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INVITED REVIEW

Food addiction and associations with mental health symptoms: a systematic review with meta-analysis

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Abstract

Background: The present study systematically reviewed the literature aiming to determine the relationships between food addiction, as measured by the Yale Food Addiction Scale (YFAS), and mental health symptoms.
Methods: Nine databases were searched using keywords. Studies were included if they reported: (i) YFAS diagnosis or symptom score and (ii) a mental health outcome, as well as the association between (i) and (ii). In total, 51 studies were included.
Results: Through meta-analysis, the mean prevalence of food addiction diagnosis was 16.2%, with an average of 3.3 (range 2.85–3.92) food addiction symptoms being reported. Subanalyses revealed that the mean number of food addiction symptoms in populations seeking treatment for weight loss was 3.01 (range 2.65–3.37) and this was higher in groups with disordered eating (mean 5.2 3.6–6.7). Significant positive correlations were found between food addiction and binge eating [mean $r = 0.602$ (0.557–0.643), $P < 0.05$], depression, anxiety and food addiction [mean $r = 0.459$ (0.358–0.550), $r = 0.483$ (0.228–0.676), $P < 0.05$, respectively].
Conclusions: A significant, positive relationship exists between food addiction and mental health symptoms, although the results of the present study highlight the complexity of this relationship.

Introduction

'Food addiction' (FA) has emerged in recent times as a possible contributor to the increasing prevalence of obesity and being overweight, the changing food environment, and the doubling of mental health conditions between 1995 and 2005 [1,2]. Currently, there is no accepted definition of FA, as distinct from other disorders of addiction or eating, because of the lack of a strong scientific evidence base [3,4]. Although controversy and debate exist in the literature about the classification and construct of FA, the most common approach to define FA is to use criterion applied to substance use disorders through a survey tool: The Yale Food Addiction Scale (YFAS). The YFAS assesses seven core symptoms of addiction as applied to food: diminished control over consumption, a persistent desire or repeated unsuccessful attempts to quit, withdrawal, tolerance, consumption of large amounts of food or over a longer period than intended, spending much time obtaining food, giving up important activities and clinically significant impairment [5]. A FA 'diagnosis' is indicated when a threshold of three or more symptoms simultaneously occur, in addition to clinically significant impairment or distress [5,6]. The YFAS tool was revised (YFAS 2.0) in 2013 to reflect the Diagnostic Statistical Manual of Mental Disorders (DSM)-5 amendments to substance use disorders, whereby substance abuse and substance dependence were combined to reflect a single substance use disorder, a criterion related to craving was added, along with a continuum of severity of

disorder ranging from mild (two or three symptoms), moderate (four or five symptoms), to severe (six or more symptoms [7]. The YFAS 2.0 tool assesses 11 symptoms and allows for a more comprehensive scope of understanding food addiction. For the current study, the term 'food addiction' (FA) is used to refer to FA as indicated by all versions of the YFAS because they have been shown previously to have a similar factor structure and report similar prevalence and symptoms [8]. FA has been reported in 20% (range 5–57%) of the population, with higher levels being reported in overweight and obese people, women, as well as in those older than 35 years [9].

Research demonstrates that higher symptom scores on YFAS tools are associated with increased craving and intakes for processed and convenience foods [10–12], higher impulsivity [13–15], elevated body mass index (BMI) and more frequent binge eating [16,17]. Higher scores on the YFAS are also associated with genetic profiles implicated in reward dysfunction [18,19] and neurophysiological correlates similar to substance-related addictive disorders [20] and are less strongly correlated with smoking, drinking and other drug use [21,22].

FA can occur with a range of symptoms and has been associated not only with both specific foods, but also eating behaviours and can occur occur independently of obesity. FA has been detected in healthy weight and non-clinical populations [9]. FA also overlaps with disordered eating, which also share common mechanisms such as impulsivity and reward dysfunction [23]. Approximately 50% of those with binge eating disorder (BED) also receive a diagnosis of FA, suggesting that FA likely to affects a subgroup of vulnerable individuals [8,24,25].

The increasing number of published studies that investigate FA do so in conjunction with other formally recognised mental health conditions, such as depression and related symptoms [20]. Indeed, epidemiological research indicates that a clustering of comorbidities is present in people reporting depression, such that the presence of depression, particularly in young adult males, is associated with twice the risk of obesity, smoking, spending more time in sedentary activities, and behaviours associated with drug and alcohol use relative to nondepressed young adults [26]. For young women with depression, the risk is six-fold of these comorbidities [27]. In addition, scientific reports reliably demonstrate that mental illness increases the use of addictive substances, including alcohol, cocaine and cigarettes, compared to the general population [28]. It is currently unclear the extent to which this occurs for FA.

Assessing mental health alongside FA could provide insights into the overlapping features of mental health conditions with addictive eating. Notably, in the substance use field, negative emotional states such as anxiety and depression play a key role in increased addiction risk [29]. These factors, including psychological stress, are hypothesised to serve as either antecedents of addiction or as contributors to increased relapse risk. Equally, these factors could also play a role in dietary relapse and weight regain in FA, which is a common feature of weight management interventions [30].

Currently, the relationship between mental health and FA has not been systematically reviewed and evaluated. The aim of the present review was to synthesise the available research to address this issue. We aimed to explore the relationship between FA, as measured by the YFAS, and major mental health symptoms. A secondary aim was to investigate the psychometric properties of the YFAS in a variety of population groups.

Materials and methods

A comprehensive search strategy was undertaken to identify published studies that used the YFAS to assess FA diagnosis or symptom scores from the year of tool development (2009) up to March 2017. The review methodology was registered with PROSPERO (ID number CRD42015026714).

Literature search

Initially nine online databases were searched, these included: MEDLINE, The Cochrane Library, EMBASE (Excerpta Medica Database), CINAHL (Cumulative Index to Nursing and Allied Health), Informit Health Collection, Proquest, Web of Science, Scopus and PsycINFO. Keywords were informed by preliminary literature searches; words used individually and in combination were: Yale Food Addiction Scale, YFAS, questionnaire; food addiction, behavioural addiction, eating behaviour, obesity, food, eat, feeding behaviour, food preferences, food habits, body mass index, overeat, hyperphagia, substance-related disorders, binge eating, hedonic eating. Both the English and American spellings of behaviour/behavior were searched. Database searches were supplemented by cited reference checks and systematic checking of reference lists of identified articles for additional relevant publications. Electronic searches were supplemented by manual cross-checking of the reference lists of relevant publications. All study designs were included.

After the removal of duplicates, titles and abstracts of identified studies were screened by two independent reviewers, with discrepancies decided by consensus using a third reviewer (TB, KP, JS). Inclusion/exclusion criteria were applied to determine the eligibility of each publication for inclusion in the review. Eligibility criteria included: participants from any age (children and adults)

any study published in English; any type of interventions/study and any types of comparators. Eligible studies needed to report the following outcomes measures: use one or more of the YFAS tools (YFAS, modified form of the YFAS or the YFAS 2.0) to assess FA; reported either the YFAS diagnosis or symptom score; a mental health outcome including but not limited to depression, anxiety, disordered eating; the association between a measure of food addiction and a mental health outcome. The articles meeting the inclusion criteria were retrieved. If eligibility status of a study was unclear from the title and abstract, the article was retrieved for further clarification.

Study quality

Retrieved studies were assessed by two independent reviewers (TB, KP, JS) using a standardised tool [31]. The quality criteria assessed nine items, of which four relate to study validity. The items assessed include: the method of sample selection, ways of dealing with confounding factors, reliability of outcome measures, and statistical analysis. Each item was classified as present ('Yes'), absent ('No') or 'Unclear' for each included study, and then each response recoded as +1, 0 and −1, respectively. Studies were classified as 'positive quality' where studies obtained a 'yes' to validity questions and had a score of ≥8. Neutral or negative quality studies were those where most of the nine quality criteria answers were 'no'. No studies were excluded based on quality ratings. Data were extracted using standardised tables developed for the review (Tables 1 and 2) and included population characteristics, YFAS and mental health outcomes. Associations in addition to the psychometric properties of the YFAS tool, if reported, were also extracted. In cases of uncertainty of study inclusion, a third independent reviewer was consulted until consensus was reached. Studies were tabulated in alphabetical order.

Data synthesis

Results of the systematic review are presented in both a narrative analysis to describe the included studies and, where possible, a meta-analysis for a more rigorous analysis [75]. If studies reported the YFAS diagnosis or symptom score, or correlation coefficients (or equivalent) between FA and a measure of mental health that assessed the same outcome, the results were pooled using meta-analysis. Given the same factor structure across all the YFAS tools as previously reported, all of the surveys were combined into one meta-analysis. Heterogeneity was assessed by I^2 statistics, and considered to be low if I^2 was ≤40% and high if I^2 was ≥75%. A random effects model for meta-analysis was used if there was significant heterogeneity ($I^2 > 40\%$) and fixed effects when homogeneous ($I^2 \leq 40\%$). The data from each study were combined using either correlation, event rate or the mean (SD), in addition to the study sample size. A subanalysis by mental health questionnaire type was also undertaken if there were sufficient studies to conduct the sensitivity meta-analyses. For all included studies, a publication bias was assessed through standardised funnel plots. Meta-analyses were conducted using Comprehensive Meta-Analysis Professional, version 2 (Englewood, NJ, USA).

Results

Description of included studies

In total, 1637 articles were initially identified (after duplicates removed) using the search strategy. Following the removal of duplicate references and the assessment of articles using the predefined inclusion criterion, 53 relevant articles concerning 51 studies were identified (Fig. 1). Primary reasons for exclusion included: not a formal study (i.e. an editorial, $n = 86$ articles), no relevant outcomes ($n = 81$ studies) and not in English ($n = 1$ study). The majority of included studies used a cross-sectional ($n = 51$ studies), case–control ($n = 2$) or intervention ($n = 1$) design (Table 1). The majority of studies were carried out in the USA ($n = 21$ studies), followed by Germany ($n = 7$), Italy ($n = 6$), Spain ($n = 4$) and France ($n = 3$). In total, 200 813 individuals were included across the studies, including two large population-based studies in the USA using the Nurses Health Study ($n = 134\ 175$ and $n = 49\ 408$) [45,60]. Excluding these two large, population-based surveys, all other studies ranged from 28 to 967 people, with an average of 343 individuals per study.

The majority of studies were carried out in adults (>18 years, $n = 47$ studies), two studies were carried out in children/adolescents [57,76], and two studies included both children and adults [42,66]. For the studies that were conducted in adults and reported a mean age, this was calculated to be 33.1 years, range (18.7–62.9 years). Ten studies were conducted in exclusively female population groups [34,42,43,45,46,49,60,64,77], with all other studies including both sexes, with an average of 74% females per study (range 55.1–93%). Only one study was identified with a high proportion of males (92%, in a veteran study) [62]. The most common population group studied were those individuals seeking a weight-loss treatment ($n = 11$ studies) [18,24,35,39–41,44,51,66,78,79]. Other groups included bariatric weight-loss groups ($n = 6$) [15,22,37,56,61,65], undergraduate/students ($n = 7$ studies) [5,35,68,71,74,80,81] and disordered eating groups ($n = 7$) [17,43,47,49,50,64,73]. The studies carried out in disordered eating groups all included bulimia nervosa (BN) and BED, with only two studies including additional eating

Table 1 Description of included studies

Author, year, country	Type of study	Number of participants	Population studied	Participant characteristics	YFAS details	Mental Health outcome assessment	Symptom (S)/ diagnosis (D)	Smoking status
Ahmed 2016, Egypt [32,33]	Cross-sectional	*n* = 401	Adolescents 11–18 years	BMI: 25.38 (6.25) 55.1% F	YFAS-C translated to Arabic	Binge Eating Scale (BES) Child depression Inventory	D + S	NR
Berenson, 2015, USA [34]	Cross-sectional	*n* = 1067	18–40 years 100% F	Hispanic *n* = 335, non-Hispanic White *n* = 288, non-Hispanic Black *n* = 444 32% HW, 28% OW, 36% OB	YFAS	BDI – fast screen	D + S	Assessed and reported
Boggiano 2014, USA [35]	Cross-sectional	*n* = 488	Undergraduate (UG) *n* = 247 students and weight loss (WL) seeking participants *n* = 241	Age UG 20.6 (4.6) WL 48.3 (13.6) (range 15–80) 29% M 71% F BMI range 17–91, 35% African American, 51% non-Hispanic white, 8% Asian	YFAS paper based as part of a broader survey	BES	S	NR
Brunault, 2014, France [36]	Cross-sectional	*n* = 553	Community	Age: 28.9 (12.0) years (95% CI 27.9–29.9 years) BMI: 22.5 (4.5) (95% CI 22.2–22.9)	YFAS French version Online questionnaire	BES; the Bulimic Investigatory Test-Edinburgh (BITE)	D + S	NR
Brunault, 2016 France [37]	Cross-sectional	*n* = 188	Bariatric surgery patients	84% F Age 40.8 (12.3) years BMI 46.0 (7.3)	YFAS French version	BDI, BES	D + S	NR
Brunault, 2017 France [38]	Cross-sectional	*n* = 330	Mean age 28.9 (11.3) years range 18–76	Nonclinical BMI 23.3 (4.9)	YFAS 2.0 French tool	BES, Questionnaire on eating and weight patterns	D + S	NR
Burmeister, 2013, USA [39]	Cross-sectional	*n* = 57	OW/OB individuals seeking 7 week WL intervention	68.4% F Age: 47.4 (13.7) BMI: 38.2 (8.1) 84.2% Caucasian 70.2% married 91.2% college education	YFAS Completed at baseline	CESD; BES	S	NR
Ceccarini *et al.* Italy [40]	Cross-sectional	*n* = 88	OW/Ob seeking WL	71.5% F 18–74 years BMI 40.8 (7.1)	YFAS – 16 Italian	BES	D + S	NR
Chao *et al.* 2017, USA [41]	Cross-sectional	*n* = 178	OW/Ob seeking WL	93% F Age: 44.2 (11.2) BMI: 40.9 (5.9) 70.8% black	YFAS	BED, depression assessed by clinical interview	D + S	NR

Table 1. Continued

Author, year, country	Type of study	Number of participants	Population studied	Participant characteristics	YFAS details	Mental Health outcome assessment	Symptom (S)/ diagnosis (D)	Smoking status
Chen *et al.* 2015 China [42]	Cross-sectional	*n* = 584	Students	100% F Age 16.47 (0.92) (14–19 years) BMI: 19.87 (2.27)	YFAS Chinese	BES	D + S	NR
Clark, USA, 2013 [22]	Cross-sectional	*n* = 67	Post bariatric surgery patients recruited from surgery support group	62.7% F Age: 42.27 years (range 25–73) 59.7% RYGB 86.6% Caucasian	YFAS Online survey Completed pre surgery	BES; Eating attitudes test; Emotional eating scale; Michigan assessment screening test for alcohol and drugs	D + S	Yes
Davis, 2011, Canada [21]	Cross-sectional	*n* = 72	Non clinical sample of OW/ OB adults	68.1% F Age: FA 35.3 years, NFA 33.0 years BMI, FA 37.5, NFA 38.8% female FA 72.2%, NFA 66.7%	YFAS Completed at home	Eating Disorder Examination (EDE); BDI; Wender Utah rating scale for ADHD; PFS; DEBQ, food craving	D + S	Yes
Davis, 2013, Canada [18]	Cross-sectional	*n* = 120	Recruited for overeating/OW study	68.3% F Age: FA 34.7 (5.9) years (range 45–44), NFA 32.5 (6.6) years (range 25–47) (NS) BMI: FA: 35.5 (7.3) (range 22–49.4), NFA 33.1 (8.9) (range 19–60)	YFAS Paper based, taken home to complete	5 items from Binge Eating Questionnaire; DEBQ, Eating Behaviours Patterns Questionnaire	D	NR
deVries *et al.* 2016 [43]	Cross-sectional	*n* = 456 BN *n* = 115 Controls *n* = 341	Recruited online targeted at forums for individuals with eating disorders	100% F Age; BN 26.4 (8.76) control 26.3 (7.42) BMI: BN 26.1 (8) controls 23.1 (5)	YFAS 2.0	EDS, EDI, depression	D + S	NR
Eichen, 2013 USA [44]	Cross-sectional	*n* = 178	OW/OB adults seeking/enrolled in behavioural weight loss treatment	51.2 (11.7) years, 36.1 (4.8), 92.1% OB, 74.7% F, 69.1% African American	YFAS Scale adapted from 'past year' to 'past month' Completed at baseline	BDI	D + S	NR
Flint, 2014, USA [45]	Cross-sectional	*n* = 134 175 YFAS and mYFAS *n* = 2061	Female nurses in the USA NHS and NHS II	100% F Age range: NHS 62–88 years, NHS II 45–64 years Weight: NHS 43.7% HW, 34.2% OW, 22.2% OB NHS II 40.2% HW, 30.5% OW, 29.2% OB	mYFAS NHS completed in written hardcopy, NHS II completed online	Binge eating, Depression determined by self report of a clinician diagnosis in previous 8 years	D	Assessed + reported

Table 1. Continued

Author, year, country	Type of study	Number of participants	Population studied	Participant characteristics	YFAS details	Mental Health outcome assessment	Symptom (S)/ diagnosis (D)	Smoking status
Frayn *et al.* 2016, Canada [46]	Case control	*n* = 66	100% F	BMI NFA 22.28 (3.66) FA 26.12 (6.93)	YFAS – completed online	EDEQ	D	NR
Gearhardt, 2009, USA [5]	Cross-sectional	*n* = 353	Undergraduate students	64.2% F Age: 20.11 (1.38) years BMI: 22.58 (3.18) 73.5% HWR, 18.7% OW, 4.7% u/weight, 2.7% OB 72.5% Caucasian	YFAS. Part of larger health behaviours online survey	BES; Eating Troubles Module (EAT); Emotional Eating Scale (EES); Rutgers alcohol problem index; Daily drinking questionnaire	D + S	
Gearhardt, 2012, USA [24]	Cross-sectional	*n* = 81	OB individuals who 'eat out of control' and seeking weight treatment	70.1% F Age: 47.47 (8.43) years (range 28–64) BMI: 40.58 (6.63) 79.3% Caucasian 82.6% had college education	YFAS. No information re completion	EDEQ; BDI; Difficulties in Emotion Regulation Scale; Rosenberg Self Esteem Scale	D + S	NR
Gearhardt, 2013, USA [47]	Cross-sectional	*n* = 96	OB BED patient respondents to a treatment study	75.8% F Age: FA 44.13 (13.41) NFA 45.13 (12.55) (range 19–65) BMI: 38.3 (5.73), 45.3% Caucasian, 32.6% African American, 12.6% Hispanic 74.7% college education	YFAS. No information re completion	EDEQ, BDI	D + S	NR
Gearhardt, 2014, USA [48]	Cross-sectional	*n* = 815	Community	88.1% F Age: 33 years range 18–73 BMI: 28.70 (8.77) (range 14.60–69.23) 79.1% Caucasian	YFAS. No details re completion	EDEQ, eating and weight patterns	D + S	NR
Gearhardt 2014, USA [10]	Cross-sectional	*n* = 89	Overweight and obese	73.8% F Age 31.27 (9.7) (18–50 years) 42% Caucasian, 33% African American Mean BMI 35.07 (8.05) range 25.37–72.62	YFAS paper based	EDEQ – restraint subscale, Hunger, Craving, liking	S	NR
Gearahrdt *et al.* 2016, USA [8]	Cross-sectional	Study 1; 535 Study 2: 224	Study 1 and 2: MTurk (18–81)	Study 1 age 33.84 (12.01), 77.6% Caucasian, 6.5% AA BMI 36.67 (76.76) Study 2; age 35.87 (12.29), 70.8% Caucasian, 8.1% AA	Study 1 and 2 YFAS 2.0	Study 1 and 2 EDDS	D + S	NR

Table 1. Continued

Author, year, country	Type of study	Number of participants	Population studied	Participant characteristics	YFAS details	Mental Health outcome assessment	Symptom (S)/ diagnosis (D)	Smoking status
Granero 2014, Spain [49]	Cross-sectional	*n* = 207	ED: AN = 40, BN *n* = 54, EDNOS *n* = 18 and 13 BED *n* = 13, healthy controls (HC) *n* = 82	100% F, ED age 29.3 (10.9) years, BMI 23.2 (7.5), mean duration of ED was 9.5 years HC age 23.4 (5.3) years, mean BMI 21.3 (3.0	YFAS translated to Spanish	Clinical Interview for DSM-IV Axis I disorders, EDI-2 and 90 symptom checklist to measure psychopathology	D + S	NR
Hilker *et al.* 2016, Spain [50]	Intervention	*n* = 66	BN patients	6 week outpatient group intervention (6 × 90 min) education BN, regular eating + food diaries Age; 29.2 (9.2)	YFAS – Spanish	EDI + clinical interview	D + S	NR
Imperatori, 2014, Italy [51]	Cross-sectional	*n* = 112	OW and OB patients seeking low energy diet therapy	71.4% female Age: 43.46 (12.91) years (range 18–73) BMI: 2.09 (6.76) (range 25.04–53.04)	Assessed at baseline YFAS translated in to Italian $\alpha = 0.87$	BES; Symptom Checklist-90-; Sociodemographic and clinical history	D + S	Tobacco use not included in analysis
Imperatori 2014, Italy [20]	Cross-sectional	*n* = 28	OW and OB Admitted to medical centre for obesity treatment	*n* = 14 overweight/OB with ≥3 FA symptoms and *n* = 14 controls with ≤2 symptoms 77.6% F Age FA 47.14 (10.96), control 40.15 (10.85) years BMI 29.35 (3.49) FA, 27.56 (1.84) controls	Assessed at baseline. I-YFAS – Italian translated, 16-items	Clinical interview + HADS to assess anxiety and depression, FCQ-Tr	D	Tobacco use in last 6 moths
Imperatori *et al.* 2016, Italy [52]	Cross-sectional	*n* = 301	OW and OB seeking LED (55% CHO, 30% fat and 15% protein	M + F Age; 47.5 (11.10) BMI: 31.64 (5.28)	YFAS – Italian	BES, HADS, CTQ	D + S	NR
Innamorati 2015, Italy [53]	Cross-sectional	*n* = 600	OW and OB	OW/OB: *n* = 300, 82% F mean age 43.55 (11.27) (range 18–73 years) BMI 32.15 (6.46) (range 25–62.5) Controls: *n* = 300, 77% F, age 41.74 (13.27) years range 22–81 BMI 23.13 (6.46) (range 16–38.05)	YFAS – Italian translated	BES	D	NR
Innamorti *et al.* 2017, Italy [54]	Cross-sectional	*n* = 322	General population	58% F Age 35.3 (14.91) BMI 22.92 (3.76)	YFAS – Italian	BES, Tobacco/Drugs and alcohol (Michigan alcohol screening test)	D + S	39.1% of those high risk for FA

Table 1. Continued

Author, year, country	Type of study	Number of participants	Population studied	Participant characteristics	YFAS details	Mental Health outcome assessment	Symptom (S)/ diagnosis (D)	Smoking status
Ivezaj *et al.* 2016 USA [55]	Cross-sectional	*n* = 502	General population	83.2% F Age 38.0 ±13.1 BMI 33.6 (6.9) Hispanic 8.6%, Black 2.4%, Asian 2.8%	YFAS completed online	EDEQ, BDI	D	NR
Koball *et al.* 2016, USA [56]	Cross-sectional	*n* = 923	Adult outpatients seeking bariatric surgery	71% F Age 47.9 (12.4) BMI 45.8 (9) (35–94)	YFAS	BDI, generalised anxiety disorder questionnaire, CTQ	D + S	NR
Laurent *et al.* 2015, USA [57]	Cross-sectional	*n* = 65	Children 9–14 years	38% OW/OB 4 public school in rural state BMI *Z*-score 0.74 (0.91) −1.2, 6.0)	YFAS-C	CDI- short form, multi-dimensional anxiety scale for children	D + S	NR
Lee 2014, Australia [58]	Cross-sectional	*n* = 479	US *n* = 215 and Australian *n* = 264	80% F Age 18–64 years, 81% Caucasian, 3% underweight, 48% normal weight, 22% o/w and 28% Obese History of anorexia 5%, BED 9%, bulimia 4%, alcoholism 4%, depression 36%	YFAS as part of larger survey	EDEQ and Likert questions on weight-based stigmatisation	D	Regular tobacco use 25%
Loxton *et al.* 2017, Australia [59]	Cross-sectional	*n* = 374	Adults 17–70 years	100% F 95% Caucasian mean age 30.58 (12.70) BMI 24 (5.95)	YFAS	BEQ, DASS 21	S	NR
Mason 2014, USA [60]	Cross-sectional	*n* = 49 408	Nurses Health Survey	100% F No trauma (*n* = 9445) Trauma no symptoms (*n* = 13 445) symptoms 1–3 (*n* = 15 757) 4–5 (*n* = 6859) 6–7 (*n* = 3902) mean age 35.3 (4.4), 94.5% Caucasian population	mYFAS	Post-traumatic Stress Disorder (PTSD) modified version of the brief Trauma Survey	D	NR
Miller-Matero *et al.* USA 2014 [61]	Cross-sectional	*n* = 142	Bariatric Surgery	81% F Age 46.26 (11.70) BMI 49.05 (9.56) 39.4% AA	YFAS	BE from interview, Hospital anxiety and depression	D + S	NR
Mitchell *et al.* 2016, USA [62]	Cross-sectional	*n* = 697	Trauma exposed veterans	93% Male Age 62.99 (12.03) (range 22–96) BMI measured NR	YFAS	EDDS, National stressful events survey (including PTSD)	S	NR

Table 1. Continued

Author, year, country	Type of study	Number of participants	Population studied	Participant characteristics	YFAS details	Mental Health outcome assessment	Symptom (S)/ diagnosis (D)	Smoking status
Meule, 2012, Germany [63]	Cross-sectional	*n* = 50	Female students	*n* = 82 screened 100% female Age; 22.3 (3.0) years (range 19–32) BMI 21.5 (2.7)	YFAS Completed on same day or within 1–2 weeks of task	CESD; FCQ-S	S	NR
Meule, 2014, Germany [64]	Cross-sectional/ case control	*n* = 109	Current BN *n* = 26 outpatient clinics, remitted BN *n* = 20 and control group *n* = 63	100% F Age: current BN 25.23 (5.82) years, remitted BN 25.55 (3.72) years, control 23.57 (4.20) years BMI: current BN 20.92 (1.92), remitted BN 21.92 (1.50), control 21.84 (2.65)	YFAS German version. No info re completion	EDEQ; DEBQ; Borderline Symptom List of BPD; Brief Symptom Inventory; CESD	D + S	NR
Meule *et al.* 2014, Germany [65]	Cross-sectional	*n* = 96	Individuals seeking bariatric surgery	65.6% F Obese BMI: 50.64 (8.99) age 39.92 (11.51)	YFAS	EDE-Q, CES-D	D + S	NR
Meule *et al.* 2015 Germany [66]	Cross-sectional	*n* = 50	OW/OB adolescents seeking WL (14–21 years)	62% F Age 16.5 (1.84) BMI 36.8 (6.18)	YFAS	EDEQ, CESD	D + S	NR
Meule *et al.* 2016 [67]	Cross-sectional	Study 1 *n* = 455 Study 2 *n* = 138	Study 1 80% University students	Study 1:89% F Age; 25.57 (6.97), BMI: 22.32 (3.6)5 Study 2: age 39.52 (10.71) BMI 48.8 (7.08)	Study1 + 2YFAS 2.0 German	Study 1: binge days items 13–15 of the EDEQ Study 2 Full EDEQ, BIS	D + S	NR
Meule *et al.* 2017 Austria [15]	Cross-sectional	*n* = 133	Individuals for bariatric surgery	77.4% F Age; FA 39.8 (10.6 NFA 39.6 (10.9) BMI FA 49.5 (7.51) NFA 48.1 (6.79)	YFAS 2.0 German version	EDEQ- binge eating questions only	D	NR
Nolan *et al.* USA 2016 [68]	Cross-sectional	*n* = 498	Student and community sample	Student 63% F Comm 59% F Age student 18.7 (0.1) Comm 44.5 (0.9) BMI student 24.5 (0.3) Comm 27.1 (0.4)	YFAS	Zung self-report depression scale, night eating, sleep quality	D + S	NR
Raymond *et al.* 2016 Australia [69,70]	Cross-sectional	*n* = 334	T2 Diabetes Individuals from a range of countries	65% F Age (27–81 years) Mean BMI 37.6 (7.99)	YFAS completed online	DASS-21	D	NR

Table 1. Continued

Author, year, country	Type of study	Number of participants	Population studied	Participant characteristics	YFAS details	Mental Health outcome assessment	Symptom (S)/ diagnosis (D)	Smoking status
Sanlier *et al.* 2016 Turkey [71]	Cross-sectional	n = 793	University Students	76% F n = 101 underweight, n = 615 normal weight, n = 77 OW/OB	YFAS – Turkey	BDI	D	NR
Tang *et al.* 2017 Singapore [72]	Cross-sectional	n = 1110	Social networking sites University College students	62% F Age 21.46 (1.80)	mYFAS	DSM5 Criteria (unclear if survey or interview) Depression, anxiety and mania	D + S	NR
Wolz *et al.* 2016, Spain [73]	Cross-sectional	n = 278	ED patients	92% F AN n = 68, BN n = 110, BED n = 39	YFAS – Spanish	EDI, UPPS, behavioural and substance addictions+ clinical interview	D + S	R
Wolz *et al.* 2017, Spain [17]	Cross-sectional	n = 315	ED patients	92% F n = 176 BN, n = 61 BED age 30.5 (10.79)	YFAS – Spanish	EDI, UPPS	S	NR
Yu *et al.* 2016, USA [74]	Cross-sectional	n = 967	College students	72.7% F BMI 23.89 (5.16) 6.3% AA	YFAS	EAT -26 broad symptoms of An and BN	D + S	NR

Wolz *et al.* 2017, Spain [17]	NR	5.36 (1.67)	NR	EDI 111.1 (40.79 UPPS – negative urgency 34.78 (6.30)	EDI and FA symptoms r = 0.18, UPPS r = 0.21, P < 0.05. The only direct predictor of FA in ED patients was negative urgency
Yu *et al.* 2016, USA [74]	FA 10.3% Nutrition students 9.5% non-nutrition 14%	1.91 (1.55) Nutrition 1.85 (1.35) non-nutrition 1.96 (1.72)	NR	BN/food pre occupation 1.31 (2.61) EAT score >20 10%	FA diagnosis increased over university years from 9.5% to 11% in nutrition students it went down from 17.9% to 7.7%, non-nutrition 12.7% to 14.5% from freshman year to senior

BDI, Beck Depression Inventory; BED, binge eating disorder; BES, binge eating survey; BMI, body mass index; BN, bulimia Nervosa; CESD, Centre of Epidemiological Studies Depression Scale; CTQ, Childhood Trauma Questionnaire; DEBQ, Dutch Eating Behavior Questionnaire; EDEQ, Eating Disorders Examination Questionnaire; EDS, EDI, eating disorder inventory; EAT, PFS, power food scale; FA,food addicted; HADS, Hospital Anxiety and Depression Scale; HW, healthy weight; NFA, not food addicted; NHS, National Health Survey; NR, not reported; OW/OB, overweight/obese; OW, overweight; UG, undergraduate; WL, weight loss; YFAS, Yale Food Addiction Scale.

Table 2 Outcomes of included studies

Author, year, country	Prevalence of FA as per YFAS diagnosis	YFAS symptoms, mean (SD)	Psychometric properties of YFAS	Mental Health outcomes	Association between YFAS outcomes (diagnosis and/or symptom scores) and mental health outcomes
Ahmed, 2016, Egypt [32,33]	FA diagnosis = 20.2% (n = 81)	Total number NR, most common symptom: persistent desire/ repeated unsuccessful attempts to quit (51%)	NR	Clinical BE 77 (19%), mild depression (18.5%), moderate depression (6%)	27.4% had probable BE and FA, and 33.8% clinical BE with FA ($P < 0.001$). FA and depression co-existed in 10.4%, FA and anxiety in 2%
Berenson, 2015, USA [34]	FA diagnosis = 2.8%	Median (IQR): Total sample = 1.0 (1–3), FA sample = 5.0 (4–6) Most common symptom: unsuccessful attempts to cut down	$\alpha = 0.87$	Mild depression n = 131, moderate depression n = 45, severe depression n = 27	BDI depression and FA symptom $r = 0.13$, $P < 0.01$
Boggiano, 2014, USA [35]	NR	Undergraduate students (UG) = 1.9 (1.3); Weight loss (WL) seeking participants = 3.1 (1.7); most common symptom NR	NR	BES scores: UG = 10.29 (7.3), WL = 16.4 (8.5)	BES scores were significantly associated with YFAS in UG group $\beta = 0.58$ and WL $\beta = 0.65$
Brunault, 2014, France [36]	FA diagnosis = 8.7%	Total sample = 1.9 (1.4) (95% CI 1.8–2.0); most common symptom NR	$\alpha = 0.76$	BES = 8.2 (8.9), BITE = 7.7 (6.4)	DIAGNOSIS: Diagnosis of FA associated with higher binge eating scores using BITE 20.5 (5.1) versus 6.5 (5.0) and BES total score 26.0 (10.2) versus 6.5 (6.6) ($P < 0.001$) SYMPTOM SCORE: YFAS symptom score was significantly correlated with binge eating scores using BITE ($r = 0.59$, $P < 0.001$), and BES ($P = 0.58$ $P < 0.001$)
Brunault, 2016, France [37]	FA diagnosis = 16.5%	Total number NR, most common symptom: persistent desire to control consumption (93.1%)	NR	Total sample (mean): BDI score = 8.1 (6.1), BES score = 11.0 (7.9); BDI score: FA 14.1 (7.4) versus NFA 6.9 (5.1); BES score: FA 21.3 (8.1) versus 9.1 (6.1)	Patients with FA reported higher prevalence of depression and binge eating than NFA
Brunault, 2017, France [38]	FA Diagnosis (overall) = 8.2%; Mild FA = 3.3%, Moderate FA = 2.1%, Severe FA = 3.0%	FA = 5.0 (3.5), NFA = 1.1 (1.8); most common symptom food consumed in larger quantities or longer period than intended	Confirmatory fit index 0.887	Eating disorders: AN = 1.5%, BN = 3.0% BED = 4.2%. FA and eating disorder: AN = 0%, BN = 0%, BED = 14.8%	Participants with FA had higher scores for BED, correlation between FA and BED $r = 0.60$ $P < 0.001$

Table 2. Continued

Author, year, country	Prevalence of FA as per YFAS diagnosis	YFAS symptoms, mean (SD)	Psychometric properties of YFAS	Mental Health outcomes	Association between YFAS outcomes (diagnosis and/or symptom scores) and mental health outcomes
Burmeister, 2013, USA [39]	FA diagnosis = 19.6%, Males = 19.3%, Females = 4.0%	Total sample = 3.13 (1.74); most common symptom NR	$\alpha = 0.90$	BES = 21.05 (7.98), CDES = 0.67 (0.46)	SYMPTOM SCORES: greater FA scores more likely to have psychological distress and depression ($r = 0.50$, $P < 0.01$). Higher FA scores positively related to BES ($r = 0.69$), emotional eating, difficulty controlling eating, weight bias internalisation. Higher YFAS scores negatively related to percentage weight loss at week 7 ($r = 0.24$, $P = 0.04$)
Ceccarini, 2015, Italy [40]	FA diagnosis = 34.1%	NFA = 2.7 (1), FA = 4 (1.1); most common symptom NR	$\alpha = 0.90$	BES: NFA = 9.4 (6.7), FA = 20 (9.3)	FA symptom scores with BES $r = 0.33$ $P < 0.01$
Chao, 2017, USA [41]	FA diagnosis = 6.7%	Total sample = 2.3 (1.6); most common symptom: persistent desire/unsuccessful attempts to quit (95%)	$\alpha = 0.71$	BED = 3.4%, Subclinical BED = 7.3%	Of those BED 50% also had FA, among those with FA 33.3% had BED or subclinical BED. The number of FA symptoms accounted for 19.1% variance in depressive symptoms. Individuals who had more FA symptoms had more depressive symptoms $r = 0.48$, $P < 0.001$
Chen, 2015, China [42]	FA diagnosis = 9.2%	Total sample: mean = 1.8, median = 1.0; most common symptom: persistent desire/unsuccessful attempts to quit	$\alpha = 0.83$	BES – NR	Correlations of symptom count with BES $r = 0.532$, $P < 0.001$
Clark, 2013, USA [22]	FA diagnosis = 53.7% (pre surgery)	NR	NR	BES – NR	DIAGNOSIS: Significant relationship between YFAS diagnosis and emotional eating ($r = 0.368$), and symptoms of eating disorders ($r = -0.269$ $P < 0.05$), no association with eating disorder severity, or the alcohol or drug test. SYMPTOM SCORE: Significant relationship between YFAS symptoms and emotional eating and binge eating scale (BES $r = 0.469$, $P < 0.05$). When controlling for eating disorders and emotional eating, YFAS explained 6% ($P = 0.014$) of variance in binge eating scores. Those meeting the FA criteria had poorer per- cent total weight loss outcomes (32% versus 27%)

Table 2. Continued

Author, year, country	Prevalence of FA as per YFAS diagnosis	YFAS symptoms, mean (SD)	Psychometric properties of YFAS	Mental Health outcomes	Association between YFAS outcomes (diagnosis and/or symptom scores) and mental health outcomes
Davis, 2011, USA [21]	FA diagnosis = 25%, Males = 6.9%, Females = 18.1%	NR	$\alpha = 0.92$	Binge Eating: FA = 72.2%, NFA = 24.1%; Severe Depression: FA = 27.8%, NFA = 3.8%	DIAGNOSIS: FA displayed greater addictive traits 16.2 (6.2) versus 12.5 (3.7) ($P = 0.003$) and lower levels for delay of discounting and gratification 231.7 (138.2) versus 306.5 (123.2) ($P = 0.035$). FA reported greater binge eating traits 4.2 (1.2) versus 2.1 (1.5), hedonic eating 84.5 (15.4) versus 56.7 (18.8), emotional eating 4.2 (0.6) versus 3.1 (1.0), food cravings 177.8 (28.2) versus 127.2 (32.3), and snacking on sweets 22.8 (5.0) versus 18.0 (4.2) ($P < 0.0001$) SYMPTOM SCORE: Addictive traits, hedonic eating, snacking on sweets and binge eating scores accounted for 56% variance in YFAS symptom scores. No significant difference in smoking status between FA and NFA
Davis, 2013, Canada [18]	FA diagnosis = 17.5%, Males = 4.2%, Females = 13.3%	NR	$\alpha = 0.92$	BES score: FA 3.8 (1.4) versus NFA 1.6 (1.6) ($P < 0.01$)	DIAGNOSIS: Significant associations between FA and binge eating ($\beta = 0.57$). Emotional eating $r = 0.21$, cravings $r = 0.04$; 24% met diagnostic criteria for BED
deVries, 2016, Germany [43]	FA diagnosis (overall) in BN = 95.7%, Mild FA = 0.91%, Moderate FA = 5.46%, Severe FA = 93.6%. FA diagnosis (overall) in control = 14.4%, Mild FA = 69.4%, Moderate FA = 14.3%, Severe FA = 16.3%	BN = 8.91 (2.22), Controls = 2.0 (2.79); most common symptom NR	$\alpha = 0.97$	Depression scale: BN = 28.6 (8.99), Controls = 12.9 (8.92), BN = 35.9 (7.46), Controls = 30.8 (5.89)	Symptoms with depression β 0.09, group 5.74, group × time −0.04 (linear regression)
Eichen, 2013, USA [44]	FA diagnosis = 15.2% (baseline)	Total sample = 2.57 (1.67), 45% reported ≥3 symptoms. Most common symptoms: inability to cut down or stop eating (96.1%); continued use despite consequences (44.4%); tolerance (36%)	$\alpha = 0.76$	BDI = 10.3 (8.0)	FA had higher total BDI scores 17.1 (6.6) ('mild' range) compared to NFA 9.2 (7.7) ('minimal' range) ($P < 0.001$) YFAS symptom correlated with BDI $r = 0.48$

Table 2. Continued

Author, year, country	Prevalence of FA as per YFAS diagnosis	YFAS symptoms, mean (SD)	Psychometric properties of YFAS	Mental Health outcomes	Association between YFAS outcomes (diagnosis and/or symptom scores) and mental health outcomes
Flint, 2014, USA [45]	FA diagnosis: Whole sample = 5.8%; NHS II = 8.4%; NHS = 2.7%. mYFAS – 9.0% YFAS – 11.4%	Most common symptoms – NHS: consumption despite significant problems (15.6%); eating same amount of food does not produce same feelings (18.4%); NHS II: consumption despite significant problems (22.3%); cutting down foods (22.9%); consume foods despite not being hungry (17.8%)	mYFAS $\alpha = 0.75$ and YFAS 2012 $\alpha = 0.84$	FA and depression: NHS = 16.1%, NHS = II 7.3%	Using the mYFAS there were significantly associations with binge eating scores ($t = 0.05$, $\beta = 0.33$, $P < 0.001$) and standard YFAS symptom ($t = 5.05$, $\beta = 0.48$, $P < 0.001$). Depression positively associated with FA in and NHS (PR 2.60 95% CI 2.28–2.97). Compared with never smoking, former smoking was positively associated with FA: NHSII (PR1.19 95% CI 1.12–1.26) and NHS (1.20, 1.07–1.36). Current smoking was inversely associated with FA: NHSII (0.69, 0.59–0.81) not significant in NHS
Frayn, 2016, Canada [46]	FA diagnosis = 100% ($n = 31$)	NR	$\alpha = 0.93$	EDE-Q FA versus NFA: Restraint 2.92 (1.13) versus 109 (0.99), Eating concern 3.14 (0.95) versus 0.57 (0.66), Shape concern 4.54 (0.96) versus 1.98 (1.32), Weight concern 3.99 (1.25) versus 1.64 (1.32)	FA had higher depression scores compared with NFA 19.41 (40.5) versus 13.82 (4.03), and FA had higher anxiety scores compared with NFA 25.58 (6.38) versus 17.23 (5.05)
Gearhardt, 2009, USA [5]	FA diagnosis = 11.4%	Total sample, median = 1; most common symptom NR	$\alpha = 0.75$	NR	DIAGNOSIS: FA diagnosis accounted for 5.8% unique variance in binge eating scores SYMPTOM SCORE: YFAS symptom count accounted for 14.8% unique variance in binge eating, correlations with BIS $r = 0.35$, EAT $r = 0.46$, EES $r = 0.51$
Gearhardt, 2012, USA [24]	FA diagnosis = 56.8%	Total sample = 4.56 (1.9) in those with FA most common symptom unable to cut down, use despite consequences	Factor structure χ^2 (14) = 15.08, *P*: 0.373, RMSEA = 0.03TLI 0.98 CFI 0.99, single factor model 77.8 of variance	Depression: FA = 72%, NFA = 40.6%; Anxiety: FA = 58.1%, NFA = 40.6%	FA not significantly related to anxiety, alcohol and drug use disorder diagnosis but significantly related to mood disorder diagnoses ($P = 0.01$), specifically major depressive disorder ($P = 0.06$). YFAS symptoms positively correlated with BDI ($r = 0.35$), and negatively correlated with self-esteem ($P < 0.01$). YFAS positively correlated with restraint and frequency of binge eating ($r = -0.27$), ($P < 0.01$), and eating disorder psychopathology ($P < 0.05$) YFAS scores accounted for 6.3% unique variance in binge eating scores ($P = 0.28$)

Table 2. Continued

Author, year, country	Prevalence of FA as per YFAS diagnosis	YFAS symptoms, mean (SD)	Psychometric properties of YFAS	Mental Health outcomes	Association between YFAS outcomes (diagnosis and/or symptom scores) and mental health outcomes
Gearhardt, 2013, USA [47]	FA diagnosis = 41.5%	Total sample = 4.33 (1.81); In those with FA most common symptom NR unable to cut down, great deal of time spent	NR	BDI = 15.09 (9.78)	DIAGNOSIS: FA diagnosis significantly associated with earlier age of being OW ($P = 0.014$) SYMPTOM SCORE: YFAS positively correlated with negative affect and emotional dysregulation, and negatively correlated with self-esteem ($P = 0.01$). YFAS scores positively correlated with frequency of binge eating, eating concern, and weight concern ($P < 0.05$) YFAS correlation with depression $r = 0.50$. FA not related to anxiety, alcohol or drug disorder
Gearhardt, 2014, USA [48]	FA diagnosis: Total = 25.7%; FA + BN = 83.6%; FA + BED = 47.2%	Total sample = 3.05 (2.0); most common symptom NR	$\alpha = 0.77$	EDE-Q total: FA = 3.99 (1.06), NFA = 2.35 (24)	FA diagnosis significantly associated with all disordered eating variables including binge eating behaviors ($P < 0.001$, $r = 0.27$). FA had significantly higher objective and subjective binge eating episodes, and were higher on all scales of the EDE-Q than NFA. BN + FA had highest subjective binge episodes compared to other groups followed by BED + FA ($P < 0.001$). Significantly higher restraint in FA ($P < 0.001$)
Gearhardt, 2014, USA [10]	NR	Total sample = 3.06 (2.13); most common symptom NR	NR	NR	Average craving = 2.97, Average restraint scale = 3.12 (1.67) (out of 6), Greater YFAS symptoms associated with higher cravings for high fat foods $d = 0.415$)
Gearhardt, 2016, USA [8]	Study 1: FA diagnosis (overall) = 14.6%; Mild FA = 1.7%, Moderate FA = 1.9%, Severe FA = 11% Study 2: FA diagnosis (overall) = 15.8%; Mild FA = 2.4%, Moderate FA = 1.9%, Severe FA = 11.5%	Total sample: Study 1 = 2.38 (3.19) Study 2 = 2.19 (1.71); most common symptom: withdrawal/ unable to cut down	$\alpha = 0.92$	Study 1 – Binge frequency: NFA = 1.32 (2.23), Mild FA = 3.33 (4.90), Moderate FA = 2.50 (4.20), Severe FA = 5.46 (3.68) Study 2 – Binge frequency not reported	Study 1: YFAS symptom with binge eating $r = 0.61$, $P < 0.05$ Study 2: YFAS symptom with Binge eating $r = 0.68$, $P < 0.05$

Table 2. Continued

Author, year, country	Prevalence of FA as per YFAS diagnosis	YFAS symptoms, mean (SD)	Psychometric properties of YFAS	Mental Health outcomes	Association between YFAS outcomes (diagnosis and/or symptom scores) and mental health outcomes
Granero, 2014, Spain [49]	FA diagnosis: ED = 72.8%, HC = 2.4%, AN = 6.3, BN = 5.3, BED = 5.92, EDNOS = 4.1	ED = 4.66, HC = 1.74; most common symptom HC unable to cut down, use depite consequences ED unable to cut down, tolerance/great deal of time spent	ED sample $\alpha = 0.71$; total sample $\alpha = 0.95$	NR	YFAS FA diagnosis between ED subtypes not significantly different: 60% AN, 81.5% BN, 76% BED, and 72.2% EDNOS. Significantly higher prevalence of FA diagnosis ($P < 0.001$), symptom scores ($P < 0.001$) and all symptoms excluding 'continued use despite consequences' in ED compared to controls ($P \leq 0.003$). The DSM addiction criteria was lowest for AN restricting subtype and highest for BN, AN-BP and BED. BMI and number of binges per week positively correlated with YFAS scores, SYMPTOM associated with Symptom checklist – depressive $r = 0.364$, anxiety $r = 0.253$
Hilker, 2016, Spain [50]	FA diagnosis: Baseline = 90.6%, Post treatment = 72.9%	Total sample (baseline) = 6.1 (1.2) Only 2 FA symptoms did not decrease post treatment 'persistent desire and tolerance'	NR	Mean onset of BN = 18.6 (5.6) years, and mean duration = 10.6 (9.1) years	Higher FA severity predicted lower likelihood of total abstinence from purging/bingeing although it did not predict being a good responder
Imperatori, 2014, Italy [51]	FA diagnosis = 33.9%	Total sample = 2.68 (1.89); most common symptom NR	$\alpha = 0.87$	BES = 14.15 (9.34), Anxiety = 0.74 (0.66), Depression = 0.93 (0.80)	28.9% FA met criteria for BED compared to 4.1% of NFA. YFAS had strong positive correlation with BES ($r = 0.78$, $P = 0.0045$), and moderate positive correlations with all the SCL-90-R psychopathology criteria including depression ($r = 0.49$) and anxiety ($r = 0.43$, all $P = 0.0045$) except phobic anxiety. More severe FA was associated with more severe psychopathology when mediated by BES ($P < 0.001$)
Imperatori, 2014, Italy [20]	FA diagnosis = 14.29%	Total sample: ≥3 symptoms 3.79 (1.19); most common symptom NR	$\alpha = 0.83$	HADS anxiety ≥3 symptoms = 9.13 (5.11), <2 symptoms = 6.18 (2.09); Depression >3 symptoms = 6.75 (5.09), <2 symptoms = 3.55 (48)	No significantly differences between HADS anxiety and depression between FA and control
Imperatori, 2016, Italy [52]	FA diagnosis = 8.0%	Total sample = 2.99 (1.96); most common symptom NR	$\alpha = 0.88$	BED prevalence = 13%, BED mean score = 14.06 (9.70). Diagnosis of FA and clinical BED = 17.3%	Association between YFAS symptoms and BES $r = 0.71$, $P < 0.01$, HADS anxiety $r = 0.39$ and HADS depression 0.41, childhood trauma $r = 0.37$, $P < 0.001$

Table 2. Continued

Author, year, country	Prevalence of FA as per YFAS diagnosis	YFAS symptoms, mean (SD)	Psychometric properties of YFAS	Mental Health outcomes	Association between YFAS outcomes (diagnosis and/or symptom scores) and mental health outcomes
Innamortori, 2015, Italy [53]	FA diagnosis (original YFAS): Controls = 11%, OW/OB = 52.3%. FA diagnosis (YFAS-16): Controls = 1.7%, OW/OB = 21%	Total number NR, most common symptoms: Persistent desire or unsuccessful attempts to cut down (91%), tolerance (51.7%)	$\alpha = 0.85$	NR	Diagnosis of FA successfully differentiated between OW/OB and controls in YFAS-16 ($P < 0.001$). YFAS-16 strongly correlated with BES total scores ($r = 0.68$, $P < 0.001$). Both the YFAS score and BES score were predictive of BMI
Innamorti, 2017, Italy [54]	High risk for FA = 7.1%	Participants of high risk for FA = 4.04 (1.07); most common symptom NR	$\alpha = 0.78$	BES participants at high risk for FA = 18.17 (8.76)	Correlation between symptoms and BES $r = 0.59$, $P < 0.01$, with alcohol $r = 0.20$, $P < 0.01$
Ivezaj, 2016 USA [55]	FA diagnosis = 26.7%	Total sample 2.4 (1.5)	NR	BED = 12%	Of those with BED 31.7% met the criteria for BED of those with FA 27.627.6 met BED criteria
Koball, 2016, USA [56]	FA diagnosis = 14%	Total sample = 2.4 (1.6), most common symptom: 'persistent desire/unsuccessful reports to quit	NR	BED: FA $n = 49$, NFA $n = 81$ Eating self efficacy: FA = 45.4 (1.6), NFA = 58.1 (0.6) No significant difference in childhood trauma scores	Patients who screened positive for FA endorsed mild/moderate levels of depression, whereas NFA had minimal depression score. Patients who screened positive for FA were more likely to report binge eating episodes, night-time eating and low eating self-efficacy. When controlling for binge eating the relationship between FA and night-time eating remained significant. Presurgical FA had no relationship with weight loss at 6 months
Laurent, 2015, USA [57]	FA diagnosis = 4%	15% ≥3 symptoms, most common symptom: given up activities	Factor score $\alpha = 0.61$, and aggregate score $\alpha = 0.89$	NR	YFAS-C symptom score was significantly associated with CDI ($P = 0.018$) r value not reported. No relationship with BMI Z-score
Lee, 2014, Australia [58]	FA diagnosis = 12%	Total number NR, most common symptoms: persistent desire or unsuccessful attempts to cut down (86%), and continued consumption despite adverse effects (29%)	NR	EDE-Q = 1.72 (0.96)	No difference in FA rates in Australian versus USA groups. Overall EDE-Q was higher among the $n = 59$ participants with FA 3.66 (1.33) versus 1.44 (1.08) NFA
Loxton, 2017, Australia [59]	NR	Total sample = 1.56 (1.34); most common symptom NR	$\alpha = 0.83$	BED = 1.23 (1.43)	YFAS scores were significantly associated with anxiety $r = 0.34$, depression $r = 0.34$, and stress $r = 0.37$

Table 2. Continued

Author, year, country	Prevalence of FA as per YFAS diagnosis	YFAS symptoms, mean (SD)	Psychometric properties of YFAS	Mental Health outcomes	Association between YFAS outcomes (diagnosis and/or symptom scores) and mental health outcomes
Mason, 2014, USA [60]	FA diagnosis: Total group = 8%, no PTSD symptoms = 6%, with 6–7 PTSD symptoms = 18%	NR	NR	No PTSD symptoms = 34%, 1–3 symptoms = 39%, 4–5 symptoms = 17%, 6–7 symptoms = 10%	In age adjusted analysis PTSD were associated with prevalence of FA in dose response manner with PRs relative to no trauma 0.96 95% CI (0.87, −1.07), 1.26 (1.14, 1.39), 1.86 (1.67, 2.05) and 2.93 (2.64, −3.25) for trauma no PTSD symptoms and from 1 to 3, 4 to 5, and 6 to 7 symptoms, respectively. Among women with at least 1 PTSD symptom the age at symptom onset was significantly associated with FA. Earlier onset predicts a higher baseline prevalence of FA, but does not influence the dose response association between additional PTSD symptoms and prevalence of FA.
Meule, 2012, Germany [63]	FA diagnosis: Low FA group = 60%, High FA group = 40%	Low FA group = 0.83 (0.38) (range 0–1), High FA group = 2.65 (0.75) (range 2–4); most common symptom NR	$\alpha = 0.83$	NR	HIGH versus LOW FA: High FA group were younger ($P < 0.05$) and had higher levels of self-reported attentional impulsivity 10.10 (2.10) versus 8.70 (2.45) ($P < 0.05$) SYMPTOM SCORE: FA symptoms positively correlated with depressive symptoms ($r = 0.29$, $P < 0.05$)
Meule, 2014, Germany [64]	FA diagnosis: Current BN = 100%, Remitted BN = 30%, Control group = 0%	Current BN = 6.27 (1.04), Remitted BN = 3.95 (1.79), Control = 0.86 (0.90), ($P < 0.001$) Most common symptoms: persistent desire or unsuccessful attempts to cut down, giving up activities and withdrawal symptoms	$\alpha = 0.94$	EDE-Q total = 4.21 (0.81)	All individuals with current BN, six with remitted BN and none of the women in the control group received a FA diagnosis. DIAGNOSIS: FA group had higher eating disorder psychopathology ($P < 0.001$). FA had higher depression scores ($P < 0.001$) and binge eating behavior ($P < 0.001$) SYMPTOM SCORE: YFAS symptom score positively correlated with all measures of eating disorder psychopathology (total $r = 0.82$, $P < 0.001$ Higher number FA symptoms related to depression ($r = 0.60$, $P < 0.001$) and binge eating behaviors ($r = 0.65$, $P < 0.001$)
Meule, 2014, Germany [65]	FA diagnosis = 70%	Total sample = 3.39 (1.75); most common symptom NR	$\alpha = 0.83$	Binge days: FA = 9.09 (9.28), NFA = 2.48 (3.55); Depression: FA = 28.55 (11.34), NFA = 17.82 (10.00)	Correlations with binge days $r = 0.45$ ($P < 0.01$), depression $r = 0.45$ ($P < 0.01$)

Table 2. Continued

Author, year, country	Prevalence of FA as per YFAS diagnosis	YFAS symptoms, mean (SD)	Psychometric properties of YFAS	Mental Health outcomes	Association between YFAS outcomes (diagnosis and/or symptom scores) and mental health outcomes
Meule, 2015, Germany [66]	FA diagnosis = 38%	Total sample = 3.38 (2.11), most common symptom: repeated unsuccessful attempts	α = 0.88	Binge days = 2.29 (3.9); BED n = 6, depression n = 5, CED depression = 23.16 (12.07)	Individuals with FA reported more binge days and had more symptoms of depression. Binge eating days (r = 0.32, P < 0.01), depression r = 0.61 (P < 0.01)
Meule, 2016, Germany [67]	Study 1: FA diagnosis (overall) = 9%; Mild FA = 1.3%, Moderate FA = 1.8%, Severe FA = 6.6%. Study 2: FA diagnosis (overall) = Mild FA = 11.3%, Moderate FA = 15%, Severe FA = 21.1%	Total number NR, most common symptoms: amount consumed and repeated attempts to cut down	Study 1 α = 0.90, Study 2 α = 0.87	Binge days – Study 1: FA = 9.98 (7.93), NFA = 1.19 (2.82) Study 2: FA = 8.39 (8.60), NFA = 2.32 (4.46)	In both studies participants with YFAS diagnosis had more binge days (Study 1 r = 0.74, and Study 2 r = 0.58). Sex not associated
Meule, 2017, Austria [15]	FA diagnosis = 47.4%	NR	α = 0.867	Binge days: FA = 8.39 (8.60), NFA = 2.32 (4.46)	Regression coefficients with BIS sub scales and control variables in predicting YFAS 2.0 BE days β 0.15 (0.04) Impulsivity (all) β 0.02 (0.01)
Miller-Matero, 2014, USA [61]	FA diagnosis = 16.9%	43% reported ≥3 symptoms 98.6% >1 symptom; most common symptom NR	NR	HADS: anxiety = 12%, depression = 14.8%	Depression (r = 0.47) and anxiety (r = 0.42) symptoms were all associated with higher FA symptoms
Mitchell, 2016, USA [62]	FA diagnosis = 2%	Norm = 1.7 (0.4) Full sample = 1.33 (1.18) Males = 1.28 (1.14); most common symptom NR	α = 0.86	NSES: Normative sample = 0, Full sample = 4.55 (5.1), Males = 4.22 (4.9); BN = 3%, PTSD = 13%	FA symptoms and PTSD r = 0.438
Nolan, USA, 2016 [68]	FA diagnosis: Student = 4.7%, Community = 12.7	Student = 1.9 (0.1), Community = 1.9 (0.1); most common symptom NR	α = 0.83	Depression: Student = 37.8 (0.6) (10.2%) Community = 38.5 (0.7) (14.3%) NEQ: Student = 13.6 (0.3) Community 14.3 (0.5)	Associations between YFAS and depression (Students r = 0.39 Community r = 0.50), YFAS with NEQ (Students r = 0.32, Community r = 0.59) P < 0.01. YFAS with sleep (Students r = 0.21, Community 0.41)

Table 2. Continued

Author, year, country	Prevalence of FA as per YFAS diagnosis	YFAS symptoms, mean (SD)	Psychometric properties of YFAS	Mental Health outcomes	Association between YFAS outcomes (diagnosis and/or symptom scores) and mental health outcomes
Raymond, 2016, Australia [69,70]	FA diagnosis = 70%	Total sample = 4.7 (2.2); most common symptom NR	NR	Depression: *t* 27.59, Anxiety: *t* 24.56, Stress: *t* 25.04. All levels higher in Australian population	Correlations YFAS symptoms with DASS Anxiety ($r = 0.78$) depression ($r = 0.79$) ($P < 0.01$). BMI and FA accounted for 63% variation in individuals depression scores, FA made more of a contribution than BMI. BMI and FA accounted for 62% variation in anxiety, FA more contribution than BMI
Sanlier, 2016, Turkey [71]	NR	FA underweight = 3.26 (1.21), Normal weight = 3.41 (1.33), OW/OB = 3.77 (1.54); Males = 3.43 (1.34), Female = 3.52 (1.39); most common symptom NR	$\alpha = 0.76$	Depression: Underweight = 13.42 (9.84), Normal = 12.63 (8.09), OW/OB = 13.42 (7.99)	Depression and FA $r = 0.297$, $P = 0.05$
Tang, 2017, Singapore [72]	FA diagnosis = 4.7%	NR	$\alpha = 0.85$	NR	Those with FA 3.7% had depression, 4.7% anxiety, and 4.3% mania
Wolz, 2016, Spain [73]	FA diagnosis (overall) = 74.8; AN = 55.9%, BN = 89.1%, BED = 87.2	Total sample = 4.76 (1.89), AN = 3.51 (1.71), BN = 5.69 (1.46), BED = 5.92 (1.36); most common symptom NR	$\alpha = 0.92$	Already defined numbers on groups	Sex, age and ED diagnostic type had a predictive capacity of $r^2 = 0.22$, positive YFAS screening is increased by high scores in reward dependence and negative urgency + a low score in the lack of premediation scale, whereas negative urgency was seen as the strongest predictor of FA. Goodness of fit $P = 0.408$
Wolz, 2017, Spain [17]	NR	Total sample = 5.36 (1.67); most common symptom NR	NR	EDI = 111.1 (40.79), UPPS – negative urgency = 34.78 (6.30)	EDI and FA symptoms $r = 0.18$, UPPS $r = 0.21$, $P < 0.05$. The only direct predictor of FA in ED patients was negative urgency
Yu, 2016, USA [74]	FA diagnosis (overall) = 10.3%; Nutrition students = 9.5%, non-Nutrition students = 14%	Total sample = 1.91 (1.55), Nutrition = 1.8 (1.35), non-Nutrition = 1.96 (1.72); most common symptom. Have tried unsuccessfully/continued despite problems	NR	BN/food pre occupation = 1.31 (2.61), EAT score >20 = 10%	FA diagnosis increased over university years from 9.5% to 11%. In Nutrition students it went down from 17.9% to 7.7%, and non-Nutrition 12.7% to 14.5% from freshman year to senior

AN, anorexia nervosa; BDI, Beck Depression Inventory; BE, binge eating; BED, binge eating disorder; BES, binge eating survey; BITE, Bulimic Investigatory Test Edinburgh; BMI, Body mass index; BN, bulimia nervosa; CESD, Centre of Epidemiological Studies Depression Scale; EAT, Eating Troubles Module; ED, eating disorder; EDE-Q, Eating Disorders Examination Questionnaire; EDNOS, eating disorder not otherwise specified; EES, emotional eating scale; FA, food addiction; HADS, Hospital Anxiety and Depression Scale; HC, healthy control; NEQ, night eating questionniare; NFA, non food addiction; NHS, National Health Survey; NR, not reported; NSES, National stressful events survey; OW/OB, overweight/obese; PTSD, post-traumatic stress disorder; UPPS, Impulsive Behavior Scale; YFAS, Yale Food Addiction Scale.

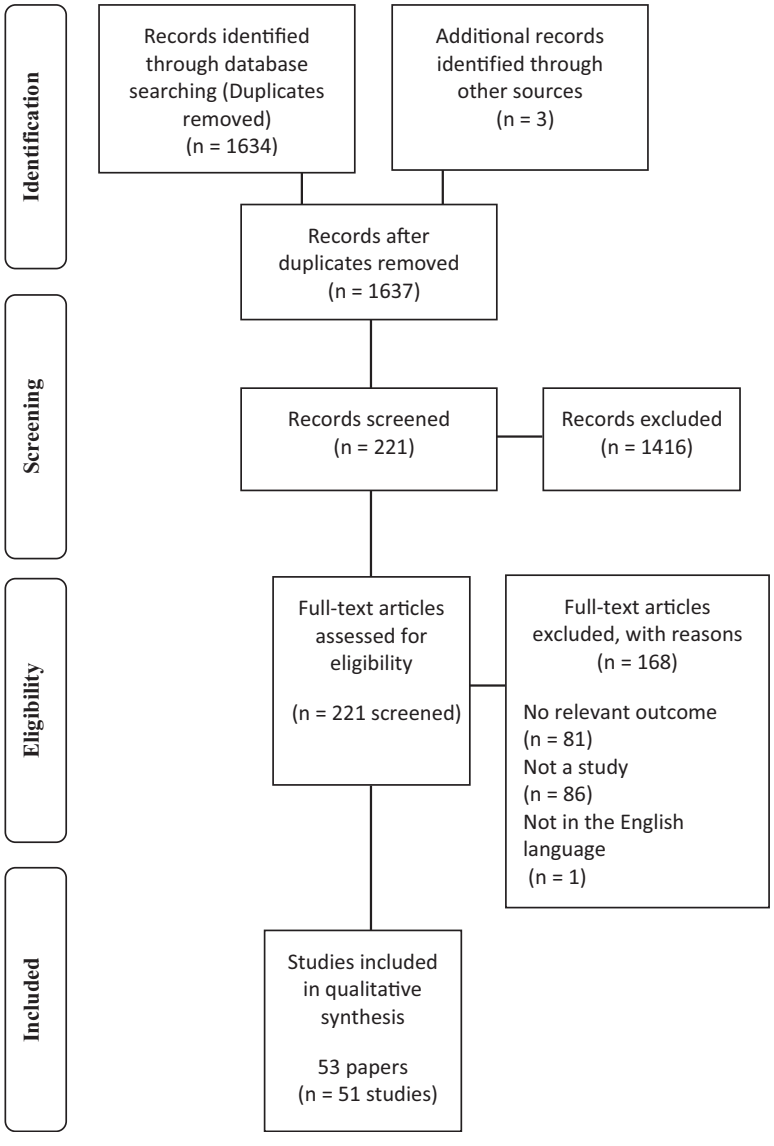


Figure 1 Flow diagram of studies included in the present review.

disorder subtypes: anorexia nervosa or eating disorder not otherwise specified (EDNOS).

Fifty-two studies reported the weight status of the population group, with many doing so objectively through direct measures of height and weight (n = 20 studies). A substantial proportion used self-reported measures only to determine weight status (n = 21 studies), with a further nine studies being unclear in their methods. Weight status was commonly reported as BMI, with 25 studies specifically in population groups where the mean BMI of the population group was classified as overweight/obese category BMI ≥25 [10,18,20,21,24,39,44,47,48,51,53]. Most studies were conducted in predominantly Caucasian populations. Fifteen studies included a population group other than Caucasian; however, other population groups such as African American or Hispanic were often in the minority and constituted <35% of the total study population [5,8,22,24,34,35,39,41,44,47,48,55,58,60].

Risk of bias

The majority of studies (77%; n = 41), were classified as neutral quality, 20% studies scored ≤4 (n = 11) and only one study rated as positive quality with a score of eight [49] (see Supporting information, Table S1). Eleven studies used an objective measure to assess mental health outcomes through use of a clinical interview, with others using a self-reported measure [17,40,41,45,49,56,61,73] for both mental health and FA. The exclusion criteria was adequately reported in the majority of studies, only one study reported specific exclusion of antidepressant medications that may be implicated in weight gain [47], two

studies excluded those with major depression [44,53], two studies excluded those with diagnosed axis I disorders [20,82] and one study excluded those with extreme alcohol use disorder [65]. A Funnel plot was generated for all the included studies, and this demonstrated that there was no publication bias in the included studies.

Food addiction outcomes

Forty-four of the 51 studies utilised the standard version of the YFAS, of which six had been converted to and validated in the following non-English languages: Italian ($n = 6$) [20,40,51–54], French ($n = 3$) [36–38], German ($n = 3$) [15,64,67], Spanish ($n = 4$) [17,49,50,73], Arabic ($n = 1$) [76,82], Chinese ($n = 1$) [42] and Turkish ($n = 1$) [71]. Three studies used the shorter version of the YFAS, referred to as the modified YFAS (mYFAS), which comprises nine questions rather than the standard 25 items [45,60,72]; these studies were larger population-based surveys. One study by Flint *et al.* [45] used both versions of the YFAS and found the prevalence of FA to be lower (9%) when using the shortened tool (mYFAS) compared to the full-length version (11.4%). Two studies used the YFAS-Children version and five studies used the revised YFAS 2.0 tool [8,15,38,43,67], which has also been converted to both French [38] and German [15,67].

Thirty-seven studies reported both diagnosis and symptom scores from the YFAS, whereas six reported diagnosis only and six symptom score only (Table 2). For diagnosis, meta-analysis ($n = 36$ studies) showed the average prevalence of FA was 16.2% (lower and upper limit 13.6–19.3%) (Fig. 2a). Three studies reported the prevalence by sex, with women and girls having a higher prevalence than men (mean = 15.4%, range: 10.2–22.8% versus mean = 10.3%, range 4–24%; $P < 0.05$). Four studies reported the prevalence of FA in disordered eating populations groups, although these were not eligible for meta-analysis because of insufficient studies that were not directly comparable (different disordered eating types, subtypes of eating disorders and differences in the reporting of prevalence of FA (i.e. only those endorsing food addiction were recruited; therefore, the prevalence was 100%). For BN, FA diagnosis rates ranged from 5.3% to 89.1% [48,49,73], with a 30% FA rate reported in those with remitted BN [64]. The rate of FA diagnosis ranged from 5.92% to 87.2% for BED [48,73], 6.3–55.9% for anorexia nervosa and 4.1% for EDNOS [49,73]. For those studies that used the revised YFAS 2.0 ($n = 5$), an additional classification of 'mild' FA occurred in 1.3–3.3%, moderate in 1.5–2.1% and severe in 3–21%.

From a meta-analysis ($n = 26$ studies) reporting on FA symptoms, the mean number of reported symptoms was 3.3 (2.85–3.92). There were sufficient similar studies reporting FA symptoms for a subanalysis of population groups within these studies. The mean number of FA symptoms in those seeking treatment for weight loss ($n = 9$ studies) was 3.01 (upper and lower limit 2.65–3.37) and 5.2 (3.6–6.7) for those with disordered eating ($n = 7$ studies). Twenty studies reported the most common symptoms endorsed, with 13 studies reporting the symptom of repeated unsuccessful attempts to cut down and eight reporting persistent desire as the most common with consumption despite significant consequences reported in six studies [44,45] and, in addition, one study in children reporting the symptom of giving up social activities [57].

Relationships between FA, smoking and other substance use were reported in several studies. There were mixed results observed for FA diagnosis with smoking, with no significant correlation reported with FA in one study [21] and an inverse association reported in another [45]. Three studies reported no significant correlation between FA diagnosis and alcohol or drug use [22,24,47].

The psychometric properties of the YFAS were reported in 33 studies, primarily as a Cronbach alpha (α). A meta-analysis of these studies indicated a mean α of 0.86, with lower and upper limits of 0.84 and 0.88. Those specifically using YFAS 2.0 tool ($n = 5$ studies) reported a mean α of 0.93 (0.86–0.97). One study by Granero *et al.* [49] calculated the psychometric properties within population subgroups; those with a diagnosed eating disorder reported a lower α than that of the whole sample (0.71 and 0.95, respectively). One study used both the standard and mYFAS within the same study, and it was considered that the mYFAS had similar psychometric properties to the standard version, both with $\alpha = 0.75$ [45].

Mental health outcomes

The most common mental health conditions reported alongside FA, in descending order, were: disordered eating ($n = 28$ studies); depression ($n = 21$ studies); anxiety ($n = 7$ studies); and post-traumatic stress disorder ($n = 2$ studies). Binge eating was the most common eating disorder within the disordered eating studies, primarily assessed through either the Binge Eating Scale (BES, $n = 13$ studies) or the Eating Disorder Examination Survey (EDES, $n = 13$ studies). For the BES, participants reported scores ranging from 3.8 to 21.05 and, for the EDES, scores ranged from 1.72 to 3.99. Depression was primarily assessed through use of either the Centre of Epidemiological Depression scale ($n = 5$ studies, scores ranged from 0.67 to 1.72) or the Beck Depression inventory ($n = 8$ studies, scores ranged from 8.1 to 15.03).

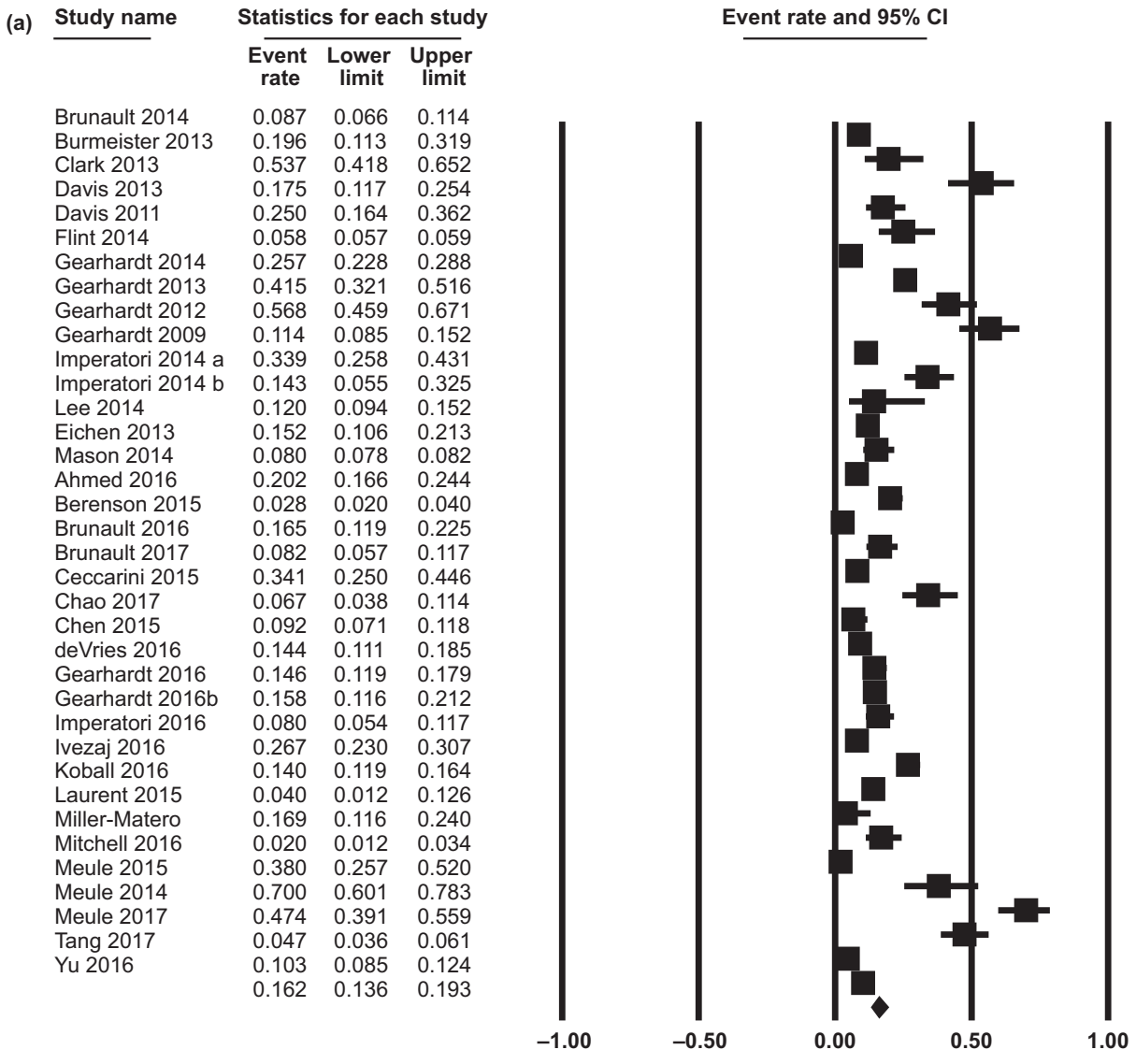


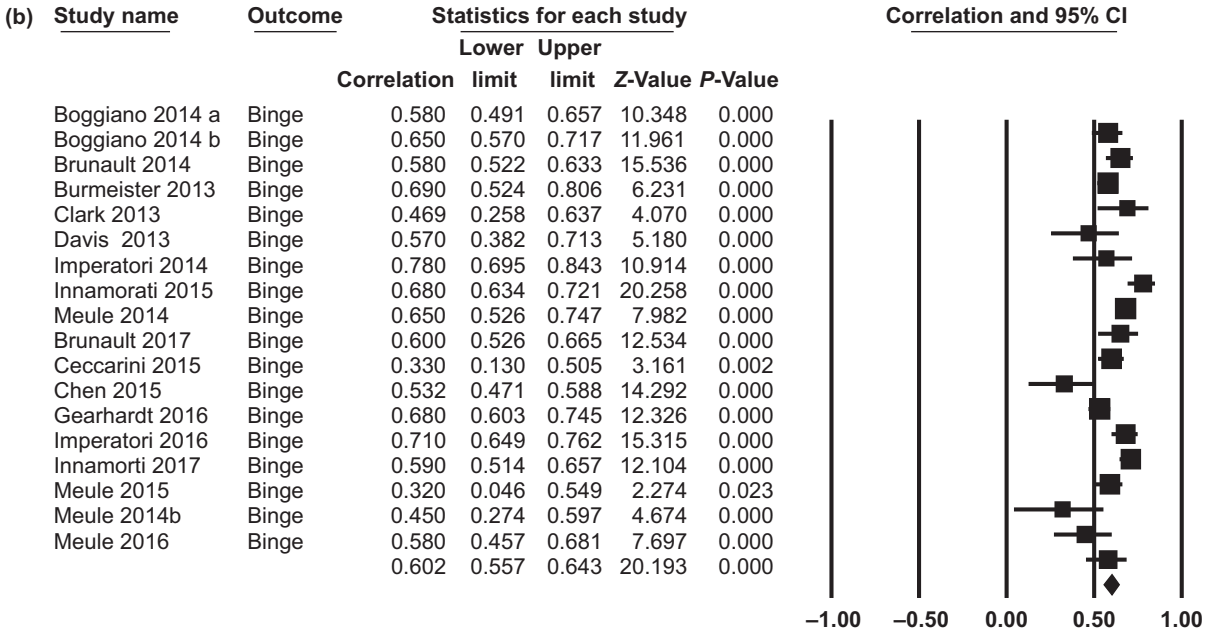
Figure 2 (a) Forest plot of food addiction prevalence. (b) Forest plot of binge eating and food addiction. (c) Forest plot of depression and food addiction.

Associations between food addiction, disordered eating and depression

Meta-analysis was possible because of the number of studies reporting similar outcome measures and associations between YFAS (FA) and (i) binge eating (n = 18 studies), depression (n = 18 studies) and anxiety (n = 5 studies). The weighted mean correlation (weighted for sample size) between binge eating (assessed by the BES and EDEQ) and FA was 0.602 (0.557–0.643) ($P < 0.05$, I^2: 76.37) (Fig. 2b). For depression and FA, the weighted mean correlation was 0.459 (0.358–0.550) ($P < 0.05$, I^2: 93.74) (Fig. 2c). For anxiety, the mean correlation with FA was 0.483 (0.228–0.676) (I^2: 96.27, $P < 0.001$). Sensitivity analyses showed no significant difference between the two depression measures used in the included studies: the CESD [r = 0.488 (0.298–0.640) ($P < 0.05$, n = 3 studies)] or the BDI [0.401 (0.279–0.510) ($P < 0.05$, n = 5 studies)]. A sensitivity analysis was not able to be completed for the different measures of binge eating or anxiety because too few studies for meaningful comparison.

Associations with other mental health outcomes

Although the included studies assessed a range of mental health outcomes, there was very little consistency between them with respect to the types of measures used, precluding meta-analysis of other mental health outcomes. For



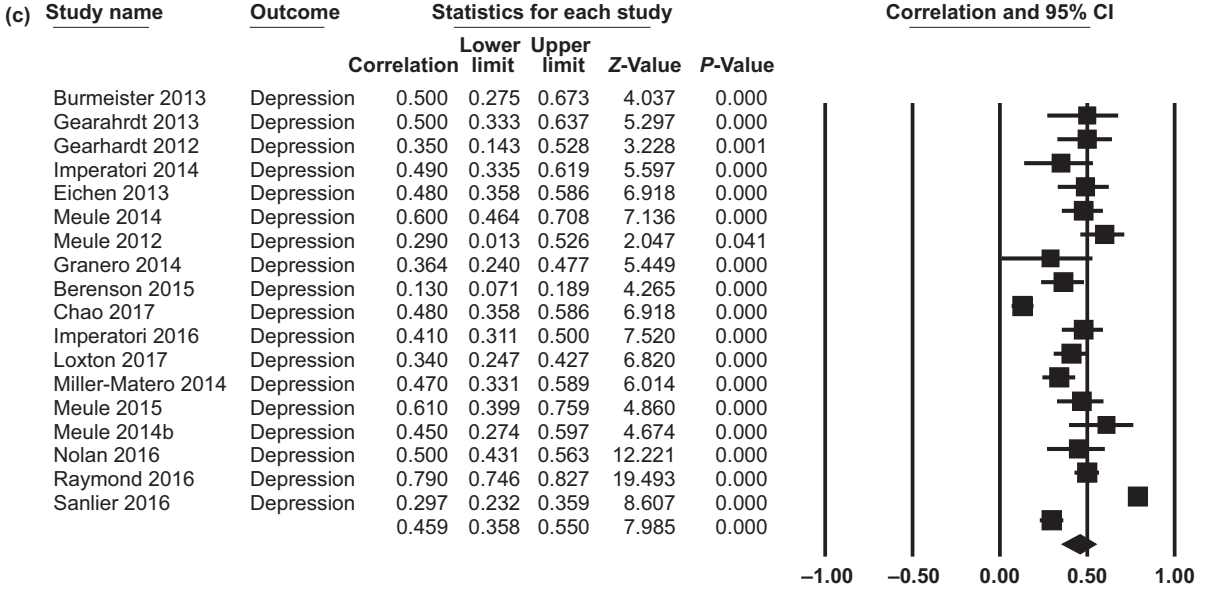


Figure 2 Continued

example, emotional eating was assessed through a wide range of survey types such as the Dutch Eating Behavior Questionnaire (DEBQ), which correlated with FA at 0.58 ($P < 0.05$). Correlations between PTSD and FA were statistically significant in one study at $r = 0.438$ [62]. In another study, an age-adjusted analysis in women revealed that PTSD was positively correlated with FA in a dose–response manner (prevalence ratio 0.96) (95% confidence interval = 0.87–1.07) [60].

Discussion

This review aimed to determine the relationship between FA as assessed by the YFAS and mental health conditions. In total, 53 studies met the inclusion criteria, with depression and binge eating being the most commonly reported outcome measured in association with 'food addiction'. The resulting analysis from this review of studies that comprised mostly cross-sectional studies suggests that positive,

moderate associations exist between FA and binge eating, FA and depression, and FA and anxiety (0.60, 0.46 and 0.48, respectively). Associations with other mental health issues (e.g. PTSD) and emotional eating were less clear because few studies consistently reported these outcome measures.

The results from the review provide evidence that positive, moderate associations exist between FA and mental health conditions, demonstrating the overlap between criteria for a range of mental health conditions (e.g. depression) and the developing construct of FA. It is possible that this overlap exists because FA is not a separate construct from depression, anxiety or disordered eating. However, it is more likely that, given the correlations with FA were only 'moderate' for these disorders (0.401–0.602), there is more to FA than that accounted for by symptoms of depression, disordered eating and anxiety. No relationship was found between FA and alcohol/other drug use, potentially indicating that FA is not better accounted for by an addiction to these substances. No studies reported on the individual survey items for mental health outcomes, which would have assisted in determining the potential areas of overlap between mental health and FA symptoms, and this should be considered in future research. Assessment of the psychometric properties of the YFAS revealed the tool is robust across adult populations and language translations. The properties of the tools were similar from the YFAS, mYFAS and revised YFAS2.0, which now includes 11 symptoms compared to seven in the original version [8].

The mean prevalence of FA across the included studies was 16.1%, with the weighted mean number of symptoms being approximately three (3.3). The number of FA symptoms was slightly higher in binge eating populations (4.6). This prevalence is slightly lower than previously reported from a review in 2014 (16.1% versus 19%), potentially attributed to our review incorporating a broader population group from a wider range of international locations, wider variation in dietary intakes and behaviours, and variation in the use of YFAS tools. Previous research that directly compared the original YFAS survey measures with the revised YFAS 2.0 demonstrates that prevalence and symptom scores are both similar to each other [8].

The results of this review provide support for reporting not only the FA diagnosis rates, but also the total number of symptoms endorsed by study samples in the future. Given the high number of individuals internationally classified as overweight, and the observation that obesity has substantially increased to 60% of the adult population [83], it is arguable that a substantial proportion across the samples in this review would have attempted weight loss. Doing so fulfills at least one of the symptoms of FA as measured by the YFAS; 'a persistent desire and unsuccessful attempts for weight loss'. This aforementioned symptom was also found to have weak agreement over time in a previous study that investigated the stability of FA over 18 months, which may infer that this symptom may fluctuate over time [84]. This makes the assessment of FA as a separate issue from obesity, more complex.

Accordingly, future FA research should consider other aspects of the condition that are not well described in either the YFAS or proposed DSM criteria to better understand how FA fits into mental health and addictive disorders. For example, cognitive inflexibility is well demonstrated in animal studies of addiction [85], and may result in impairments in decision making often seen in FA. In addition, rigid habitual-like behaviours and perseverative negative thoughts, which are pathologies of severe mental health conditions (e.g. obsessive-compulsive disorder, schizophrenia, and depression), are also worthy of consideration in developing further the construct of FA [86].

Given the subjective, self-report nature of both the mental health symptoms and YFAS in this review, the results should be interpreted accordingly. Only five studies included a clinical interview for mental health disorder, which is the gold standard in the mental health field. To advance the FA construct, clinician rated scales, and more objective measures of both mental health and FA symptoms, should be used or developed. This is of particular interest in this field given the controversies that exist with relation to FA [4].

The strengths of this systematic review include the robust methodological quality, completed in accordance with the PRISMA statement, and the number of studies included in the review. A limitation is that only studies published in English were included. There was a high level of statistical heterogeneity among the included studies, which indicates that the results should be interpreted with caution. We addressed statistical heterogeneity by reporting random effects meta-analysis and subgroup analyses. The potential sources of heterogeneity included variations in the assessment of mental health outcomes, the participant populations including those seeking weight loss/bariatric surgery were over-represented and few in the free-living community groups, sex, age, ethnicity, and the differing study protocols. The review was also limited by the less than optimal methodological quality of some of the included studies. Predominantly, studies with the majority of the population group being results for women require replication in more representative samples of the general population. A common side effect of antidepressants and many antipsychotics is fluctuations in weight status, with some producing weight gain and some associated with mild weight loss; thus, more work needs to be conducted to determine where FA may fit into this clinical picture [87,88]. Medication use was not well reported or assessed in the included studies and thus this limits the interpretation of the review findings.

Despite all study types being included in this review, all studies that met the inclusion criteria were cross-sectional in design, restricting causal inferences from being drawn for FA and mental health symptoms. There was also an over-representation of women; hence, more work needs to be conducted to firmly establish whether an independent 'food addiction' construct exists in broader population groups, particularly males.

This review synthesises the current evidence base of food addiction and mental health symptoms. The results highlight that the research area of food addiction is still in its infancy. Similar to other comorbidities, such as depression and addiction, which often co-occur together, FA could also be a potential contributor to mental health disorders, and is worthy of future research. The results of the review provide insight indicating that recruitment to FA studies without the co-morbidities of depression or binge eating may be difficult. Future studies will need to screen for these conditions, and adjust for these confounders in their statistical analysis. Importantly, a failure to do so may have been contributing to the controversies reported in the existing literature about the concept of FA as a distinct disorder from the other comorbidities with which it may present, as well as the challenges reported in treating eating disorders and obesity in the broader research and clinical literature.

Transparency declaration

The lead author affirms that this manuscript is an honest, accurate and transparent account of the study being reported. The reporting of this work is compliant with PRISMA guidelines. The lead author affirms that no important aspects of the study have been omitted and that any discrepancies from the study as planned (protocol has been registered with PROSPERO, ID number CRD42015026714) have been explained.

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Conflict of interests, source of funding and authorship

The authors declare that they have no conflicts of interest.
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TB designed and led the review. TB, KP and JS screened articles and completed data extraction and quality checking. FKL and CD assisted in interpretation of findings. All authors approved the manuscript.

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Supporting information

Additional Supporting Information may be found online in the supporting information tab for this article:
Table S1. Quality assessments of included studies.

