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Prevalence and Multidimensional Model of Disordered Eating in Youths With Type 1 Diabetes: Results From a Nationwide Population-Based Study

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Abstract

Objective: The aim of this study was to report nationwide data of the prevalence of disordered eating behaviors (DEBs) in adolescents with type 1 diabetes (T1D) and to evaluate a multidimensional model of eating problems, analyzing how psychopathological problems are associated with DEBs and with metabolic control.

Methods: This study was carried out using a cross-sectional design with a sample of 1,562 patients with T1D (812 male), aged 11–19 years. Participants were recruited from multiple pediatric diabetes centers ($N = 30$) located in northern, central, and southern Italy, and they individually completed the Diabetes Eating Problem Survey–Revised (DEPS-r) and the Youth Self-Report (YSR). Sociodemographic and clinical data were also gathered. Multiple-group structural equation modeling was used to investigate the relationships between internalizing/externalizing symptoms, DEBs, and glycosylated hemoglobin (HbA1c) values.

Results: A total of 29.7% of the participants reported DEBs (DEPS-r scores ≥ 20), 42.4% reported insulin manipulation (IM). The prevalence of DEBs was higher for female participants ($p \leq .001$). The model explains 37% of the variance in disordered eating, 12% in IM, and 21% in HbA1c values. Body mass index, externalizing symptoms, and internalizing symptoms were significantly and positively associated with DEBs, which in turn were significantly and positively associated with HbA1c values (all $p \leq .001$). Externalizing ($p \leq .001$) and internalizing ($p \leq .01$) symptoms were also directly associated with HbA1c values.

Conclusion: Given the relevant prevalence of DEBs, their significant positive association with psychopathological symptoms, and their relationship with worse diabetes outcomes, regular psychological screening and support is needed to ensure the best care of adolescents with T1D.

Keywords: adolescence; eating problems; psychopathological symptoms; type 1 diabetes

Introduction

Individuals with type 1 diabetes (T1D), especially youth, are at increased risk for disordered eating behaviors (DEBs) (Conviser et al., 2018; Hanlan et al., 2013; Young et al., 2013). Several risk factors are hypothesized to be involved in favoring an increased prevalence of DEBs in the T1D population (Goebel-Fabbri, 2009; Philpot, 2013; Pinhas-Hamiel et al., 2015). In fact, T1D is strongly associated with several of the eating disorder (ED)/DEB risk factors identified in psychosocial risk models for the development of DEBs that have been proposed for the general population (e.g., the dual pathway model), such as internalization of the thin ideal, body dissatisfaction, higher body mass index (BMI) (i.e., weight gain resulting from intensive diabetes management), and interpersonal difficulties (Colton et al., 2007; Stice et al., 2002). Similarly, more recent theoretical models for DEBs in individuals with T1D (e.g., the modified dual pathway model) have proposed—and preliminarily verified—that some T1D-specific factors may also be recognized as increasing the risk of developing DEBs, such as attention to food portions and weight, dietary regimens, hunger/satiety disruptions, fluctuations in blood glucose levels, and food addiction (Peterson et al., 2015, 2018; Rancourt et al., 2019; Treasure et al., 2015).

The most recent theoretical risk models for DEBs in T1D individuals tested the role of psychological risk factors, which were mainly conceptualized as perfectionism, depression, low self-esteem (Treasure et al., 2015), negative urgency (Rose et al., 2020), body dissatisfaction, and negative affect (Rancourt et al., 2019; Smith et al., 2020). However, these models still lack a detailed/wider explanation of the psychopathological problems that are associated with risk of DEBs in T1D individuals, in particular externalizing symptoms. Similarly, the few existing nationally representative epidemiological/cohort studies conducted on the prevalence of DEBs in individuals with T1D (Norway, Wisting et al., 2013a; Germany/Austria, Scheuing et al., 2014; Germany, Bächle et al. 2016; Australia, Araia et al., 2017; and US, Nip et al.,

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2019) focused their attention mainly on DEB rate estimations, rather than on possible psychopathological symptoms associated with risk of DEBs.

Given the evidence in individuals without T1D (Keski-Rahkonen & Mustelin, 2016; Swanson et al., 2011) indicating that eating problems are strongly associated with psychopathological conditions (e.g., mood and anxiety disorders), as well as the significant relationship between psychopathology and high glycosylated hemoglobin (HbA1c) levels in adolescents with T1D (Northam et al., 2005), it is critical to more deeply explore the association between psychopathological problems and DEBs.

The present study aimed to: (a) report nationwide data of DEB prevalence in adolescents with T1D (continuing a previous report on the current study's mid-term results, Troncone et al., 2022) and (b) evaluate a multidimensional model of DEBs in adolescents with T1D, to identify how psychopathological problems might be associated with DEBs and with metabolic control (measured by current HbA1c values). Consistent with previous theoretical DEB models (Goebel-Fabbri, 2009; Stice et al., 2002; Treasure et al., 2015), the contribution of BMI to DEBs and metabolic control was also tested.

It was hypothesized that psychopathological problems (conceptualized as externalizing and internalizing symptoms) and BMI have a positive association with DEBs, which in turn have a significant positive association with HbA1c values. In the hypothesized model, celiac disease and thyroiditis were analyzed as potential moderators of all expected relationships, given their high comorbidity ratio as autoimmune conditions co-occurring with T1D (Nederstigt et al., 2019) and given the greater likelihood of DEB development in individuals with T1D and an additional autoimmune disease (Tokatly Latzer et al., 2018; Wotton et al., 2016). In addition, sociodemographic data [age, gender, socioeconomic status (SES)] and clinical factors (specifically, type of therapy) were considered as co-variates.

The representation of the hypothesized model is shown in Figure 1 (for the sake of simplicity, the effects of the covariates are not included). Factors and pathways theorized by existing theoretical models for DEBs were highlighted together with the novel pathway delineated by the model proposed in the present study.

Methods

Participants

A total of 1,691 patients with T1D visiting the outpatient diabetes clinic of pediatric diabetes centers ($N = 30$) located in northern, central, and southern Italy were invited to participate in the project DiabEaT1 (Disordered eating behaviors and behavioral and emotional problems in Italian adolescents with type 1 diabetes: A nationwide population-based study), a national, cross-sectional study funded by the University of Campania "Luigi Vanvitelli." Participants were eligible for inclusion if they were 11–19-year-olds, had T1D onset at least 1 year before enrollment, and were accompanied by primary caregiver who was able to read and complete the study materials. Participants were excluded if they present comorbidities with developmental, cognitive, or psychiatric disorders (e.g., autism spectrum disorders, intellectual disabilities, psychosis, depression) or medical conditions (e.g., epilepsy, vitiligo, psoriasis). Of the patients who were approached, $n = 4$ refused to participate, and $n = 1{,}609$ met the inclusion criteria and filled out the measures. The sample consisted solely of White Italian adolescents.

Measures

A brief form was used to collect information on participants' demographic and clinical characteristics for age, sex, height, weight, HbA1c, type of therapy [as multiple daily injections (MDI), continuous subcutaneous insulin infusion (CSII), or injection port]. Case record files were reviewed to obtain any missing data. Patients' SES was measured using a total score on the Barratt Simplified Measure of Social Status (BSMSS) (Barratt, 2006), which assesses SES by inquiring about participants' primary caregiver(s)'s educational attainment and occupational status; scores range from 8 to 66, with higher scores indicating higher SES.

The presence of DEBs was investigated using the Diabetes Eating Problem Survey–Revised (DEPS-r), a 16-item self-report questionnaire (Markowitz et al., 2010). It is specifically designed for individuals with T1D to identify disordered eating related to diabetes and to assess weight-reducing tools that are unique to individuals with T1D, such as insulin restriction or omission. Higher scores indicate more eating problems; specifically, DEPS-r scores of 20 or higher were

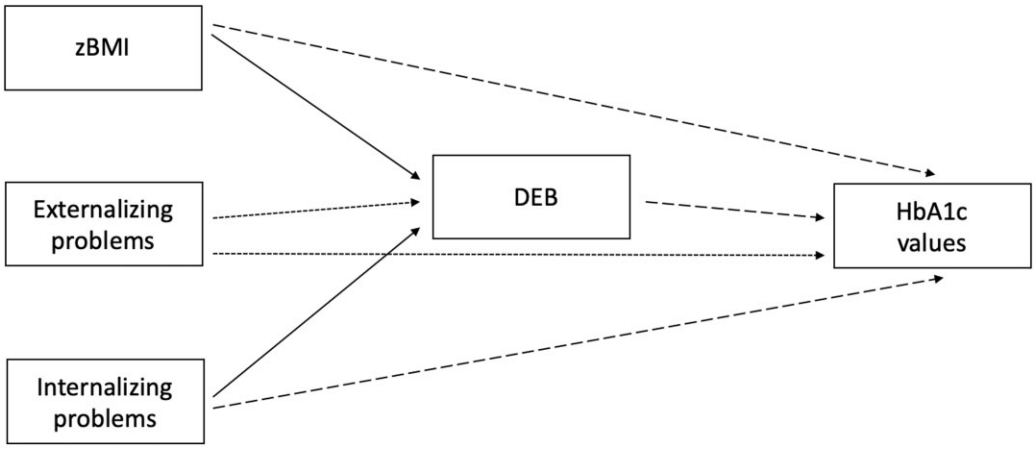

Figure 1. Conceptual model of the paths of influence.

Note. Solid lines indicate established pathways in the dual pathway model (Stice, 2002); dashed lines indicate associations proposed in the modified dual pathway model (Peterson et al., 2015); dotted lines indicate novel paths (i.e., externalizing symptoms) added by the current study.

considered to indicate the presence of DEBs (Markowitz et al., 2010; Wisting et al., 2019).

Previous evidence has demonstrated that the DEPS-r has satisfactory psychometric properties (Atik Altınok et al., 2017; Saßmann et al., 2015; Wisting et al., 2013b), including in Italian samples (Cherubini et al., 2018; Pinna et al., 2017). In the current study, the DEPS-r showed good Cronbach's α reliability coefficient (α = 0.84).

Consistent with the previous research (Troncone et al., 2022; Wisting et al., 2013a), in the present study, insulin omission/restriction was operationally defined as an answer of at least "sometimes" to DEPS-r items 2 ("When I over-eat, I do not take enough insulin to cover the food") or 8 ("After I overeat, I skip my next insulin dose"), and this behavior was categorized as intentional insulin manipulation (IM). In addition, to analyze different potential paths of the multidimensional model of DEBs, DEBs were operationalized into two continuous subdimensions: IM (i.e., sum of scores to the DEPS-r items 2 and 8) and disordered eating (DE; i.e., sum of all scores to all DEPS-r items except 2 and 8).

The presence of psychopathological problems in adolescents was evaluated using the Youth Self-Report (YSR) (Achenbach, 1991), a 112-item self-report questionnaire consisting of eight subscales (somatic complaints, anxious/depressed behavior, social problems, thought problems, attention problems, delinquent behavior, aggressive behavior, and withdrawal), a total problems scale, and two composite scales for internalizing symptoms (i.e., withdrawing, anxiety/depressive, and somatic complaints) and externalizing symptoms (i.e., rule-breaking, hyperactivity, and aggression). The YSR is a gold standard in assessment of psychopathological problems among youths, characterized by sound psychometric properties reported in most countries (Achenbach & Rescorla, 2001). In the present study, the YSR showed satisfactory Cronbach's α reliability coefficients (Internalizing α = 0.89; Externalizing α = 0.87).

Procedure

The study was approved by the ethical committees of the participating centers. Participants were recruited during their routine visits to a pediatric diabetes center's clinic. Clinicians identified patients who met the inclusion criteria, whom they provided with an introduction to the study, after which they asked the patients to participate. Medical records were used to confirm that the inclusion/exclusion criteria were met. A trained member of the research team administered the tests in private patient waiting rooms; adolescents filled out the DEPS-r and the YSR, and parents completed the BSMSS. All participants and parents gave their written informed consent to participate. Further details about the methodology of the study are described in Troncone et al. (2022).

Data Analysis

Of those who agreed to participate, 43 patients incompletely filled out the questionnaires and were thus excluded; as a result, analyses were conducted with responses from the remaining 1,562 participants (92.4%, 750 female). Descriptive analyses were conducted to investigate variable distributions. A set of bivariate appropriate analyses (χ^2, *t*-test) were performed according to the categorical or continuous nature of variables, in order to compare the prevalence of DEBs between groups (i.e., male and female participants). Pearson's correlations were calculated to investigate bivariate relationships among the variables of interest.

To test the multidimensional model of DEBs, patients with injection port as type of therapy ($n = 9$) and patients with missing data for one or more variables who were included in the model ($n = 16$) were eliminated from the analyses. The final sample consisted of 1,537 participants (737 female), including $n = 1{,}312$ participants with only T1D and $n = 225$ participants with T1D and other autoimmune diseases (celiac disease and/or thyroiditis).

Multiple-group structural equation modeling (SEM) was used to test the hypothesis (Figure 1), with the absence or presence of co-occurring autoimmune conditions as the grouping variable. The model included six observed variables: zBMI (standardized BMI scores), externalizing symptoms, internalizing symptoms, IM, DE, and HbA1c values. Gender, age, SES, and type of therapy (MDI, CSII) were included in the model as covariates influencing all variables. To test the equivalence of the structural parameters across groups (participants with T1D vs. participants with T1D and celiac disease and/or thyroiditis), parameters were freely estimated in the first step. In the second step, structural paths and correlations were constrained to be equal across groups.

All the analyses were conducted using maximum likelihood estimations (Muthén & Muthén, 2017). Indirect effects were estimated, and bootstrapping was used to estimate the standard errors and the 95% bias-corrected confidence intervals of these coefficients (MacKinnon, 2008). Several indexes were used to determine model fit: the comparative fit index (CFI; Bentler, 1990), the Tucker–Lewis index (TLI; Tucker & Lewis, 1973), and the root mean square error of approximation (RMSEA) with associated 90% confidence intervals (Brown & Cudeck, 1993). Values of CFI > 0.90 and TLI > 0.90 indicated satisfactory fit, and RMSEA values between 0 and 0.05 indicated excellent fit (Hu & Bentler, 1999). The Satorra–Bentler chi-square difference test ($\Delta SB\chi^2$) was used to compare the fit of nested models (Satorra, 2000). Descriptive and bivariate analyses were performed using SPSS version 21.0 for Macintosh, and SEM was computed using the Mplus version 7.4 software.

Results

Clinical, demographic, DEPS-r, and YSR data are shown in Table I. (Data from the comparison of participants with T1D and comorbid autoimmune conditions vs. those with only T1D are displayed in Supplementary data 2.)

A total of 29.7% of the participants screened positive for DEB presence (DEPS-r scores ≥ 20), and 42.4% reported IM. Girls had a higher prevalence of DEBs than boys ($p \leq .001$), while no gender differences were observed in IM ($p > .05$). Girls also showed higher internalizing symptoms ($p \leq .001$).

Pearson correlations among study variables were computed separately for participants with only T1D and participants with T1D and other disease (celiac diseases and/or thyroiditis) and are shown in Table SI (see Supplementary data 3).

SEM

The fit indices of the first model were $\chi^2(4) = 6.26$, $p = .18$, RMSEA = 0.03 (0.0; 0.07), TLI = 0.99, CFI = 0.99; subsequently, when structural paths and correlations were constrained to be equal across groups, and the fit indices for this model were $\chi^2(41) = 46.44$, $p = .26$, RMSEA = 0.01 (0.0;

Table I. Demographic Characteristics, Clinical Characteristics, DEPS-r and YSR Data of the Whole Sample, Grouped by Gender as M (SD) and N (%)

	Whole sample, $N = 1562$ *M* (*SD*)	Males, $n = 812$ *M* (*SD*)	Females, $n = 750$ *M* (*SD*)	Males versus females test
Age (years, month) range	15.09 (1.77) (11–19.08)	15.14 (1.75)	15.03 (1.8)	$t(1560) = 1.242$
SES	30.76 (11.22)	31.1 (11.17)	30.39 (11.27)	$t(1560) = 1.247$
Comorbidities				
Celiac disease (*n*, %)	119 (7.6)	52 (6.4%)	67 (8.93%)	$\chi^2 = 21.735$***
Thyroiditis (*n*, %)	102 (6.5)	33 (4.06%)	69 (9.2%)	
Both (*n*, %)	6 (.4)	3 (0.37%)	3 (0.4%)	
HbA1c (%)	7.74 (1.28)	7.65 (1.21)	7.83 (1.36)	$t(1560) = -2.627$**
Type of therapy				
MDI (*n*, %)	912 (58.4)	496 (61.08%)	416 (55.45%)	$\chi^2 = 5.127$
CSII (*n*, %)	641 (41)	312 (38.42%)	329 (43.87%)	
Injection port (*n*, %)	9 (.4)	4 (0.49%)	5 (0.67%)	
Diabetes duration (years)	6.81 (4.04)	6.65 (4.11)	6.99 (3.95)	$t(1560) = -1.623$
zBMI[a]	0.48 (0.91)	0.35 (0.96)	0.63 (0.82)	$t(1560) = -6.176$***
YSR				
Internalization	13.98 (9.53)	10.82 (7.63)	17.41 (10.18)	$t(1560) = -14.395$***
Externalization	10.85 (6.64)	10.54 (6.72)	11.19 (6.54)	$t(1560) = -1.950$
DEPS-r				
Total score	15.56 (10.96)	13.05 (9.31)	18.27 (11.93)	$t(1560) = -9.574$***
Score ≥20 (*n*, %)	464 (29.7)	173 (21.3%)	291 (38.8%)	$\chi^2 = 57.146$***
IM (*n*, %) [b]	663 (42.4)	345	318	$\chi^2 = 0.001$

Note. Data are presented as mean values and standard deviation, and *N* (%). CSII = continuous subcutaneous insulin infusion; DEPS-r = Diabetes Eating Problem Survey–Revised; HbA1c = glycosylated hemoglobin; IM = insulin manipulation; MDI = multiple day injection; *SD* = standard deviation; SES = socioeconomic status; YSR = Youth Self-Report.

[a] zBMI = standardized BMI scores calculated according to the Centers for Disease Control and Prevention's pediatric growth charts (Kuczmarski et al., 2002).

[b] Answers indicating skipping or reducing at least "sometimes" were classified as insulin misuse.

** $p \leq .01$.

*** $p \leq .001$.

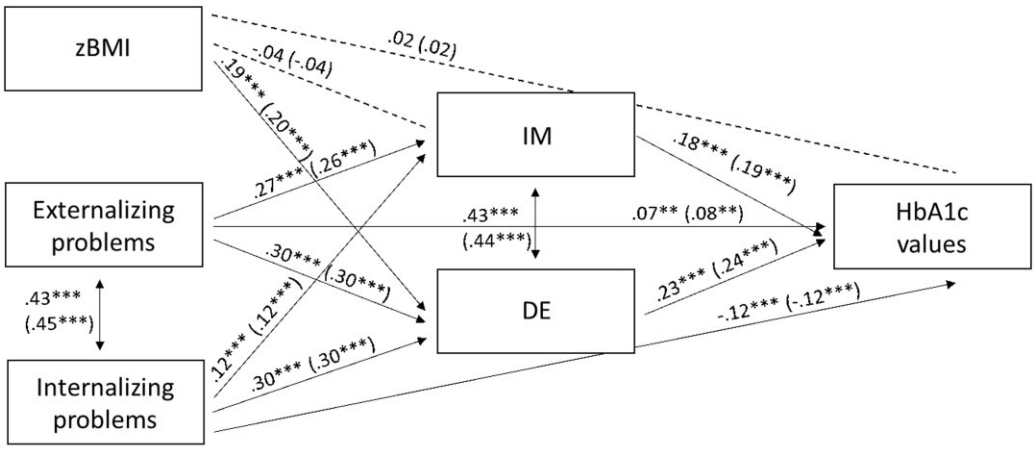

Figure 2. Relations between BMI, externalizing problems, internalizing problems, IM, DE, and HbA1c values. Standardized path coefficients.

Note. Parameters for patients with only T1D are shown without brackets, parameters for patients with T1D and other diseases (celiac diseases and/or thyroiditis) are shown in brackets. BMI = body mass index; DE = disordered eating (sum of all scores to DEPS-r's item excluding 2 and 8); IM = insulin manipulation (sum of scores to DEPS-r's item 2 and 8); T1D = type 1 diabetes. ** $p \leq .01$; *** $p \leq .001$.

0.03), TLI = 0.99, CFI = 0.99. The $\Delta\chi^2$ statistics revealed that the fit of the constrained model across groups was significantly better than that of the unconstrained model ($\Delta\chi^2(37) = 40.17$, $p = .33$). Therefore, we chose this last model with total invariance across groups, because it showed better fit and a non-significant $\Delta\chi^2$ statistic.

As shown in Figure 2, the results indicated that: externalizing symptoms were positively correlated with internalizing symptoms, and DE was positively correlated with IM; zBMI, externalizing symptoms, and internalizing symptoms were significantly and positively associated with DE, which in turn was significantly and positively associated with HbA1c values; and externalizing symptoms and internalizing symptoms were significantly and positively associated with IM, which in turn was significantly and positively associated with HbA1c values. Moreover, externalizing symptoms were directly and positively associated with HbA1c values, while internalizing symptoms were directly and negatively associated with HbA1c values. zBMI was not significantly associated with IM or HbA1c values. To present it in simplified terms, the paths of the covariates are reported in Table III.

With regard to the bootstrapping method, the analysis of the indirect effects showed the following relationships: zBMI was positively associated with HbA1c values via DE;

Table II. Standardized Indirect Effects

Independent variables	Mediation variables	Dependent variable HbA1c Estimate	95% CI
zBMI	DE	0.04***; 0.05***	0.03–0.06; 0.03–0.06
Externalizing symptoms	IM	0.05***; 0.05***	0.03–0.07; 0.03–0.07
	DE	0.07***; 0.07***	0.05–0.09; 0.05–0.09
Internalizing symptoms	IM	0.02**; 0.02**	0.01–0.03; 0.01–0.04
	DE	0.07***; 0.07***	0.05–0.09; 0.05–0.10

Note. The standardized coefficients are reported for participants with only T1D and participants with T1D and comorbid celiac disease and/or thyroiditis, respectively. CI = confidence interval; DE= disordered eating; HbA1c = glycosylated hemoglobin; IM = insulin manipulation; T1D = type 1 diabetes.
** $p < .01$.
*** $p < .001$.

Table III. Standardized Effects of Gender, Age, Socio Economic Status (SES) and Type of Therapy on zBMI, Externalizing Problems, Internalizing Problems, IM, DE, and HbA1c Values

	zBMI	Externalizing problems	Internalizing problems	IM	DE	HbA1c values
1. Gender	0.15***; 0.15***	0.06*; 0.06*	0.35***; 0.35***	−0.05*; −0.05*	0.12***; 0.12***	0.04; 0.04
2. Age	−0.10***; −0.09***	0.07**; 0.07**	0.06*; 0.05*	0.01; 0.01	0.01; 0.01	−0.02; −0.02
3. SES	−0.06*; −0.05*	−0.08**; −0.08**	−0.06*; −0.05*	−0.02; −0.02	−0.06**; −0.06**	−0.13***; −0.13***
4. Type therapy	−0.03; −0.03	−0.07*; −0.07*	0.03; 0.03	−0.01; −0.01	−0.05*; −0.05*	−0.19***; −0.21***

Note. The standardized coefficients are reported for patients with only T1D and patients with T1D and other diseases (celiac diseases and/or thyroiditis), respectively. Gender was coded as 1 = males, 2 = females. Type of therapy was coded as 1 = multiple daily injections, 2 = continuous subcutaneous insulin infusion. DE = disordered eating (sum of all scores to DEPS-r's item excluding 2 and 8); DEPS-r = Diabetes Eating Problem Survey–Revised; HbA1c = glycosylated hemoglobin; IM = insulin manipulation (sum of scores to DEPS-r's item 2 and 8); T1D = type 1 diabetes.
* $p \leq .05$.
** $p \leq .01$.
*** $p \leq .001$.

externalizing symptoms were positively associated with HbA1c values via IM and DE; and internalizing symptoms were positively associated with HbA1c values via IM and DE (Table II).

Gender was positively associated with zBMI, externalizing symptoms, internalizing symptoms, and DE and was negatively associated with IM. Age was negatively associated with zBMI and positively associated with externalizing symptoms and internalizing symptoms. SES was negatively associated with zBMI, externalizing symptoms, internalizing symptoms, DE, and HbA1c values. Type of therapy (i.e., CSII use) was negatively associated with externalizing symptoms, DE, and HbA1c values (Table III).

Overall, the model explains a significant percentage of the variance for IM (12% for participants with only T1D and 11% for participants with T1D and comorbid celiac and/or thyroiditis), for DE (37% for participants with only T1D and 37% for participants with T1D and comorbid celiac and/or thyroiditis), and for HbA1c values (21% for participants with only T1D and 23% for participants with T1D and comorbid celiac and/or thyroiditis).

Discussion

The present study aimed to investigate the prevalence of DEBs in adolescents with T1D and the association between eating problems, psychopathological symptoms, zBMI, and glycemic control to propose a multidimensional model of DEBs.

To the authors' knowledge, this is the first study conducted on a large sample of adolescents with T1D that simultaneously analyzed the role of sociodemographic (gender, age, SES), clinical (type of therapy, zBMI), and psychopathological variables (externalizing symptoms and internalizing symptoms) in glycemic control and the development of DEBs. In particular, the direct and indirect effects of these variables, as well as the moderating role played by co-occurring autoimmune conditions with T1D, were analyzed to define a multidimensional model that took into account the complexity of the developmental pathway of DEBs and the consequent high HbA1c levels in adolescents with T1D.

Results showed that, consistent with previous research (38% Araia et al., 2017; 34.4% Cherubini et al., 2018; 21.2% Nip et al., 2019; 37.7% Troncone, Cascella et al., 2020), participants showed a high prevalence of DEBs (29.7%), which were observed in almost three in ten of all participants. Similarly, participants reported high IM rates (42.4%), with even higher results than the majority of prevalence estimates described in other studies on adolescents (up to 5.3% Bächle et al., 2016; up to 8.9% Cherubini et al., 2018; up to 40% Pinhas-Hamiel et al., 2015; up to 29.5% Schober et al., 2011; 19% Snyder et al., 2016; up to 41.4% Wagner & Karwautz, 2020; 31.6% Wisting et al., 2013a). In addition, in line with previous studies (Araia et al., 2017; Snyder et al., 2016; Troncone, Chianese et al., 2020), this study found no significant gender differences in IM frequency.

As hypothesized, the model indicated that in both adolescents with only T1D and those with comorbid celiac and/or thyroiditis, zBMI and psychopathological symptoms can be correlated with DEBs, which in turn is negatively associated with metabolic control. In particular, significant indirect effects suggested that zBMI was found to be positively associated with high HbA1c levels via DE, and internalizing and externalizing symptoms were found to be positively associated with high HbA1c levels via IM and DE.

These findings are consistent with research on youths and adolescents in the general population indicating internalizing/externalizing symptoms as risk factors for the development of ED pathology and identifying eating pathology as a variant of internalizing disorders (Adambegan et al., 2012; Aimé et al., 2008). Similarly, the findings are also in line with studies documenting high rates of comorbidity between EDs and internalizing/externalizing symptoms in general population samples (Mitchell et al., 2014; Slane et al., 2010) and in youth with T1D (Troncone et al., 2022), as well as the negative impact of this association on metabolic control (Conviser et al., 2018; Northam et al., 2005; Pinhas-Hamiel et al., 2015; Wagner & Karwautz, 2020). In addition, this study's model indicated a direct effect of internalizing symptoms and externalizing symptoms (but not of zBMI) on HbA1c values, suggesting that psychopathological symptoms are negatively associated with the diabetes control regardless of the presence of DEBs. It is reasonable to suppose that the presence of externalizing symptoms—manifesting in rule-breaking behavior, aggression, and hyperactivity—may interfere with high adherence to diabetes regimens and relate to higher HbA1c (Luyckx et al., 2010; McDonnell et al., 2007). However, given the extensive research showing the positive relationship between depressive/anxious symptoms and HbA1c levels (Buchberger et al., 2016; Hood et al., 2011), the negative association between internalizing symptoms and glycemic control is less clear and therefore must be further explored. It could be hypothesized that since the YSR internalizing symptoms composite score includes many items related to anxiety and somatic symptoms (versus depression), a higher score could potentially also be the product of the greater attention that such youth give to their own bodies. This attention—which can be considered a result of the direct effects of living with a chronic illness, of the developmental phase, and of the reactions and interest of the adults (parents, doctors etc.) around them- might somehow lead the patients to a stricter adherence to their diabetes regimen and therefore to lower HbA1c values.

Regarding zBMI, it should be noted that the analysis of the indirect effects confirmed that zBMI was positively associated with HbA1c values only via DE, indicating that higher weight may primarily be associated with higher HbA1c if mediated by the presence of DEBs. It can be hypothesized that higher weight may result in higher body dissatisfaction and greater desire to be thinner, which in turn may push adolescents (already struggling with developmental issues such as self and body image concerns) to adopt unhealthy strategies to lose weight (DEBs—e.g., binge eating, overeating, breaking dietary rules, etc.), which negatively affect metabolic outcomes (Broadley et al., 2019; Winston, 2020). No associations were observed between zBMI and IM. To this end, it should be noted that while previous research has recognized the contribution of weight gain (especially as result of the initiation of insulin treatment) to IM onset (Pinhas-Hamiel et al., 2015) and regards weight concerns as an IM risk factor (Hall et al., 2021; Peveler et al., 2005), the little existing evidence on the BMI–IM association is contradictory (Philippi et al., 2013; Troncone et al., 2022; Wisting et al., 2015). However, all results regarding IM should be interpreted with caution: the method to operationalize IM, and the fact that the items on the DEPS-r did not explicitly ask about insulin restriction/omission for the purpose of weight loss, could have potentially biased IM estimation and could explain the lack of its association with zBMI.

In a consideration of the effect of covariates, and consistent with most extant T1D evidence (Cherubini et al., 2018; Gesuita et al., 2017; Hanlan et al., 2013; Rose et al., 2020; Wisting et al., 2013a), it is worth noting that female gender and lower SES were found to be significantly associated with higher psychopathological symptoms, zBMI, HbA1c values, and DEBs; in addition, type of therapy (using CSII) was associated with lower externalizing symptoms, lower DE, and better glycemic control. Specifically, the relationship observed between SES and DEBs is consistent with previous research (Iafusco, 2004; Troncone, Chianese et al., 2020), and it can probably be considered to be in line with evidence indicating a positive association between high SES and better health status/quality of life (Frank et al., 2003; Hassan et al., 2006; Tsiouli et al., 2013).

This study's cross-sectional nature should be considered as a limitation, and it does not permit determinations of causal influence. The current mediation analysis violates the temporal requirement of mediation, and the causal pathways proposed here will need to be confirmed in longitudinal studies. In addition, the exclusion of participants with mental health problems—who are likely to also be more vulnerable to DEBs and who are characterized by internalizing/externalizing symptoms—may have introduced a potential sample selection bias affecting the results and the generalizability of this study. The lack of racial/ethnic diversity among participants may also limit the extent to which the findings can be generalized to other racial/ethnic groups. A further limitation is that potential personal variables (e.g., perfectionism, self-esteem, body image satisfaction) that may play a role in developing DEBs were not considered. Similarly, in the testing of the multidimensional model of DEBs, calculating IM and DE scores based on parts of the whole set of DEPS-r items may affect the validity of the DEPS-r measure, requiring great caution in the interpretation of these two DEB subdimensions' results.

Future research should address these limitations. In particular, the relationships between DEBs and psychopathological symptoms need to be examined over time/prospectively, to determine whether internalizing/externalizing symptoms precede the development of DE and affect downstream glycemic outcomes or whether these relationships occur in reverse. Such studies should also include individuals with co-occurring T1D and mental health disorders. As a next step, further studies implementing a cross-lagged model could provide an answer to this question.

Given the heightened risk of diabetes complications and mortality associated with co-occurring T1D–DEBs (Broadley et al., 2020; Goebel-Fabbri et al., 2008; Winston, 2020), it is very important to identify youth with T1D at risk for developing DEBs. This study's findings of an association between internalizing/externalizing symptoms, DEB, and diabetes control together with a deeper comprehension of demographic and clinical factors that are associated with DEBs may contribute to significantly increasing knowledge in this field.

All of these results underscore the need to continually monitor the psychological conditions of adolescents with T1D, as it is the only way to effectively care for and manage the emotionally and physically demanding chronic pathology of T1D, especially in the challenging yet critical developmental phase that is adolescence (Delamater et al., 2018). To detect

emerging difficulties early—both in eating behaviors and in general psychological functioning—it would be useful for clinicians involved in diabetes care to work in a multidisciplinary team in which psychologists are actively engaged in T1D patients' care. As suggested by the current results, DEBs need to be accurately screened and understood as situated within the more general comprehension of psychological functioning of youth with T1D. Therefore, T1D management requires that periodical psychological assessment should be routine, regardless of the presence of manifesting psychopathological or eating symptoms. In addition, the multidimensional nature of DEBs (indicated by the present results) indicates the need for an integrated multidisciplinary approach to treating DEBs in youth with T1D. After appropriate assessment and case conceptualization of individuals with T1D and DEB, each intervention should be tailored to address internalizing/externalizing symptoms, as well as aspects of the diabetes regimen (e.g., dietary) that can promote weight gain and then facilitate body concerns and dissatisfaction, especially in adolescents.

Supplementary Data

Supplementary data can be found at: https://academic.oup.com/jpepsy.

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Author Contributions

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Conflicts of interest

None declared.

Data Availability

Data are available upon reasonable request.

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