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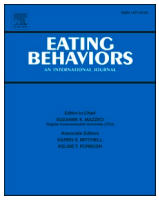

Prevalence of eating disorder symptoms in people with insulin-dependent-diabetes: A systematic review and meta-analysis

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ABSTRACT

Aims: To examine the prevalence of eating disorder symptoms (EDS) in 16 years and older individuals with insulin-dependent diabetes including both clinical and subclinical eating disorder symptoms.
Methods: We searched PubMed, Embase, Scopus, PsycINFO, and CINAHL databases to discover studies reporting prevalence of eating disorder symptoms in patients with insulin-dependent diabetes (both type 1 and type 2). We performed a meta-analysis to estimate the pooled prevalence of eating disorder symptoms and an independent meta-analysis to estimate the prevalence of insulin omission.
Results: A total of 45 studies were included in the meta-analysis of eating disorder symptoms. Diabetes Eating Problem Survey (DEPS-R) was the most frequently used screening tool (in 43 % of studies, $n = 20$). The pooled prevalence of eating disorder symptoms was 24 % (95 % CI 0.21–0.28), whereas in studies using DEPS-R, it was slightly higher, 27 % (95 % CI 0.24–0.31), with the prevalence ratio (PR) of 1.1. The prevalence differed between screening tools ($\chi^2 = 85.83$, df = 8, $p < .0001$). The sex distribution was associated with the observed prevalences; in studies with a higher female prevalence (>58 %), the pooled eating disorder symptom prevalence was higher [30 % (95 % CI 0.26–0.34) vs. 18 % (95 % Cl 0.14–0.22), PR 1.7]. The prevalence of insulin omission was 21 % (95 % CI 0.13–0.33).
Conclusions: Eating disorder symptoms and insulin omission are common in patients with insulin-dependent diabetes regardless of age. DEPS-R is the most used screening tool. Studies with a higher proportion of female participants report higher prevalence rates.

1. Introduction

Eating disorders are more prevalent in people with diabetes than in the general population and they are also more deadly (Broadley et al., 2020; Colton et al., 2015). Many diabetes-related factors increase the risk of eating disorders, such as concerns over shape and weight, a focus on diet and carbohydrates, and difficulties coping with a long-term condition (JDN17-6-228-32.pdf, n.d.; Nip et al., 2019; The Diabetes Control And Complications Trial Research Group, 2001). The etiology, predictive factors, and onset of eating disorder symptoms differ between type 1 and type 2 diabetes (Gagnon et al., 2017). Certain risk factors, such as high body mass index (BMI), body dissatisfaction, deficient coping strategies, and symptoms of depression, are associated with eating disorders of both type 1 and type 2 diabetes (Carroll et al., 1999; Crow et al., 2001; Goebel-Fabbri, 2009; Herpertz, Albus, et al., 1998; Mannucci et al., 2005a). Patients with insulin-dependent diabetes have a unique form of disordered eating known as insulin omission. Insulin omission refers to intentionally skipping insulin doses to lose glucose

Abbreviations: DEPS-R, Diabetes Eating Problem Survey; EAT(-26 and -40), Eating Attitudes Test; EDE, semi-structured interview Eating Disorder Examination; EDEQ, Eating Disorder Examination Questionnaire; EDI, The Eating Disorder Inventory; QEWP, Questionnaire on Eating and Weight Patterns; SCOFF, Questionnaire of the Acronyms Sick, Control, One, Fat, Food.

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calories through the glucose excretion in the urine, leading to weight loss (De Paoli & Rogers, 2018). Even as a subclinical eating disorder symptom, it can have severe consequences due to the impact of chronic hyperglycemia, and the increased risk of life-threatening diabetic emergencies, such as diabetic ketoacidosis, hospitalizations and premature death (Gibbings et al., 2021). Apart from insulin omission, observed eating disorders in patients with diabetes are the same as in the general population: the most common disorders are 'eating disorder not otherwise specified' (EDNOS), anorexia nervosa and bulimia nervosa (Mannucci et al., 2005a). Alongside with these disorders are subclinical eating disorder symptoms that do not meet criteria for a clinical eating disorder but cause increased stress, loss of control and difficult feelings like guilt (Goddard & Oxlad, 2023).

Prevalence of eating disorders in patients with diabetes varies from 0 % to 32 %, which may largely be due to different study designs for example whether or not subclinical eating disorder symptoms are included (Bryden et al., 1999; Colton et al., 2015; Mannucci et al., 2005a). In a previous meta-analysis conducted in adolescents with type 1 diabetes, 7 % of patients had an eating disorder and up to 40 % had subclinical eating disorder symptoms (Young et al., 2013a). Prevalence of insulin omission has been between 4 and 40 % in previous literature (Bächle et al., 2016; Bernstein et al., 2013; Peveler et al., 2005; Troncone et al., 2022; Wisting et al., 2013). Although awareness of disordered eating has increased in healthcare, a recent study showed that >60 % of healthcare professionals working with diabetes expressed low confidence in identification of co-morbid type 1 diabetes and eating disorder (Tan & Spector-Hill, 2021). In addition, 78 % of them used no screening instruments for disordered eating in this population (Tan & Spector-Hill, 2021). The American Diabetes Association recommends routine screening for disordered eating in children from 10 to 12 years using a diabetes-specific eating disorder screening tool, Diabetes Eating Problems Survey Revised (DEPS-R) (American Diabetes Association, 2021). There are multiple different screening tools and in a recent systematic review, DEPS-R was the most widely used validated tool in adolescents with type 1 diabetes (Markowitz et al., 2010; Pursey et al., 2020). However, DEPS-R has not yet been validated against a measure of disordered eating.

Our primary aim was to systematically review and meta-analyze studies reporting the prevalence of eating disorder symptoms in insulin-dependent diabetes patient populations. We also studied if some screening tools were associated with higher or lower prevalence rates than others. As a secondary aim, we aimed at investigating the prevalence of insulin omission in adult populations of patients with type 1 diabetes, and discovering possible factors that may affect the reported prevalences of eating disorder symptoms.

2. Methods

2.1. Data sources and search

This systematic review and meta-analysis followed the Preferred Reporting Items for Systematic Reviews and Meta-Analyses (PRISMA) guidelines with 2020 updates (Page et al., 2021) in accordance with a pre-registered protocol on the Prospero database (ID-code CRD42021224215, https://www.crd.york.ac.uk/prospero/display_record.php?ID=CRD42021224215). The detailed search strategy is presented in Supplemental Table S1, and it was performed together with a librarian consult from University of Eastern Finland. The Literary search was up to the sixth of August 2023. The following electronic databases were searched: PubMed, Scopus, PsycINFO and CINAHL. We included articles reporting insulin-dependent diabetes and eating disorder symptoms. Studies with all forms of comparator(s)/controls and without a comparator group were included.

2.2. Study selection

Two researchers (HL and PN) independently screened titles and abstracts in Rayyan (Ouzzani et al., 2016), resolved discrepancies through discussions, and identified a set of studies for the full-text review. The same researchers then screened full texts in Covidence and agreed upon a final set of studies to be included. The only automatic tool used in Rayyan and Covidence was the detection of duplicates. To be eligible, the study had to 1) be a human study (cohort, case-cohort, case-control, or a baseline assessment of clinical trials), 2) focus on adolescent and adult populations (mean age at least 16 years), 3) focus on diabetes patients with insulin treatment, and 4) report the prevalence of eating disorder symptoms. We excluded non-original papers (reviews, commentaries, editorials, or letters). We set the age limit of 16 years because in Finland, the care of pediatric patients transfers to the adult unit at the age of 16. If the mean age was under 16 years, but patients older than that were presented separately in results, the study was included. We included both type 1 and type 2 diabetes with insulin treatment in order to include all patients of potential insulin dependent diabetes. Articles were limited to English language. No sex/gender restriction was included.

2.3. Data extraction

Three researchers (HL, PN and EM) independently collected data from the study reports. Discrepancies were resolved through discussion. The following data were collected: author names, year of publication, journal, study name and design, location, sample and control group sizes, sex, mean age of participants, assessment tools used to screen eating disorder symptoms, and the prevalence of eating disorder symptoms. The outcome, a positive screening finding of eating disorder symptoms, was defined as exceeding the cut off score of each screening assessment tool. Since in many screening tools there are multiple different versions of the survey, with different cut-off scores, we used the same cut-off score as was used in the original article. Insulin restriction was considered positive if the participants answered affirmatively to the following questions: "Do you use less insulin than you should?" (Albaladejo et al., 2023a; Bernstein et al., 2013; Goebel-Fabbri et al., 2008a), "Do you deliberately inject too little insulin to lose weight?" (Fairburn et al., 1991; Falcão et al., 2017; Marcus et al., 1992; Philippi et al., 2013; Stancin et al., 1989), and "Do you use insulin restriction as a means of weight control?" (Herpertz, Wagener, et al., 1998b). Moreover, we included a study using a clinical interview to investigate insulin restriction as a weight management strategy (Biggs et al., 1994) and a study where insulin omission was identified based on two DEPS-R items ("When I overeat, I do not take enough insulin to cover the food" and "After I overeat, I skip my next insulin dose.") where the responses at least "sometimes" was classified as insulin omission behavior (Yafei et al., 2023).

2.4. Data analysis

Altogether 77 studies were identified for a systematic review (Supplemental Table S2), out of which 45 studies were included in the main meta-analysis (Affenito et al., 1997; Albaladejo et al., 2023b; Apergi et al., 2020; Araia et al., 2017; Bächle et al., 2015; Bächle et al., 2016; Baechle et al., 2019; Barbanti et al., 2020; Bikri et al., 2021; Broadley et al., 2018; Cantwell & Steel, 1996; Colton et al., 2013; Doyle et al., 2017; Engström et al., 1999; Falcão et al., 2017; Friedman et al., 1998; Fritzen et al., 2021; Gagnon et al., 2017; Gorin et al., 2008; Grylli et al., 2010; Herpertz, Wagener, et al., 1998b; Johnson et al., 2014; Keane et al., 2018; Latzer et al., 2018; Lok et al., 2023; Luyckx et al., 2019; McClintock et al., 2022; Merwin et al., 2014; Nilsson et al., 2020; Nip et al., 2019; Philippi et al., 2013; Pinna et al., 2017; Pinna et al., 2022; Pollock-BarZiv & Davis, 2005; Quinn et al., 2016; Rancourt et al., 2019; Rodin et al., 1985; Ryan et al., 2008; Rydall et al., 1997; Stancin et al.,

1989; Watt et al., 2022; Wisting et al., 2013; Wisting et al., 2018; Wisting et al., 2021; Yafei et al., 2023). For the main analysis, we included studies reporting the prevalence of eating disorder symptoms in population of interest and the outcome was defined as exceeding the cut-off score of each assessment tool in question. If the study was presenting more than one measure for screening disordered eating, we chose the measure that was the most common in our data of the meta-analysis. We excluded articles using an assessment tool so infrequent that it was present only once in the data, and if <90 % of the study population had insulin treatment (Supplemental Table S3). Before the main meta-analysis, we performed preliminary analyses. First, we detected one outlier, Alessi et al. (2020), and excluded it. Alessi et al. 2020 reported a very high prevalence of eating disorders (76 %) in a population consisting mainly of middle-aged males, and this combination evidently distinguished Alessi et al. 2020 from all other studies included. Second, we executed a meta-regression to reveal possible associations of age, female proportion, publication year, and sample size with the prevalence of eating disorder symptoms. We applied these thresholds in the main meta-analysis. Altogether, the main analysis consisted of three sub-group analyses to detect associations of the screening tool used, sex (≤58 vs. >58 % of females), and continent with the reported prevalence of eating disorder symptoms. An additional meta-analysis regarding the prevalence of insulin omission based on dichotomized information on the intentional insulin omission (no vs. yes) was performed including 13 studies. R 4.1.2 with the 'meta' package served as a statistical platform for the analyses (Balduzzi et al., 2019). To estimate heterogeneity in the meta-analysis, we computed I^2 and interpreted I^2 >75 % to indicate a high proportion of true heterogeneity (Higgins et al., 2003).

2.5. Quality assessment

Quality assessment was conducted by HL and PN using Joanna Briggs Institute Critical Appraisal Checklist for Studies Reporting Prevalence Data (Munn et al., 2015). Discrepancies were resolved by discussion. The checklist includes nine items with response options concerning sample frame, sampling technique, sample size, description of subjects and setting, coverage of the sample, valid methods of diabetes and disordered eating, statistical analysis, and response rate. Quality assessment scores from each study included in the main meta-analysis are presented in study characteristics table (Table 1). Quality assessment scores from all studies included in the systematic review are shown in the supplementary material (Supplemental Table S4). Studies receiving 7–9 points were considered high quality, 4–6 points medium quality, and 0–3 points low quality studies.

3. Results

3.1. Study identification

A flow chart presents description of the selection process according to the PRISMA statement (Fig. 1). Altogether 1910 studies were identified. After removing duplicates, a total of 1470 studies were screened based on titles and abstracts. Altogether 265 studies were included in the full-text assessment and from those, a total of 77 studies were selected in the systematic review and 45 studies in the main meta-analysis (Affenito et al., 1997; Albaladejo et al., 2023b; Apergi et al., 2020; Araia et al., 2017; Bächle et al., 2015; Bächle et al., 2016; Baechle et al., 2019; Barbanti et al., 2020; Bikri et al., 2021; Broadley et al., 2018; Cantwell & Steel, 1996; Colton et al., 2013; Doyle et al., 2017; Engström et al., 1999; Falcão et al., 2017; Friedman et al., 1998; Fritzen et al., 2021; Gagnon et al., 2017; Gorin et al., 2008; Grylli et al., 2010; Herpertz, Wagener, et al., 1998c; Johnson et al., 2014; Keane et al., 2018; Latzer et al., 2018; Lok et al., 2023; Luyckx et al., 2019; McClintock et al., 2022; Merwin et al., 2014; Nilsson et al., 2020; Nip et al., 2019; Philippi et al., 2013; Pinna et al., 2017; Pinna et al., 2022; Pollock-BarZiv & Davis, 2005; Quinn et al., 2016; Rancourt et al., 2019; Rodin et al., 1985; Ryan et al., 2008; Rydall et al., 1997; Stancin et al., 1989; Watt et al., 2022; Wisting et al., 2013; Wisting et al., 2018; Wisting et al., 2021; Yafei et al., 2023). The mean pairwise Cohen's Kappa was 0.81 in the full text screening phase.

3.2. Study characteristics

The main meta-analysis included 11,592 subjects and 2521 cases of disordered eating. The most frequently used screening tool, DEPS-R, was used in 20 studies. Other tools used in more than one study were EAT-26 and EAT-40 (Eating Attitudes Test), EDE-Q (Eating Disorder Examination Questionnaire), EDI (The Eating Disorder Inventory), EDE (semi-structured interview Eating Disorder Examination), SCOFF (questionnaire of the acronyms Sick, Control, One, Fat, Food), DSED (Diagnostic Survey for Eating Disorders), and QEWP (Questionnaire on Eating and Weight Patterns). In 35 studies, both males and females were included, but in 4 of these, information on the number of females meeting the inclusion criteria was missing. Additionally, 10 studies were conducted exclusively in females. Altogether 25 studies were conducted in Europe, 12 in North America, 2 in Asia, 2 in South America, 2 in Australia, 1 in Middle East and 1 in Africa. Table 1 describes the characteristics of the included studies in the main meta-analysis.

In the quality assessment of studies included in the main meta-analysis, 28 studies were classified as high quality, 17 studies as medium quality, and none as low quality.

3.3. Primary results

The overall prevalence of eating disorder symptoms was 24 % (random effects model, 95 % CI 0.21–0.28, I^2 92,7 %). The Egger's regression test indicated no asymmetry in the funnel plot ($t = 0.94$, df = 43, $p = .353$) that is typically applied to assess publication bias (Egger et al., 1997) (Supplemental Fig. 1). Disorder screening assessment tools used in the original studies included DEPS-R, EDI, EAT-26, EAT-40, SCOFF, EDE, EDE-Q, DSED, and QEWP. The type of the assessment tool associated statistically significantly with the prevalence rates ($\chi^2 = 85.83$, df = 8, $p < .0001$) (Fig. 2). DEPS-R was the most frequently used tool ($n = 20$). The pooled prevalence of eating disorder symptoms in studies using DEPS-R was 27 % (95 % CI 0.24–0.31, I^2 87%). The proportion of true heterogeneity was high (>75 %) both in the analysis of 45 studies and in the analysis of 20 DEPS-R studies. The proportion of true heterogeneity was 0 % in two studies using DSED tool and reporting the pooled prevalence of 31 % (95 % CI 0.24–0.39) and as well as in two studies using QEWP tool and reporting the pooled prevalence of 12 % (95 % CI 0.10–0.14).

3.4. Secondary results

The prevalence of eating disorder symptoms was statistically significantly higher ($\chi^2 = 16.13$, df = 2, $p = .0003$ for the comparison) in studies of which sample consisted of >58 % female participants (30 % in a random effects model, 95 % CI 0.26–0.34, I^2 81%) compared to studies with a lower female proportion (18 %, 95 % Cl 0.14–0.22, I^2 92%) with the prevalence ratio of 1.7 (Fig. 3, Supplemental Fig. 2). The proportion of true heterogeneity was high (>75 %) in both subgroups, female >58 % vs. ≤58 %. Four studies did not report the female proportion and in those, the pooled prevalence was 29 % (95 % CI 0.17–0.45, I^2 97%) i.e., in between that of studies with >58 % and ≤ 58 % female participants. Moreover, a continent was associated with the prevalence of eating disorder symptoms ($\chi^2 = 116.45$, df = 6, $p < .0001$ for the comparison) so that the pooled prevalence was highest in South America (46 %, 95 % CI 0.41–0.51, I^2 0%) and lowest in Asia (13 %, 95 % CI 0.10–0.17, I^2 0%) (Supplemental Fig. 3), but there was limited variation in country of study. Sample size ($\chi^2 = 3.16$, df = 1, $p = .076$), publication year ($\chi^2 = 1.95$, df = 1, $p = .163$), and age ($\chi^2 = 1.99$, df = 1, $p = .159$) revealed no

Table 1
Study characteristics.

Reference (country)	Diabetes type	*n* (n F)	Age (mean, SD)	Measure of EDS	Events	QA score
Affenito et al. 1997 (USA)	DM1	90 (90)	28.8	EDE BULIT-R	27	6
Albaladejo et al. 2023 (France)	DM1	198 (62)	51	SCOFF IO	43	7
Apergi 2020 (Greece)	DM1	100 (71)	35.9 (10.7)	DEPS-R EAT-26	40	6
Araia 2017 (Australia)	DM1	477 (296)	16 (2)	DEPS-R	181	7
Baechle et al. 2019 (Germany)	DM1	1318 (734)	17.8 (3.4)	SCOFF	142	9
Barbanti et al. 2020 (Italy)	DM2	887 (440)	67	EAT BTO	31	7
Bikri et al. 2021 (Marocco)	DM1	140 (75)	46.75 (8.92)	EAT-26	36	5
Broadley et al. 2018 (Australia)	DM1	74 (63)	28.5 (6.5)	EDE-Q DEPS-R	25	5
Bächle et al. 2015 (Germany)	DM1	211 (126)	19.4 (2.1)	SCOFF	46	5
Bähle et al. 2016 (Germany)	DM1	819 (404)	16.3 (2.3)	SCOFF	142	8
Cantwell et al. 1996 (UK)	DM1	48 (48)	24.4 (4.4)	EAT-40	30	6
Colton et al. 2013 (Canada)	DM1	98 (98)	16.5 (1.6)	cEDE	48	6
Doyle et al. 2017 (USA)	DM1	60 (27)	21.0 (2.5)	DEPS-R	14	7
Engström et al. 1999 (Sweden)	DM1	89 (89)	16.3 (1.4)	EDI	15	7
Falcao et al. 2017 (Portugal)	DM1	55 (37)	24.78 (4.18)	EDE-Q IO	16	6
Friedman et al. 1998 (France)	DM1	69 (35)	26.7 (8.2)	EAT BITE	3	8
Fritzen et al. 2021 (Brazil)	DM1	166 (89)	33	EAT-26	79	6
Gagnon et al. 2017 (Canada)	DM1DM2	140 (not reported)	DM1 34 (15.1), DM2 52 (12.6)	EDE-Q version 6	39	5
Gorin et al. 2008 (USA)	DM2	5145 total, 902 IDDM (2839)	- a	QEWP	107	7
Grylli et al. 2010 (Austria)	DM1	76 (76)	17.2 (2.1)	EDE 12	23	6
Herpertz et al. 1998 (Germany)	DM1 DM2	662 (DM1 340, DM2 322) (356)	DM1 = 36,3 (10.6), DM2 = 54.2 (8.1)	EDI BSQ FSE IO	18(EDI) 20 (IO)	9
Johnson et al. 2014 (UK)	DM1	96 (57)	18.1 (1.3)	DEPS-R	30	8
Keane et al. 2018 (Ireland)	DM1	49 (20)	21.4 (2.5)	EDE-Q version 6	7	6
Latzer et al. 2018 (Israel)	DM1	136 (77)	DM1 + CD 16.5 (3.7) DM1 16.7 (4.6)	EAT-26	18	6
Lok et al. 2023 (China)	DM1	228 (108)	38 (12.92)	DEPS-R	30	8
Luyckx et al. 2019 (Belgium)	DM1	300 (170)	20.8 (3.31)	DEPS-R	57	8
McClintock et al. 2022 (New Zealand)	DM1	200 (80)	19.3	DEPS-R	61	7
Merwin et al. 2014 (USA)	DM1	276 (189)	43.5 (13.71)	DEPS-R	60	9
Nilsson et al. 2020 (Denmark)	DM1	192 (91)	15.5 (3.4)	DEPS-R	21	7
Nip et al. 2019 (USA)	DM1 DM2	DM1 2156, DM2 149 (1174)	DM1 17.7 (4.3) DM2 21.8 (3.5)	DEPS-R	457	9
Philippi et al. 2013 (Brazil)	DM1	189 (141)	26.0 (9.8)	BITE EAT-26 BES IO	85	7
Pinna et al. 2017 (Italy)	DM1 DM2	211 (103)	- b	EDI-3 DEPS-R	46	8
Pinna et al. 2022 (Italy)	DM1	172 (86)	36.76 (9.87)	DEPS-R	33	7
Pollock-BarZiv et al. 2005 (Canada)	DM1	51 (51)	21.5	DSED EDI	14	5

(*continued on next page*)

Table 1 (*continued*)

Reference (country)	Diabetes type	*n* (n F)	Age (mean, SD)	Measure of EDS	Events	QA score
Quinn et al. 2016 (USA)	DM1	43 (23)	- c	DEPS-R	10	8
Rancourt et al. 2019 (USA)	DM1	511 (331)	young adults:21.20 (2.10), adults 30.51 (2.81)	DEPS-R	163	9
Rodin et al. 1985 (Canada)	DM1	46 (46)	17.2	EDI EAT-26	9	6
Ryan et al. 2008 (France)	DM1, DM2	94 (34)	- d	QEWP-R TFEQ	4	6
Rydall et al. 1997 (Canada)	DM1	91 (91)	19 (2)	DSED	30	8
Stancin et al. 1989 (USA)	DM1	59 (59)	21.5 (2.7)	EDI IO	21	7
Watt et al. 2022 (England, Australia)	DM1	199 (100)	32.1 (12.8)	DEPS-R	62	7
Wisting et al. 2013 (Norway)	DM1	770 (390)	14.6 (2.6)	DEPS-R EAT	50	7
Wisting et al. 2018 (Norway)	DM1	282 (170)	42.11 (15.19)	DEPS-R	57	8
Wisting et al. 2021 (Norway)	DM1	35 (35)	25.34 (3.71)	DEPS-R DRES	15	4
Yafei et al. 2023 (Saudi Arabia)	DM1	265 (163)	17.7 (3.5)	DEPS-R IO	72	9

Table of study characteristics of the studies in primary meta-analysis. Abbreviations: BAB-T = Assessment of Anorexia-Bulimia -Teenage version, BED = binge-eating disorder, BES = Binge Eating Scale, BITE = Bulimic Investigatory Test, BSQ = Body Shape Questionnaire, BTO = Bratman Test for orthorexia, BULIT-R = The Bulimia Test -Revised, CD = Celiac Disease, DM1 = type 1 Diabetes Mellitus, DM2 = type 2 Diabetes Mellitus, DEPS-R = Diabetes Eating Problem Survey, DRES = Dutch Restrained Eating Scale, DSED = Diagnostic Survey of Eating Survey, EAT(−26 and − 40) = Eating Attitudes Test, EDE = semi-structured interview Eating Disorder Examination, EDEQ = Eating Disorder Examination Questionnaire, EDI = The Eating Disorder Inventory, EDS = eating disorder symptoms, FSE = Food Service Establishment Compliance Questionnaire, F = female, IDDM = insulin dependent diabetes mellitus, IO = insulin omission, QA = quality assessment, QEWP = Questionnaire on Eating and Weight Patterns, SCOFF = questionnaire of the acronyms Sick, Control, One, Fat, Food, SD = standard deviation, TEFQ = Three Factor Eating Questionnaire, UK = United Kingdom. References are in the electronical supplemental material.
a Age was between 45 and 76 years, mean age was not determined.
b Median age was 38 years.
c Median age was 19 years.
d Age between 18 and 70 years.

significant associations with the prevalence in the meta-regression and thus were not analyzed in the final meta-analysis.

Based on the additional meta-analysis of 13 original studies (2210 subjects and 531 cases) the pooled prevalence of insulin omission was 21 % (random effects model, 95 % CI 0.13–0.33, $I^2 = 96$ %) (Supplemental Fig. 4). The proportion of true heterogeneity was high (>75 %). Characteristics of the studies included in the additional meta-analysis are reported in Supplemental Table S5.

4. Discussion

4.1. Main findings and comparison with previous studies

This systematic review and meta-analysis provided significant new information about the prevalence of eating disorder symptoms among patients with insulin-dependent diabetes. Although previous meta-analyses have been conducted on this topic, those have focused on adolescents only (Young et al., 2013b) or focused on clinical eating disorders, excluding subclinical eating disorder symptoms from the analysis (Mannucci et al., 2005b). The collected literature information here extends up until the beginning of August 2023, and therefore gathers an updated summary.

We identified 45 studies with 11,592 subjects and 2521 cases of eating disorder symptoms. Our main finding is that the overall pooled prevalence of eating disorder symptoms was 24 %, and even 21 % of adult patients are recognized to omit insulin. In children and adolescents, the prevalence of eating disorder symptoms has been previously examined (Young et al., 2013a), and it appears to be higher (40 %) than in adults. Our results contribute new knowledge regarding the prevalence of insulin omission among adults. The conclusion that 21 % of adults with insulin-dependent diabetes omit insulin is concerning, as earlier research has shown that insulin omission leads more often to complications like retinopathy and nephropathy than other weight control behaviors (Goebel-Fabbri et al., 2008b; Takii et al., 2008). However, recent studies suggest that for individuals who omit insulin, the desire to lose weight is more important than the risk of complications (Goddard & Oxlad, 2023). That might partially explain why health care professionals often feel ill-equipped to treat both comorbidities simultaneously (Macdonald et al., 2018). Our findings emphasize that in clinical practice, it should be acknowledged that nearly one-fourth of adult patients with insulin-dependent diabetes suffer from eating disorder symptoms.

In our meta-analysis, the prevalence of eating disorder symptoms was higher in females than in males, which is consistent with earlier studies (Young et al., 2013a). A possible hypothesis for this gender difference is that screening measures fail to notice the male gender-related symptoms of eating disorders, for example the expression of dissatisfaction with body image (Furnham et al., 2002). Still, when male-specific symptoms are acknowledged, females have a higher prevalence of eating disorders than males (Bratland-Sanda & Sundgot-Borgen, 2012). Additionally, our results indicate that the level of prevalence is significantly dependent on the type of screening tool used. The most frequently used tool was DEPS-R, used in 20 studies, with the pooled disorder prevalence 27 % i.e., slightly higher than in the entire dataset. Recent literature confirms that DEPS-R is the most used measure (Pursey et al., 2020), but future validation studies are needed to examine if DEPS-R is the most accurate screening method. Even though DEPS-R has high sensitivity to screen eating disorder symptoms, its specificity remains undecided (Ryman et al., 2019). The Italian version of DEPS-R had high validity also when compared with a clinical interview of eating disorder diagnoses according to DSM-IV or DSM-5 criteria, but this finding requires repetition in other language versions (Pinna et al.,

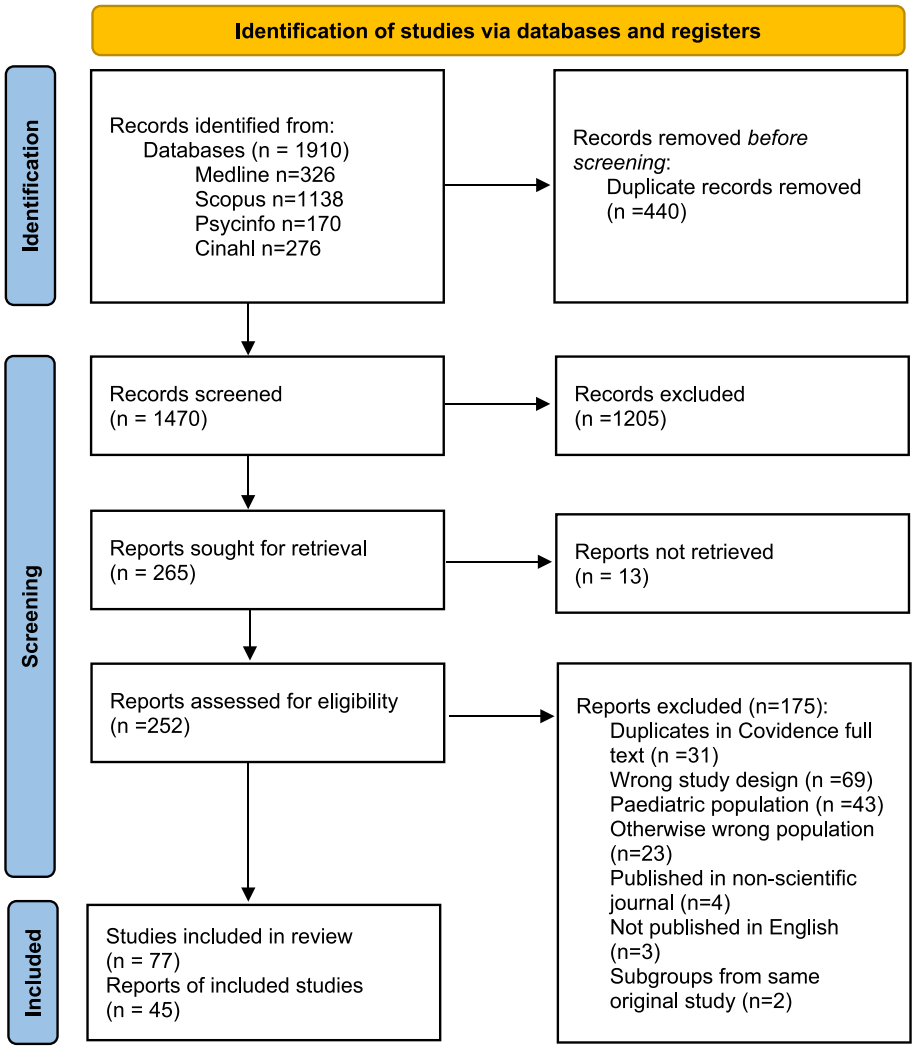

Fig. 1. PRISMA 2020 flow diagram.

2017). Hopefully, future research will compare DEPS-R with a diagnostic interview in different demographic settings to confirm the best screening measure for eating disorder symptoms in diabetes.

4.2. Limitations

The limitations of our study included the high proportion of true heterogeneity across the original studies and I^2 exceeded 75 % in each of them. However, this is common in meta-analyses of prevalence studies of mental disorders (Baxter et al., 2013; Ferrari et al., 2013). For example, the original studies had used different assessment tools for the screening of eating disorder symptoms and the type of the tool evidently associated with the level of prevalence. Consequently, it was challenging to try to draw a comprehensive and reliable conclusion regarding the overall pooled prevalence based on the entire dataset of 45 studies. In fact, the pooled prevalence based solely on 20 studies applying the most used assessment tool, DEPS-R, may be a more reliable estimate of the overall prevalence of eating disorder symptoms in adult patients with insulin-dependent diabetes. However, there are also two DEPS-R related limitations. First, even though DEPS-R is the most widely used screening tool, it has not been validated against a measure of disordered eating (Pursey et al., 2020). Secondly, our conclusions are based on assumption that DEPS-R scores above 20 indicate clinically significant eating disorder. This threshold of 20 was chosen based on previous literature where this cut-off score has been established to indicate the need for further clinical assessment of eating pathology (Young et al., 2013a). It is possible that some participants with DEPS-R scores above 20 may not actually have clinically significant eating disorder symptoms, which could partly explain why the prevalence was higher in DEPS-R studies compared to other measures. On the other hand, DEPS-R is the only measure evaluating eating disorder symptoms specific to diabetes (such as insulin restriction/omission), so it is also possible that its sensitivity is better compared to other measures in this population.

One limitation was that the publication year was used in the subgroup analyses in the meta-analysis instead of the year of the data collection. This choice was made simply because the latter was not reported in all studies. Thus, it is not possible to state based on this meta-analysis whether the prevalence of disordered eating has increased in 2020s or not. Also, analyzing the prevalence exclusively by sex was not possible in this meta-analysis because of a lack of reported results concerning prevalence rates separately by sex in many studies. The inclusion of a small group of patients with insulin treated type 2 diabetes needs also to be considered. The etiology and nature of eating disorders differ between type 1 and type 2 diabetes, even though those are partly overlapping (Gagnon et al., 2017). Although insulin treatment alone does not imply that eating disorders in individuals with diabetes are similar, we wanted to include all patients with potential insulin-dependent diabetes to comprehensively assess insulin restriction/omission as one specific eating disorder symptom. Similar search terms of insulin-dependent diabetes have also been used in previous high-quality

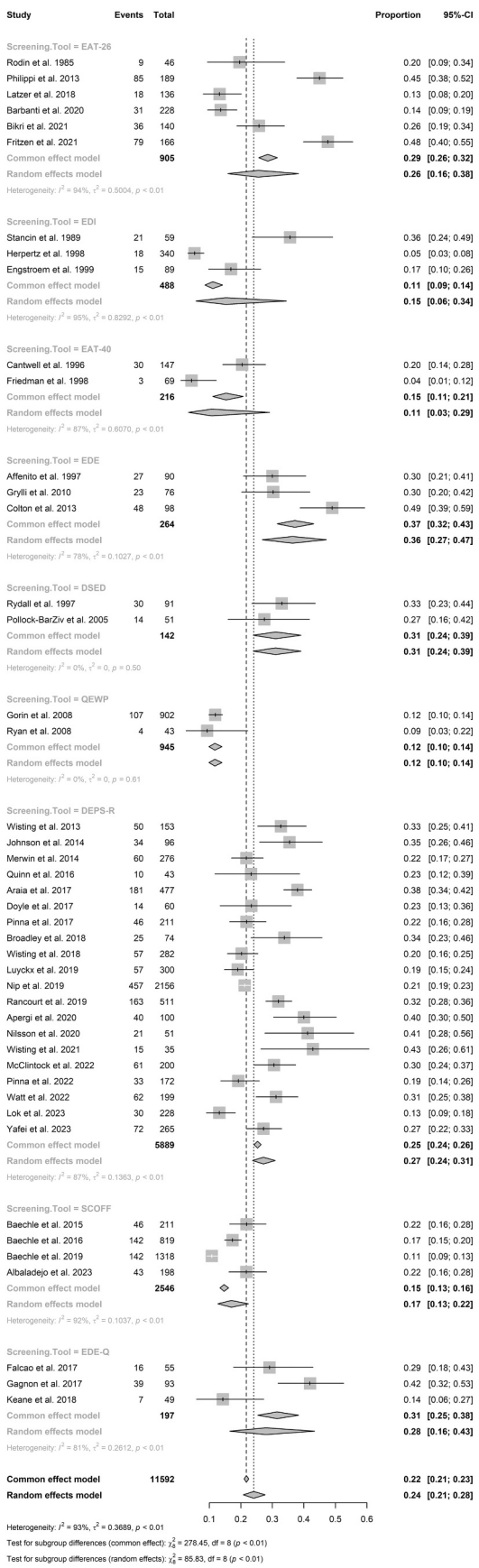

Fig. 2. Forest plot of studies by screening assessment tool.

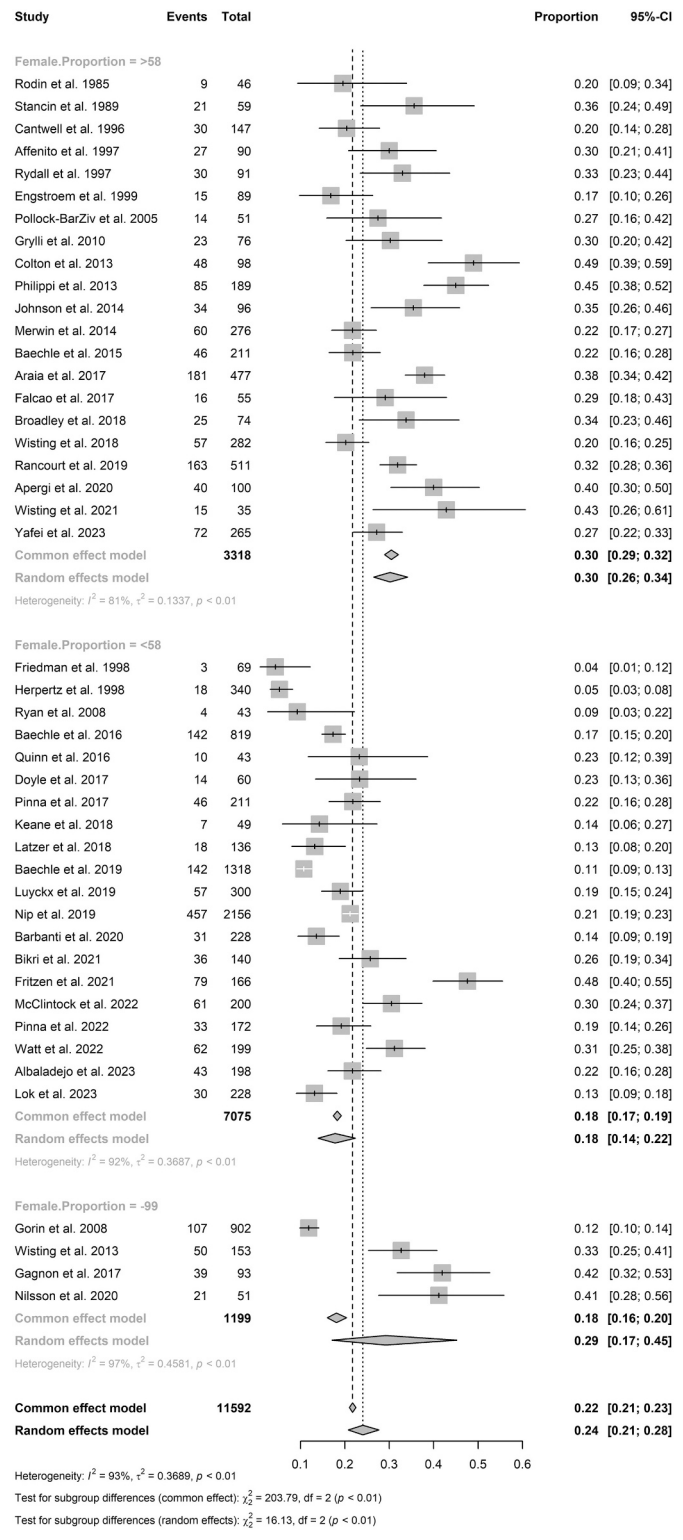

Fig. 3. Forest plot of studies by female proportion (<58 %, >58 %, unknown).

systematic reviews (De Paoli & Rogers, 2018).

4.3. Implications

The future aim should be to identify patients with eating disorder symptoms by systematic screening, since concurrent eating disorder and type 1 diabetes increase the risk of diabetic complications, admission rates to hospital and even the risk of death when compared with patients

with type 1 diabetes but without an eating disorder (Gibbings et al., 2021; Keane et al., 2018; Scheuing et al., 2014). In addition to diabetes related complications, a recent study showed that eating disorder behavior in patients with type 1 diabetes was also associated with depression and distorted body image (Salah et al., 2022). Unfortunately, disordered eating behavior has tendency to persist even when there is improvement in body image (Troncone et al., 2018). When disordered eating symptoms are recognized by the health care professionals, they can provide special psychiatric and nutritional care for the patients suffering from those symptoms. However, health care professionals often fail to sympathize psychosocial effects and emotional issues related to insulin-dependent diabetes (Balfe et al., 2013) and thus more research and consciousness about eating disorder symptoms with diabetes is needed. Early recognition and appropriate treatment of disordered eating behavior, as well as other mental-physical multimorbidities of diabetes, reduces morbidity and mortality of patients and is cost-effective (Banstola et al., 2023; Gibbings et al., 2021).

5. Conclusions

This meta-analysis validates earlier findings from individual studies, indicating that insulin omission and other eating disorder symptoms are prevalent not only among children and adolescents with insulin-dependent diabetes but also among adults. Our present finding is that in this geographically wide-ranging meta-analysis DEPS-R is the most used screening tool and it appears to be associated with the higher level of prevalence of eating disorder symptoms.

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Credit authorship contribution statement

Pia E. Niemelä: Writing – original draft, Visualization. **Hanna A. Leppänen:** Writing – original draft, Formal analysis. **Ari Voutilainen:** Writing – original draft, Methodology, Formal analysis, Data curation. **Essi M. Möykkynen:** Visualization. **Kirsi A. Virtanen:** Writing – review & editing, Supervision, Conceptualization. **Anu A. Ruusunen:** Writing – review & editing, Supervision, Conceptualization. **Reeta M. Rintamäki:** Writing – review & editing, Supervision, Conceptualization.

Declaration of competing interest

Regarding authors PN, HL, AV, EM, AR, KV and RR, no potential conflicts of interest relevant to this article were reported.

Data availability

The data, code and other materials that support the findings of this review study are available in the electronical supplemental material. Additional data, if needed, are available from the corresponding author, Hanna Leppänen, upon reasonable request.

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Appendix A. Supplementary data

Supplementary data to this article can be found online at https://doi.org/10.1016/j.eatbeh.2024.101863.

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