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Journal of Psychiatric Research 175 (2024) 393–404

Contents lists available at ScienceDirect

Journal of Psychiatric Research

journal homepage: www.elsevier.com/locate/jpsychires

Dietary intake of adults with eating disorders: A systematic review and meta-analysis

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ARTICLE INFO

Keywords:
Macronutrients
Micronutrients
Energy intake
Anorexia nervosa
Bulimia nervosa
Binge-eating disorder

ABSTRACT

Studies have confirmed the link between altered dietary intake and eating disorders (EDs), although no systematic assessment of this research exists. Rigorous synthesis of dietary intake in anorexia nervosa (AN), bulimia nervosa (BN), binge-eating disorder (BED), and similar EDs is needed to explore similarities and differences. In accordance with the Preferred Reporting Items for Systematic Reviews and Meta-Analyses statement, we conducted a systematic review and quantitative synthesis of studies of dietary intake. Searches of three electronic databases resulted in thirty-nine included studies. Meta-analyses of subsets of these studies were undertaken to summarise macronutrient intake across AN, BN, and BED. Study quality was assessed using the American Academy of Nutrition and Dietetics Quality Criteria Checklist, with ratings either Positive (k = 27) or Neutral (k = 12). Adults with AN had low energy intake and those with BED reported elevated macronutrient intake. Individuals with BN reported wide variation in energy intake, including some of the highest estimates. Individuals with AN were likely to under-consume key micronutrients, with sodium potentially over-consumed in BN and BED. Vitamin D was under-consumed across all disorders. This meta-analysis highlights important diagnostic differences and synthesises dietary intake in EDs, with particular relevance to risk assessment and treatment.

1. Introduction

Eating disorders (EDs) are mental illnesses associated with a range of adverse psychological and physical complications. Adequate nutrition is crucial in supporting basic biological needs (Reiter and Graves, 2010) and disturbed eating patterns represent both predisposing and maintenance factors in EDs. For example, evidence suggests that individuals with anorexia nervosa (AN) have a low total energy intake compared to those without AN (Schebendach et al., 2019), whereas those with binge-eating disorder (BED) have a high total energy intake (Raymond et al., 2007); both patterns can result in negative health outcomes. Irregular dietary patterns are a key component of ED assessment (National Institute for Health and Care Excellence [NICE], 2017) and are targeted across evidence-based treatments for EDs (e.g., Fairburn, 2008; Lock and Le Grange, 2013).

Intake of protein, carbohydrates, and fats (collectively referred to as macronutrients) provides energy and is essential for sustaining life (Venn, 2020). Individuals with AN frequently avoid consuming energy-dense foods, particularly fats (Schebendach et al., 2019), in contrast to those with BED or bulimia nervosa (BN) who typically consume an excess of carbohydrates and fats (Segura-García et al., 2014). Similarly, inadequate intake of micronutrients – a term covering essential vitamins and trace minerals – can also negatively affect health (Black, 2003), and is often variable in EDs (Setnick, 2010).

Whilst evidence regarding the role of restricted dietary intake in the development of EDs is mixed (Stewart et al., 2022), it is likely that dietary intake interacts with ED symptoms to influence both physiological and cognitive processes (e.g., Datta et al., 2021) and detail about dietary intake can be used to inform diagnostic criteria. For instance, DSM-5 (American Psychiatric Association [APA], 2013) refers to an "altered consumption" of food intake (p. 329) and there is evidence of diagnostic differences in food choice (e.g., Eichin et al., 2023) and eating patterns under controlled conditions (e.g., see Mourilhe et al., 2021).

Understanding the dietary intake of those with EDs can enhance early intervention, prevent the development of more severe illness, and improve chances of recovery (Treasure et al., 2015). In addition to clarifying differences between diagnoses, providing data on dietary intake can inform pathology findings, given that the varying dietary practices seen across EDs may not correspond to nutrient levels seen in blood samples (Setnick, 2010).

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https://doi.org/10.1016/j.jpsychires.2024.05.038
Received 8 November 2023; Received in revised form 9 April 2024; Accepted 15 May 2024
Available online 16 May 2024

The aim of this systematic review and meta-analysis is to synthesise and report the dietary intake of adults with EDs, with reference to specific numerical values. Doing so will pull together findings from diverse samples and afford a more complete description of dietary intake, including investigation of diagnostic differences. The findings will be of use to clinicians and researchers assessing dietary intake in EDs, and can assist efforts at early detection, prevention, and treatment of EDs, as well as informing risk management.

2. Material and methods

The current review followed and is reported in line with the guidelines of Preferred Reporting Items for Systematic Reviews and Meta-Analyses (PRISMA; Page et al., 2021) (Supplementary Table 1).

2.1. Search strategy

An online search was conducted using three electronic databases (Scopus, Medline, Web of Science) to identify relevant papers published to December 6, 2022 (with no date restriction for inception). The search terms selected were: ("dietary intake" OR nutrition* OR "nutritional content" OR "food intake" OR "energy intake") AND ("eating disorder*" OR "anorexia nervosa" OR "bulimia nervosa" OR bulimi* OR "binge eating disorder" OR BED OR OSFED OR "other specified feeding or eating disorder" OR EDNOS OR "eating disorder not otherwise specified") AND adult. Reference lists of relevant publications were also searched to identify studies not picked up by the electronic search. Upon completion of the initial search, records from different databases were merged, duplicates removed, and Titles and Abstracts of selected studies were reviewed independently by two authors (PEJ, KP). Selected full-texts were then reviewed by two authors using criteria agreed *a priori* to establish whether studies were eligible for inclusion (see below); any disagreements were resolved through discussion. The eligibility criteria were piloted on a sample of six studies, after which minor changes were made to the criteria (e.g., clarification on age cutoff).

2.2. Inclusion and exclusion criteria

Studies were eligible for inclusion if they met the following criteria: (1) participants had a current, clinically verified, diagnosis of AN, BN, BED, eating disorder not otherwise specified (EDNOS), or other specified feeding or eating disorder (OSFED) according to ICD or DSM criteria; (2) empirical studies published in peer-reviewed academic journals; (3) dietary intake was referenced with a specific numerical value; (4) the dietary recall period was no more than one month; (5) participants were 18 years of age or over (given different nutritional needs in children; Wiklund et al., 2022); (6) texts in the English language. As the change from DSM-IV (APA, 1994) to DSM-5 (APA, 2013) involved the inclusion of OSFED and the removal of EDNOS, both terms were used in this review. Case studies of individuals were excluded. Individuals with a sole diagnosis of specific disorders under the 'other specified' categories (i.e., purging disorder, night eating syndrome) or other feeding and eating disorders (i.e., pica, rumination disorder, avoidant/restrictive food intake disorder) were excluded. This was done to retain a focus on disorders resembling AN, BN, and BED and due to unclear causes and inconsistent definitions around some of these syndromes (e.g., Beauchamp et al., 2021; Vander Wal, 2012). Studies where participants were in an active treatment which would likely have affected reported intake, reported factors which might have affected interpretation of the findings (e.g., pregnancy), or where data collection took place outside the natural environment (e.g., in a laboratory or whilst being treated in hospital) were excluded. Participants who were starting treatment, including as inpatients, and recalled their intake prior to treatment were not excluded.

2.3. Data extraction

A data extraction table was developed, and two reviewers (PEJ, SS) independently extracted the data from the final sample based on: author, year of publication, country, design, sample size, ED diagnosis, sample characteristics (gender, age, race, ethnicity, socioeconomic status, body mass index [BMI], setting), nutritional assessment method, and dietary information reported (calories, macronutrients, micronutrients). In instances where energy intake was reported as joules this was converted into kilocalories (239 kilocalories = 1 MJ). Nutritional data are summarised as mean (SD).

2.4. Quality assessment

The quality of each full-text was assessed using the American Academy of Nutrition and Dietetics Quality Criteria Checklist for primary research (QCC; Academy of Nutrition and Dietetics, 2012; see Supplementary Table 2), which has been used in similar reviews (e.g., Lai et al., 2014; Teasdale et al., 2019) and is "based on the quality constructs and domains identified in the Agency for Healthcare Research and Quality report on Systems to Rate the Strength of Scientific Evidence" (Handu et al., 2016, p. 317). Papers were rated based on four relevance questions and ten validity questions. Each question was assigned "yes" if the criterion was met, "no" if the criterion was not met, "unclear" if it was not made clear, or "Not Applicable" if it did not apply. An overall quality score is generated as follows: (a) negative (six or more answers are marked "no"); (b) neutral (questions 2, 3, 6, 7 marked as "no"); (c) positive (most of the answered marked as "yes" including 2, 3, 6, 7). All studies were included in the review, as the sample was expected to be heterogenous (with several small studies) and this was a descriptive study of dietary intake. To detect publication bias, we looked at funnel plots and applied Egger's regression test to quantify the risk of publication bias influencing findings for key outcomes.

2.5. Statistical analysis

Meta-analysis of means was undertaken using the *metamean* function in R version 4.1.2 (package *meta* version 6.5-0; Schwarzer, 2007) and combined using a random-effects model to produce pooled estimates and 95% confidence intervals; Egger's test was also conducted using this function. Heterogeneity was assessed using the Cochran's Q and I^2 statistics. For studies that did not report SDs alongside means, values were imputed where possible using the 'modified range' method (Walter and Yao, 2007). In light of expected heterogeneity by diagnosis, meta-analysis for subgroups was not considered if samples were small (i.e., $k < 10$ studies; Schwarzer et al., 2015) or where diagnostic groups were mixed.

3. Results

The systematic review identified 10990 eligible studies. After removing duplicates, 10519 unique titles were identified. Review of Titles and Abstracts resulted in the exclusion of 10400 articles, leaving 119 full texts for review. Two further articles were found through hand-searching (Cheng et al., 2020; Rossiter et al., 1992). We were unable to access the full text for eight articles. Upon screening full-texts, 39 articles were included in the systematic review (Fig. 1). Where possible, dietary intake data from sub-samples (e.g., different ED diagnoses) were extracted for inclusion in meta-analyses.

3.1. Study characteristics

Study characteristics are presented in Table 1. Fifteen studies were conducted in the USA (N = 511), five studies in Germany (N = 161), four studies in the UK (N = 126), three in Italy (N = 186), two studies each in Sweden (N = 523), Brazil (N = 84), Canada (N = 23), and the

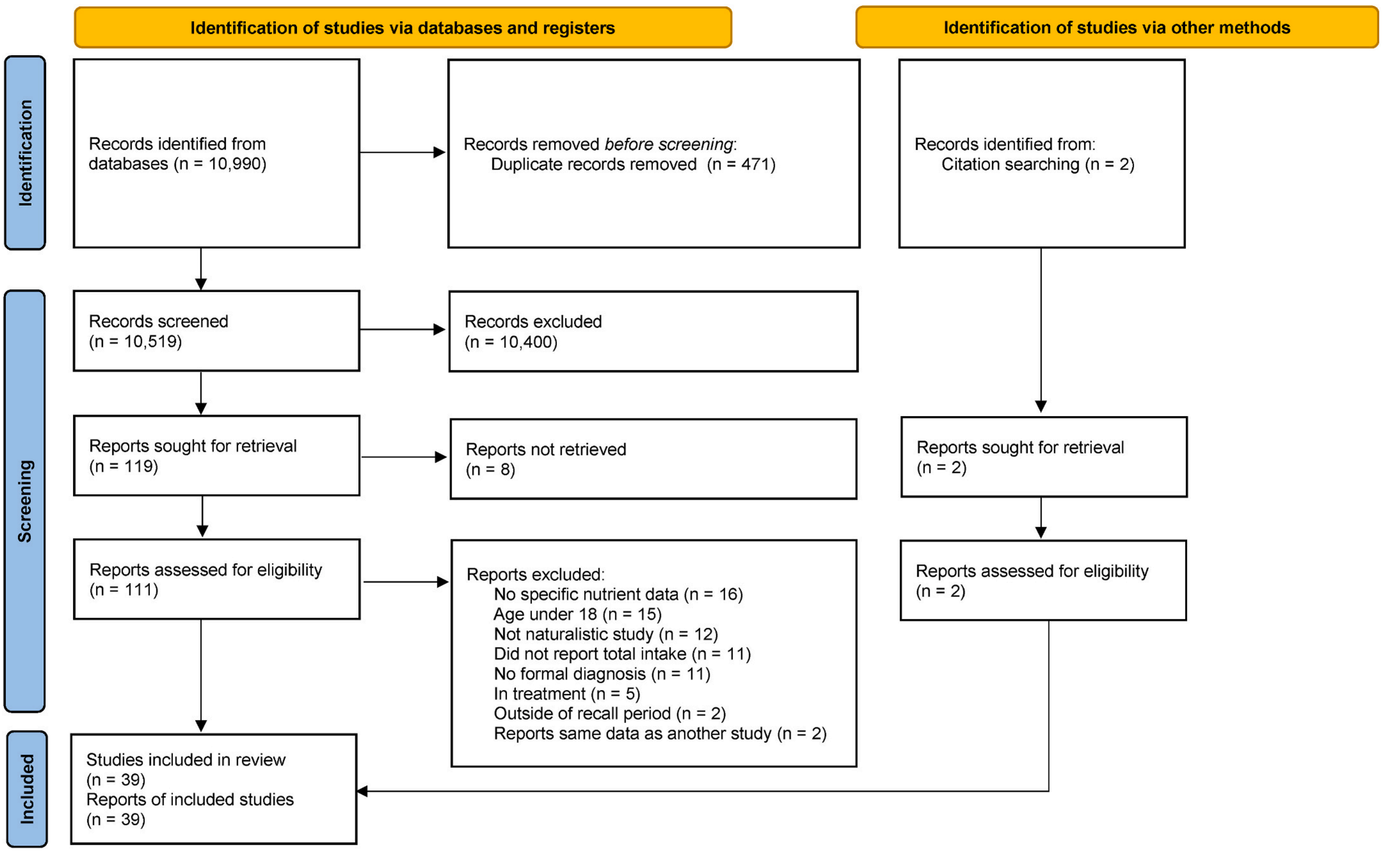

Fig. 1. PRISMA flow diagram of study search and selection.

Netherlands (N = 32), and one each in Belgium (N = 42), China (N = 84), France (N = 120), and Israel (n = 59). The earliest included study was published in 1985.

In total, 1941 participants were included in the review, 621 of whom were diagnosed with AN, 484 BED, 366 BN, and 470 in mixed diagnostic groups. There were no studies of those receiving a formal diagnosis of OSFED related to AN, BN, or BED, although one study (Burd et al., 2009) included some individuals with "subsyndromal AN" according to DSM-IV criteria (p. 372); many of these individuals would likely meet criteria for AN in DSM-5 (given the broader diagnostic criteria; Hoek, 2014) and were therefore included. DSM-IV (APA, 1994) was most commonly used in the included studies (k = 24), with all DSM manuals since DSM-III (APA, 1980) used. Sample sizes ranged from 8 to 430 (median = 28.5), with an age range of 18–65 years. The sample consisted of predominantly female participants (n = 1738; male n = 131; not reported/Other n = 72). Mean BMI was reported in 31 studies, ranging from 13.5 to 49.8 kg/m^2. Nine studies reported race or ethnicity, and six reported socioeconomic status (see Table 1).

A range of different nutritional assessment methods was used to obtain information on dietary intake, principally using self-report. The most commonly used was a 24-h dietary recall (in 12 studies), and a 7-day food diary was used in eight studies. Other methodologies included different timeframes and one study used ecological momentary assessment over the course of one week. Of the 39 studies, quality ratings were all Neutral (k = 12) or Positive (k = 27). Quality criteria less frequently addressed (or unclear) included: handling of study dropouts and missing data; incorporation of blinding; and declaration of funding.

Egger's test suggested no evidence of publication bias for studies of energy intake (p = 0.43), carbohydrate intake (p = 0.54), or protein intake (p = 0.85). The result for fat intake, however, was suggestive of publication bias ($t = 2.35$, $df = 15$, $p = 0.033$; see Supplementary Fig. 1).

3.2. Data synthesis

Fig. 2 provides a summary of the energy intake of the 47 diagnostic sub-samples included in the systematic review. Meta-analysis was conducted on studies of different diagnostic groups including macronutrients (overall energy intake, protein, carbohydrate, fat). Micronutrients were reported in a small number of studies and meta-analysis was not deemed appropriate.

3.3. Macronutrients

Table 2 provides a summary of the energy intake and macronutrients consumed by adults with EDs with recommended dietary intake (RDI) included for comparison (taken from Public Health England [PHE], 2016). Meta-analysis suggested a mean energy intake of 2102 kcal/day across all EDs (95% CIs = 1842–2364 kcal); there were insufficient data from five studies to include in the meta-analysis. Dietary intake differed across disorders, which may explain the substantial heterogeneity detected ($I^2 = 98.4\%$, $Q = 2459.2$, df = 40, $p < 0.0001$). Average protein intake across all samples (k = 16) was 69.3 g/day (95% CIs: 55.1–86.6g/day), slightly above the RDI, average carbohydrate intake was 229.0g/day (k = 16, CIs: 192.9–265.0g/day), and average fat intake was 62.0g/day (k = 17, CIs: 44.7–79.3g/day).

Looking at samples by diagnosis, subgroup analyses of energy intake indicated a significant effect of diagnosis ($p < 0.001$). Specifically, those with AN (k = 15) reported a mean energy intake of 1311 kcal (95% CIs: 1114–1509 kcal), significantly lower than those with BED 2429 kcal (k = 12, CIs: 2275–2583 kcal) and those with BN 2696 kcal (k = 10, CIs: 2008–3383 kcal); see also Supplementary Table 3. Subgroup analyses were not conducted for other nutrients due to small sample sizes, particularly in the BN group (e.g., see Cuijpers et al., 2021; Schwarzer et al., 2015).

Table 1
Characteristics of studies included in the systematic review.

First Author, year	Country	Sample	Setting	Gender	Mean age, years (range)	Race/Ethnicity	Socioeconomic status	Mean BMI (kg/m^2)	Nutritional assessment method
Alpers and Tuschen-Caffier 2004	Germany	BN (N = 39)	Outpatient/ treatment-seeking	Female	24.8 (NR)	NR	NR	20.4	2-day dietary diary
Alvarenga et al., 2003	Brazil	BN (N = 30)	Outpatient	Female	27.2 (NR)	Majority White	Majority had University degree	25.5	14-day dietary diary
Burd et al., 2009	USA	AN/“subsyndromal”[a] AN (N = 84)	Community	Female	24.4 (18–51)	96.4% Caucasian, Other NR	NR	17.2	24-h dietary recall
Cheng et al., 2020	China	BED (N = 84)	Outpatient	Female (*n* = 43) Male (*n* = 41)	32.8[a] (18–40)	NR	NR	28.38[b]	24-h dietary survey
Chiurazzi et al., 2017	Italy	AN-R (N = 13)	Outpatient	Female	21.8 (18–29)	NR	NR	14.7	7-day food diary
Crisp (2006)	UK	AN-R (*n* = 19), AN-BP (*n* = 11)	Treatment-seeking	Female	AN-R: 20.7 (NR), AN-BP: 21.3 (NR)	NR	NR	AN-R: 14.6, AN-BP: 16.2	24-h dietary recall
Elmore and de Castro 1991	USA	BN (N = 19)	Community	Female	22 (18–35)	NR	NR	NR	7-day food diary
Engel et al., 2009	USA	BED (N = 9)	Community	NR	37.3 (NR)	100% Caucasian	NR	42.3	7-day Ecological Momentary Assessment
Fichter et al., 1990	Germany	BN (N = 24)	Community or Outpatients	Female	26.7 (NR)	NR	NR	NR	21-day diary
Fitzgibbon and Blackman 1999	USA	BED (*n* = 35), BN (*n* = 42)	Treatment-seeking	Female (*n* = 70) Male (*n* = 7)	BN: 28.0 (NR), BED: 40.3 (NR)	White (87%), Other NR	Over 75% had some University education	BED: 41.1, BN: 23.5	Self-report (not specified)
Goodman et al., 2018	USA	BED (N = 26)	Community	Female (*n* = 22) Male (*n* = 4)	38.04 (18–57)	White (88%) African American (8%) Other (4%)	NR	34.49	24-h dietary recall x 3
Greeno and Wing 1996	USA	BED (N = 38)	Community	Female	39.07 (18–55)	NR	NR	37.41	6-day food diary
Hadigan et al., 2000	USA	AN (N = 30)	Research facility	Female	23.8 (18–35)	NR	NR	NR	One-month diet history
Hilbert and Tuschen-Caffier 2007	Germany	BED (*n* = 20), BN (*n* = 20)	Community	Female	BED = 36.65 (NR), BN = 24.47 (NR)	NR	BED = 70% ‘Low’, 30% ‘High’, BN = 45% ‘Low’, 55% ‘High’	BED: 32.99, BN: 23.13,	Food diary
Horvath et al., 2015	Brazil	BED (N = 54)	Outpatient	Female (*n* = 26), Male (*n* = 22), Other (*n* = 6)	42.32 (NR)	NR	NR	49.8	24-h dietary records x 3 (food weighed)
Jacoangeli et al., 2002	Italy	AN (N = 49)	Outpatient	Female	23.17 (NR)	NR	NR	16.7	NR
Kirkley et al., 1985	USA	BN (N = 22)	Outpatient	Female	NR (18–46)	NR	NR	NR	7-day food diary
Lacey and Gibson 1985	UK	BN (N = 30)	Outpatient	Female	NR (18+)	NR	NR	NR	14-day dietary diary (only “middle 5 days” analysed)
Latzer et al., 2020	Israel	BN (*n* = 12), BED (*n* = 22), BN/BED + NES (*n* = 25)	Outpatient	Female	27.5 (18–60)	Israeli (84.5%) Other (15.5%)	Working (93.8%), Not working (6.2%); Education (12.7 years)	25.3	7-day food diary
Lear et al., 1997	Canada	AN (N = 15)	Outpatient	Female	28 (19–49)	NR	NR	16.8	3-day food diary
Leyrolle et al., 2021	Belgium	BED (N = 42)	Outpatient	Male and female (*ns* NR)	NR	NR	NR	35.3	24-h dietary recall
Masheb et al., 2016	USA	BED (N = 50)	Treatment-seeking	Female (*n* = 38) Male (*n* = 12)	45.83 (29–60)	Caucasian (*n* = 40), African American (*n* = 9), Hispanic American (*n* = 1)	42 (84%) attended or finished University	39.2	24-h dietary recall x 2

(*continued on next page*)

Table 1 (*continued*)

First Author, year	Country	Sample	Setting	Gender	Mean age, years (range)	Race/Ethnicity	Socioeconomic status	Mean BMI (kg/m^2)	Nutritional assessment method
Milosevic et al., 1997	UK	AN + BN (N = 15)	Outpatient	NR	25.7 (18–43)	NR	NR	21.3	1-week food record
Onur et al., 2005	Germany	AN (N = 28)	Pre-admission	Female	25 (NR)	NR	NR	15.1	3-day food record
Patsalos et al., 2021	UK	AN (N = 51)	NR	Female	24 (NR)	Caucasian (88.2%), Black/Asian/Minority Ethnic group (11.8%)	NR	16.1	Food Frequency Questionnaire
Raatz et al., 2015	USA	AN-R (*n* = 46), AN-BP (*n* = 29)	Community	Female	22.5 (19–30)	NR	NR	17.2	24-h dietary recall x 3
Raymond et al., 2003	USA	BED (N = 12)	Community	Female	37.9 (18–55)	NR	NR	39.6	24-h recall x 6
Raymond et al., 2012	USA	BED (N = 17)	Community	Female	30.8 (18–45)	NR	NR	34.8	24-h recall x 6
Rigaud et al., 2009	France	AN-R (*n* = 83); AN-BP (*n* = 37)	Inpatient (prior to refeeding)	96% female	26.0 (NR)	NR	NR	13.5	Dietary recall x 3
Rossiter et al., 1988a	USA	BN (N = 20)	Outpatient and Community	Female	30.9 (21–48)	NR	NR	NR	1-week food diary
Rossiter et al., 1988b	USA	BN (N = 10)	Outpatient and Community	Female	30.4 (18–65)	NR	NR	NR	1-week food diary
Rossiter et al., 1992	USA	BED (N = 22)	Outpatient	Female	44.4 (NR)	NR	NR	33.0	7-day food diary
Segura-García et al., 2014	Italy	AN-R (*n* = 37), AN-BP (*n* = 18), BN (*n* = 40), BED (*n* = 29)	Outpatient	Female	AN-R: 21.1 (NR), AN-BP: 25.3 (NR), BN-P: 24.0 (NR), BED: 33.5 (NR)	100% Caucasian	"Low-middle socioeconomic class, with secondary or higher education level"	AN-R: 16.2, AN-BP: 16.6, BN: 22.1, BED: 35.7	7-day food diary
van Binsbergen et al., 1988	Netherlands	AN (N = 20)	Outpatient	Female	24.7 (18–35)	NR	NR	14.4	Dietary history
van der Ster Wallin et al., 1995	Sweden	AN-R (*n* = 31)	Inpatient (pre-admission)	Female	27.0 (7.1)	NR	NR	NR	24-h dietary recall
van Marken Lichtenbelt et al., 1997	Netherlands	AN (N = 12)	Community	Female	34.3 (21–46)	NR	NR	16.5	7-day food diary
Waisberg and Woods 2002	Canada	AN (N = 8)	Outpatient clinic	Female (*n* = 7), Male (*n* = 1)	27.2 (20–38)	NR	NR	18.3	Food records (duration unspecified)
Wiklund et al., 2022	Sweden	BN & BED (N = 430)	Community	Female (*n* = 391) Male (*n* = 39)	Female: 28.2, Male: 28.9 (Range = 18–51)	NR	NR	Female: 26.0, male: 26.1	Food frequency questionnaire
Woell et al., 1989	Germany	BN (N = 30)	NR	Female	27.0 (20–41)	NR	NR	20.54[b]	24-h dietary recall for 3 weeks

Note. AN, anorexia nervosa; AN-BP, anorexia nervosa–binge-purge subtype; AN-R, anorexia nervosa–restrictive subtype; BN, bulimia nervosa; BED, binge-eating disorder; ED, eating disorder; NES, night eating syndrome; NR, not reported.

[a] The authors use this term to refer to those meeting DSM-IV-TR criteria for AN, except for one symptom.

[b] Calculated by authors, [c]Calorie intake for a group of 10 women treated with imipramine are reported in both source papers, so this was only accounted for once (Rossiter et al., 1988a).

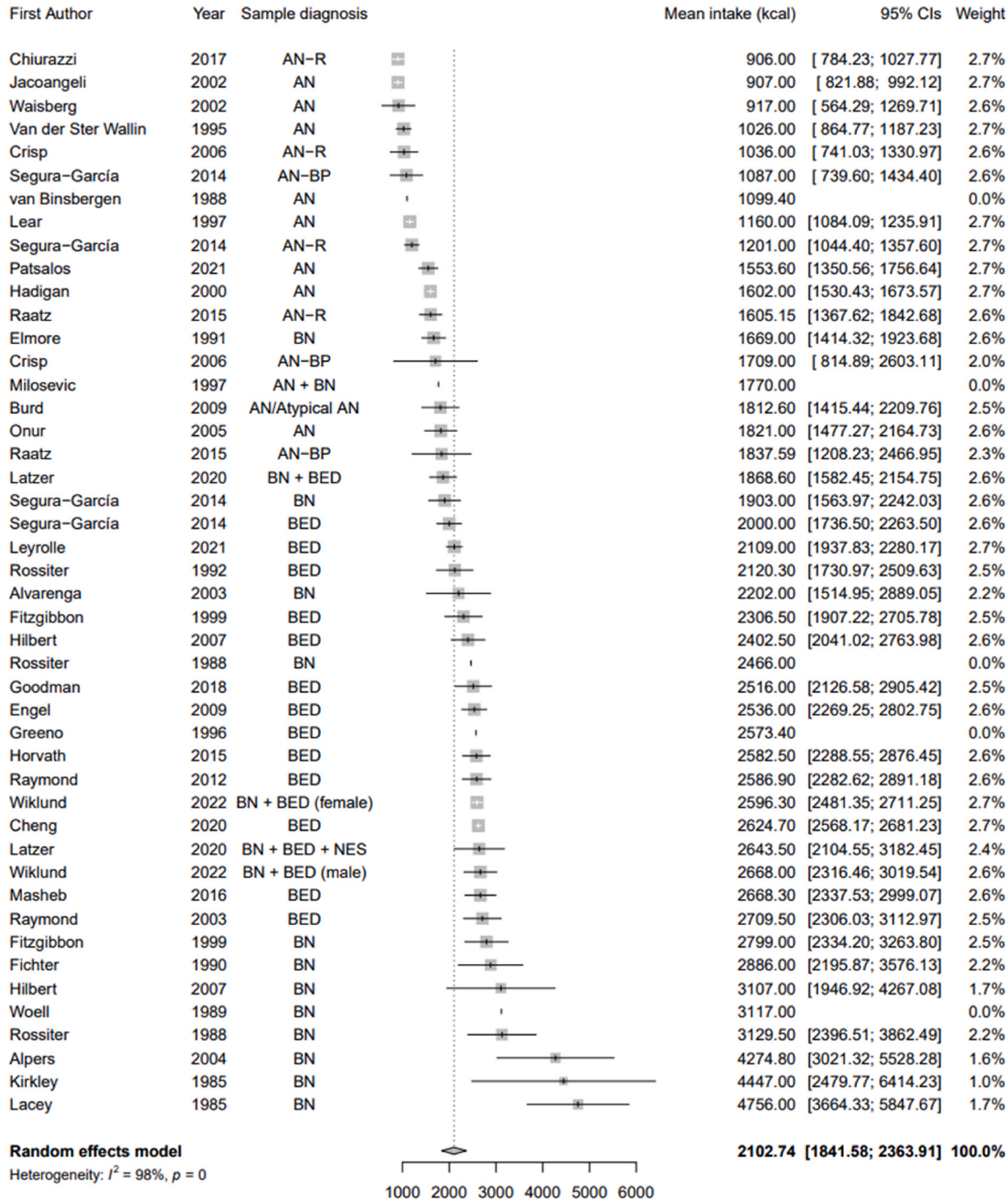

Fig. 2. Forest plot of mean energy intake (kcal) for studies included in meta-analysis. *Note.* AN, anorexia nervosa; AN-BP, anorexia nervosa–binge-purge subtype; AN-R, anorexia nervosa–restrictive subtype; BN, bulimia nervosa; BED, binge-eating disorder; NES, night eating syndrome.

Participants with AN consumed the lowest energy intake (range: 906–1838 kcal/day), with the mean of every sample falling below the minimum recommendation of 2000 kilocalories per day (PHE, 2016). Protein intake ($k = 9$, mean = 53.7g/day, range: 38.7–77.0g/day) was similar to the RDI, and both carbohydrate ($k = 8$, mean = 193.2g/day, range: 128.0–265.5g/day) and fat ($k = 10$, mean = 37.5g/day, range: 23.6–64.8g/day) intakes were lower than recommendations (PHE, 2016).

The mean energy intake of individuals with BED ranged between 2000 and 2710 kcal/day, generally exceeding the RDI for women. Protein intake ($k = 5$, mean = 97.6g/day, range: 71.6–142.2g/day) was around double the RDI, carbohydrate intake was similar to the RDI ($k = 5$, mean = 256.4g/day, range: 216.0–325.7g/day), and fat intake ($k = 5$, mean = 98.3g/day, range: 79.0–127.8g/day) was also higher.

Energy intake of those with BN ranged between 1669 and 4756 kcal/day. Protein ($k = 2$, mean = 68.9g/day, range: 68.6–69.2g/day), carbohydrate ($k = 2$, mean = 301.8g/day, range: 241.2–369.6g/day), and fat ($k = 2$, mean = 91.2g/day, range: 73.1–115.0g/day) intakes all exceeded the RDI, using data from two studies.

Table 2
Energy and macronutrient intake of adults with an ED expressed as mean and standard deviation (SD).

First author, year	Sample	Energy (kcal/day)	Protein (g/day)	Carbohydrate (g/day)	Fat (g/day)
Recommended daily intake		W: 2000 M: 2500	W: 45 M: 55.5	W: ≥267 M: ≥333	W: <78 M: <97
Alpers, 2004	BN (N = 38)	4274.8 (3942.4)	NR	NR	NR
Alvarenga et al., 2003	BN (N = 30)	2202.0 (1920.0)	NR	NR	NR
Burd et al., 2009	AN/“subsyndromal”[b] AN (N = 84)	1812.6 (1857.2)	NR	NR	NR
Cheng et al., 2020	BED (N = 84)	2624.7 (264.35)[a]	142.20 (31.8)[a]	228.5 (46.9)[a]	127.8 (31.8)[a]
Chiurazzi et al., 2017	AN-R (N = 13)	906.0 (224.0)	50.8 (15.6)	128.0 (42.2)	23.6 (10.3)
Crisp (2006)	AN-R (N = 19)	1036.0 (656.0)	45 (NR)	143 (NR)	35 (NR)
Crisp (2006)	AN-BP (N = 11)	1709.0 (1513.0)	77 (NR)	226 (NR)	59 (NR)
Elmore, 1991	BN (N = 19)	1669.0 (566.39[a])	NR	NR	NR
Engel et al., 2009	BED (N = 9)	2536.0 (408.3[a])	NR	NR	NR
Fichter,1990	BN (N = 24)	2886.0 (1725.0)	NR	NR	NR
Fitzgibbon, 1999	BED (N = 35)	2306.5 (1205.2)	71.6 (37.1)	266.1 (176.0)	107.2 (61.6)
Fitzgibbon, 1999	BN (N = 42)	2799.0 (1536.9)	69.2 (40.4)	369.6 (183.2)	115.0 (79.5)
Goodman et al., 2018	BED (N = 26)	2516.0 (1013.1)[a]	NR	NR	NR
Greeno, 1996	BED (N = 38)	2573.4[a] (NR)	93.0 (NR)	288.0 (NR)	117.0 (NR)
Hadigan et al., 2000	AN (N = 30)	1602.0 (200.0)	63.1 (7.1)	265.5 (25.3)	36.1 (10.0)
Hilbert, 2007	BED (*n* = 20)	2402.5 (824.8)	NR	NR	NR
Hilbert, 2007	BN (*n* = 20)	3107.0 (2647.0)	NR	NR	NR
Horvath et al., 2015	BED (N = 54)	2582.5 (1343.6[a])	113.4 (83.1)[a]	325.7 (147.4)[a]	84.4 (43.5)[a]
Jacoangeli et al., 2002	AN (N = 49)	907.0 (304.0)	NR	NR	NR
Kirkley et al., 1985	BN (N = 22)	4447.0 (4707.8)	NR	NR	NR
Lacey, 1985	BN (N = 30)	4756.0 (3050.74)[a]	NR	NR	NR
Latzer et al., 2020	BN + BED (*n* = 34)	1868.6 (851.3)	NR	NR	NR
Latzer et al., 2020	BN + BED, with comorbid NES (*n* = 25)	2643.5 (1374.9)	NR	NR	NR
Lear et al., 1997	AN (N = 15)	1160.0 (150.0)	NR	NR	NR
Leyrolle et al., 2021	BED (N = 42)	2109.0 (566.0)	88.2 (19.3)	216.0 (52.7)	91.4 (41.8)
Masheb et al., 2016	BED (*n* = 41)	2668.3 (1080.6)	NR	NR	NR
Milosevic et al., 1997	AN + BN (*n* = 15)	1770.0 (NR)	61.3 (NR)	208.5 (NR)	76.8 (NR)
Onur et al., 2005	AN (N = 28)	1821.0 (928.0)	NR	NR	NR
Patsalos et al., 2021	AN (N = 51)	1553.6 (739.8)	63.9 (31.4)	204.4 (108.7)	57.4 (35.3)
Raatz et al., 2015	AN-R (N = 46)	1605.2 (822.0)[a]	64.1 (30.2)[a]	234.3 (116.2)[a]	47.0 (33.1)[a]
Raatz et al., 2015	AN-BP (N = 29)	1837.6 (1729.2)[a]	64.7 (67.8)[a]	260.3 (224.0)[a]	64.8 (74.4)[a]
Raymond et al., 2003	BED (N = 12)	2709.5 (713.1)	NR	NR	NR
Raymond et al., 2012	BED (N = 17)	2586.9 (640.1)	NR	NR	NR
Rigaud et al., 2009	AN (N = 120)	NR	NR	NR	29.0 (18.0)
Rossiter et al., 1988a	BN (*n* = 20)	3129.5 (1672.5)[a]	NR	NR	NR
Rossiter et al., 1988b	BN (N = 10)	2466.0 (NR)	NR	NR	NR
Rossiter et al., 1992	BED (N = 22)	2120.3 (931.7)[a]	NR	NR	NR
Segura-García et al., 2014	AN-R (*n* = 37)	1201.0 (486.0)	53.2 (22.3)	162.2 (71.5)	41.5 (19.8)
Segura-García et al., 2014	AN-BP (*n* = 18)	1087.0 (752.0)	41.0 (24.2)	151.8 (116.4)	37.8 (29.9)
Segura-García et al., 2014	BN (*n* = 40)	1903.0 (1094.0)	68.6 (32.2)	241.2 (134.0)	73.1 (48.5)
Segura-García et al., 2014	BED (*n* = 29)	2000.0 (724.0)	74.4 (20.6)	256.2 (94.9)	79.0 (35.4)
van Binsbergen et al., 1988	AN (N = 20)	1099.4[a] (NR)	NR	NR	NR
van der Ster Wallin et al., 1995	AN (*n* = 31)	1026.0 (458.0)	44.0 (24.0)	155.0 (80.0)	25.0 (14.0)
Waisberg and Woods, 2002	AN (N = 8)	917.0 (509.0)	38.7 (24.6)	NR	25.2 (17.1)
Wiklund et al., 2022	BN and BED (female-only, *n* = 391)	2596.3 (1159.7)[a]	NR	NR	NR
Wiklund et al., 2022	BN and BED (male only, *n* = 39)	2668.0 (1120.1)[a]	NR	NR	NR
Woell et al., 1989	BN (N = 30)	3117.0[a] (NR)	NR	NR	NR

Note. AN, anorexia nervosa; AN-BP, anorexia nervosa–binge-purge subtype; AN-R, anorexia nervosa–restrictive subtype; BN, bulimia nervosa; BED, binge-eating disorder; ED, eating disorder; NR, not reported; kcal, calories; g, grams. Recommended daily intake derived from Public Health England (2016).
[a] value(s) computed by authors.
[b] The authors use this term to refer to those meeting DSM-IV-TR criteria for AN, except for one symptom.

3.4. Micronutrients

Summaries of mineral and trace element and vitamin intake can be found in Tables 3 and 4, alongside RDIs.

3.4.1. Mineral intake

Details of mineral intake were provided in ten studies, sampling individuals with AN, BED, and BN. The most commonly reported (in nine samples) was calcium intake, which varied from 427 mg/day to 1703 mg/day, straddling the RDI of 700 mg (PHE, 2016). Individuals with AN generally consumed less than those with BED or BN, who usually consumed above the RDI. It is possible that iron and potassium are also under-consumed in AN samples, with intake of most minerals appearing adequate (on average) across non-underweight binge-eating disorders. Three studies included an estimate of sodium, which indicated potential over-consumption in BN (Woell et al., 1989) and BED (Horvath et al., 2015), and relatively low intake in AN (Chiurazzi et al., 2017). All studies including an estimate of phosphorous intake suggested average consumption above the RDI.

3.4.2. Vitamin intake

A summary of the intake of vitamins in adults with EDs can be found in Table 4 alongside RDIs. Seven samples were included, although not all included assessments of certain vitamins. The small sample suggests that participants with AN may consume an inadequate intake of some vitamins (particularly Vitamin A and Vitamin D) although many were in-line with the RDI. Individuals with BN and BED typically exceeded RDIs, with the exception of Vitamin D, although sample sizes were small.

4. Discussion

The aim of this systematic review was to synthesise and report the

Table 3
Daily dietary mineral intake of adults with an ED expressed as mean and standard deviation (SD).

First Author, year	Sample	Sodium (mg/day)	Potassium (mg/day)	Calcium (mg/day)	Phosphorus (mg/day)	Iron (mg/day)	Zinc (mg/day)	Iodine (mg/day)	Magnesium (mg/day)
Recommended daily intake (mg)		1600	W: 3500 M: 3500	W: 700 M: 700	W: 550 M: 550	W: 14.8 M: 8.7	W: 7 M: 9.5	W: 140 M: 140	W: 270 M: 300
Alvarenga et al., 2003	BN (n = 19)	NR	NR	1286.2 (NR)	1030.9 (NR)	12.5 (NR)	9.3 (NR)	NR	245.6 (NR)
Chiurazzi et al., 2017	AN-R (n = 13)	729.0 (372.0)	1845.0 (743.0)	427.0 (158.0)	736.0 (180.0)	8.0 (2.91)	4.82 (2.18)	124.0 (108.0)	NR
Horvath et al., 2015	BED (N = 54)	4523.8 (NR)	3211.2 (NR)	785.0 (NR)	NR	16.6 (NR)	15.8 (NR)	NR	NR
Jacoangeli et al., 2002	AN (N = 49)	NR	NR	1059.0 (463.0)	NR	NR	NR	NR	NR
Patsalos et al., 2021	AN (N = 51)	NR	NR	NR	NR	10.9 (5.2)	7.3 (3.2)	NR	319.6 (129.6)
van der Ster Wallin et al., 1995	AN (n = 31)	NR	NR	NR	NR	8.7 (5.0)	NR	NR	NR
van Marken Lichtenbelt et al., 1997	AN (N = 12)	NR	NR	973.0 (433.0)	NR	NR	NR	NR	NR
Waisberg, 2002	AN (N = 8)	NR	NR	472.3 (449.1)	NR	9.2 (7.9)	NR	NR	NR
Wiklund et al., 2022	BN and BED (female-only, n = 391)	NR	3574.4 (1503.5)	1109.0 (648.8)	1775.5 (910.6)	15.3 (8.4)	15.4 (8.3)	267.4 (133.2)	479.3 (229.7)
Wiklund et al., 2022	BN and BED (male only, n = 39)	NR	3555.3 (1326.4)	1082.6 (564.1)	1763.8 (832.7)	15.7 (8.6)	14.9 (7.2)	255.6 (100.6)	491.3 (149.2)
Woell et al., 1989	BN (N = 30)	3400 (NR)	3200.0 (NR)	1703.0 (NR)	1608.5 (NR)	16.0 (NR)	11.2 (NR)	NR	395.8 (NR)

Note. AN, anorexia nervosa; AN-R, anorexia nervosa–restrictive subtype; ED, eating disorder; mg, milligrams. Recommended daily intake derived from British Nutrition Foundation (2021) based on age 19–50 years.

Table 4
Daily vitamin intake of adults with an ED expressed as mean and standard deviation (SD).

First Author, year	Sample	Vitamin A (μg/day)	Vitamin b-6 (mg/day)	Vitamin b-12 (μg/day)	Vitamin C (mg/day)	Vitamin D (μg/day)	Vitamin E (mg/day)	Thiamine (mg/day)	Riboflavin (mg/day)	Niacin (mg/day)	Folate (μg/day)
Recommended daily intake		W: 600 M: 700	W: 1.2 M: 1.4	W: 1.5 M: 1.5	W: 40 M: 40	W: 10 M: 10		W: 0.80 M: 0.90	W: 1.1 M: 1.3	W: 17 M: 16	W: 200 M: 200
Alvarenga et al., 2003	BN (n = 19)	8679.4	1.6 (NR)	6.9 (NR)	296.8 (NR)	15.8[a] (NR)	11.8[b] (NR)	NR	2.1 (NR)	22.1 (NR)	225.1[c] (NR)
Chiurazzi et al., 2017	AN-R (n = 13)	551.0 (399.0)[d]	0.6 (0.5)	3.5 (1.4)	123.0 (73.8)	0.9 (1.1)	3.3(3.0)[e]	0.58 (0.17)	1.20 (0.67)	9.41 (3.47)	127.0 (86.1)
Horvath et al., 2015	BED (N = 54)	673.42 (NR)	2.00 (NR)	5.21 (NR)	NR	0.18 (NR)	5.06 (NR)	NR	NR	NR	NR
Patsalos et al., 2021	AN (N = 51)	251.89 (368.00)	1.83 (0.89)	4.27 (3.69)	146.15 (90.44)	2.04 (2.32)	12.58 (5.53)	1.51 (0.81)	1.81 (1.12)	20.51 (10.60)	323.52 (183.11)
Wiklund et al., 2022	BN and BED (female-only, n = 391)	1067.2 (621.0)[f]	2.2 (1.0)	4.6 (3.2)	89.1 (51.9)	5.6 (3.9)	14.9 (7.0)	1.6 (0.9)	1.9 (1.1)	43.6 (23.2)	433.1 (215.4)
Wiklund et al., 2022	BN and BED (male only, n = 39)	977.7 (537.8)[f]	2.2 (1.1)	4.5 (2.7)	89.2 (49.0)	5.8 (3.7)	14.9 (6.9)	1.6 (1.0)	1.9 (1.1)	42.0 (21.8)	429.0 (180.8)
Woell et al., 1989	BN (N = 30)	700 (NR)	1.6 (NR)	5.4 (NR)	80.0 (NR)	4.4 (NR)	12.7 (NR)	NR	NR	NR	168.0 (NR)[c]

Note. AN-R, anorexia nervosa–restrictive subtype; AN, anorexia nervosa; ED, eating disorder; mg, milligrams; μg, microgram. Recommended daily intake derived from British Nutrition Foundation (2021) based on age 19–50 years.
[a] Reported in source paper as 15.8 mg.
[b] Reported in source paper as α tocopherol equivalents.
[c] Reported in source paper as Folic acid.
[d] Reported in source paper as 551.0 mg.
[e] Reported in source paper as 3.33 μg.
[f] Reported in source paper as retinol equivalent.

dietary intake of adults with EDs with reference to specific numerical values. This is the first systematic review of the literature, combining data from 39 studies and more than 1900 participants. Individuals with AN, BN, and BED were included, summarising energy intake, macronutrients, and micronutrients. Data were combined with meta-analysis to quantify the overall macronutrient intake of adults with EDs.

The intake of the overall sample was in line with guidelines for the energy intake of adult women (e.g., PHE, 2016; see also Zhou et al., 2003), although subgroup analyses identified differences between individuals with different ED diagnoses, as expected. When looking further at diagnostic differences, a below-average total energy intake was frequently reported, in line with previous research (e.g., Marzola et al., 2013). When compared to the RDI, adults with AN had considerably lower calorie, carbohydrate, and fat intakes, an issue which is consistently reported across the literature (e.g., Marzola et al., 2013; Schebendach et al., 2019) and commensurate with current diagnostic criteria (e.g., APA, 2013). Low fat intake can lead to numerous adverse health outcomes due to the energy dense profile of fats and the consequences of lipid depletion (Duerksen and McCurdy, 2005), and may explain the malnutrition seen in AN (Lloyd et al., 2021). Similarly, avoidance of carbohydrates is consistently reported across participants, which is often in the pursuit of avoiding energy-dense foods (Segura-García et al., 2014). Protein intake of individuals with AN was generally in line with the RDI, supporting the findings of controlled studies (e.g., Fernstrom et al., 1994).

Adults with BED reported an elevated energy intake, suggesting that calorie consumption is consistently higher than the RDI, a finding which is in line with laboratory studies (e.g., Raymond et al., 2007). Fat and protein intake followed a similar pattern – on average, exceeding the RDI – although carbohydrate intake was similar to the RDI for women (257 vs. 267g/day). Whilst elevated consumption of carbohydrate and fat during binge episodes has been well-documented (e.g., Presseller et al., 2023), the finding that overall protein intake was high relative to the RDI was unexpected. Although the results of some studies have suggested that protein intake in EDs on a "typical" day is low (Ayton et al., 2021, p. 2), experimental studies, such as that of Schmidt et al. (2023), found higher protein intake in individuals with BED compared to individuals without BED, although this difference did not reach the conventional criterion for statistical significance ($p = 0.052$). Inconsistent findings could reflect the small sample sizes typically used in dietary intake studies, the methods used to recall intake (e.g., Mourilhe et al., 2021), or the higher overall energy intake of individuals with BED (see also Bottera and De Young, 2023).

There was less data available for meta-analysis from studies of individuals with BN, although data from these samples included some of the highest reported energy intakes. This is consistent with a recent review looking specifically at episodes of binge eating in the laboratory (Mourilhe et al., 2021) and supports, to some extent, the theory that dieting and compensatory behaviours (such as purging) serve to increase overall calorie intake (e.g., Fairburn et al., 2003), often leading to 'vicious cycles' whereby continued compensation reinforces further binge eating. Wide variation was seen within the BN samples in particular; Kirkley et al. (1985), for instance, reported a range of intakes between 450 kcal and 18,202 kcal per day. Consumption of all macronutrients (protein, carbohydrates, and fat) exceeded guidelines, and supports previous findings that there are some differences in eating behaviour between individuals with BED and those with BN (Walsh and Boudreau, 2003). Further study seems warranted given the small samples sizes and wide confidence intervals around many of the estimates for BN samples.

Overall, few studies reported micronutrient intake in EDs, although some consistent findings emerged. Low levels of calcium intake were seen exclusively in AN samples, which can be detrimental and result in low bone density (Misra et al., 2006) and increased fracture risk (Fazeli and Klibanski, 2014). Similarly, intake of Vitamin D, which is essential for calcium absorption, was low compared to the RDI in all studies, with sample means ranging from 0.18 to 5.8 μg/day (RDI = 10 μg/day; PHE, 2016). This adds support to suggestions that Vitamin D deficiency needs to be addressed in recovery from an ED (Velickovic et al., 2013), and clinicians should be aware that this occurs across the ED spectrum (i.e., not solely in the presence of low body weight). Intake of other micronutrients, such as Zinc, was observed to be low in a small number of studies in this review. Low zinc levels are also seen in blood and urine tests, and have been suggested as maintaining factors in EDs (e.g., McClain et al., 1992). In addition to representing important treatment targets, these findings might help explain the self-prescription of nutritional supplements in individuals with EDs (Setnick, 2010).

4.1. Strengths and limitations

This review summarises what is known regarding the dietary intake of adults with AN, BN, and BED, with samples including those who are severely unwell and those living in the community. A large number of eligible studies were reviewed across several databases and the study adopted double-screening throughout. To some extent we were also able to explore the macronutrient and micronutrient intake across these disorders, although research was limited. Further research in this area, including larger samples, would be beneficial to improve overall understanding of the dietary intake of adults with EDs and more consistent reporting (including as many nutrients as possible) would also permit more thorough comparison across studies.

The current review was limited to papers written in English and grey literature was not reviewed. Lack of prospective registration may have introduced bias and decreased transparency. Whilst an effort was made to include all relevant literature (and over 10,000 unique articles were evaluated), case studies were excluded to manage heterogeneity and a minority of studies reported macronutrients in a format that could not be converted and were therefore excluded. Although tests for publication bias were generally not significant, findings, particularly related to fat intake, should be interpreted in light of this possibility, particularly given the suggestion that Egger's test may not work well for certain measures of effect size (Pustejovsky and Rodgers, 2019). Quality ratings were acceptable across studies, with similar design shortcomings to those noted in other reviews of dietary intake (e.g., Teasdale et al., 2019). Although studies were not excluded based on quality, alternative ratings of study quality were considered and may have resulted in different conclusions due to different weightings of study criteria, for instance (e.g., see O'Connor et al., 2015).

As nutritional needs of children differ to those of adults (British Nutrition Foundation, 2021; Wiklund et al., 2022), several studies were excluded as a number of participants were aged under 18 years, which limited the articles available for review. For many studies, samples were either exclusively female or combined intake from both men and women (cf. Wiklund et al., 2022). Given the different dietary needs of men and women, further studies should look at the dietary intake of men with EDs as the sample included here was small and heterogenous.

Whilst a strength of the review was coverage of a large time period and aggregation of data from over 1900 individuals, different diagnostic manuals were used in the included studies, which might have introduced heterogeneity within ED subgroups. Due to small sample sizes for those diagnosed according to DSM-5 (which included broader diagnostic criteria than the preceding DSM-IV; Hoek, 2014), subgroup analyses were not conducted to investigate whether use of different diagnostic manuals was related to dietary intake and some feeding and eating disorders (e.g., night eating syndrome) were not included. Similarly, all studies looked at individuals at one point in time, and thus it was not possible to consider diagnostic movement and investigate how dietary intake might change longitudinally within the same individual. This might represent an important prognostic factor given that 'movement' between AN and BN in particular can reduce the likelihood of remission from an eating disorder (Schaumberg et al., 2019).

A range of dietary assessment methods were used, with most papers using a form of self-report measure, which is potentially subject to recall bias and needs to strike a balance between accurate recall and a sufficient timeframe (e.g., Subar et al., 2020). Participants who felt ashamed of their dietary intake may have underreported due to social desirability bias, with research suggesting that those who are overweight are more likely to misreport dietary intake (Livingstone and Black, 2003). Similarly, those with 'restricted' dietary intakes may have been biased towards over-reporting (e.g., Hadigan et al., 2000; see also Ravelli and Schoeller, 2020), although a strength of the meta-analysis used here is aggregation of data from different methods of dietary report. Comparisons against the RDI can be problematic as these values will vary according to a range of factors, such as activity levels, which cannot be accounted for. In addition, the RDI was based on those aged 19–64 years in England, although age in particular related closely to the range of those included in the review. Finally, the samples were predominately comprised of middle-aged White/Caucasian women, limiting generalisability and knowledge of male and other minority groups.

4.2. Future recommendations

Based on the present review, more research is needed to advance knowledge and understanding of the dietary intake of adults with EDs, such as those with OSFED and several aspects of those with BN. Future studies should aim to recruit (and describe) more inclusive and diverse samples and explore micronutrient intake in particular. Including at least mean and SD intake will also facilitate straightforward comparisons, and it might be of interest to consider whether modifications to diagnostic criteria are related to different dietary intakes between EDs. Finally, using technology, such as a mobile app, to collect information on dietary intake across a long-term period might reduce recall bias and improve accuracy (Ambrosini et al., 2018).

4.3. Implications

The findings of this review synthesise knowledge regarding the dietary intake of adults with EDs and can be used to inform interventions, nutritional counselling, and psychoeducation used in the treatment of EDs, in addition to informing guidelines for the nutritional management of EDs (e.g., Royal College of Psychiatrists, 2005). Given that medication such as selective serotonin reuptake inhibitors may be less effective in the presence of malnutrition (see Haleem, 2012), the findings might also inform pharmacologic interventions, particularly for those with AN who frequently reported an inadequate dietary intake, consistent with current diagnostic criteria. The findings also suggest that providing education regarding the importance of micronutrients, fat intake, and regular eating is well-supported. Finally, clinicians are advised to be mindful of, and sensitive to, the presence of both nutritional deficiencies and the risks of over-consumption frequently seen across EDs.

CRediT authorship contribution statement

Paul E. Jenkins: Conceptualization, Formal analysis, Methodology, Writing – original draft, Writing – review & editing. **Katy Proctor:** Conceptualization, Methodology, Writing – original draft. **Sarah Snuggs:** Formal analysis, Writing – review & editing.

Declaration of competing interest

No potential conflicts of interest are declared.

Acknowledgement

This research was supported by the Undergraduate Research Opportunities Programme, which provides opportunities for University of Reading undergraduates to undertake summer research positions at the University.

Appendix A. Supplementary data

Supplementary data to this article can be found online at https://doi.org/10.1016/j.jpsychires.2024.05.038.

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Denotes inclusion in the systematic review

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