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SHORT REPORT

Personality in Type 1 Diabetes and the Impact of Personality Traits on the Effects of Introducing Diabetes Technology

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Aim: How well new technology is applied to the daily management of type 1 diabetes (T1D) may be highly influenced by personality traits. The number of studies examining how personality traits influence diabetes self-management technologies such as continuous glucose monitoring and carbohydrate counting with automated insulin bolus calculation based on carbohydrate ratios and insulin sensitivity is scarce. Derived from a randomized controlled trial, we aimed to examine the association between personality traits and glycemic and patient-reported outcomes in adults with T1D on multiple daily insulin injections initiating flash glucose monitoring and carbohydrate counting with automated bolus calculation.

Methods: Personality trait scores from The Five-Factor Inventory-3 were analyzed in 170 individuals. We assessed baseline ($n = 168$) and changes ($n = 34$) in HbA1c, and patient-reported outcomes (validated questionnaires on diabetes distress, diabetes treatment satisfaction, diabetes psychosocial self-efficacy, diabetes quality of life) in bivariate and partial correlation analyses with personality traits (neuroticism, extraversion, openness to experience, agreeableness, and conscientiousness).

Results: Adjusted for sex, age, and diabetes debut age, higher agreeableness correlated negatively with baseline HbA1c (partial correlation −0.20, $p < 0.05$) but positively with HbA1c change over time (0.36, $p < 0.05$). Higher neuroticism score was associated with higher baseline distress (0.39, $p < 0.001$) and lower baseline psychosocial self-efficacy (−0.43, $p < 0.001$), quality of life (−0.32, $p < 0.001$) and treatment satisfaction (−0.18, $p < 0.05$).

Conclusion: This study confirms that personality traits are associated with glycemia and patient-reported outcomes in adults with T1D. Consequently, tailored diabetes management approaches are likely to enhance overall outcomes, especially when incorporating diabetes technology.

Keywords: personality traits, diabetes, glycemic effect, patient-reported outcomes

Introduction

The relationship between type 1 diabetes (T1D) and personality is complex. Personality traits may influence diabetes management, while living with diabetes may lead to stress and depression and potentially changes in personality traits over time.[1–3] T1D is an autoimmune disease, causing insulin deficiency, requiring life-long insulin treatment and adherence to different treatment modalities is pivotal to optimal outcomes. Diabetes self-management is, from a clinical perspective, crucial to achieve the best outcomes in general and with diabetes technology. Recent technological advancements in diabetes self-management offer a promising outlook for enhancing treatment and patient-reported outcomes among persons with (T1D treated with multiple daily insulin injections).[4] Advanced carbohydrate counting, defined as bolus calculation based on carbohydrate ratios and insulin sensitivity,[5] has been shown to improve HbA1c and treatment satisfaction compared with experience-based insulin bolus dosing.[6,7] Training in automated bolus calculation (ABC), may be even more efficient than manual bolus calculation.[6,8] Intermittently scanned CGM (isCGM) provides

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glucose data on request and glucose alarms. Several studies have evaluated isCGM in terms of glycemic effectiveness and person-related outcomes.[9]

Although personality traits are likely to influence the adoption of new technology in the treatment of chronic diseases, their role in diabetes management remains poorly understood. Currently, the five-factor model of personality is the most commonly used model in health research and related fields,[10] but only few studies have analyzed if the 'big five' personality traits (neuroticism, extraversion, openness to experience, agreeableness, and conscientiousness) predict self-management behaviors in T1D. Neuroticism, characterized by emotional instability or worry, may be associated with poorer glycemic control,[11] while high levels of conscientiousness, reflecting self-discipline, structure and organization, may be associated with more consistent self-caring behaviors such as, for example, glucose monitoring.[12,13] In fact, conscientiousness along with agreeableness (eg, cooperative skills, kindness)[13] or agreeableness alone[11] may predict lower HbA1c over 3 years. However, conscientiousness has also been associated with more frequent hypoglycemic episodes in people treated with insulin pumps.[14] Neuroticism has been linked to lower levels of diabetes efficacy and higher levels of depressive symptoms in people with type 2 diabetes,[1] indicating that personality traits may also play an important role in terms of patient-reported outcomes.[15]

Understanding the relationship between specific personality traits and the adoption of self-management technologies, such as CGM, could possibly help tailor technological treatments to the preferences of users. However, to our knowledge, no studies have yet examined the association between personality traits and the management of newly introduced technologies such as CGM, and how such associations might impact treatment outcomes, including glycemic control and patient-reported outcomes.

This study is a secondary analysis of a randomized controlled trial, conducted in people with T1D with no prior experience with initiating technology as part of diabetes management, in which we aimed to examine:

1) Correlations of the "big five" personality traits with HbA1c and patient-reported outcomes prior to treatment, and
2) Correlations of the personality traits with changes in HbA1c and with patient-reported outcomes in a group of participants allocated both isCGM and ABC.

Materials and Methods

A total of 170 adults diagnosed with T1D for more than one year and treated with multiple daily insulin injections (3–5 injections per day) as well as traditional blood glucose measurements (finger prick) and HbA1c >7.0% (53 mmol/mol) participated in a large randomized controlled trial. The participants were randomized to usual care (n = 42), carbohydrate counting with ABC (n = 41), isCGM (n = 48), or ABC + isCGM (n = 39).[16] Detailed information on nutritional recommendations, glycemic targets, method of insulin therapy, and the process of educating participants on using an automated bolus calculator and isCGM has previously been described.[16,17] All participants were naïve, ie, new-beginners to both interventions before entering the study, since the ongoing practice of daily advanced carbohydrate counting and use of CGM/isCGM were predefined exclusion criteria.

Severe diabetes complications, gastroparesis, other medical or psychological conditions judged unsuitable for participation, etc. were exclusion criteria. All participants were recruited from five diabetes out-patient clinics in the Capital Region of Denmark, and they were followed for 26 weeks. The participants completed the NEO-FFI-3 (NEO five-factor inventory) at baseline, which is a short 60 item self-report inventory version of the NEO-PI-3 personality inventory designed to measure the "Big Five" personality traits.[18] The Big Five personality traits are:

- Neuroticism (N): Measures emotional stability and the tendency to experience negative emotions such as anxiety, depression, and vulnerability.
- Extraversion (E): Assesses sociability, assertiveness, energy, and positive emotionality.
- Openness to Experience (O): Reflects imagination, creativity, curiosity, and a preference for variety and intellectual engagement.
- Agreeableness (A): Evaluates interpersonal qualities like altruism, trust, and kindness.
- Conscientiousness (C): Measures self-discipline, organization, responsibility, and goal-directed behavior.

The NEO-FFI-3 comprises 12 items for each trait, using 1–5 points a Likert scale where participants indicate the degree to which they agree or disagree with each statement.[19] The NEO-FFI-3 is used world-wide and is a well-validated test of the big five personality traits. We used the Danish translation of the test.

Other clinical and patient-reported outcomes were assessed both at baseline before initiating new technologies and after 26 weeks of the allocated intervention. HbA1c was measured locally with high-performance liquid chromatography on a Tosoh G7 (Tosoh Bioscience, Japan). The following questionnaires were used to evaluate diabetes distress, diabetes treatment satisfaction, diabetes psychosocial self-efficacy, and diabetes quality of life, respectively: the Problem Areas in Diabetes Questionnaire (PAID),[20] the Diabetes Treatment Satisfaction Questionnaire (DTSQ),[21] the Diabetes Empowerment Scale (DES short form) and Diabetes-dependent quality of life (ADDQoL-19).[22,23] A total of 141 (83%) participants completed participation and provided both baseline and study end data. At baseline, the NEO-FFI-3 was completed by 168 participants, while 34 participants in the ABC + isCGM intervention group completed the post-intervention measures. The questionnaire was primarily filled out electronically by the participants at home shortly after screening for inclusion.

Baseline associations of the five personality traits with HbA1c and the self-report measures were analyzed in linear models. To address the challenge of comparing regression coefficients for outcomes and predictors with different standard deviations, the results of the following models are presented as bivariate and partial correlations: Unadjusted bivariate correlations, model 1 adjusting for sex, age, and diabetes debut age, and model 2 adjusting for the covariates in model 1 and including all personality traits in the same model. The same models were used in analyses of associations of personality traits with change in HbA1c and change in self-reported measures based on the results of the ABC + isCGM intervention group. Patients with missing data were excluded from the analyses. At baseline, there were only two patients without personality scores, but there were five patients with missing data in ABC + isCGM intervention group (1 with missing NEO-FFI-3 scores and 4 with missing post-intervention scores). Due to the small sample size, exclusion of five patients could in principle influence the results, and consequently a sensitivity analysis was conducted using Full Information Maximum Likelihood (FIML), which includes information from patients with missing data.

Ethical and Data Sharing Statement

The original trial was carried out in accordance with the Helsinki Declaration after approval by the Capital Regional Scientific Ethics Committee in Denmark (H-17040573). The data collection was performed in accordance with the General Data Protection Regulation (P-2019-107). The trial was registered at ClinicalTrials.gov (registration no. NCT03682237). Informed consent was obtained from the study participants prior to the original study commencement. All data that support the findings of this study are available from the corresponding author upon reasonable request until 2029.

Results

Baseline characteristics for the entire cohort with 168 participants (37% females) were (mean (range)): age 47 (21–78) years, diabetes duration 20 (1–57) years and HbA1c 8.3 (7.1–12.1) % (67 (54–109) mmol/mol) (Table 1). Patient-reported outcomes scores before intervention were (mean (SD)): ADDQoL −1.82 (1.59), DES 3.52 (0.60), DTSQ (n = 167) 25.20 (6.15) and PAID (n = 160) 23.81 (16.15). NEO trait scores were (mean, SD): n*euroticism* 29.48 (7.59), *extraversion* 42.32 (6.59), *openness* 39.80 (6.72), *agreeableness* 43.26 (5.65) and *conscientiousness* 44.99 (6.23).

For the group of 34 (29% females) randomized to treatment with ABC + isCGM, baseline characteristics were age 48 (22–71) years, diabetes duration 23 (5–56) years and HbA1c 8.3 (7.1–9.8) % (67 (54–84) mmol/mol). Patient-reported outcomes scores before intervention were ADDQoL −1.85 (1.60), DES 3.40 (0.59), DTSQ 26.03 (5.18) and PAID 21.25 (15.49). NEO trait scores were *neuroticism* 29.91 (8.29), *extraversion* 41.88 (5.95), *openness* 38.91 (6.61), *agreeableness* 43.68 (3.99) and *conscientiousness* 44.62 (6.88).

In the entire cohort, *agreeableness* showed a weak, but significant negative correlation with baseline HbA1c, indicating that higher *agreeableness* is associated with lower baseline HbA1c levels (Table 2). Baseline HbA1c did not correlate with any other personality traits.

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Table 1 Baseline Demographics, Patient-Reported Outcome Scores and NEO Trait Baseline Scores Across the Entire Study Cohort (n=168) and the ABC + isCGM Intervention Group (n = 34)

	Entire Study Cohort	ABC+isCGM Intervention Group
Baseline demographics	***Mean (Range)***	***Mean (Range)***
Numbers (females %)	168 (37%)	34 (29%)
Age (years)	47 (21–78)	48 (22–71)
Diabetes duration (years)	20 (1–57)	23 (5–56)
HbA1c (%)	8.3 (7.1–12.1)	8.3 (7.1–9.8)
HbA1c (mmol/mol)	67 (54–109)	67 (54–84)
Patient-reported outcome scores	***Mean (SD)***	***Mean (SD)***
ADDQoL[A]	−1.82 (1.59)	−1.85 (1.60)
DES[B]	3.52 (0.60)	3.40 (0.59)
DTSQ[C]	25.20 (6.15)[D]	26.03 (5.18)
PAID[E]	23.81 (16.15)[F]	21.25 (15.49)
NEO[G] trait baseline score	***Mean (SD)***	***Mean (SD)***
Neuroticism	29.48 (7.59)	29.91 (8.29)
Extraversion	42.32 (6.59)	41.88 (5.95)
Openness	39.80 (6.72)	38.91 (6.61)
Agreeableness	43.26 (5.65)	43.68 (3.99)
Conscientiousness	%1.99 (6.23)	%1.62 (6.88)

Notes: [A]Diabetes-dependent quality of life (ADDQoL-19). [B]Diabetes Empowerment Scale (DES short form). [C]Diabetes Treatment Satisfaction Questionnaire (DTSQ). [D]For DTSQ n = 167. [E]Problem Areas in Diabetes Questionnaire (PAID). [F]For PAID n = 160. [G]NEO-FFI-3 (NEO five-factor inventory).

Regarding patient-reported outcomes, the baseline scores for diabetes distress (PAID), quality of life (ADDQoL) and diabetes psychosocial self-efficacy (DES short form) showed moderate correlations with *neuroticism* with unadjusted r values of 0.37–0.44 and a lower correlation for treatment satisfaction (DTSQ) (unadjusted r = 0.22). Higher *neuroticism* scores were associated with higher distress and lower psychosocial self-efficacy, quality of life and treatment satisfaction. The only other personality trait associated with baseline self-report measures was *conscientiousness*, showing that high *conscientiousness* was weakly (unadjusted r = 0.24), but significantly, associated with elevated levels of baseline psychosocial self-efficacy.

In the ABC + isCGM intervention group, *agreeableness* was the only personality trait showing a correlation with a change in HbA1c from the introduction of technologies to study end. The correlation was positive and higher in the adjusted models (r = 0.36), but only significant in the model that did not include mutual adjustment for all personality traits. Additionally, there were some indications of significant associations of *extraversion* with diabetes psychosocial self-efficacy and satisfaction with treatment. In contrast to the baseline scores, *neuroticism* did not show significant correlations with change in the self-reported measures.

The FIML sensitivity analyses showed essentially the same results for bivariate correlations and model 1 for the ABC + isCGM intervention group. However, for model 2, the association of *agreeableness* with HbA1c change became significant and this was in fact also the case for the association between *openness* and HbA1c change. Finally, the

Table 2 Bivariate and Partial Correlations Between NEO-FFI Personality Traits and the Baseline Scores and Change Scores on HbA1c and Inventories. Results for Baseline Scores are Based on the Full Sample (n = 168), While Results for Change Scores are Based on the ABC + isCGM Intervention Group (n = 34) Where (-) Indicates a Negative Association and () Indicates a Positive Association

NEO-FFI-3[A] trait Baseline Score	Pre-Intervention			Change Scores		
	Bivariate Correlation	**Model 1[B]**	**Model 2[C]**	**Bivariate Correlation**	**Model 1[B]**	**Model 2[C]**
Neuroticism						
HbA1c	−0.02	−0.05	−0.03	0.03	−0.01	−0.05
ADDQoL[D]	−0.34***	−0.32***	−0.32***	0.13	0.12	0.17
DES[E]	−0.44***	−0.43***	−0.37***	0.26	0.24	0.31
DTSQ[F]	−0.22**	−0.18*	−0.15	−0.03	−0.05	0.20
PAID[G]	0.40***	0.39***	0.42***	−0.26	−0.26	−0.31
Extraversion						
HbA1c	0.02	0.01	−0.05	−0.00	−0.01	−0.01
ADDQoL	0.01	0.02	−0.08	0.14	0.06	0.03
DES	0.12	0.14	−0.07	0.24	0.20	0.40*
DTSQ	−0.01	0.02	−0.05	0.43*	0.39*	0.36^
PAID	0.05	0.02	0.16	−0.16	−0.09	−0.19
Openness						
HbA1c	−0.04	−0.00	0.04	−0.22	−0.27	−0.32
ADDQoL	0.03	−0.01	0.02	−0.07	−0.09	−0.02
DES	0.08	0.07	0.05	0.08	0.07	0.11
DTSQ	−0.04	−0.09	−0.10	0.24	0.24	0.30
PAID	−0.00	0.04	0.05	0.18	0.20	0.16
Agreeableness						
HbA1c	−0.19*	−0.20*	−0.21**	0.27	0.36*	0.37^
ADDQoL	0.10	0.10	0.09	−0.26	−0.18	−0.22
DES	−0.01	0.02	−0.02	0.10	0.16	0.26
DTSQ	0.01	0.03	0.03	−0.03	−0.03	−0.07
PAID	−0.06	−0.10	−0.10	−0.15	−0.25	−0.27
Conscientiousness						
HbA1c	0.08	0.09	0.09	0.09	0.17	0.08
ADDQoL	0.08	0.09	−0.02	0.20	0.14	0.21
DES	0.24**	0.27***	0.13	−0.15	−0.22	−0.29
DTSQ	0.12	0.15	0.10	0.20	0.19	0.15
PAID	−0.05	−0.08	0.05	−0.17	−0.11	−0.10

Notes: [A]NEO-FFI-3 (NEO five-factor inventory). [B]Model 1 adjusted for sex, age, and diabetes debut age for baseline scores for change scores in the ABC+isCGM intervention group. [C]Model 2 adjusted for covariates as in model 1 but including all 5 personality traits in the same model. [D]Diabetes-dependent quality of life (ADDQoL-19). [E]Diabetes Empowerment Scale (DES short form). [F]Diabetes Treatment Satisfaction Questionnaire (DTSQ). [G]Problem Areas in Diabetes Questionnaire (PAID). *p < 0.05, **p < 0.01 og ***p < 0.001, ^marginal significance P< 0.06.

association between *extraversion* and DTSQ also became significant. In these three cases, table 2 shows relatively high correlations that were non-significant in the reduced sample, presumably because of weak statistical power.

Discussion

We employed the NEO-FFI-3 for personality trait assessment in a large randomized controlled trial focusing on diabetes technology interventions among adults with T1D.

At baseline, neuroticism showed moderately strong correlations with most diabetes self-report measures, reflecting associations between higher neuroticism and higher distress, lower psychosocial self-efficacy, quality of life and treatment satisfaction. Higher agreeableness scores were associated with lower HbA1c, and higher conscientiousness was associated with elevated levels of psychosocial self-efficacy. Analyses of change from baseline to follow-up in the ABC + isCGM subgroup only revealed significant positive associations of extraversion with treatment satisfaction and associations between higher scores on agreeableness and higher HbA1c.

The baseline pattern of positive and negative correlations of self-report measures with *neuroticism* indicates that higher *neuroticism* is associated with higher levels of diabetes-related distress and reduced quality of life. Typically, associations of *neuroticism* with distress and quality of life are also observed in healthy populations,[24] and thus our findings suggest that diabetes distress may be substantially influenced by the personality trait. However, there is evidence that chronic disease may lead to personality change,[25] which could possibly influence the correlations of *neuroticism* with self-report measures in our study. However, a Danish study observed prospective associations between *neuroticism* and the risk of mental disorders. Therefore, it is likely that neuroticism is a risk factor for diabetes-related stress and depression.[26]

At baseline, *agreeableness* was the only trait associated with lower HbA1c. Concerning self-report measures, higher *neuroticism* at baseline was associated with higher distress, lower psychosocial self-efficacy, lower quality of life and treatment satisfaction, while higher *conscientiousness* was associated with elevated levels of psychosocial self-efficacy. This association between *agreeableness* and better glycemic control has been observed in several previous studies,[12,27] but there are also negative findings.[14] Typically, studies finding associations with agreeableness have also observed associations between conscientiousness and better glycemic control, and it is unclear why we were not unable to replicate this finding. The lack of an association in our study may not only reflect weak statistical power, since the non-significant correlations were slightly positive, suggesting a possible association between higher *conscientiousness* and less glycemic control. In contrast, the significant positive correlation between *conscientiousness* and psychosocial self-efficacy is in line with previous studies.[12,14] Brickman et al suggest that low levels of *conscientiousness* may result in modified patient behavior, impacting glycemic control in patients with accelerated renal deterioration.[12] Similar conclusions were drawn in a recent study by Niemiec et al where the authors argue that higher degrees of *conscientiousness* may be related to more frequent hypoglycemic episodes among insulin pump users.[14]

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The analysis of change from baseline to post-intervention in the combined ABC + isCGM intervention group showed few significant correlations. Weak evidence suggests that *agreeableness* was associated with post-intervention increase in HbA1c, which contradicts the finding of an inverse correlation between *agreeableness* and baseline HbA1c. The discrepancy might be explained if participants with better baseline glycemic control were more likely to increase in Hb1Ac over time than those with higher baseline HbA1c. There was somewhat stronger evidence that *extraversion* was associated with an increase in treatment satisfaction scores. For *neuroticism,* there were no significant correlations, but the correlations for PAID were negative, reflecting that high *neuroticism* was associated with a post-intervention decrease in diabetes distress. The intervention study showed that the combination of ABC + isCGM was associated with better glycemic control[16] and this may have had a particular positive effect in participants with high *neuroticism* scores.

This study is a large-scale study evaluating the associations between personality traits, person-related and glycemic outcomes in T1D. However, the interpretation of findings in the ABC + isCGM group should consider the weak statistical power, the large number of statistical tests, and the fact that the FIML sensitivity analyses showed more significant associations for the model with mutual adjustment for personality traits. Finally, it is important to remember that personality may have a broader influence on diabetes related social interactions, including interactions and communication with health professionals, spouses and other important family members.[1] Illuminating the role of these factors would require a separate study with a focus on personality and social interaction and communication. Further, precautions must be made due to the small sample size in the post-intervention group which may affect the robustness of some of the findings, particularly those related to changes in outcomes over time.

Conclusions

In summary, we have confirmed findings from previous studies and extended the understanding of how personality traits are associated with glycemic and patient-reported outcomes. In terms of the technological interventions in the current study, it is still not possible to predict outcomes based on personality traits among adults with T1D. However, appropriate tailoring of diabetes management considering multiple factors to ensure an individualized approach may help enhance overall diabetes outcomes. For now, it seems reasonable to argue that all persons with T1D who are willing to try technology as part of the diabetes treatment should be offered the opportunity. Future studies of the relationship between personality traits and the adoption of self-management technologies should employ larger samples.

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Disclosure

The authors report no conflicts of interest in this work.

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