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Gastrointestinal symptoms as comorbid manifestations of type 1 diabetes mellitus in children

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Abstract. *Introduction.* The incidence of type 1 diabetes mellitus among children and adolescents worldwide is characterized by significant variability, ranging from 5 to 50 new cases per 100,000 individuals under 20 years of age per year, with an average of approximately 14 cases per 100,000. The peak incidence occurs in the 10–14-year age group. After puberty, incidence rates decrease in young women but remain relatively high in young men under 20 years of age. Type 1 diabetes mellitus in childhood is a chronic autoimmune disease accompanied not only by impaired carbohydrate metabolism but also by damage to various organs and systems. Increasing attention is being paid to gastrointestinal disorders in children with type 1 diabetes, as these disorders may occur already in the early stages of the disease, even in the absence of classic microvascular and macrovascular complications.
Aim. The aim of the study was to assess the frequency and intensity of gastrointestinal symptoms in children with type 1 diabetes and to compare the clinical profile of gastrointestinal disorders with that of the control group.
Materials and Methods. The study was conducted as a comparative cross-sectional clinical study. It included 49 children with type 1 diabetes who were under observation in a specialized endocrinology department, as well as 49 children in the control group. The control group consisted of children without diabetes mellitus, chronic gastrointestinal diseases, acute infectious diseases at the time of examination, celiac disease, inflammatory bowel disease, or medication use that could affect the motility or function of the digestive system.
Results. In children with type 1 diabetes, gastrointestinal symptoms were significantly more frequent and more pronounced than in healthy peers, with significantly higher rates of reflux, abdominal pain, nausea, vomiting, diarrhea, and constipation observed in the diabetes group (all $p<0.05$). For several symptoms, median values were the same in both groups or equal to zero; however, the type 1 diabetes group had wider interquartile ranges, higher percentile values, and greater variability. The most pronounced intergroup differences were observed for pain, nausea, and diarrhea, which were characterized not only by higher frequency but also by greater intensity of manifestations. Individual upper and lower gastrointestinal symptoms in children with type 1 diabetes tended to occur in combination.
Conclusions. In children with type 1 diabetes, gastrointestinal symptoms are systemic and clinically significant. The results indicate an increased frequency and severity of symptoms from different parts of the gastrointestinal tract in children with type 1 diabetes.

Keywords: diabetes mellitus, type 1, gastrointestinal diseases, gastrointestinal symptoms, child, adolescent.

Introduction

The prevalence of type 1 diabetes mellitus (T1D) is increasing. In 2024, 219,000 new cases of T1D were registered worldwide among children and adolescents under 20 years of age. In addition, over the past 30 years, the annual rate of T1D diagnosis among children, adolescents, and young adults has increased from 1.5% to 3.4% [1]. In view of the above, the study of concomitant clinical manifestations of this disease is of particular relevance. One insufficiently studied but clinically significant aspect of the course of T1D in children is gastrointestinal symptomatology, which may affect metabolic control, quality of life, and the risk of complications [2].

The wide range of prevalence rates of gastrointestinal symptoms in children and adolescents with T1D indicates significant heterogeneity of gastrointestinal manifestations in this population. According to three studies, the frequency of gastrointestinal symptoms in children with T1D ranged from 44.9% to 75%, indicating a high prevalence of such disorders. At the same time, some studies have reported lower rates, such as 21.7% in pediatric patients; however, even these values exceed the prevalence of gastrointestinal

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symptoms in a large healthy pediatric population, which is approximately 14%. Such variability in results emphasises the complexity of assessing gastrointestinal disorders in T1D and the need for their systematic study. In addition, preliminary data indicate that patients with T1D and existing gastrointestinal symptoms have an almost twofold higher risk of developing diabetic complications, namely 1.92 times higher, compared with individuals without such manifestations [3]. Overall, these findings justify the importance of detailed investigation and profiling of gastrointestinal disorders in children with T1D, as well as their comparison with a healthy pediatric population, in order to optimise clinical management and enable the early identification of risk groups [4].

Aim

To assess the frequency and intensity of gastrointestinal symptoms in children with T1D and compare the clinical profile of gastrointestinal disorders with those of the control group.

Materials and Methods

The study was conducted at the clinical base of Bogomolets National Medical University, Kyiv City Clinical Hospital No. 18. This was a single-center comparative cross-sectional study conducted between September 2026 and December 2026. It included 49 children with T1D and 49 healthy controls.

The inclusion criteria were age between 6 and 17 years, a confirmed diagnosis of type 1 diabetes in the study group, and the availability of symptom data obtained directly from the participant or from a parent/legal guardian. Written informed consent was obtained from parents and/or legal representatives. The exclusion criteria included previously diagnosed organic gastrointestinal diseases, such as inflammatory bowel disease, celiac disease, or peptic ulcer disease; acute infectious illness at the time of assessment; confirmed neurological or systemic disorders affecting gastrointestinal function; and/or refusal to participate.

Gastrointestinal symptoms were assessed using a structured symptom checklist adapted for the purposes of this study. The checklist included heartburn, reflux, bloating, anorexia, upper abdominal pain, lower abdominal pain, nausea, vomiting, early satiety, constipation, and diarrhea. Participants, or their parents/guardians in the case of younger children, were asked to report the presence or absence of each symptom. Symptom intensity was additionally evaluated using an ordinal three-point scale: 0 – absent, 1 – mild, and 2 – severe. The checklist was designed to capture common gastrointestinal complaints encountered in pediatric clinical practice. In the context of the applied symptom checklist, the term "anorexia" referred to an episodic decrease in appetite or a reduced desire to eat, rather than clinically significant appetite loss or eating disorders.

The data were processed using GraphPad Prism 10.6.1 for Windows (San Diego, CA, USA). Pearson's chi-square test was applied to compare categorical variables. Quantitative data were presented as medians and interquartile ranges. The Mann–Whitney U test was used to compare ordinal variables between groups. Effect sizes were calculated using Cramér's V for chi-square tests and $r=Z/\sqrt{N}$ for Mann–Whitney U tests. A p-value < 0.05 was considered statistically significant. To account for multiple comparisons across 11 gastrointestinal symptoms, the Bonferroni correction was applied, resulting in an adjusted significance threshold of $p<0.0045$.

Results

The study included 49 children with T1D and 49 age- and sex-matched healthy controls. The control group included children with no chronic diseases, no acute infections at the time of examination, and no history of gastrointestinal disorders. There were no statistically significant differences between the T1D and control groups in terms of age, sex, weight, height, or BMI ($p>0.05$). The demographic, clinical, and anthropometric characteristics of the

Table 1. Basic demographic, clinical, and anthropometric characteristics of study participants

Characteristic	Control (n=49)	T1D (n=49)	p-value
Age, years, median (IQR)	12 (9–15)	12 (9–15)	0.88
Male, n (%)	25 (51%)	26 (53%)	0.84
Female, n (%)	24 (49%)	23 (47%)	0.84
Duration of T1D, years	–	3 (1–6)	–
HbA1c, %, median (IQR)	–	7.8 (7.0–8.5)	–
Weight, kg	39 (31–50)	40 (32–52)	0.72
Height, cm	149 (137–160)	150 (138–162)	0.65
BMI, kg/m²	16.9 (15.5–19.0)	17.2 (15.8–19.5)	0.70

Source: compiled by the authors of this study

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participants are summarised in Table 1. The study population showed heterogeneity in T1D duration and glycemic control, reflecting real-world clinical variability. Anthropometric measures were generally comparable with those of healthy controls, indicating that the observed gastrointestinal differences were not due to major differences in growth or nutritional status.

The prevalence of gastrointestinal symptoms was compared between children with T1D and controls using the χ^2 test with Cramér's V. The frequency of heartburn was higher in children with T1D than in the control group, although the difference was not statistically significant (39.0% vs. 24.5%, V=0.15; p>0.05). Reflux was significantly more common in patients with T1D, occurring in 75.5% of cases compared with 55.0% in the control group (Cramér's V=0.21; p<0.05). Bloating was observed in the majority of examined children in both groups, affecting 78.0% of patients with T1D and 75.5% of controls (V=0.02; p>0.05).

Anorexia was reported in 59.0% of children with T1D and 82.0% of children in the control group (V=0.25; p<0.05). The frequency of upper abdominal pain was significantly higher in patients with T1D than in controls (78.0% vs. 47.0%, Cramér's V=0.32; p<0.01). Similarly, lower abdominal pain was significantly more frequent in children with T1D than in the control group (55.0% vs. 33.0%, V=0.23; p<0.05).

Nausea was significantly more common in children with T1D than in controls (78.0% vs. 47.0%, Cramér's V=0.32; p<0.01). Vomiting was more frequent in children with T1D than in the control group, although the difference was not statistically significant (59.0% vs. 43.0%, V=0.16; p>0.05). The frequency of early satiety was higher in the T1D group than in the control group (73.0% vs. 49.0%, V=0.25; p<0.05).

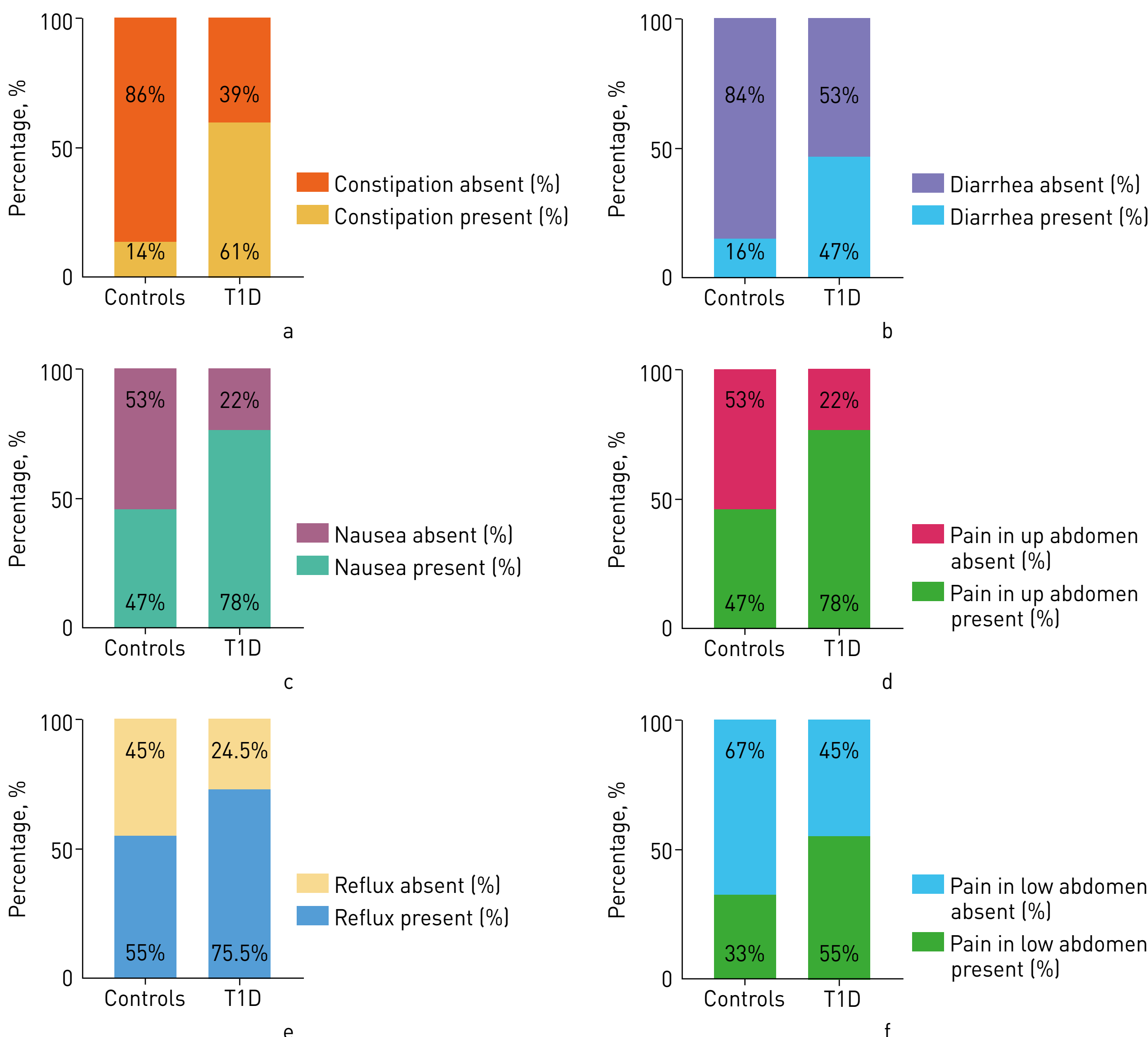

Figure 1. Distribution of gastrointestinal symptoms in T1D and control groups. Data expressed as percentages

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Diarrhea was observed more often in children with T1D than in controls (47.0% vs. 16.0%, Cramér's V=0.33; p<0.01). Constipation was significantly more common in children with T1D than in the control group (61.0% vs. 14.0%, V=0.48; p<0.0001) (Figure 1).

Beyond frequency analysis, the severity of gastrointestinal symptoms was evaluated using median values and interquartile ranges, with group differences assessed by the Mann–Whitney U test with r = Z/√N for effect size. The analysis of heartburn across groups revealed significant differences. Median heartburn in T1D group was 0 (0-1.5) points, while in control group – 0 (0-0.5), r=0.17 (p<0.05). The analysis of reflux also revealed significant differences: the median reflux was 1 (0-2) points in T1D group and 0 (0-1) in control group, r=0.2 (p<0.05).

There weren't significant differences of bloating in groups: median bloating in T1D groups was 1 (1-3) points, in control group – 1 (0.5-2), r=0.14 (p>0.05). The analysis of anorexia didn't reveal significant differences either. Median values were 1 (0-2) in T1D and 1 (1-1.5) in control group, r=0.03 (p>0.05).

The analysis of pain in upper abdomen differed significantly between groups: median value in T1D group was 2 (1-3) points and in control group 0 (0-1), r=0.47 (p<0.0001). The pain in lower abdomen also showed significant difference: T1D group – 1 (0-2) points, control group – 0 (0-1), r=0.25 (p<0.01).

The analysis of nausea across groups revealed significant differences: the median nausea was 2 (1-3) points in T1D group and 0 (0-2) points in control group, r=0.34 (p<0.001). The analysis of vomit in T1D and control group revealed significant differences too. Median values were – 1 (0-2) in T1D group and 0 (0-2) respectively, r=0.19 (p<0.05).

The analysis of rapid saturation between T1D and control groups showed significant differences. The median value of rapid saturation in T1D group was 1 (0-2) points, while in control group – 0 (0-2), r=0.22 (p<0.05). As for the diarrhea – significant differences between groups were observed. The median value in T1D group was 0 (0-2) points, in control group – 0 (0-0), r=0.31 (p<0.01).

Finally, the analysis of constipation across T1D and control groups revealed certain differences. Median values were 1 (0-3) points in T1D group, 0 (0-0) points in control group, r=0.42 (p<0.0001).

Discussion

Our study demonstrates that gastrointestinal symptoms are both more frequent and more intense in children with type 1 diabetes (T1D) than in healthy controls. These findings reveal a clear association between T1D and an increased prevalence and severity of upper gastrointestinal symptoms, including heartburn and nausea. Crucially, the differences between the two groups involve not only symptom

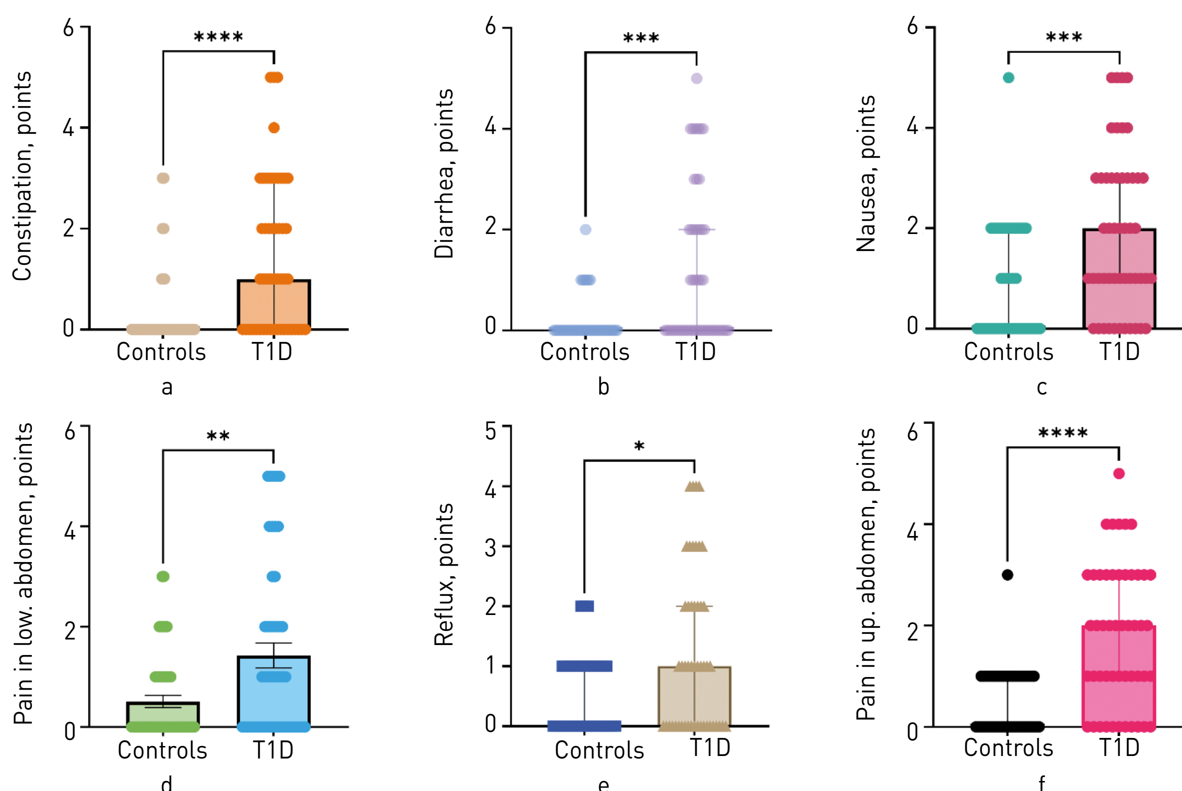

Figure 2. Severity of gastrointestinal symptoms in T1D and control groups.
* – p<0.05, ** – p<0.01, *** – p<0.001, **** – p<0.0001. Data expressed as Median (IQR).

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prevalence but also symptom severity, emphasizing the clinical relevance of these gastrointestinal manifestations.

Children within the T1D group exhibited both a higher incidence and a more pronounced course of gastroesophageal reflux. The development of these symptoms can be attributed to the interplay between autonomic diabetic nephropathy and gastroduodenal dysmotility. Dysfunction of the vagus nerve and intramural nerve plexuses, compounded by blood glucose fluctuations, disrupts gastric motility and secretion. Clinically, this manifests as delayed gastric emptying, reflux and nausea. While these symptoms are functional in nature for a significant proportion of children with T1D, their systematic occurrence and distinct presentation compared to healthy controls suggest underlying structural and functional alterations in gastrointestinal regulation rather than incidental complaints [3, 4].

Furthermore, children with T1D experienced a significantly higher frequency and intensity of upper abdominal pain compared control group. This robust intergroup difference confirms a strong link between T1D and abdominal pain syndrome. The primary pathophysiological drivers of upper abdominal pain in T1D are thought to be chronic hyperglycemia, metabolic imbalance and forthcoming oxidative stress, which collectively induce autonomic nerve damage, impair gastroduodenal motility and heightened visceral sensitivity [5]. Our data align with earlier research by Lodefalk and Aman, who highlighted that gastrointestinal symptoms are common in adolescents with T1D. Nevertheless, when evaluating comparative trends, our results reveal a persistent gap between the diabetic group and healthy controls—a finding that contrasts with the Lodefalk and Aman study, where no significant intergroup differences were identified. This variation underscores that although optimal glycemic management is paramount, other underlying clinical factors may independently contribute to the onset and intensity of these gastrointestinal disorders [6].

In our cohort high prevalence rates were observed for nausea (78%), abdominal pain (78%), gastroesophageal reflux (75.5%) and early satiety (73%). These data resonate with the findings of Selbuz and Bulus, who noted that 54% pf pediatric T1D patients reported at least one gastrointestinal complaint, with reflux and abdominal pain being the most frequent [4]. On the contrary, abdominal bloating did not differ significantly between the T1D and control groups, despite a trend toward higher mean values and greater variability in the T1D cohort. This lack of significance may point to clinical heterogeneity, suggesting that bloating characterizes a specific subset of patients with more advanced gastrointestinal dysfunction rather than the entire cohort. Similarly, the identical median intensity of anorexia across both groups points to a comparable baseline manifestation, even though its frequency varied (59% in T1D vs 82% in controls) [4, 6].

Early satiety was nominally significantly more pronounced in the T1D group than in controls. Although the absolute difference between the medians was only 1 point, this finding suggests a heightened perception of early satiety in children with T1D. Even subtle changes in subjective symptoms can carry clinical weight, as they potentially alter eating behavior, compromise glycemic control, and diminish quality of life. Given the relatively small effect size, these statistical differences must be interpreted with caution. Future large-scale studies that account for disease duration, glycemic control, and the presence of diabetic neuropathy are needed to clarify the precise clinical significance of these variations [7].

Functional gastrointestinal symptoms – such as nausea, abdominal pain and early satiety – are widely documented in pediatric T1D, especially in patients with suboptimal glycemic control. One cross-sectional study revealed that nearly 89% of children with T1D suffered from more than one gastrointestinal symptom, with a marked increase in frequency when Hb1Ac>7%. Another study tracking 359 adolescents via the Gastroparesis Cardinal Symptom Index (GCSI) reported that 75% had multiple gastrointestinal symptoms, and approximately 17% had scores indicative of severe motor impairment. The 73% prevalence of early satiety observed in our study mirrors these published trends [8].

Constipation also emerged as a prominent manifestation, affecting more than half of the children with T1D – a rate substantially higher than that seen in the general population. While the baseline prevalence of constipation in the general pediatric population ranges from 0.7% to 29.6% (and stood at 14% in our control group, closely matching the 15.6% reported in a Dutch cohort aged 8–17 years), its frequency was markedly elevated in our T1D group [9, 10]. This stark contrast highlights the profound impact of T1D and its complications on intestinal motor function.

Diarrhea symptoms were similarly more frequent and severe in T1D patients than in healthy controls. Although the median values for diarrhea were zero in both groups, non-parametric analysis unveiled significant differences in data distribution [10, 11]. This indicates a greater proportion of non-zero, elevated scores within the T1D cohort, whereas the symptom was virtually absent among controls. Such a

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discrepancy between median values and comparative analysis is driven by the asymmetric data distribution and a high volume of zero scores, which is a standard feature of clinical symptom scales. Nonetheless, the higher mean values (1.18±1.54) and wider scoring range (1–5) in the T1D group reflect a clinically meaningful shift toward greater gastrointestinal distress [12].

From a pathophysiological perspective, the most compelling finding is the coexistence of opposing intestinal phenotypes – diarrhea and constipation – within the T1D cohort. This overlap cannot be explained by functional disorders alone. Instead, the simultaneous presentation of diarrhea and constipation reflects a deeper dysregulation of enteric neurovascular control, triggered by chronic oxidative stress and hyperglycemia-induced microangiopathy, which serves as an early marker of systemic diabetic complications [12, 13].

Limitations

This study has several limitations that should be acknowledged. The cross-sectional design does not allow for establishing causal relationships between T1D and gastrointestinal symptoms. The results reflect associations rather than direct pathophysiological effects. The study was conducted at a single center with a relatively limited sample size, which may affect the generalizability of the results. Although multiple comparisons were addressed using Bonferroni correction, the analysis of numerous symptoms increases the possibility of type I error, and p-values should be interpreted with caution. Symptom intensity was evaluated using an ordinal scale, which reflects subjective perception rather than objectively measured severity.

Conclusions

1. This comparative assessment established the frequence and intensity profiles of gastrointestinal symptoms in children with T1D relative to control group, establishing a distinct clinical spectrum of gastrointestinal disorders associated with pediatric diabetes.

2. Children with T1D exhibit a significantly higher prevalence and severity of gastrointestinal symptoms – most notably gastroesophageal reflux, abdominal pain, nausea, vomiting, early satiety, diarrhea and constipation – indicating that T1D involves a systemic disruption of gastrointestinal regulation.

3. These results hold significant clinical and scientific value, demonstrating that gastrointestinal complaints in children with T1D are not random occurrences, but rather a systemic component of the disease's clinical course.

4. The practical utility of these results lies in justifying the implementation of active gastrointestinal symptom screening in pediatric T1D care. Early detection of functional disorders is vital for optimizing glycemic control, adjusting nutritional management, and ultimately improving the patient's overall quality of life.

Article Declarations

Raw Data and Materials. The raw data and materials supporting the findings of this study are available from the corresponding author upon reasonable request.

Study Limitations. This study has several limitations, including the limited sample size and the single-center nature of the study, which may restrict the generalizability of the findings. Further studies with larger cohorts are needed to confirm the obtained results.

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Ethics Approval Statement. The study was reviewed and approved by the Bioethics Committee of Bogomolets National Medical University (Kyiv, Ukraine), Protocol No. 166 dated 19.12.2026. The study was conducted in accordance with the ethical principles of the Declaration of Helsinki (2013 revision). Written informed consent was obtained from the parents or legal guardians of all participants prior to inclusion in the study.

Conflict of Interest. The authors declare that there is no conflict of interest and no financial interest in the preparation of this article. All authors have read and approved the final version of the manuscript. All authors have agreed to publish this manuscript.

AI Statement. Artificial intelligence tools were used only for language editing, grammar correction, and improvement of the clarity of the manuscript. The authors reviewed and approved the final version of the text and take full responsibility for the content of the article.

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Шлунково-кишкові симптоми як коморбідні прояви цукрового діабету 1 типу у дітей

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Анотація. *Вступ.* Захворюваність на цукровий діабет 1 типу серед дітей та підлітків у всьому світі характеризується значною варіабельністю та коливається від 5 до 50 нових випадків на 100 000 осіб віком до 20 років на рік, в середньому близько 14 на 100 000, причому пік захворюваності припадає на вікову групу 10–14 років, а після закінчення статевого дозрівання спостерігається зниження показників у молодих жінок та відносно високий рівень у молодих чоловіків віком до 20 років. Цукровий діабет 1 типу в дитячому віці – це хронічне аутоімунне захворювання, яке супроводжується не тільки порушенням вуглеводного обміну, але й ураженням різних органів та систем. Все більша увага приділяється шлунково-кишковим розладам у дітей з діабетом 1 типу, які можуть виникати вже на ранніх стадіях захворювання, навіть за відсутності класичних мікро- та макросудинних ускладнень.

Мета. Метою дослідження було оцінити частоту та інтенсивність шлунково-кишкових симптомів у дітей з діабетом 1 типу та порівняти клінічний профіль шлунково-кишкових розладів з показниками контрольної групи.

Матеріали та методи. Дослідження проводилося як порівняльне, перехресне клінічне дослідження. У дослідженні взяли участь 49 дітей з діабетом 1 типу, які перебували під наглядом у спеціалізованому ендокринологічному відділенні, а також 49 дітей контрольної групи без цукрового діабету, хронічних захворювань шлунково-кишкового тракту, гострих інфекційних захворювань на момент обстеження, целіакії,

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запальних захворювань кишечника та прийому ліків, що можуть впливати на моторику або функцію травної системи.
Результати. У дітей з діабетом 1 типу шлунково-кишкові симптоми були значно частішими та більш вираженими порівняно зі здоровими однолітками, зі значно вищою частотою рефлюксу, болю в животі, нудоти, блювання, діареї та запору (усі $p<0,05$). За низкою симптомів медіанні значення в обох групах були однаковими або дорівнювали нулю, але група з діабетом 1 типу мала ширший міжквартильний діапазон, вищі перцентилі та більшу варіабельність. Найбільш виражені міжгрупові відмінності стосувалися болю, нудоти та розладів кишечника, які характеризувалися не лише вищою частотою, але й вищою інтенсивністю проявів. Окремі симптоми верхніх та нижніх відділів шлунково-кишкового тракту у дітей з діабетом 1 типу мали тенденцію до поєднання.
Висновки. У дітей з діабетом 1 типу шлунково-кишкові симптоми є системними та клінічно значущими. Діабет вражає весь шлунково-кишковий тракт. Результати вказують на необхідність раннього та систематичного скринінгу шлунково-кишкових розладів у цієї категорії пацієнтів.

Ключові слова: цукровий діабет 1 типу, захворювання шлунково-кишкового тракту, шлунково-кишкові симптоми, діти, підлітки.

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