multiple Regression Analysis for Sociodemographic, Clinical and Psychological Variables Predicting the HbA1c Level

Predictors	*B*	*SE*	β	*t*	*p*	95% Bca CI	VIF
(*constant*)	8.62	0.30		3.46	<0.001	8.04; 9.21	
Gender (ref. male)	0.01	0.05	0.004	0.18	0.868	−0.09; 0.10	1.07
Age (in years)	−0.01	0.003	−0.11	−4.95	<0.001	−0.02; −0.01	1.26
Education (ref. primary)							
Secondary	−0.25	0.06	−0.11	−4.43	<0.001	−0.36; −0.13	1.51
Higher education	−0.32	0.08	−0.10	−3.89	<0.001	−0.47; −0.17	1.55
Place of residence (ref. rural area)							
Small town	−0.04	0.07	−0.02	−0.63	0.568	−0.17; 0.09	1.74
Big city	−0.22	0.07	−0.10	−3.45	<0.001	−0.36; −0.08	1.83
BMI (kg/m2)	0.01	0.01	0.05	2.32	0.044	0.001; 0.02	1.05
Number of complications	0.15	0.02	0.14	6.23	<0.001	0.10; 0.20	1.28
Disease duration	0.06	0.05	0.03	1.47	0.178	−0.03; 0.15	1.26
WHO-5	0.001	0.01	0.003	0.11	0.921	−0.01; 0.01	1.26
Perception of self-influence on the diabetes course	−0.10	0.03	−0.09	−3.60	<0.001	−0.16; −0.04	1.51
Coping style (ref. task-oriented style)							
Avoidance-oriented style	0.12	0.09	0.03	1.25	0.214	−0.06; 0.29	1.76
Best solution-oriented style	0.07	0.09	0.02	0.78	0.407	−0.10; 0.24	1.51
Emotion-oriented style	0.07	0.10	0.02	0.69	0.470	−0.12; 0.27	1.64
Mixed style	0.04	0.07	0.02	0.58	0.556	−0.09; 0.16	2.18
Model summary: R^2_{adj} = 0.07; $F(15, 2244) = 12.37$; p <0.001							

Note: Each of the dummy coded variables uses one degree of freedom.
Abbreviations: BMI, body mass index; ref, reference category, a category of comparison for the other categories; 95% Bca CI, 95% Bias-corrected and accelerated confidence intervals.

in big cities had lower levels of HbA1c than those living in rural areas (β = −0.10; 95% Bca CI: −0.36 – −0.08). Also, participants with secondary and higher education had lower HbA1c than patients with primary education (β = −0.11; 95% Bca CI: 0.36, −0.13; β = −0.10; 95% Bca CI: −0.47 – −0.17, respectively). The higher the BMI value, the higher the HbA1c levels (β = 0.05; 95% Bca CI: 0.001–0.02). A greater number of complications had the most significant importance on the higher HbA1c levels in comparison to other variables in the model (β = 0.14; 95% Bca CI: 0.10–0.20).

Relationships and Comparisons of Sociodemographic, Clinical and Psychological Characteristics in People with Different BMI

The basic correlation analysis between BMI and categorical variables as well comparisons of continuous variables according to BMI categories were presented in Table S6 and S7. There was a statistically significant difference in the age according to the category of body mass according to BMI (normal, overweight, obese). People with obesity were significantly older than people with normal weight. There was a statistically significant difference in the disease duration according to the categories of BMI (normal, overweight, obese). People with obesity had suffered from the T2DM for a significantly longer time than people with normal weight and overweight (see Table S6).

Sociodemographic, Clinical and Psychological Predictors of the BMI

A multiple logistic regression with bootstrapping method was performed to investigate the effects of age, sex, education level, place of residence, duration of the disease, number of complications, depression, perception of self-influence on the course of diabetes and styles of coping with stress on the likelihood that participants had a BMI above norm (see Table 3). The logistic regression model was statistically significant when compared to the null

Table 3 Summary of Multiple Logistic Regression Analysis with Bootstrap Method (5000 Samples) for Sociodemographic, Clinical and Psychological Variables Predicting the BMI

DV: BMI (kg/m2)								
Predictors	**B**	**SE**	**Wald's χ^2**	**df**	***p***	**Exp(B)**	**95% BCa CI**	
							Lower	**Upper**
(constant)	1.86	0.61	9.37	1	0.002	6.40		
Sex (ref. male)								
Female	0.05	0.14	0.15	1	0.699	1.05	0.81	1.38
Age	0.01	0.01	1.42	1	0.233	1.01	0.99	1.03
Education level (ref. primary)								
Secondary education	−0.08	0.17	0.22	1	0.642	0.92	0.66	1.29
Higher education	−0.20	0.23	0.74	1	0.390	0.82	0.52	1.29
Place of residence (ref. rural area)								
Small town	−0.05	0.19	0.07	1	0.793	0.95	0.66	1.37
Big city	−0.05	0.19	0.06	1	0.802	0.95	0.65	1.39
Disease duration	−0.01	0.01	0.48	1	0.488	0.99	0.97	1.02
Number of complications	0.25	0.08	10.70	1	<0.001	1.29	1.11	1.50
WHO-5	0.01	0.02	0.58	1	0.445	1.01	0.98	1.05
Perception of self-influence on the diabetes course	−0.20	0.09	5.47	1	0.019	0.82	0.69	0.97
Coping style (ref. task-oriented style)								
Avoidance-oriented	−0.64	0.26	6.21	1	0.013	0.52	0.32	0.87
Mixed	−0.08	0.20	0.17	1	0.684	0.92	0.63	1.36
Best solution-oriented	−0.23	0.26	0.83	1	0.362	0.79	0.48	1.31
Emotion-oriented	−0.23	0.32	0.55	1	0.459	0.79	0.43	1.47

Notes: Hosmer & Lemeshow test: $\chi2(8) = 3.651$; $p = 0.887$; Classification accuracy: 88.3%; Nagelkerke $R^2 = 0.030$; $\chi2(14) = 34.612$; $p = 0.002$.
Abbreviations: BMI, body mass index; ref, reference category, a category of comparison for the other categories; 95% Bca CI, 95% Bias-corrected and accelerated confidence intervals.

model, $\chi^2(14) = 34.61$, p = 0.002. The model explained 3.0% (Nagelkerke R^2) of the variance in BMI and correctly classified 88.3% of above norm BMI cases. The Hosmer and Lemeshow statistic suggests that the model is fit to the data $\chi2(8) = 3.65$; $p = 0.887$.

It was found that increasing numbers of complications were associated with an increased likelihood of exhibiting BMI above norm (OR = 1.29; 95% Bca CI: 1.11, 1.50). Additionally, increase in the perception of self-influence on the diabetes course was associated with lower odds of occurrence of BMI above norm (OR = 0.82; 95% Bca CI: 0.69, 0.97). It turned out that patients using avoidance-oriented coping styles were significantly less likely to suffer from BMI above norm (OR = 0.52; 95% Bca CI: 0.32, 0.87) than patients who present task-oriented coping styles.

Discussion

The obtained results indicate that psychosocial factors have a weak but significant relationship with the levels of HbA1c – similar to the American studies the results of which have been assessed by experts who recommend their inclusion in the management of diabetes (ADA).[36] The relatively large study group of patients in an advanced stage of diabetes treatment is a strong point of this research. Psychological measures were used in shortened versions due to limited time for patients' participation as the study was conducted during regular medical visits, when treatment with human insulin was switched into treatment with analogues of insulin.

The choice of the examined factors was based on theoretical presumptions of the Psychodiabetic Kit, verified in research[20] and on the Polish guidelines on the management of patients with diabetes.[37]

The analysis of the relationship between psychosocial factors and the levels of HbA1c showed low, but statistically significant correlations with number of complications, perception of self-influence on the course of diabetes, well-being (risk of depression) and the disease duration. Also noteworthy is the higher level of HbA1c in the group with maladaptive styles of coping with stress when compared to the group with adaptive styles. Patients who used the best solution-oriented coping style had lower HbA1c levels than those who used the avoidance or emotion oriented styles. The relationships of psychological variables with blood glucose levels turned out to be significant, but weak. These data are consistent with the conclusions of the meta-analysis that psychological interventions have minimal clinical benefit in improving glycemic control for adults with type 2 diabetes.[12] The observed differences in HbA1c levels indicate that glycemic control is the weakest among less educated people living in smaller towns and indicates groups of people who require intensification of educational interactions. These observations are compatible with conclusions about the need for such research, formulated by the authors of literature review on sociodemographic, psychological and social factors of glycemic control.[38]

Significant predictors of higher levels of HbA1c after adjusting for the other variables were: younger age, basic level of education, living in the rural areas, higher BMI, greater number of complications, and lower perception of self-influence on the course of the disease. A multiple linear regression analysis led to the construction of a model that explains only 7% of the variability in HbA1c scores, which indicates weak relationships between HbA1c levels and psychological and sociodemographic factors. Compared with the results of longitudinal studies in Saudi Arabia (in which regression analysis showed that poor glycemic control was influenced by family history of diabetes, longer duration of diabetes, insufficient exercise, and overweight or obesity),[7] in this study, with all the variables - the number of late complications for the higher HbA1c levels was most significant in the model. These data are consistent with the results of longitudinal studies showing that disease duration, insulin use and baseline HbA1c, rather than psychological variables, were most important for achieving optimal glycated hemoglobin levels.[39]

Obesity is one of the best documented risk factors in the development of type 2 diabetes. Its treatment may delay the progression from prediabetes to type 2 diabetes and is also beneficial in the treatment of type 2 diabetes.[40,41,] Long-term weight loss improves glycemic control and reduces the need for glucose-lowering drugs.[42–44] Reducing body weight by at least 5% produces measurable improvements in glycemic control.[45]

In the presented study, the average BMI was 29.69 and was on the verge of obesity, for which a BMI of 30.0 is assumed. With such a distribution (a small group of people with normal body weight), it is more difficult to demonstrate the relationship between the correct BMI and the studied variables.

Group comparisons indicated that obese individuals were significantly older than those with normal weight and have had diabetes for significantly longer than those

with normal weight or overweight. A regression analysis showed that the increase in the number of complications is associated with the probability of BMI above norm and the increased perception of self-influence on the course of diabetes is associated with a lower probability of BMI above norm. Patients who used avoidance-oriented coping styles were less likely to have BMI above norm than those who used task-oriented coping styles.

The obtained data indicate the importance of the perception of self-influence or coping styles on the level of body weight, which is important as these variables may be shaped by psychological interventions. It should be noted, however, that this model explains only 3% of the BMI variance, which suggests a more important role for other variables.

Conclusions

The obtained results indicate the legitimacy of taking into account the discussed factors in the pursuit of glycemic control, as well as show potential areas for intensifying educational activities i.e. improving the effectiveness of programs addressed to people with type 2 diabetes (poorly educated, living in rural areas). The results also indicated the possibility of improving the course of diabetes by shaping the perception of self-influence on the course of diabetes which can lead to both decreasing of HbA1c levels and maintaining normal BMI. In addition, in the treatment of diabetes, special emphasis should be placed on preventing disease complications, as an increase in the number of complications is a risk factor for both the increase in HbA1c levels and the increase of BMI above norm.

1. Statistically significant, but weak relationships between the HbA1c levels and the following factors were found: sociodemographic (the levels of glycemic control were negatively related to age; the worse HbA1c was in the rural area and among people with primary education in comparison with those with secondary and higher education and living in large cities), clinical (worse glycemia was related to the number of complications and BMI) and psychological (perception of self-influence on the course of diabetes). The regression analysis model explains only 7% of the variance of variables and covers age, perception of self-influence, number of complications, place of residence, education level and BMI.

2. The obese respondents in comparison to overweight/normal weight patients were the most common among women, patients with primary education, living in rural areas and using maladaptive coping styles. The obese patients were older in comparison to overweight and normal weight respondents, while the people with normal weight had suffered from diabetes for a shorter time and had higher levels of quality of life as well as the perception of self-influence on the diabetes course than patients with BMI above norm. The logistic regression analysis showed that the increasing number of complications was associated with an increased likelihood of exhibiting BMI above norm, while the increase in the perception of self-influence on the diabetes course was associated with lower odds of occurrence of BMI above norm. It also turned out that patients using avoidance-oriented coping styles were significantly less likely to suffer from BMI above norm than patients who presented task-oriented coping styles. The logistic regression model explained 3.0% of the variance in the occurrence of BMI above norm.

Ethical Approval

The study was conducted in accordance with the Declaration of Helsinki. The study was approved by Bioethics Committee of Medical University of Warsaw.

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Disclosure

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