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Association of short – and long-term metabolic control parameters with personality traits in adult type 1 diabetes treated with personal insulin pumps

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Summary

Aim. Several studies have assessed the association between personality traits and metabolic outcomes in children and adolescents with type 1 diabetes (T1DM). The aim of this observational single-visit study was to investigate whether specific personality traits were related to the degree of metabolic control/diabetes duration in adult T1DM patients.

Method. Data were collected from 56 adults (40 men) with T1DM treated in a tertiary care center. "Big Five" personality traits were assessed using the NEO-Five Factor Inventory questionnaire. Several variables were obtained from the insulin pumps, glucometers and blinded continuous glucose monitoring system.

Results. All personality traits but neuroticism (low level of the trait) showed average intensity. Agreeableness was associated with most variables from CGMS data. Higher conscientiousness was associated with longer diabetes duration. Higher neuroticism was correlated with greater glycemic variability (GV), while high Extraversion was associated with lower GV. Lower Openness was associated with prolonged time in clinically significant hypoglycaemia

Conclusions. Our study suggests that personality traits manifest in individual approach to diabetes management and emotion regulation, translating also into the attitude to treatment. On the other hand, T1DM patients' overall trait scores were consistent with healthy

nonpsychiatric norms, which debunks myths and stereotypes suggesting that chronic disease is usually associated with psychopathology.

Key words: diabetes type 1, insulin pump, personality traits

Introduction

Developing self-awareness is a key task during maturation [1]. In the literature, several models within the chronic conditions have emphasized the importance of patients' self-awareness and insight for their physical and psychosocial functioning [2].

Personality is one of the key concepts in psychology and psychiatry. There are a number of theories describing the functioning of personality (typological, psychodynamic, behavioral-cognitive, humanistic-existential, systemic interaction, trait theories, genetic and neurological theories). These theories should be understood as a tool for the logical ordering of empirical facts, ascertained by clinicians or on the basis of experiments, as well as of the human knowledge system. It is a theoretical conceptual construct relating to the properties of an individual. Most theories of personality describe it as a relatively stable structure upon reaching maturity but developing throughout the life of the individual. The development of personality is influenced by the structure and reactivity of the central nervous system, genetic predisposition, early childhood relationships with caregivers, later social interactions, economic, cultural, historical and health context, and a number of individual factors. When describing personality functioning, we take into account the affective, cognitive and behavioral dimensions. The diagnosis of personality and its possible disorders requires taking into account a number of factors and is based both on the observation of the examined person, the analysis of his way of building relationships, defense mechanisms, styles of coping with emotions, the way of perceiving oneself and others, one's past, present and future, as well as results of diagnostic tests [3–5].

Personality traits are seen as the basic manifestation of an individual's mental state and allow the differentiation of personality functioning between individuals. Nowadays, most researchers agree that personality can be subsumed under five dimensions (e.g., Five Factor Model – Big Five): (1) Extraversion (energy, sociability and experiencing frequent positive moods), (2) Agreeableness (kindness, empathy and cooperativeness), (3) Conscientiousness (self-discipline, organization and responsibility), (4) Neuroticism, sometimes named by its polar opposite, Emotional Stability (the ability to deal with negative emotions), and (5) Openness to Experience (the way an individual seeks and deals with new information) [2, 6].

According to transactional stress theory and coping model, adjusting to chronic illness results from a complex interplay of demographic (e.g., sex and age) and clinical parameters (e.g., illness type and severity), coping strategies, and perceptions of self. Recent studies have demonstrated the importance of personality traits and self-esteem for glycemic control, treatment adherence, quality of life, and coping in type 1 diabetes [7, 17]. However, the experience of psychosocial difficulties can also shape one's personality [1].

Personality and self-esteem play a key role in understanding how patients adjust to their illness [1]. Personality traits such as low optimism, high negative emotional

expressiveness and high hostility have been reported to be associated with type 2 diabetes (T2DM) risk, whereas high levels of stress resilience, high life satisfaction and emotional vitality have protective effect [6]. Personality traits may directly or indirectly influence glucose dysregulation in diabetic patients (pessimism has been shown to be independently associated with higher fasting insulin levels via behavioral changes in diet, physical activity, smoking, and alcohol use; optimism was associated with higher likelihood of healthy behaviors such us healthier diet) [6]. In young type 1 diabetic patients (T1DM) it was shown that higher Agreeableness, higher Conscientiousness and lower Neuroticism were associated with better glycemic control [7, 8]. Similarly, in older patients aged 16–104 years (number of participants >26,000) higher Conscientiousness was related consistently to lower HbA1c (meta-analysis) [17].

Taking into account longer observation, lower Conscientiousness and higher Extraversion predicted a relative decrease in treatment adherence in emerging adult with T1DM. Poorer treatment adherence, in turn, was related to decreases in Conscientiousness and Agreeableness over time. Finally, lower Conscientiousness predicted poorer glycemic control 1 year later [1, 16]. Interestingly, extreme scores on emotional regulation (either low or high) were shown to be related to more rapid deterioration in renal function [11].

The current parameters of metabolic control of type 1 diabetes include, in addition to the HbA1c percentage, also standardized variables obtained from the continuous glucose monitoring system, such as: mean blood glucose, glycemic variability (CV), time spent in the target range (TIR), time spent below the target range (TBR), time spent above the target range (TAR), and other [12].

Insulin pump therapy (continuous subcutaneous insulin infusion, CSII) reduces the number of hypoglycemic episodes, improves the quality of life, and there is good evidence that even without continuous glucose monitoring (CGM) connectivity, is effective at improving and maintaining good metabolic control and possibly other outcomes in many people with type 1 diabetes [18]. It was shown that personality traits may be associated with the style of learning and motivation to learn and that is why they may influence the way in which individuals use electronic devices [19, 20]. Recently, it has been shown that combination of specific personality traits, social skills, family support and sport traditions as well as hereditary factors and access to the new technologies in T1DM treatment under the supervision of highly qualified specialist in diabetology, resulted in a unique and inspiring success of the patient in life, sport and diabetes management [21].

Several studies have assessed the association between personality traits and metabolic outcomes in children and adolescents with type 1 diabetes (T1DM), to our best knowledge there have been only one study in adults subjects treated with insulin pumps [22]. None of them assessed association between personality and parameters from continuous glucose monitoring systems.

Aim

The aim of this observational study was to investigate whether specific personality traits were related to the degree of metabolic control/diabetes duration in adult T1DM patients.

Material and methods

The inclusion criteria for the study included the presence of type 1 diabetes mellitus (E10 according to ICD-10), treatment with a personal insulin pump for at least a year, the latest HbA1c level <75 mmol/mol (9%), and no complications or comorbidities. Diagnosis of type 1 diabetes mellitus was made based on the World Health Organization criteria, the presence of typical clinical symptoms and insulin therapy requirement from the beginning of the disease. The chronic diabetes complications were assessed based on medical records, previously carried out tests and consultations done prior to the study.

Patients were treated with the following insulin pumps: Accu-Check Spirit Combo (Roche Diabetes Care, Basel, Switzerland) – 16 patients (28.6%), MiniMed Paradigm REAL-Time (715) – 11 patients (19.6%), MiniMed Paradigm (722) – 19 patients (33.9%), MiniMed Veo (Medtronic, Minneapolis, MN) – 5 patients (8.9%), MiniMed Paradigm (712) – 2 patients (3.6%), MiniMed 640G – 2 patients (3.6%) or Accu-Check Spirite – 1 patient (1.8%); and used the following rapid-acting insulin analogues: aspart (NovoNordisk) – 23 patients (41.1%), lispro (Ely Lilly) – 25 patients (44.6%) or glulisine (Sanofi-Aventis) – 8 patients (14.3%).

Data on HbA1c level (measured just after filling in the questionnaires), number of blood glucose measurements per day, percentage of basal insulin, daily dose of insulin per kg (DDIkg), time in range (TIR, 70–180 mg/dl), time below range (TBR, <70 mg/dl and TBR2, <54 mg/dl), mean glucose from CGMS in the last 10 days were downloaded from patients' devices (using dedicated software): personal insulin pumps, glucometers and blinded continuous glucose monitoring system (Dexcom G4).

The selected standardized parameters from the CGM system are presented in Table 1.

Table 1. **Clinical characteristics and selected parameters of continuous glucose monitoring in T1DM patients**

Variables	Mean ± SD	Median	Q1–Q3
Clinical data			
Age [years]	25.1 ± 5.8	23.5	21–28
Diabetes duration [years]	7.5 ± 4.5	7.0	4.5–11.0
Time on CSII[a] [years]	12.7 ± 6.4	14.0	7.9–17.1
Percentage of basal insulin [%]	41.1 ± 11.0	41.5	36.5–47
Number of BG[b] measurements per day [n]	7.3 ± 3.0	7.4	6.0–9.1

table continued on the next page

Daily insulin dose per kg of body mass [IU/kg]	0.71 ± 0.16	0.71	0.60–0.81
HbA1c level [%/mmol/mol]	6.9 ± 0.9	6.9	6.4–7.4
Dexcom G4 data			
Mean glycemia from CGM[c] [mg/dl]	148 ± 32	142	127–159
Time spent below 54 mg/dL [%]	5.2 ± 5.4	4.1	1.9–6.0
Time spent below 70 mg/dl [%]	12.4 ± 8.7	11.1	6.3–15.2
Time spent over 180 mg/dL [%]	28.2 ± 15.8	25.8	17.0–33.5
Time in range 70–180 mg/dL [%]	59.4 ± 12.5	61.8	53.5–66.5
Big Five Traits			
Conscientiousness [sten]	6.7 ± 2.4	7	6–8
Agreeableness [sten]	6.4 ± 2.4	7	5–8
Emotional regulation /neuroticism [sten]	3.7 ± 2.2	3	2–5
Extraversion [sten]	6.5 ± 2.1	7	6–8
Openness [sten]	5.0 ± 2.1	5	4–6.2

[a] – continuous subcutaneous insulin infusion; [b] – blood glucose; [c] – continuous glucose monitoring

Big Five personality traits were assessed using the Polish-language version of the NEO-Five Factor Inventory (NEO-FFI) questionnaire. These five factors are termed Conscientiousness, Agreeableness, Neuroticism, Extraversion, and Openness to experience. Conscientiousness refers to an individual's tendency to be reliable, perseverant and self-disciplined. Agreeableness refers to one's tendency to be empathetic, considerate, friendly, and helpful. Neuroticism refers to a person's capability to regulate their emotional responses to their environment and others. Extraversion refers to an individual's tendency to be gregarious, assertive, and seeking out social situations. Openness refers to one's tendency to be imaginative, sensitive, and having intellectual curiosity [23].

The questionnaire contained 60 descriptive statements, 12 items per domain. Items were scored on a 5-point scale designed to reflect the participant's score on each item, with scores ranging from 1 ("strongly disagree") to 5 ("strongly agree"). The results were analyzed by a licensed clinical psychologist according to the key provided in the Polish adaptation of the textbook for the interpretation of personality traits [9]. Sten scores (taking into account the average results in a given population and the age and sex of the subjects) were calculated. The final results were shown on a 1–10 point scale. The level of each personality trait is defined by the numerical and descriptive method; a score of 1–4 (inclusive) points indicates a low level of the trait, a score of 4–7 points indicates a moderate level, and a score of 7 (inclusive)–10 points indicates a high level. High vs. low sten scores groups were compared.

Additionally, we have used the PSS10. PSS10 measures the degree to which a person perceives life as stressful during the past month. Statements are classified on a five-point Likert-type scale from 0 ("never") to 4 ("very often"). The higher the total score, the intensity of perceived stress is greater [24]

Differences between the groups were analyzed with Student's *t*-test or non-parametric test, such as the Wilcoxon test (Shapiro–Wilk test was used to assess normality of the distribution). To compare two categorical variables, the Chi^2 test was used. $p<0.05$ was considered statistically significant. Univariate regression analysis was used to assess correlation between HbA1c level, CGM variables and personality traits (sten).

Results

Data were collected from 56 adults (40 men) with T1DM treated in a tertiary care center (aged 25.1 ± 5.8 years; diabetes duration of 12.7 ± 6.4 years; treated with insulin pumps for 7.5 ± 4.5 years [mean ± *SD*]).

The mean levels of the assessed parameters were as follows: HbA1c 6.9 ± 0.9% (52 mmol/mol), glucose tests per day 7.3 ± 3.0. Mean TIR was 59.4 ± 12.5%, mean TBR 12.4 ± 8.7%, mean TBR2 5.2 ± 5.4. All personality traits but Neuroticism (low level of the trait) was on average level of intensity. The characteristics of the study group are presented in Table 1.

Optimal metabolic control (HbA1c <6.5%) was found in 18 subjects with a mean HbA1c of 6.0 ± 0.4% (44 ± 5.5 mmol/mol). Non-optimal control was observed in 38 subjects with a mean HbA1c of 7.4 ± 0.7% (65 ± 8.7 mmol/mol). When comparing two groups in terms of above metabolic control higher, Neuroticism was associated with poorer metabolic control (2.7 vs. 4.1 sten, $p = 0.024$).

When using regression analysis, none of the traits (sten values) were associated with HbA1c level, DDIkg, number of blood glucose measurements per day or percentage of basal insulin (all p values <0.05).

The global level of stress measured with the PSS10 was in the range of mean sten results, which is comparable for general population.

The most essential observation worth in-depth consideration concerns Agreeableness (high vs. low sten groups), which was associated with most variables from CGMS data: mean glucose ($p = 0.0008$), median glucose ($p = 0.0167$), TAR ($p = 0.0056$), TBR ($p = 0.0153$), TBR2 ($p = 0.0320$).

Also, higher Conscientiousness was associated with longer diabetes duration (above or equal to median – 14 years; $p = 0.0307$)

Important observation concerns Glycemic variability: higher Neuroticism was correlated with greater GV ($p = 0.004$), while high Extraversion was associated with lower GV ($p = 0.03$)

Lower Openness to experience was associated with prolonged time in clinically significant hypoglycemia ($p = 0.025$).

Discussion

Previous studies have demonstrated the importance of Big Five personality traits for glycemic control, treatment adherence and quality of life in young type 1 diabetes patients [1, 4–14]. The aim of this study was to investigate whether personality traits

were related to the degree of short – and long-term metabolic control parameters and diabetes duration in adult T1DM patients treated with personal insulin pumps.

The analysis of personality traits (Extraversion, Openness to experience, Agreeableness, and Conscientiousness) in the entire group of subjects revealed average levels of each trait, low for Neuroticism). Similar data indicating average intensity of five typical personality traits were found in a large group of emerging adults aged 18–35 with T1DM [25]. This observation indicates that T1DM patients' personality functioning does not differ from the general population, thus T1DM does not imply personality psychopathology. This is especially important in the context of social stigma associated with diabetes [26].

Our study is in line with our expectations and previous reports suggesting that specific personality traits manifest in the way people build relations, how they express their emotions and cope with everyday challenges, thus also affect the way patients cooperate with their doctors as well as their general attitude to chronic illness [27–29].

Indicated in the study strong association between Agreeableness and most variables from CGMS data may be the manifestation of the fact that this personality trait positively predicts subjective well-being [30]. This may help the patients adapt more easily to the demands associated with T1DM treatment, be open for new technologies, such as CGMS and personal insulin pump, as well as facilitate patient-doctor relation.

Some studies have showed that patients with diabetes might have lower levels of emotional stability (higher Neuroticism), given the elevated depression rates observed in this population [1]. Moderate levels of Neuroticism in type 1 diabetes patients were associated with a higher probability to adhere to physician's guidelines [11]. In another study of adolescents with type 1 diabetes, higher Neuroticism was linked with lower insulin administration [9]. When dividing our population on the basis of optimal and not optimal HbA1c level for this group (individual target 6.5%), Neuroticism was significantly higher in non-optimally treated patients with high GV. Patients' lowered emotional stability might be due to the psychosocial distress resulting from the demands imposed by diabetes [30]. However, in our group the level of stress was rather average, despite that these patients were treated with personal insulin pumps which require more attention, virtually increasing stress levels [21]. In a study conducted by Taylor et al. [14] high Neuroticism at diagnosis was consistently associated with poorer self-reported diabetes quality of life at 4 months and at 12 months after diagnosis. A prospective study showed elevated Neuroticism scores in persons who later developed a first episode of clinical depression. Depression, in turn, hypothetically may decrease compliance [32]. A study conducted by Wheeler et al. [9] showed the negative correlation between the overall Neuroticism domain score and insulin administration. Extreme Neuroticism scores were associated with faster progression of renal deterioration [11]. To sum up, higher Neuroticism may worsen metabolic control of T1DM patients through compliance mediated mechanisms.

In our study, higher Extraversion was associated with lower GV. Studies have found that Extraversion enhances happiness indirectly through social support [33]. Patients with high Extraversion deal with their emotions by activity, speak about their problems, search for solution, and it may be suggested that thus they positively and

constructively act-out their emotions instead of suppressing them in the body, which can cause blood glucose fluctuations.

Lower Openness to experience was associated with prolonged time in clinically significant hypoglycemia, which may be associated with the speed of action undertaken by the patient during hypoglycemia and the lower sensitivity to low glucose level.

The study indicated that higher Conscientiousness was associated with longer diabetes duration. Previous report showed that lower Conscientiousness was associated with diabetes duration in women but not in men [1]. Conscientiousness includes traits such as orderliness, self-efficacy, self-discipline, dutifulness, achievement striving, and cautiousness. A higher conscientiousness is linked with tendency to keep things in order and perfectionism [34]. The overrepresentation of men in our cohort could result in opposite outcome. Individuals diagnosed with diabetes for a longer time might have learned to accept their illness as part of the self, resulting in stronger diabetes integration and even personal growth [27].

Contrary to our expectations, patients did not show correlation between HbA1c level and any Big Five traits. Some such correlations were observed in young T1DM patients [7, 8, 17]. However, because personality traits may change with age and life experience, extrapolation of findings from studies of children and adolescents to adults is inappropriate. Our results are in line with recent Polish report where personality traits of adult T1DM patients were not essential for metabolic control assessed on the basis of HbA1c level (continuous variable) [20]. When thinking about factors affecting patients' metabolic control we have to take into account the role of the clinician (it was shown more demanding and dogmatic clinician appeared to have better outcomes) and some socioeconomic factors [28, 29].

Limitations

First, data were gathered through self-report questionnaires only. A full description of personality functioning has not been made, and the focus has been on selected areas consistent with the Big Five Model. Although self-report is the most valid measure to assess variables such as personality, future research would benefit by using data from multiple sources such as direct interview. One may speculate that assessing these variables longitudinally would allow for examining their developmental interplay.

Second, the Neuroticism domain includes anxiety, angry hostility, depression, self-consciousness, impulsiveness, so it would be important in future studies to asses associated factor components to make a more in depth analysis of those aspects of personality, concerning also possible psychopathology. Also, other psychological factors are worth to be taken into account in analyzing metabolic control [35, 36]. Such studies are now in progress in our Clinic. Finally, our study was a single centre study from Poland, thus the results will not necessarily translate to other ethnic groups or countries with different healthcare systems.

Also, we carried out the study in a sample of a population of T1DM patients. However, due to the fact that this is a selected group of patients, the obtained results cannot be generalized for the entire population of patients with T1DM. In future studies

exploration on connection between personality disorders and diabetes control would be essential, also taking into account the bidirectional connections – the impact of the personality disorder on the metabolic control and vice versa in patients who were diagnosed with T1DM in early childhood.

Overrepresentation of men in our study was due to the parallel physical activity study performed by this group of patients – men were probably more prone to be involved in physical fitness assessment [37].

Compliance with ethics guidelines

Ethical approval for the study was granted by the Jagiellonian University Bioethics Committee (1072.6120.113.2017). All procedures followed were in accordance with the ethical standards of the responsible committee on human experimentation (institutional and national) and with the Helsinki Declaration of 1975, as revised in 2000. Informed consent for being included in the study was obtained from all patients.

Conclusions

1. Greater Neuroticism was associated with poorer metabolic control.
2. Agreeableness was associated with most of the CGMS variables: mean glycemia, median glycemia, TAR, TBR and TBR2.
3. Greater Conscientiousness was associated with a longer duration of diabetes.
4. Higher Neuroticism was correlated with greater variability, while high Extraversion was associated with a lower coefficient of variation of glycemia.
5. Lower Openness to experience was associated with a prolonged duration of clinically significant hypoglycemia

Our study indicates that personality traits manifest in individual approach to diabetes management and emotion regulation, translating also into the attitude to treatment. On the other hand, T1DM patients' overall trait scores were consistent with healthy nonpsychiatric norms, which may debunk myths and stereotypes suggesting that chronic disease is usually associated with psychopathology. Notwithstanding limitations of the study, it is pioneer in investigating the patients' personality in terms of new technologies use in T1DM treatment. This study presents their daily functioning and, hence, if replicated, could be a great add in tailoring intervention programs which take into account the personality of the individual patient.

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