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Anxiety, Diabetes Distress, and Quality of Life in Adults with Type 1 Diabetes Treated With or Without Closed-Loop Technology: A Pilot Study

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Abstract

Background

Type 1 diabetes requires continuous self-management and may be associated with elevated anxiety, diabetes-related distress, and reduced quality of life. Although advanced diabetes technologies may improve treatment safety and metabolic outcomes, their association with psychological functioning remains uncertain. The aim of this study was to examine the relationship between anxiety and quality of life in adults with type 1 diabetes and to assess whether these outcomes differed according to the use of closed-loop technology.

Methods

This pilot cross-sectional observational study included 50 adults with type 1 diabetes treated at a diabetology outpatient clinic. Twenty participants were using a closed-loop system and 30 were treated without closed-loop technology. Anxiety, life satisfaction, psychological well-being, and diabetes-related emotional burden were assessed with the State-Trait Anxiety Inventory (STAI), Satisfaction With Life Scale (SWLS), WHO-5 Well-Being Index, Problem Areas in Diabetes questionnaire (PAID), and Diabetes Distress Scale (DDS-17). Group comparisons were performed with the Mann-Whitney U test, and associations between variables were examined using Spearman's rho.

Results

Higher state and trait anxiety were associated with lower life satisfaction and psychological well-being, as well as with greater diabetes-related emotional burden and diabetes distress. No statistically significant differences were found between participants using a closed-loop system and those treated without it with regard to anxiety, quality of life, or emotional burden.

Discussion

Higher anxiety and diabetes-related burden were associated with poorer psychological outcomes. No statistically significant differences in the assessed psychological outcomes were observed between participants treated with and without closed-loop technology.

Conclusions

Assessment of anxiety and diabetes-related distress should be considered an important component of comprehensive care in adults with type 1 diabetes, regardless of the technology used.

type 1 diabetes; anxiety; quality of life; psychological well-being; diabetes distress; diabetes technology

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INTRODUCTION

Type 1 diabetes is a chronic autoimmune disease that leads to absolute insulin deficiency and requires patients to monitor their blood glucose continuously, make numerous therapeutic decisions throughout the day, and maintain a high level of self-management. Contemporary treatment of this condition relies on intensive insulin therapy, which is increasingly implemented using advanced diabetes technologies, such as continuous glucose monitoring systems, insulin pumps, and hybrid closed-loop systems. According to the current Diabetes Poland position statement, the aim of treatment is not only to improve metabolic parameters, but also to increase treatment safety, reduce the risk of acute and chronic complications, and improve the patient's everyday functioning [1]. At the same time, technological progress does not eliminate all the difficulties associated with living with a chronic disease, and increasing attention is being paid to the psychological consequences of type 1 diabetes.

The literature emphasizes that people living with type 1 diabetes are exposed not only to somatic burden, but also to chronic emotional tension, anxiety, and distress related to the daily management of the disease. A particularly important distinction is the one between depression, general psychological distress, and diabetes distress, which refers to the specific burden resulting from treatment demands, the sense of responsibility for glycemic control, and concerns about the consequences of the disease [2]. One of the most frequently described problems is also fear of hypoglycemia, which may affect health behaviors, the patient's sense of safety, and quality of life. It has been pointed out that fear of hypoglycemia remains one of the key psychological problems in adults with type 1 diabetes, even in the era of modern therapeutic technologies [4,5].

Quality of life in people with type 1 diabetes is a multidimensional construct that includes psychological well-being, life satisfaction, sense of agency, social functioning, and the subjective assessment of disease burden. The contemporary approach to diabetes treatment is moving away from a model in which treatment effectiveness is assessed solely on the basis of biochemical indicators, such as HbA1c or time in range. It is increasingly emphasized that a patient may achieve clinical improvement while still experiencing reduced psychological well-being, increased anxiety, or elevated diabetes-related distress [2,3]. For this reason, the assessment of quality of life and emotional functioning is now considered an important element of comprehensive diabetes care [1,3].

The impact of advanced diabetes technologies on patients' psychosocial functioning has attracted particular research interest. Expert commentaries and review papers suggest that these technologies may improve treatment safety, reduce some of the daily burden associated with diabetes management, and increase treatment satisfaction; however, their psychological impact is not unequivocal and may depend on many additional factors [3]. For some patients, hybrid closed-loop systems may provide a greater sense of safety and make everyday life easier, whereas for others they may involve the need to adapt to a new treatment model, increased vigilance, difficulty fully trusting the device, or a sense of partial loss of control over therapy [3,5]. This means that the mere presence of modern technology does not automatically translate into improved psychological well-being.

An important context for these considerations is provided by studies conducted in the Krakow center. These studies have shown that the use of advanced hybrid closed-loop systems may be associated with improvements in selected psychological parameters and quality of life in adults with type 1 diabetes, especially in those who had not previously used advanced diabetes technologies [6,7]. At the same time, other analyses from the same research environment have pointed to the importance of diabetes distress, diabetes-related burnout, and a broader spectrum of psychological symptoms in patients with type 1 diabetes, highlighting the need for a more complex view of the relationship between technology-based treatment and emotional functioning [8,9]. In addition, experience from the Polish cohort of patients using advanced hybrid closed-loop systems has shown that the successful implementation of technology requires not only medical preparation, but also adequate educational and organizational support [10]. In light of these findings, it seems reasonable to ask wheth-

er the type of treatment technology itself is the main factor differentiating patients' psychological functioning, or whether anxiety level and the individual experience of living with the disease are more important. This issue is significant from both a theoretical and a practical perspective, because it may help to better understand the limits of the impact of modern diabetes technologies and identify areas in which the optimization of medical treatment alone may not be sufficient.

The aim of the present study was to examine the relationship between anxiety and selected indicators of quality of life in adults with type 1 diabetes, taking into account the use of advanced diabetes technology. More specifically, we analyzed the associations between state and trait anxiety and life satisfaction, psychological well-being, diabetes-related emotional problems, and diabetes distress. We also compared participants using a closed-loop system with those treated without closed-loop technology.

MATERIALS AND METHODS

The study was designed as a pilot cross-sectional observational study intended to explore associations between anxiety, diabetes-related distress, quality of life, and treatment technology, and to inform the design of a larger study. A total of 50 adults with type 1 diabetes treated at the Diabetology Outpatient Clinic of the University Hospital in Krakow were included. The sample was selected purposively. The inclusion criteria were age > 18 years, type 1 diabetes duration of at least 1 year, and the ability to complete the questionnaires independently. The exclusion criteria were active substance dependence, pregnancy, severe somatic disease, a diagnosis of schizophrenia, and lack of written informed consent. The study protocol was approved by the Bioethics Committee of the Jagiellonian University (approval no. 118.0043.1.402.2025).

Schizophrenia was specified as an exclusion criterion because severe psychotic symptoms could substantially affect the ability to complete self-report questionnaires reliably. Other mental disorders were not used as general exclusion criteria, as the pilot study was intended to reflect the psychological heterogeneity of adults receiving routine diabetes care.

Of the 50 participants, 20 were treated using a closed-loop system and 30 were treated without closed-loop technology, using either multiple daily injections (MDI) or continuous subcutaneous insulin infusion (CSII). Data were collected from October to December 2025 during direct contact with the patients.

For the purposes of this pilot analysis, participants were classified according to the broad treatment strategy documented at study inclusion: use of a closed-loop system versus treatment without closed-loop technology. Detailed information on system generation, specific device, duration of use, previous technology exposure, and the MDI/CSII distribution was not collected in a standardized form suitable for further analysis. Accordingly, no additional technology-specific subgroup analyses were performed.

Because this was an exploratory pilot study focused primarily on psychological questionnaire outcomes, the pilot dataset did not include a sufficiently complete and standardized set of detailed sociodemographic, metabolic, and treatment-history variables to permit a reliable extended baseline comparison. No additional retrospective data collection or post hoc subgroup analyses were therefore undertaken. This limitation is acknowledged below. Owing to the pilot design and the scope of the available dataset, these data were not available for the present analysis and no further analyses were performed.

The psychological variables included in the present analyses were assessed with standardized instruments: the State-Trait Anxiety Inventory (STAI), the Satisfaction With Life Scale (SWLS), the WHO-5 Well-Being Index, the Problem Areas in Diabetes questionnaire (PAID), and the Diabetes Distress Scale (DDS-17) [6,10-15]. The STAI was used to assess state and trait anxiety, the SWLS to measure life satisfaction, the WHO-5 to assess psychological well-being, and the PAID and DDS-17 to assess diabetes-related emotional burden and distress.

All questionnaires were established, validated instruments. Because the pilot database contained scale totals rather than a complete item-level dataset for every instrument, internal-consistency coefficients could not be calculated for the present sample. This is acknowledged as a methodological limitation. Owing to the ab-

sence of complete item-level data in the pilot dataset, no reliability analyses were performed.

Statistical analysis was performed using non-parametric methods because of the sample size and the distributional characteristics of the variables. The Mann-Whitney U test was used to compare the two independent groups, and Spearman's rho was used to assess associations between anxiety and the selected indicators of quality of life and emotional burden. Spearman's rho coefficients were treated as effect-size estimates for correlational analyses. Because the analyses were exploratory, no correction for multiple testing was applied; therefore, findings close to the conventional significance threshold should be interpreted cautiously. Exact p values are reported, and statistical significance was set at $p < 0.05$.

Given the exploratory pilot design and the absence of retained full statistical output required to calculate additional between-group effect-size estimates consistently, no further post hoc analyses were performed. Exact p values are reported, while Spearman's rho coefficients provide effect-size estimates for the correlational analyses. The small sample size and limited precision of the between-group comparisons are explicitly acknowledged in the Limitations section.

The analyses were based on the available complete scale scores in the pilot dataset. No imputation was performed. Because detailed item-level missingness indicators were not retained consistently across all instruments, a more granular missing-data analysis was not possible and was not undertaken post hoc.

RESULTS

First, we examined whether participants using a closed-loop system differed from those treated without closed-loop technology (MDI/CSII) in anxiety, life satisfaction, psychological well-being, and diabetes-related emotional burden. No statistically significant between-group differences were found for any of the analyzed variables. Detailed results are presented in Table 1.

Table 1. Comparison of psychological outcomes and quality of life between participants using a closed-loop system and those treated without it

Variable	Closed-loop system (n = 20), Me (Q1–Q3)	With MDI or CSII (n = 30), Me (Q1–Q3)	p
State anxiety (STAI)	40.5 (33.0–48.5)	40.5 (33.0–46.0)	0.851
Trait anxiety (STAI)	42.5 (35.0–50.0)	43.0 (35.0–49.0)	0.968
Life satisfaction (SWLS)	22.0 (15.0–25.0)	20.5 (17.0–25.0)	0.706
Psychological well-being (WHO-5)	11.0 (8.5–14.5)	13.5 (10.0–15.0)	0.261
Diabetes-related emotional problems (PAID)	28.8 (8.8–41.9)	30.0 (20.0–50.0)	0.234
Overall diabetes distress (DDS-17)	2.5 (1.7–4.5)	2.4 (1.8–2.9)	0.434

Note: Comparisons were performed using the Mann–Whitney U test.

Source: authors' own analysis based on the study results.

No statistically significant differences in the analyzed psychological outcomes were observed between participants using a closed-loop system and those treated without closed-loop technology. Thus, participants using closed-loop technology did not report significantly lower anxiety or significantly better quality of life than participants in the MDI/CSII group.

Next, we assessed the relationships between anxiety and selected indicators of quality of life and emotional burden in the entire study sample. Higher anxiety was consistently associated with poorer psychological functioning and greater diabetes-related emotional burden. These relationships were observed for both state anxiety and trait anxiety.

State anxiety was negatively correlated with life satisfaction (rho = – 0.285; p = 0.045) and psychological well-being (rho = – 0.503; p < 0.001). Positive correlations were also found between state anxiety and diabetes-related emotional problems measured with the PAID scale (rho = 0.324; p =

0.022), as well as overall diabetes distress measured with the DDS-17 (rho = 0.349; p = 0.013). Thus, higher current anxiety was associated with lower well-being and greater emotional burden related to living with diabetes.

The association between state anxiety and life satisfaction (rho = – 0.285; p = 0.045) was small and should be interpreted cautiously, particularly because no correction for multiple comparisons was applied.

Stronger associations were observed for trait anxiety. Trait anxiety was negatively correlated with both life satisfaction (rho = – 0.508; p < 0.001) and psychological well-being (rho = – 0.698; p < 0.001), and positively correlated with diabetes-related emotional problems (rho = 0.496; p < 0.001) and overall diabetes distress (rho = 0.574; p < 0.001). Detailed results are presented in Table 2.

Table 2. Relationships between anxiety level and selected indicators of quality of life and emotional burden in the overall study sample (N = 50)

Variable	State anxiety (STAI), rho (p)	Trait anxiety (STAI), rho (p)
Life satisfaction (SWLS)	-0.285 (0.045)	-0.508 (<0.001)
Psychological well-being (WHO-5)	-0.503 (<0.001)	-0.698 (<0.001)
Diabetes-related emotional problems (PAID)	0.324 (0.022)	0.496 (<0.001)
Overall diabetes distress (DDS-17)	0.349 (0.013)	0.574 (<0.001)

Note: Spearman's rho correlation coefficients.

Source: authors' own analysis based on the study results.

Overall, anxiety was significantly associated with quality of life and psychological functioning in adults with type 1 diabetes. These associations were observed in the overall sample and should not be interpreted as demonstrating that anxiety is more important than treatment technology. Higher anxiety co-occurred with lower life satisfaction, lower psychological well-being, and greater diabetes-related emotional burden. Because of the cross-sectional design, these findings should be interpreted as associations rather than causal relationships.

DISCUSSION

The present study showed that higher anxiety was associated with poorer quality of life and greater diabetes-related emotional burden in adults with type 1 diabetes. Both state anxiety and trait anxiety were linked to lower life satisfaction and psychological well-being, as well as to higher PAID and DDS-17 scores. These findings support the view that emotional functioning should be assessed alongside metabolic outcomes in the routine care of adults with type 1 diabetes [1,2,20].

An important finding was the absence of statistically significant differences between participants using a closed-loop system and those treated without closed-loop technology. This does not support the assumption that more advanced treatment technology automatically translates into better psychological functioning. Previous studies suggest that diabetes technologies may improve treatment safety and selected clinical outcomes, but their psychosocial effects are more heterogeneous and may depend on patient-related factors, expectations, adaptation to device use, and the quality of educational and organizational support [3,16,19].

Importantly, the median WHO-5 score was 11.0 in the closed-loop group and 13.5 in the MDI/CSII group. Because a raw WHO-5 score below 13 has been proposed as an indicator of poor mental well-being warranting further assessment, the level observed in the closed-loop group may be clinically meaningful despite the absence of a statistically significant between-group difference [13].

Our results are also consistent with reports showing that psychological burden may persist despite the use of advanced diabetes technology. Ernst et al. studied adolescents and young adults with type 1 diabetes (mean age 20.7 years) using automated insulin delivery and found that treatment satisfaction could coexist with clinical-

ly relevant anxiety, reduced well-being, and distress [21]. Although their sample was younger than that included in the present study, the findings similarly indicate that improvements in diabetes technology and psychological well-being do not necessarily occur in parallel.

Fear of hypoglycemia may be one factor helping to explain this pattern. Peter et al. showed that fear of hypoglycemia remains a common and clinically meaningful problem in adults with type 1 diabetes [4]. Likewise, Martyn-Nemeth et al. emphasized that even modern technologies do not fully eliminate this type of anxiety, because it is also shaped by previous experiences, cognitive appraisals, coping style, and anticipatory worry [5]. This broader psychiatric and psychological context may help explain why technology alone was not associated with better emotional outcomes in the present sample.

The present findings also highlight the clinical importance of diabetes distress as a construct related to, but distinct from, depression or general psychological distress [2]. The observed associations between anxiety and both PAID and DDS-17 scores are in line with studies showing that diabetes-related distress is closely linked to everyday functioning and glycemic regulation in people with type 1 diabetes [16,18]. From a psychiatric and psychotherapeutic perspective, these results support the value of screening for elevated anxiety and diabetes distress as potentially modifiable targets for intervention.

The present results should also be interpreted in relation to previous studies from the Krakow research group. Earlier work suggested that implementation of an advanced hybrid closed-loop system may improve selected psychological outcomes, particularly in patients who were previously naive to advanced diabetes technology [6,7]. At the same time, other studies from this group have emphasized the roles of diabetes distress, burnout, and broader psychological symptomatology in adults with type 1 diabetes [8,9]. Taken together, these findings suggest that technology may be helpful, but that its psychological effects are not uniform and may depend on individual psychological characteristics and the context of implementation [16,18].

The practical implication of these findings is that comprehensive diabetes care should include not only optimization of insulin therapy and the use of advanced devices, but also routine assessment of anxiety and diabetes-related distress. This approach is consistent with current recommendations emphasizing psychological well-being as an important component of diabetes care [1,19,20].

LIMITATIONS

The results should be interpreted in light of several limitations. This was an exploratory pilot study based on a relatively small sample, which limits generalizability and the precision of between-group estimates and may have reduced the power to detect differences. The study was cross-sectional and based on a single assessment point, so no causal or temporal inferences can be drawn. The pilot dataset was designed primarily around psychological questionnaire outcomes and did not contain a sufficiently complete, standardized set of detailed sociodemographic, metabolic, psychiatric-treatment, technology-history, and item-level variables for reliable extended analyses. Consequently, no additional retrospective data collection, post hoc subgroup analyses, reliability calculations, or further statistical analyses were undertaken. The broad technology grouping may also have obscured differences between specific systems and treatment histories. These limitations reflect the exploratory pilot design and the scope of the available dataset. The present manuscript therefore reports only the analyses that could be performed reliably using the data collected.

CONCLUSIONS

Anxiety was closely associated with quality of life and diabetes-related emotional burden in adults with type 1 diabetes. In this sample, no statistically significant differences in psychological functioning were observed between participants treated with and without closed-loop technology. These findings support a holistic model of care in which advanced diabetes technology is combined with systematic attention to anxiety, diabetes distress, and psychological support.

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