Eating and Weight Disorders - Studies on Anorexia, Bulimia and Obesity (2022) 27:945–959
https://doi.org/10.1007/s40519-021-01212-6

ORIGINAL ARTICLE

Food addiction comorbid to mental disorders in adolescents: a nationwide survey and register-based study

Christina Horsager[1,2] · Emil Færk[1] · Ashley N. Gearhardt[3] · Marlene Briciet Lauritsen[1,2] · Søren Dinesen Østergaard[4,5]

Received: 19 February 2021 / Accepted: 8 May 2021 / Published online: 5 June 2021

Abstract

Purpose Adolescence is a high-risk period for development of addictive behavior. This may also apply to addiction-like eating of highly processed foods—commonly referred to as "food addiction". Adolescents with mental disorder may be at particularly elevated risk of developing food addiction as addiction often accompanies mental disorder. However, there are only few studies in adolescents investigating this potential comorbidity. Therefore, the primary aim of this study was to examine the food addiction symptom load, as measured by the dimensional Yale Food Addiction Scale for Children—version 2.0 (dYFAS-C 2.0), among adolescents with a clinically verified mental disorder.

Method A total of 3529 adolescents aged 13–17 were drawn from the Danish Psychiatric Central Research Register, stratified on six major diagnostic categories of mental disorders; psychotic disorders, affective disorders, anxiety disorders, eating disorders, autism spectrum disorders, and attention deficit disorders. Via their parents, these adolescents were invited to participate in a web-based survey. Data on health and socioeconomic factors from the Danish registers were linked to both respondents and non-respondents, allowing for thorough attrition analysis and estimation of weighted dYFAS-C 2.0 scores.

Results A total of 423 adolescents participated in the survey (response rate 12.0%). The mean weighted dYFAS-C 2.0 total score was 13.9 (95% CI 12.6; 14.9) for the entire sample and varied substantially across the diagnostic categories being highest for those with psychotic disorder, mean 18.4 (95% CI 14.6; 14.9), and affective disorders, mean 19.4. (95% CI 16.3; 22.5). Furthermore, the dYFAS-C 2.0 total score was positively correlated with body mass index (BMI) ($r = 0.33$, $p < 0.05$).

Conclusion Food addiction symptomatology seems to be prevalent among adolescents with mental disorder, particularly affective and psychotic disorders. As obesity is a tremendous problem in individuals with mental disorder further investigation of food addiction in young people with mental disorder is called for. This could potentially aid in the identification of potential transdiagnostic targets for prevention and treatment of obesity in this group.

Level of evidence Level IV, Observational cross-sectional descriptive study combined with retrospective register data.

Keywords Food addiction · Mental disorder · Comorbidity · Adolescence · Psychometrics · Epidemiology

Introduction

The adolescent brain is characterized by a heightened drive for reward and an inhibitory control system, which is not fully developed [1, 2]. Partly due to this imbalance, adolescence represents a vulnerable period with regard to development of addiction of substances such as alcohol, marihuana, cocaine, etc. [1, 3, 4]. Addiction to other and more accessible substances with rewarding potential may, however, also be prevalent in adolescence.

Research from the past decade has shown that highly processed foods with high levels of saturated fat and refined carbohydrates (like chips, cookies, pizza, and

✉ Christina Horsager
christina.pedersen@rn.dk

1 Research Unit for Child- and Adolescents Psychiatry, Aalborg University Hospital, Psychiatry, Mølleparkvej 10, 9000 Aalborg, Denmark

2 Department of Clinical Medicine, Aalborg University, Aalborg, Denmark

3 University of Michigan, Psychology, Ann Arbor, MI, USA

4 Department of Affective Disorders, Aarhus University Hospital, Psychiatry, Aarhus, Denmark

5 Department of Clinical Medicine, Aarhus University, Aarhus, Denmark

chocolate) trigger reward-related neural responses resembling those seen for conventional substances of abuse [5, 6]. In some individuals, this may trigger addictive-like consumption of highly processed foods—now commonly referred to as "food addiction" [7, 8]—a phenotype carrying all the hallmarks of addiction of conventional substances of abuse (including continued use despite negative consequences, loss of control, tolerance, withdrawal, and craving), only with food as the abused substance.

It is well established that addictive disorders (alcohol, cannabis, cocaine, etc.) often co-occur with (other) mental disorders, both among adults [9] and adolescents [10]. Therefore, it has been investigated that the same could apply for mental disorder and food addiction. In adults, symptoms of depression, anxiety, and eating disorder have already been widely investigated in relation to food addiction. For instance, the meta-analysis by Burrows et al. [11] found moderately strong associations between food addiction and symptoms of depression 0.459 (95% CI 0.358; 0.550), anxiety 0.483 (95% CI 0.228; 0.676), and binge eating 0.602 (95% CI 0.557; 0.643), respectively. Also, results from the adult FADK sample [12] showed that those with a clinically verified mental disorders had a significantly higher prevalence of food addiction compared to controls from the general population. For instance, 29% of adults with an affective disorder met the criteria for food addiction, compared to only 9% of the general population controls [13, 14]. However, there are only few studies on the potential comorbidity between mental disorders and food addiction among adolescents—most of which suggest a positive relationship as that observed for adults [7, 15–20]. However, these studies have typically been based on self-reported symptoms of mental disorder [21–24], which likely has resulted in report bias. Furthermore, sampling procedures have often been based on self-inclusion, while information on those not participating is lacking, introducing a substantial risk of selection bias. To further elucidate the likely association between food addiction and mental disorder among adolescents, while minimizing the impact of the biases described above, we conducted a study with three sequential aims:

(I) To examine the psychometric properties of the dimensional Yale Food Addiction Scale for children 2.0 (dYFAS-C 2.0) via a survey in a random sample of adolescents with clinically verified mental disorders from six major diagnostic categories.
(II) To evaluate the generalizability of the results of the survey informed by data from the Danish nationwide registers on sociodemographic and health-related factors available for both the survey respondents and the non-respondents (attrition analysis).
(III) To estimate weighted dYFAS-C 2.0 scores across the major diagnostic categories of mental disorders, taking attrition into account.

The main hypotheses of the study were that the dYFAS-C 2.0 is a psychometrically valid measure of food addiction in adolescents with mental illness and that food addiction is highly prevalent among adolescents with mental illness.

Materials and methods

Study design and setting

The study is based on data from the Food Addiction Denmark (FADK) Project, a large survey and register-based study conducted in the country of Denmark in February 2018. The project is described in depth by Horsager et al. [12] and outlined below in brief for the data used in the present study.

Participants

A total of 3529 adolescents aged 13–17 years were randomly drawn from the Danish Psychiatric Central Research Register (DPCRR). The DPCRR contains information on all diagnoses assigned in relation to inpatient, outpatient, and emergency room contacts at Danish psychiatric hospitals since 1995 [25]. To be available for extraction, the adolescents had to have Danish-born parents, and be born in Denmark (to ensure language proficiency). Furthermore, the adolescents had to live with at least one parent/legal guardian with a valid, non-protected Danish postal address. Adolescents living in an institution were therefore not eligible for extraction. If siblings were randomly sampled, they could all participate.

To ensure that all major mental disorders were studied, we sampled randomly within six major diagnostic categories according to the ICD-10 Classification of Mental and Behavioral Disorders—Diagnostic criteria for research (ICD-10) [26]. A total of 625 adolescents were randomly drawn from each category; psychotic disorders (ICD-10 F20), affective disorders (ICD-10 F30), anxiety disorders (ICD-10 F40), eating disorders (ICD-10 F50), autism spectrum disorders (ICD-10 F84), and Attention Deficit Disorders (ICD-10 F90.0, F90.1, F90.8, and F98.8). To be included, one should be registered in the DPCRR with a contact to psychiatric inpatient or outpatient hospital service in the period from 2013 to 2017. Contacts to psychiatric emergency rooms were excluded due to the potential lower validity of the diagnoses assigned in relation to these short encounters. The extraction from the diagnostic categories was hierarchal, with the most severe diagnostic category drawn first (first F20, then

F30, and F40, and so forth), and the adolescents could only be included once. Because psychotic disorders are not commonly diagnosed among adolescents, all 404 adolescents diagnosed with a psychotic disorder in the defined time period were included.

Survey procedure

The adolescents were invited via the electronic secure mail system (eBoks) used by Danish public authorities [27]. The invitation was sent to the cohabiting legal guardian's (and to both in the case, there were two) eBoks account to ensure that they were informed of the purpose of the study, and able to give informed consent on behalf of their child. The invitation included a personal web-link to a web-based questionnaire, and it was specified that the adolescents should fill in the questionnaire themselves. If the invitees had not responded to the invitation within 6 weeks, a reminder and invitation was sent via surface mail.

Ethics

The invitation material included concise information on the study purpose and clearly stated that participation was voluntary, and that the consent to participate could be withdrawn at any time. In Denmark, the legal age is 18 years. Therefore, the legal guardian had to decide whether their child should have the opportunity to participate in the study. For this reason, the invitation was sent to the legal guardian(s) as described above. In Denmark, Ethical Review Board approval is not required, when a survey-based study does not involve biomedical intervention [28]. Access to data from the registers as well as the invitation and study methodology were approved by Statistics Denmark and the Danish Health Data Authority. The project was registered with record number 2008-58-0028 at the Danish Data Protection Agency. After the survey was completed, data from the survey and from the Danish registers were de-identified and stored by Statistics Denmark.

Measures

The included measures are equivalent to those used in prior validation studies of the YFAS 2.0 and the dYFAS-C 2.0 [7, 14]:

The dimensional Yale Food Addiction Scale for children 2.0 (dYFAS-C 2.0) In children and adolescents, symptoms of food addiction can be assessed via the dYFAS-C 2.0 [7], which is modeled upon the DSM-5 criteria [29] for substance use disorder, and represents an updated version of the YFAS-C, which was modeled upon the DSM-IV [15]. The dYFAS-C 2.0 consists of 16 items, which reflects symptoms of addictive behavior (e.g., continued use despite negative consequences, loss of control, tolerance, withdrawal, and craving) and the scoring is based on the year leading up to the assessment. Each of the 16 dYFAS-C 2.0 items are scored from 0 to 4 and the range of the total score is consequently 0–64. The dYFAS-C 2.0 demonstrated good psychometric properties in the original validation study in adolescents with overweight or obesity [7]. In the present study, complete response to the dYFAS-C 2.0 required having answered all of the 16 dYFAS-C 2.0 items. Participants with partial response to the dYFAS-C 2.0 (e.g., only answering three out of 16 items), hindering the calculation of a total score, were categorized as non-respondents.

The Eating Disorder Examination Questionnaire (EDE-Q) The EDE-Q originates from the clinical interview Eating Disorder Examination (EDE), which is validated across age and a variety of settings [30]. For the analyses of the convergent validity, the subscales on eating-, weight-, and shape concern and the total score were used [31]. For the incremental validity and convergent validity analyses, binge eating frequency was used. Finally, for the analyses on the discriminant validity, the subscale on dietary restraint was used [31, 32].

The ADHD Subscale of the Symptom Checklist-92 (SCL-92) The SCL-92 is a well-validated self-report rating scale, which includes several subscales examining a broad range of psychopathology [33]. In the present study, the SCL-92 ADHD subscale was included as a measure of impulsivity and ADHD symptomatology—both of which are associated with food addiction [34]. The SCL-92 ADHD subscale was included as a convergent measure in the construct validity analyses.

The Alcohol Use Disorder Test (AUDIT) The AUDIT is a self-report measure of alcohol dependence and problematic use of alcohol. The AUDIT has been validated across various populations including adolescents [35]. The AUDIT was included as a discriminant measure in the construct validity analyses, as studies have found alcohol dependence to correlate negatively or not to correlate with food addiction [36].

Weight and height Weight and height were self-reported. In children and adolescents, the Body Mass Index (BMI) varies with sex and age, and therefore, the BMI Z-score [37], which takes common growth according to age and sex into account, was used [38]. The BMI Z-score was categorized according to the WHO [38]; underweight/thinness < -2 SD, normal weight -2 SD $> +1$ SD, overweight $+1$ SD $< +2$ SD, and obese $> +2$ SD. The BMI Z-scores were assessed for outliers, and BMI Z-scores $> +5.5$ and < -4.5 were considered to be biologically implausible (none in the current study).

Register data for the attrition analyses

Data on demographics, socioeconomics, and health were obtained from the nationwide Danish registers, which contains data on all Danish citizens [39]. Data were available for both respondents and non-respondents, and were linked at an individual but de-identified level. The data included: information on age, sex, parents' marital status, degree of urbanization (population density at the place of living), and place of living (region) from the Danish Civil Registration System [40]. Information on parental education (highest completed level) from the Population Education Register [41]. Information on parental occupational status from the Registers on Personal Labor Market Affiliation [42]. Information on the family's equivalized disposable income, which takes the number of family members into account, from the Income Statistics Register [43]. Information on lifetime mental disorder for both parents and invitees from the Psychiatric Central Research Register [25]. Information on lifetime use of psychotropic medication for both parents and invitees from the National Prescription Register [44], and parental and adolescent lifetime medical comorbidity operationalized by the Charlson Comorbidity Index [45] from the National Patient Register [46]. The specified categorization of each demographic, socioeconomic, and health variable is provided in supplement S1.

Statistics

Before all statistical analyses were conducted, the underlying model assumptions were checked. All analyses were conducted using Stata version 15.1.

I: Psychometric validation of the dYFAS-C 2.0

Validation of the dYFAS-C 2.0 The psychometric validation analyses were conducted in accordance with the original work by Schiestl and Gearhardt [7], including confirmatory factor analyses examining the fit for a single factor model using the following fit indices; comparative fit index (CFI), Tucker–Lewis index (TLI), root-mean-square error of approximation (RMSEA), and standardized root-mean-square residual (SRMR) [47], and an examination of the internal consistency quantified using Cronbach's alpha.

Construct validity The convergent validity and the discriminant validity [7, 15, 32] were examined by Pearson's correlations comparing the dYFAS-C 2.0 total score with theoretically associated or non-associated constructs (see further description of the hypothesized convergent and discriminant constructs in the section on Measures). Only complete responses on the measures of theoretically associated constructs were used for the correlation analyses, and *n* is therefore always reported for a given analysis. Pearson correlation coefficients at $(|r|) \geq 0.30$ were considered for relevant associations [48] with the significance level at $p < 0.05$.

Incremental validity For the incremental validity analysis, we used multiple hierarchical regression analysis [7, 32]. The predictive effect on the BMI Z-score was estimated for binge eating frequency and the dYFAS-C 2.0 total score, respectively. In the first model, binge eating frequency was entered as the only explanatory variable for the BMI Z-score. In the second model, the dYFAS-C 2.0 total score was entered along with binge eating frequency to evaluate the unique variance in the BMI Z-score accounted for by each of the two measures.

II: Attrition analysis

The attrition analysis compared the respondents (complete response to the dYFAS-C 2.0) with the non-respondents using descriptive statistics. For categorical variables, proportions were reported, and for continuous variables, means, and standard deviations (SDs) were reported. Comparisons between respondents and non-respondents were carried out using Chi-square test/Fisher's exact test and by Student's simple *t* test, as appropriate.

III: Estimation of the weighted dYFAS-C 2.0 total score

The crude mean dYFAS-C 2.0 total score and 95% CI were reported for the whole population and stratified on the six diagnostic categories. Furthermore, estimates were stratified on sex, and the difference in dYFAS-C 2.0 score between the sexes was tested via the student's *t* tests. Because the dYFAS-C 2.0 total score was not normally distributed, bootstrapping with 1000 replications was used to estimate the standard error. The weighted mean dYFAS-C 2.0 scores were computed using augmented inverse probability weighted (AIPW) estimator [49, 50]. The same variables as used in the attrition analyses were included in the weighting of the scores, namely age, sex, parental marital status, parental socioeconomic factors (parental highest educational level, parental occupation status, and equivalised disposable income), urbanization, place of living, prior lifetime somatic illness of the invitee (the Charlson Comorbidity Index), prior lifetime mental disorders of the invitee, and finally prior lifetime use of psychotropic medication of the invitee. Due to a relatively low number of participants in the different diagnostic categories, it was not possible to stratify on specific diagnoses within these categories, as this could have led to identification of individual participants. In addition, the relatively low number of participants in the diagnostic categories violated the assumptions for the AIPW estimator in the sex-stratified analyses. Therefore, only the crude

dYFAS-C 2.0 scores are reported for males and females, respectively.

Results

Survey response rate

Figure 1 illustrates the overall survey participation based on complete respondents of the dYFAS-C 2.0, and the response rate of the invitees from the six diagnostic categories.

The overall response rate was 12.0% ($n = 423$), the mean age of the respondents was 15.5 years, and 63.8% of the respondents were female. The response rates for the diagnostic categories ranged from 10.0% for adolescents with psychotic disorders and attention deficit disorders, to 21.5 and 22.5% among those with eating disorders and anxiety disorders, respectively.

I: Psychometric validation of the dYFAS-C 2.0

Factor structure and internal consistency The factor loadings for the 16 dYFAS-C 2.0 items are provided in Supplement S2. The confirmatory factor analyses demonstrated good fit to a single factor model with factor loadings in the range from 0.38 ("I ate certain food all day long") to 0.87 ("I really wanted to cut down or stop eating certain kinds of foods, but I just couldn't."), all with p values < 0.001. The fit indices were; the CFI = 0.85, the TLI = 0.82, the RMSEA = 0.12, and the SRMR = 0.06. The internal consistency Cronbach's alpha was 0.94.

Construct validity The results of the analyses of convergent validity and discriminant validity of the dYFAS-C 2.0 are provided in Table 1. All measures of eating pathology were moderately or strongly correlated with the dYFAS-C 2.0 total score. The same applied for the BMI Z-score, the ADHD subscale, and AUDIT score who were all positively and moderately correlated with the dYFAS-C 2.0 total score.

Incremental validity of the dYFAS-C 2.0 In the model having binge eating frequency as the only explanatory variable for BMI Z-score, binge eating was a significant predictor of the BMI Z-score [$t = 3.91$, coeff. = 0.25 (0.12; 0.38), $p < 0.001$] explaining 3.7% of the variance. When adding the dYFAS-C 2.0 total score to the model ($n = 395$), binge eating frequency was no longer a predictor of the BMI Z-score [$t = 0.04$, coeff. = 0.003 (− 0.15; 0.15), $p = 0.968$], but the dYFAS-C 2.0 total score was [$t = 5.33$, coeff. = 0.033 (0.02; 0.05), $p < 0.001$], accounting for additional 6.5% of the variance.

II: Attrition analysis

The results of the attrition analysis are shown in Table 2.

Respondents were more likely to be female than non-respondents. With regard to age, parental marital status, and parental occupational status, there were no substantial differences between respondents and non-respondents. Parents of respondents had a higher education level and equivalated disposable income compared to parents of non-respondents.

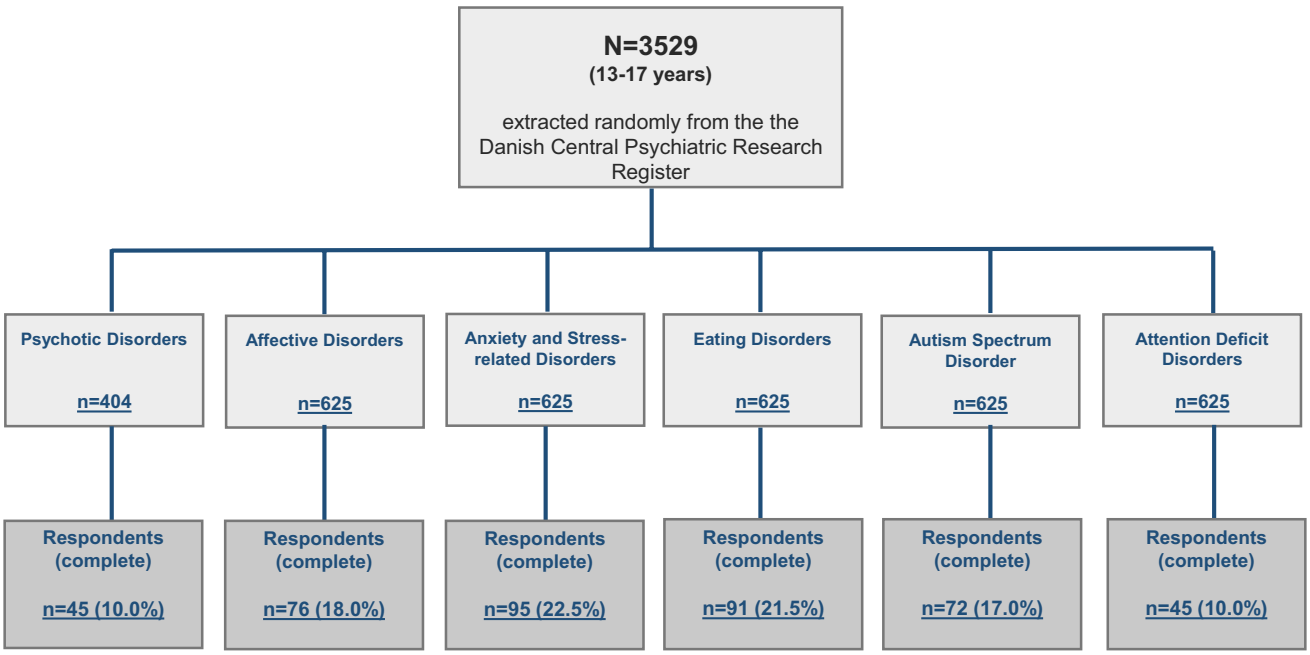

Fig. 1 Flowchart

Table 1 Correlation matrix illustrating convergent validity and discriminant validity for the dimensional dYFAS-C 2.0 symptom score

Psychiatric population	dYFAS-C 2.0 symptom count (*n*)	Age (*n*)	ADHD (SCL-92) (*n*)	Restrained eating (EDE-Q) (*n*)	Eating concern (EDE-Q) (*n*)	Shape concern (EDE-Q) (*n*)	Weight concern (EDE-Q) (*n*)	Binge eating frequency (EDE-Q) (*n*)	Eating pathology (Global EDE-Q score) (*n*)	BMI z-score (*n*)	Alcohol dependence (AUDIT) (*n*)
dYFAS-C 2.0 symptom count	1 (423)										
Age	0.17* (423)	1 (423)									
ADHD (SCL-92)	0.43* (393)	0.14* (411)	1 (411)								
Restrained eating (EDE-Q)	0.32* (415)	0.21* (433)	0.41* (406)	1 (433)							
Eating concern (EDE-Q)	0.43* (376)	0.21* (393)	0.40* (379)	0.70* (388)	1 (393)						
Shape concern (EDE-Q)	0.41* (390)	0.23* (407)	0.49* (397)	0.77* (402)	0.72* (376)	1 (407)					
Weight concern (EDE-Q)	0.46* (399)	0.22* (416)	0.51* (406)	0.74* (412)	0.71* (383)	0.94* (404)	1 (416)				
Binge eating frequency (EDE-Q)	0.60* (408)	0.13* (426)	0.28* (409)	0.33* (421)	0.48* (391)	0.33* (405)	0.33* (414)	1 (426)			
Eating pathology (global EDE-Q score)	0.43* (355)	0.24* (369)	0.45* (360)	0.86* (369)	0.83* (369)	0.96* (369)	0.94* (369)	0.38* (367)	1 (369)		
BMI z-score	0.33* (398)	0.13* (418)	0.10* (407)	0.07 (412)	0.03 (382)	0.13* (401)	0.16* (410)	0.19* (413)	0.09 (363)	1 (418)	
Alcohol dependence (AUDIT)[1]	0.33* (283)	0.41* (295)	0.13* (288)	0.25* (292)	0.23* (268)	0.30* (284)	0.27* (290)	0.11 (292)	0.31* (255)	0.09 (292)	1 (295)

EDE-Q Eating Disorder Examination Questionnaire, *SCL-92* the Symptom Checklist-92, *AUDIT* the alcohol use disorder test

*Significance level $p < 0.05$

[1]The sex-stratified correlation: males 0.08 ($n = 92$), females 0.30* ($n = 191$)

Table 2 Attrition analysis comparing respondents with non-respondents

	Respondents	Non-respondents	*p* value[A]
Overall response rate (%)	423 (12.0)	3106 (88.0)	–
Age (years) mean/SD	15.5 (1.3)	15.5 (1.4)	0.967
Sex (female) (%)	270 (63.8)	1681 (54.1)	< 0.001
Parental marital status (%)			
Married or cohabiting	295 (69.7)	2135 (68.7)	
Single	128 (30.3)	971 (31.3)	
Missing[B]			0.676
Parental highest educational level (%)			
Lower secondary school	22 (5.2)	323 (10.4)	
Upper secondary school	7 (1.7)	82 (2.6)	
Vocational or short-cycle higher education	178 (42.1)	1455 (46.9)	
Medium-cycle higher education including bachelor[C]	145 (34.3)	814 (26.2)	
Long-cycle higher education[D]	71 (16.8)	422 (13.6)	
Missing[B] $n = 15/n = 8$			< 0.001
Parental highest occupation status (%)			
In the labor force	383 (90.5)	2698 (86.9)	
Unemployment, sick pay, leave of absence	9 (2.1)	50 (1.6)	
Disability pension, social security benefit	26 (6.2)	306 (9.9)	
Enrolled in education[B] $n = 27/n = 27$	–	–	
Missing[B] $n = 23/n = 28$			0.123
Equivalated disposable yearly income (%) Quintiles			
< 22,713 euro	61 (14.4)	643 (20.7)	
22,713–31,038 euro	107 (25.3)	901 (29.0)	
31,038–38,186 euro	122 (28.8)	683 (22.0)	
38,186–47,931 euro	78 (18.4)	483 (15.6)	
> 47,931 euro	54 (12.8)	385 (12.4)	
Missing[B] $n = 18/n = 12$			0.002
Degree of urbanization[E] (%)			
Densely populated	96 (22.7)	691 (22.3)	
Intermediate populated, largest town with ≥ 40,000 inhabitants	47 (11.1)	485 (15.6)	
Intermediate populated, largest town with < 40,000 inhabitants	103 (24.4)	694 (22.3)	
Intermediate populated, largest town with < 15,000 inhabitants	13 (3.1)	95 (3.1)	
Thinly populated, largest town with ≥ 15,000 inhabitants	67 (15.8)	451 (14.5)	
Thinly populated, largest town with < 15,000 inhabitants	97 (22.9)	690 (22.2)	
			0.284
Geography/region (%)			
Capital	117 (27.7)	879 (28.3)	
Central Jutland	96 (22.7)	765 (24.7)	
Northern Jutland	31 (7.3)	259 (8.3)	
Zealand	78 (18.4)	583 (18.8)	
Southern Denmark	101 (23.9)	620 (20.0)	
			0.419
Parental lifetime mental disorder (%)[F]			
Any mental disorder (binary *y*/*n*)	50 (11.8)	497 (16.0)	0.025
Adolescent lifetime mental disorder (%)[F,G]			
Psychotic disorders (F20–F29)	56 (13.2)	451 (14.5)	0.481
Mood disorders (F30–F33)	112 (26.5)	870 (28.0)	0.509
Anxiety disorders (F40–F42, F431)	162 (38.3)	967 (31.1)	0.003
Eating disorders (F50)	103 (24.4)	621 (20.0)	0.037
Autism spectrum disorders (F84.0, F84.1, F84.5, F84.8)	115 (27.2)	841 (27.1)	0.962

Table 2 (continued)

	Respondents	Non-respondents	*p* value[A]
Attention deficit/hyperactivity disorders (F90, F90.1, F90.8, F98.8)	108 (25.5)	1133 (36.5)	< 0.001
Parental lifetime use of psychotropic medication			
Any psychotropic medication (binary *y*/*n*)	205 (48.5)	1776 (57.2)	0.001
Adolescent lifetime use of psychotropic medication[G]			
Any psychotropic medication (binary *y*/*n*) -all categories together ($n = 3750$)	197 (46.6)	1634 (52.6)	0.020
Antipsychotics	55 (13.0)	439 (14.1)	0.529
Lithium	–	–	–
Anxiolytics	33 (7.8)	217 (7.0)	0.540
Antidepressants	93 (22.0)	608 (19.6)	0.244
ADHD medication	84 (19.9)	862 (27.8)	0.001
Parental lifetime physical illness (%) (Charlson Comorbidity Index)[H]			
No/low	321 (75.9)	2422 (78.9)	
Moderate	89 (21.0)	626 (20.1)	
Severe/high	13 (3.1)	56 (1.8)	
			0.180
Adolescent lifetime physical illness (%) (Charlson Comorbidity Index)[H]			
No/low	381 (90.1)	2730 (87.9)	
Moderate	41 (9.7)	375 (12.1)	
Severe/high $n^b = 11$			
			0.094

[A]Comparing responders with non-responders. All tests are performed as Chi-square tests except for the comparison of age between groups where the two-sample *t* test was used

[B]Numbers cannot be shown according to rules enforced by Statistics Denmark (due to risk of identification of individuals)

[C]Medium-cycle higher education including bachelor degrees refers to, e.g., nurses, teachers, physiotherapists, and midwifes

[D]Long-cycle higher education refers to master level and PhD degrees obtained at universities

[E]Based on EUROSTAT's DEGURBA categorization (https://www.dst.dk/en/Statistik/dokumentation/nomenklaturer/urbaniseringsgrad--degurba----danmarks-statistik)

[F]According to the International Classification of Diseases edition 10, World Health Organization, Geneva. Any contact (both in- and outpatient) with a psychiatric hospital registered in the Psychiatric Central Research Register in the period from 1969 and onwards

[G]Individuals are allowed to be in more than one category, for each analysis $n = 3750$

[H]Based on hospital contacts (both in- and outpatients) registered in the Danish National Patient Register since 1977. The total Charlson Comorbidity Index score was categorized into: 0 no comorbidity; 1–2 moderate comorbidity; and 3 or more as high/severe comorbidity

With regard to urbanization and place of living, there were not substantial differences. The parents of the respondents were less likely to have a lifetime mental disorder compared to parents of non-respondents. The same applied for the adolescents, where respondents were less likely to be registered with lifetime use of psychotropic medication compared the non-respondents.

III: Estimation of the weighted dYFAS-C 2.0 total score

The crude and weighted estimates of the mean dYFAS-C 2.0 score are presented in Table 3.

The crude mean dYFAS-C 2.0 score was 13.8 (95% CI 12.6; 14.9), and higher for females 16.0 (95% CI 14.5; 17.5) than males 9.9 (95% CI 8.3; 11.4), $p < 0.001$. The weighted mean dYFAS-C 2.0 total score 13.8 (95% CI 12.6; 14.9) did not differ from the crude. For all six diagnostic categories, females had higher dYFAS-C 2.0 scores compared to males; however, the difference was only significant for psychotic disorders ($p = 0.006$) and anxiety disorders ($p = 0.031$). For females, participants with psychotic disorder had the highest dYFAS-C 2.0 score 23.2 (95% CI 17.4; 29.0). For males, the highest score was found in participants with affective disorders 15.7 (95% CI 8.3; 23.1).

As shown in Fig. 2, the mean dYFAS-C 2.0 score increased going from a lower to a higher weight category.

Discussion

In the present study based on data from the FADK project [12], it was demonstrated that the psychometric properties of the dYFAS-C 2.0 were sound among adolescents

Table 3 dYFAS-C 2.0 total score in the six diagnostic categories of mental disorders, stratified on sex

Diagnostic categories mean [95% CI]	Mean dYFAS-C 2.0 total score				
	Total crude dYFAS-C 2.0 score estimate	Total weighted dYFAS-C 2.0 score estimate[1,2]	Female crude dYFAS-C 2.0 score estimate	Male crude dYFAS-C 2.0 score estimate	Comparison between sexes (*p* value[3])
Total population	13.8 [12.6; 14.9]	13.8 [12.6; 14.9]	16.0 [14.5; 17.5] (*n* = 270)	9.9 [8.3; 11.4] (*n* = 153)	< 0.001
Psychotic disorders	18.8 [14.4; 23.3]	18.4 [14.6; 22.1]	23.2 [17.4; 29.0] (*n* = 28)	11.5 [5.7; 17.4] (*n* = 17)	0.006
Affective disorders	18.8 [15.7; 21.9]	19.4 [16.3; 22.5]	19.6 [16.1; 23.0] (*n* = 61)	15.7 [8.3; 23.1] (*n* = 15)	0.296
Anxiety disorders	13.1 [11.0; 15.2]	13.0 [10.7; 15.3]	14.6 [12.0; 17.2] (*n* = 65)	9.8 [6.4; 13.2] (*n* = 30)	0.031
Eating disorders	13.4 [10.8; 15.9]	13.2 [10.7; 15.8][4]	13.7 [11.0; 16.4] (*n* = 85)	9.0 [1.6; 16.4] (*n* = 6)	0.140
Autism spectrum disorders	9.4 [7.4; 11.4]	9.3 [7.3; 11.3]	12.1 [7.6; 16.6] (*n* = 20)	8.3 [6.1; 10.5] (*n* = 52)	0.099
Attention deficit disorders (ADHD/ADD)	9.7 [6.8; 12.5]	10.0 [8.2; 11.9][5]	11.4 [5.7; 17.1] (*n* = 11)	9.1 [5.7; 12.5] (*n* = 33)	0.473

[1]Based on augmented inverse probability weighted (AIPW) estimation, *n* = 625 (*n* = 403 for psychotic disorders)

[2]The variables "medication for addiction disorders" and "lithium" violated the AIPW model and were therefore not included

[3]Simple *t* test. Because of violated model assumptions (outcome was not normally distributed), bootstrapping with 1000 replications was used to estimate SE

[4]The variable "ADHD medication" violated the AIPW model and was therefore not included

[5]The variables "psychotic disorders" and "eating disorders" violated the AIPW model and were therefore not included

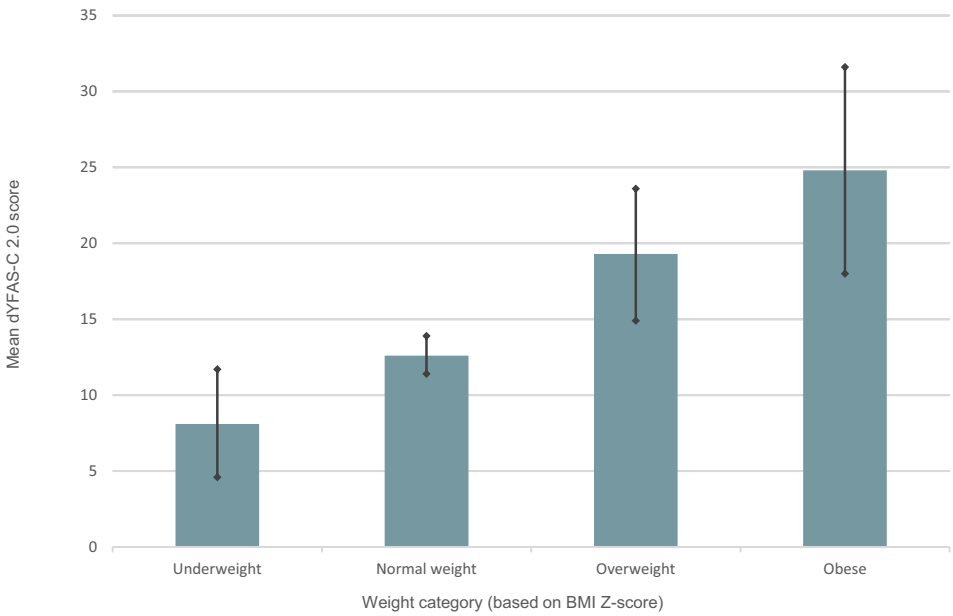

Fig. 2 Mean dYFAS-C 2.0 scores for BMI Z-score weight categories

with clinically verified mental disorder. Attrition analyses informed by sociodemographic and health-related register data on all invitees showed that the parents of the respondents had a slightly higher educational level and income and were less likely to have a lifetime mental disorder compared to the parents of non-respondents. The weighted estimates of the mean dYFAS-C 2.0 total score—taking attrition into account—suggested that symptoms of food addiction are particularly prevalent among adolescents with affective and psychotic disorders.

The psychometric analyses showed that the dYFAS-C 2.0 is a psychometric valid measure of food addiction in adolescents with mental disorder. Specifically, the one-factor model was confirmed and the factor loadings were slightly higher than in the first (and only) validation study of this scale [7]. This also applied to both the internal consistency

and the fit indices for the single factor model. Hypothesis testing with theoretically convergent and discriminant measures was used to examine the construct validity. The results were comparable to those from other validation studies of both the adult YFAS 2.0 [14, 32] and the dYFAS-C 2.0 [7]. All measures of eating pathology correlated positively with the dYFAS-C 2.0 score, which is in accordance with the high prevalence of food addiction found in populations with eating disorders [11, 51]. Furthermore, the strong positive association between food addiction and BMI (obesity) observed in studies among adolescents with less psychiatric morbidity [7, 15, 19] seems to extend to adolescents with clinically verified mental disorder. Finally, the dYFAS-C 2.0 accounted for 6.5% of the unique variance in the BMI Z-score, predicting the BMI Z-score over and above binge eating frequency. For comparison, the dYFAS-C 2.0 only accounted for 3.4% of the variance in BMI Z-score in the original validation study by Schiestl and Gearhardt [7]. While these results are promising with regard to the validity of the dYFAS-C 2.0, both research studies and clinical settings would benefit greatly from establishment of clinically informed cut-offs for the YFAS-C 2.0, which would allow for identification of children and adolescents with clinically significant food addiction.

Interestingly, the AUDIT score (problematic alcohol use) correlated positively with the dYFAS-C 2.0 score. This was somewhat surprising as the AUDIT was hypothesized to be a discriminant measure that would "compete" with food addiction [52]—as reported in studies among adults [36, 53]. However, in a prior study of adolescents, Mies et al. also found that food addiction was associated with substance use [54]. This co-occurrence of addictive-like eating and alcohol-related problems in adolescence may be explained from a developmental perspective. In the emerging phase of addiction, adolescents may have a problematic use of several addictive substances at the same time, like alcohol and processed food, since the "drug of choice" is yet to be consolidated. To get a better understanding of the relationship between food addiction and problematic alcohol (and other substances) use in adolescence—and their temporal association—longitudinal studies are needed.

The results of the attrition analysis practically showed the same attrition pattern as for the adult populations [13, 14] with a slight overrepresentation of respondents (or parents of the respondent) with higher education and income. However, when weighting the dYFAS-C 2.0 total scores based on the attrition analysis, they were virtually identical to the crude scores—for all diagnostic categories. This suggests that despite the quite low response rate, attrition from the survey did not impact the estimation of the dYFAS-C 2.0 scores substantially. This is in line with the results from our prior studies of food addiction in both adolescents and adults from the FADK sample, in which the crude and weighted estimates of the prevalence of food addiction did also not differ substantially [13, 14, 55].

Notably, across all diagnostic categories of mental disorder, females had higher dYFAS-C 2.0 total scores compared to males. This is in accordance with prior findings (see the review by Penzenstadler et al. [51]) and indicates that the female preponderance in food addiction is also present for adolescents with mental disorder.

The weighted dYFAS-C 2.0 total score varied substantially across the diagnostic categories, ranging from 9.3 (95% CI 7.3; 11.3) for autism spectrum disorders to 19.4 (95% CI 16.3; 22.5) for affective disorders. For comparison, we recently reported a weighted mean dYFAS-C 2.0 total score of 12.0 (95% CI 11.2; 12.9) for adolescents from the general Danish population [55]. Hence, adolescents with affective and psychotic disorders have substantially higher weighted dYFAS-C 2.0 scores compared to adolescents from the general population.

Somewhat surprisingly, the dYFAS-C 2.0 total scores of participants with eating disorder were relatively low, and among the lowest when compared to the other diagnostic categories. This is in contrast to other studies finding that symptoms of food addiction were highly prevalent among adolescents with eating disorder [21, 22]. The low food addiction symptom load may be at least partly explained by the quite large representation of anorexia nervosa among the participants with eating disorder ($n = 59/91$). Furthermore, within the eating disorder spectrum, diagnostic crossover between diagnoses are quite common—most often the crossover goes from anorexia nervosa to a bingeing eating disorder [56]. Consequentially, it could be hypothesized that participants with anorexia nervosa—due to their low age—have not yet experienced a diagnostic crossover to a potentially more bingeing eating pattern. Actually, Cinelli and colleagues speculated that food addiction symptomatology in adolescents with anorexia nervosa could predict such diagnostic cross over to binge eating behavior [22].

Among participants with ADHD, the food addiction symptom load was relatively low. Due to the well-known association between ADHD and substance use disorders [57], and between ADHD and obesity [58], this finding was surprising. In addition, several studies have found an association between impulsivity (a core symptom of ADHD) and food addiction [34]. The low food addiction symptom load may be explained by the male preponderance in ADHD [59], and the female preponderance in food addiction. Also, side-effects (appetite suppression) of ADHD medication may play a role [60].

Adolescents with affective disorders, including both depressive disorder and bipolar disorder, had the highest weighted dYFAS-C 2.0 score of all diagnostic categories. Symptoms of depression have been widely investigated in relation to food addiction, and a positive association has

been reported both among adults [11, 36] and adolescents [24, 61]. While the relationship between depression and obesity has typically been described as being bidirectional [62, 63], recent studies have proposed that the effect predominantly goes from obesity to depression [64, 65]. This would suggest that food addiction—via obesity—may have the potential of inducing depressive disorder. However, the temporal aspect of the associations between food addiction, obesity, and depression remains unknown, and should be subjected to further study.

The second highest dYFAS-C 2.0 total score was found among respondents with psychotic disorder. This is in accordance with the findings reported by Teasdale et al. (using the adult YFAS 2.0) who found a high prevalence of food addiction among adolescents with psychotic disorder [23]. Among adults, a few studies investigating food addiction in the context of psychotic disorder (schizophrenia) have also found it to be quite prevalent [66, 67]. The appetite stimulating effect of many antipsychotic drugs may explain part of this association [68]. Accordingly, Teasdale et al. found that drug naïve adolescents with psychotic disorder had a lower daily energy intake compared to those in treatment with antipsychotics [23]. The impaired executive function and negative symptoms commonly seen in psychotic disorders may be other contributors to the association with food addiction [69] as these symptoms often manifest as sedentary lifestyle and poor diet with resulting obesity [70]. Also, addiction disorders are frequent comorbidities to psychotic disorder [71], which may explain the proneness toward rewarding highly processed foods. If food addiction indeed plays a role in the development of obesity in psychotic disorders, it could represent an important target for prevention and treatment.

Limitations

The general limitations of the FADK project, which provides data to this study, have been discussed in depth by Horsager et al. [12]. For that reason, the primary focus will be on the limitations related specifically to the examination of food addiction in adolescents with mental disorder. First and foremost, data from the survey were cross-sectional. Consequently, the temporal aspect of the association between food addiction and mental disorder cannot be investigated. Second, there was a quite low response rate of 12.0% ($n = 423$), and even lower for some diagnostic categories (e.g., ADHD 10.0%). For ethical reasons, the adolescents were invited via their legal guardian(s), and this "barrier" may partly explain the low response rate. Furthermore, it is likely that parents of adolescents with a mental disorder may find that participation would be too stressful for the adolescent. This tendency may be more pronounced among parents of adolescents with more severe psychopathology. Based on the apparent association between food addiction and more severe psychopathology [11], this could have resulted in an underrepresentation of participants with severe psychopathology and a consequential underestimation of the dYFAS-C 2.0 scores. Third, while the availability of register data on a large variety of sociodemographic and health-related data for both respondents and non-respondents enabled the estimation of weighted dYFAS-C 2.0 scores, it is important to note that the AIPW model can only weigh based on the variables included in it. For that reason, it is an important limitation that BMI Z-scores on non-respondents were not available and we were therefore not able to factor in the quite low mean BMI Z-scores of the respondents (compared to the general adolescent Danish population [72]). Due to the strong association between food addiction and BMI [51], the dYFAS-C 2.0 total score estimates are likely underestimated. This is probably also the reason why the dYFAS-C 2.0 total scores in the present study were considerably lower than those found in the original study including a non-clinical sample of adolescents with overweight or obesity [7]. Fourth, to ensure that invitees were able to understand the questionnaire, invitees had to have Danish-born parents and be born in Denmark (approximately 87% of the population in Denmark [73]). This limits the generalizability of the findings. Relatedly, adolescents who were institutionalized or otherwise in the care of the authorities were not included. Fifth, invitees had to be registered in the DPCRR with a contact to a psychiatric inpatient or outpatient hospital service in the period from 2013 to 2017. The period of 5 years ensured that a sufficient number of cases were available for random sampling from each diagnostic category (this was not possible for psychotic disorders where all adolescents with psychotic disorders were included). As a consequence, at the time of the survey, the invitees did not necessarily belong to the diagnostic category from which they were initially drawn, or their mental disorder could have remitted. This adds some uncertainty to the food addiction prevalence estimates across the diagnostic categories investigated in this study. Finally, it is important to note that the construct of food addiction is still a subject of debate [74–76]. However, Schulte et al. [77] recently applied Blashfield's criteria for a new diagnostic category on the food addiction construct, and concluded that a large body of literature now supports that food addiction indeed seems to have clinical utility.

Conclusion

This is the first study to validate the dYFAS-C 2.0 and investigate symptoms of food addiction symptomatology in a random sample of adolescents with clinically verified mental disorder. The findings suggest that the dYFAS-C 2.0 is also a sensitive measure for detecting emerging symptoms

of food addiction among adolescents with mental disorder. Furthermore, the results indicate that symptoms of food addiction are quite prevalent among adolescents with clinically verified mental disorder—especially affective and psychotic disorders. As obesity is a tremendous problem in individuals with mental disorder—often having its onset in adolescence—further investigation of food addiction in young people is called for. Such studies will likely contribute to our understanding of the temporal aspects of the association between mental disorder, food addiction and obesity, and thereby aid in the identification of potential transdiagnostic targets for prevention and treatment.

What is already known on this subject?

Adolescence is a high-risk period for development of addictive behavior. Having a mental disorder may increase the risk of developing food addiction as addiction disorders often co-occur with mental disorders.

What this study adds?

The study found food addiction symptomatology to be relatively prevalent among adolescents with affective and psychotic disorders and to correlate positively with BMI.

Supplementary Information The online version contains supplementary material available at https://doi.org/10.1007/s40519-021-01212-6.

Acknowledgements We thank Helle Jakobsen for statistical advice, and Christian Uggerby, MD for contributing to the translation of the YFAS-C 2.0.

Author contributions The study was designed by CH, MBL, and SDØ. The data were analyzed by CH and EF. Results were interpreted by CH, ANG, MBL, and SDØ. The first version of this manuscript was drafted by CH and revised critically for important intellectual content by EF, ANG, MBL, and SDØ. The final version of the manuscript was approved by all authors prior to submission.

Funding This work is supported by grants from the Beckett Foundation (17-0-0822), the A.P Møller Foundation of Medical Science (17-L-0013) and the Heinrich Kopps Grant (all to CH), and a PhD fellowship from Aalborg University Hospital, Psychiatry (to CH). SDØ is supported by the Novo Nordisk Foundation (Grant Number: NNF20SA0062874), the Lundbeck Foundation (Grant Numbers: R358-2020-2341 and R344-2020-1073), the Danish Cancer Society (Grant Number: R283-A16461), the Central Denmark Region Fund for Strengthening of Health Science (Grant Number: 1-36-72-4-20), the Danish Agency for Digitisation Investment Fund for New Technologies (Grant Number 2020-6720), and Independent Research Fund Denmark (Grant Number: 7016-00048B). The funding sources had no role in the design and conduct of the study; collection, management, analysis, and interpretation of the data; preparation, review, or approval of the manuscript; and decision to submit the manuscript for publication.

Data availability In accordance with Danish legislation, the original (individual-level) data cannot be shared due to their personal sensitive nature.

Declarations

Conflict of interest Dr. Østergaard received the 2020 Lundbeck Foundation Young Investigator Prize. The remaining authors declare no conflicts of interest.

Ethical approval This study was performed in accordance with the principles of the Declaration of Helsinki. Ethical Review Board approval is not required for survey and register-based studies in Denmark if they do not include collection of biological material. The questionnaire and survey methodology was approved by the Danish Health Data Authority. The use of data from the Danish registers was approved by Statistics Denmark and the Danish Health Data Authority. Data obtained from the survey and data from the Danish registers were de-identified by Statistics Denmark. The project was registered with record number 2008-58-0028 at the Danish Data Protection Agency.

Informed consent The included adolescents were invited via their parents (legal guardians) to ensure that the parents were informed on the purpose of the study. This procedure ensured that the parents were able to decide whether their child should have the opportunity to participate in the survey, and to provide informed consent. Furthermore, the parents were informed that participation in the survey was voluntary, and that the consent to participate could be withdrawn at any time.

Consent to participate The adolescents were invited via their parents (legal guardians) to ensure that the parents were informed on the purpose of the study. This procedure ensured that the parents were able to help decide whether their child should have the opportunity to participate in the survey. Furthermore, the invitees were informed that survey participation was voluntary and that their consent to participate could be withdrawn at any time.

References

1. Casey BJ, Jones RM (2010) Neurobiology of the adolescent brain and behavior: implications for substance use disorders. J Am Acad Child Adolesc Psychiatry 49:1189–1201. https://doi.org/10.1016/j.jaac.2010.08.017
2. Hardee JE, Phaneuf C, Cope L, Zucker R, Gearhardt A, Heitzeg M (2020) Neural correlates of inhibitory control in youth with symptoms of food addiction. Appetite 148:104578. https://doi.org/10.1016/j.appet.2019.104578
3. Crews F, He J, Hodge C (2007) Adolescent cortical development: a critical period of vulnerability for addiction. Pharmacol Biochem Behav 86:189–199. https://doi.org/10.1016/j.pbb.2006.12.001
4. Steinberg L (2010) A dual systems model of adolescent risk-taking. Dev Psychobiol 52:216–224. https://doi.org/10.1002/dev.20445
5. Schulte EM, Sonneville KR, Gearhardt AN (2019) Subjective experiences of highly processed food consumption in individuals with food addiction. Psychol Addict Behav 33:144–153. https://doi.org/10.1037/adb0000441
6. Lindgren E, Gray K, Miller G, Tyler R, Wiers CE, Volkow ND et al (2018) Food addiction: a common neurobiological mechanism with drug abuse. Front Biosci 23:811–836. https://doi.org/10.2741/4618

7. Schiestl ET, Gearhardt AN (2018) Preliminary validation of the Yale Food Addiction Scale for children 2.0: a dimensional approach to scoring. Eur Eat Disord Rev 26:605–617. https://doi.org/10.1002/erv.2648
8. Small DM, DiFeliceantonio AG (2019) Processed foods and food reward. Science 363:346–347. https://doi.org/10.1126/science.aav0556
9. Plana-Ripoll O, Pedersen CB, Holtz Y, Benros ME, Dalsgaard S, de Jonge P et al (2019) Exploring comorbidity within mental disorders among a Danish national population. JAMA Psychiat 76:259–270. https://doi.org/10.1001/jamapsychiatry.2018.3658
10. Conway KP, Swendsen J, Husky MM, He JP, Merikangas KR (2016) Association of lifetime mental disorders and subsequent alcohol and illicit drug use: results from the national comorbidity survey-adolescent supplement. J Am Acad Child Adolesc Psychiatry 55:280–288. https://doi.org/10.1016/j.jaac.2016.01.006
11. Burrows T, Kay-Lambkin F, Pursey K, Skinner J, Dayas C (2018) Food addiction and associations with mental health symptoms: a systematic review with meta-analysis. J Hum Nutr Diet 31:544–572. https://doi.org/10.1111/jhn.12532
12. Horsager C, Østergaard SD, Lauritsen MB (2019) The food addiction Denmark (FADK) project: a combined survey- and register-based study. Acta Neuropsychiatr 31:325–336. https://doi.org/10.1017/neu.2019.34
13. Horsager C, Færk E, Lauritsen M, Østergaard S (2021) Food addiction comorbid to mental disorder: a nationwide survey and register-based study. Int J Eat Disord 54:545–560. https://doi.org/10.1002/eat.23472
14. Horsager C, Færk E, Lauritsen MB, Østergaard SD (2020) Validation of the Yale Food Addiction Scale 2.0 and estimation of the population prevalence of food addiction. Clin Nutr 39:2917–2928. https://doi.org/10.1016/j.clnu.2019.12.030
15. Gearhardt AN, Roberto CA, Seamans MJ, Corbin WR, Brownell KD (2013) Preliminary validation of the Yale Food Addiction Scale for children. Eat Behav 14:508–512. https://doi.org/10.1016/j.eatbeh.2013.07.002
16. Richmond RL, Roberto CA, Gearhardt AN (2017) The association of addictive-like eating with food intake in children. Appetite 117:82–90. https://doi.org/10.1016/j.appet.2017.06.002
17. Schulte EM, Jacques-Tiura AJ, Gearhardt AN, Naar S (2017) Food addiction prevalence and concurrent validity in African American adolescents with obesity. Psychol Addict Behav. https://doi.org/10.1037/adb0000325
18. Rodrigue C, Gearhardt AN, Bégin C (2019) Food addiction in adolescents: exploration of psychological symptoms and executive functioning difficulties in a non-clinical sample. Appetite 141:104303. https://doi.org/10.1016/j.appet.2019.05.034
19. Burrows T, Skinner J, Joyner MA, Palmieri J, Vaughan K, Gearhardt AN (2017) Food addiction in children: associations with obesity, parental food addiction and feeding practices. Eat Behav 26:114–120. https://doi.org/10.1016/j.eatbeh.2017.02.004
20. Yekaninejad MS, Badrooj N, Vosoughi F, Lin C-Y, Potenza MN, Pakpour AH (2021) Prevalence of food addiction in children and adolescents: a systematic review and meta-analysis. Obes Rev. https://doi.org/10.1111/obr.13183
21. Albayrak O, Focker M, Kliewer J, Esber S, Peters T, de Zwaan M et al (2017) Eating-related psychopathology and food addiction in adolescent psychiatric inpatients. Eur Eat Disord Rev 25:214–220. https://doi.org/10.1002/erv.2509
22. Cinelli G, Bifone C, Criscuolo M, Bifone C, Chianello I, Castiglioni MC et al (2020) Food addiction in a group of Italian adolescents diagnosed for eating disorder. Nutrients 12:1524. https://doi.org/10.3390/nu12051524
23. Teasdale SB, Burrows TL, Hayes T, Hsia CY, Watkins A, Curtis J et al (2019) Dietary intake, food addiction and nutrition knowledge in young people with mental illness. Nutr Diet. https://doi.org/10.1111/1747-0080.12550
24. Borisenkov MF, Popov SV, Tserne TA, Bakutova LA, Pecherkina AA, Dorogina OI et al (2020) Food addiction and symptoms of depression among inhabitants of the European North of Russia: associations with sleep characteristics and photoperiod. Eur Eat Disord Rev 28:332–342. https://doi.org/10.1002/erv.2728
25. Mors O, Perto GP, Mortensen PB (2011) The Danish psychiatric central research register. Scand J Public Health 39:54–57. https://doi.org/10.1177/1403494810395825
26. World Health Organization (1993) The ICD-10 classification of mental and behavioural disorders—diagnostic criteria for research. World Health Organization, Geneva
27. The Agency for Digitisation M of FD (2020) Mandatory digital post from public authorities, eBoks. https://en.digst.dk/policy-and-strategy/mandatory-digitisation/digital-post/. Accessed 1 May 2020
28. The Danish National Committee on Health Research Ethics (2018) Act on research ethics review of health research projects. https://en.nvk.dk/rules-and-guidelines/act-on-research-ethics-review-of-health-research-projects. Accessed 16 Sept 2020
29. American Psychiatric Association (2013) Diagnostic and statistical manual of mental disorders (DSM-5). Revised, 5th edn. American Psychiatric Publishing
30. Berg KC, Peterson CB, Frazier P, Crow SJ (2012) Psychometric evaluation of the eating disorder examination and eating disorder examination-questionnaire: a systematic review of the literature. Int J Eat Disord 45:428–438. https://doi.org/10.1002/eat.20931
31. Aloi M, Rania M, Muñoz RCR, Murcia SJ, Fernández-Aranda F, De Fazio P et al (2017) Validation of the Italian version of the Yale Food Addiction Scale 2.0 (I-YFAS 2.0) in a sample of undergraduate students. Eat Weight Disord 22:527–533. https://doi.org/10.1007/s40519-017-0421-x
32. Gearhardt AN, Corbin WR, Brownell KD (2016) Development of the Yale Food Addiction Scale version 2.0. Psychol Addict Behav 30:113–121. https://doi.org/10.1037/adb0000136
33. Carrozzino D, Vassend O, Bjørndal F, Pignolo C, Olsen LR, Bech P (2016) A clinimetric analysis of the Hopkins Symptom Checklist (SCL-90-R) in general population studies (Denmark, Norway, and Italy). Nord J Psychiatry 70:374–379. https://doi.org/10.3109/08039488.2016.1155235
34. VanderBroek-Stice L, Stojek MK, Beach SR, VanDellen MR, MacKillop J (2017) Multidimensional assessment of impulsivity in relation to obesity and food addiction. Appetite 112:59–68. https://doi.org/10.1016/j.appet.2017.01.009
35. Rumpf HJ, Wohlert T, Freyer-Adam J, Grothues J, Bischof G (2013) Screening questionnaires for problem drinking in adolescents: performance of AUDIT, AUDIT-C CRAFFT and POSIT. Eur Addict Res 19:121–127. https://doi.org/10.1159/000342331
36. Nunes-Neto PR, Kohler CA, Schuch FB, Solmi M, Quevedo J, Maes M et al (2017) Food addiction: prevalence, psychopathological correlates and associations with quality of life in a large sample. J Psychiatr Res 96:145–152. https://doi.org/10.1016/j.jpsychires.2017.10.003
37. Butte NF, Garza C, de Onis M (2007) Evaluation of the feasibility of international growth standards for school-aged children and adolescents. J Nutr 137:153–157. https://doi.org/10.1093/jn/137.1.153
38. World Health Organization Geneva (2007) Growth reference 5–19 years—BMI for age. https://www.who.int/growthref/who2007_bmi_for_age/en/. Accessed 3 Feb 2020
39. Thygesen LC, Daasnes C, Thaulow I, Brønnum-Hansen H, Bronnum-Hansen H (2011) Introduction to Danish (nationwide) registers on health and social issues: structure, access, legislation,

and archiving. Scand J Public Health 39:12–16. https://doi.org/10.1177/1403494811399956
40. Schmidt M, Pedersen L, Sørensen HT (2014) The Danish civil registration system as a tool in epidemiology. Eur J Epidemiol 29:541–549. https://doi.org/10.1007/s10654-014-9930-3
41. Jensen VM, Rasmussen AW (2011) Danish education registers. Scand J Public Health 39:91–94
42. Petersson F, Baadsgaard M, Thygesen LC (2011) Danish registers on personal labour market affiliation. Scand J Public Health 39:95–98. https://doi.org/10.1177/1403494811408483
43. Baadsgaard M, Quitzau J (2011) Danish registers on personal income and transfer payments. Scand J Public Health 39:103–105. https://doi.org/10.1177/1403494811405098
44. Pottegård A, Schmidt SAJ, Wallach-Kildemoes H, Sørensen HT, Hallas J, Schmidt M (2017) Data resource profile: The Danish national prescription registry. Int J Epidemiol 46:798–798f. https://doi.org/10.1093/ije/dyw213
45. Charlson ME, Pompei P, Ales KL, MacKenzie CR (1987) A new method of classifying prognostic comorbidity in longitudinal studies: development and validation. J Chronic Dis 40:373–383. https://doi.org/10.1016/0021-9681(87)90171-8
46. Lynge E, Sandegaard JL, Rebolj M (2011) The Danish national patient register. Scand J Public Health 39:30–33. https://doi.org/10.1177/1403494811401482
47. Hu LT, Bentler PM (1999) Cutoff criteria for fit indexes in covariance structure analysis: conventional criteria versus new alternatives. Struct Equ Model 6:1–55. https://doi.org/10.1080/10705519909540118
48. Cohen J (1988) Statistical power analysis for the behavioral sciences, 2nd edn. Lawrence Erlbaum Associates, New York
49. Cao W, Tsiatis AA, Davidian M (2009) Improving efficiency and robustness of the doubly robust estimator for a population mean with incomplete data. Biometrika 96:723–734. https://doi.org/10.1093/biomet/asp033
50. Glynn AN, Quinn K (2010) An introduction to the augmented inverse propensity weighted estimator. Polit Anal. https://doi.org/10.1093/pan/mpp036
51. Penzenstadler L, Soares C, Karila L, Khazaal Y (2018) Systematic review of food addiction as measured with the Yale Food Addiction Scale: implications for the food addiction construct. Curr Neuropharmacol 17:526–538. https://doi.org/10.2174/1570159x16666181108093520
52. Volkow ND, Wang G-J, Tomasi D, Baler RD (2013) The addictive dimensionality of obesity. Biol Psychiatry 73:811–818. https://doi.org/10.1016/j.biopsych.2012.12.020
53. Masheb RM, Ruser CB, Min KM, Bullock AJ, Dorflinger LM (2018) Does food addiction contribute to excess weight among clinic patients seeking weight reduction? Examination of the modified Yale food addiction survey. Compr Psychiatry 84:1–6. https://doi.org/10.1016/j.comppsych.2018.03.006
54. Mies GW, Treur JL, Larsen JK, Halberstadt J, Pasman JA, Vink JM (2017) The prevalence of food addiction in a large sample of adolescents and its association with addictive substances. Appetite 118:97–105. https://doi.org/10.1016/j.appet.2017.08.002
55. Horsager C, Færk E, Gearhardt A, Østergaard S, Lauritsen M (2021) Validation of the dimensional Yale Food Addiction Scale for Children 2.0 and estimation of the weighted food addiction score in a sample of adolescents from the general population. Eat Weight Disord. https://doi.org/10.1007/s40519-021-01113-8
56. Tozzi F, Thornton LM, Klump KL, Fichter MM, Halmi KA, Kaplan AS et al (2005) Symptom fluctuation in eating disorders: correlates of diagnostic crossover. Am J Psychiatry 162:732–740. https://doi.org/10.1176/appi.ajp.162.4.732
57. van Emmerik-van OK, van de Glind G, van den Brink W, Smit F, Crunelle CL, Swets M et al (2012) Prevalence of attention-deficit hyperactivity disorder in substance use disorder patients: a meta-analysis and meta-regression analysis. Drug Alcohol Depend 122:11–19. https://doi.org/10.1016/j.drugalcdep.2011.12.007
58. Hanć T, Cortese S (2018) Attention deficit/hyperactivity-disorder and obesity: a review and model of current hypotheses explaining their comorbidity. Neurosci Biobehav Rev 92:16–28. https://doi.org/10.1016/j.neubiorev.2018.05.017
59. Willcutt EG (2012) The prevalence of DSM-IV attention-deficit/hyperactivity disorder: a meta-analytic review. Neurotherapeutics 9:490–499. https://doi.org/10.1007/s13311-012-0135-8
60. Posner J, Polanczyk GV, Sonuga-Barke E (2020) Attention-deficit hyperactivity disorder. Lancet 395:450–462. https://doi.org/10.1016/S0140-6736(19)33004-1
61. Zhao Z, Ma Y, Han Y, Liu Y, Yang K, Zhen S et al (2018) Psychosocial correlates of food addiction and its association with quality of life in a non-clinical adolescent sample. Nutrients. https://doi.org/10.3390/nu10070837
62. Luppino FS, De Wit LM, Bouvy PF, Stijnen T, Cuijpers P, Penninx BWJH et al (2010) Overweight, obesity, and depression: a systematic review and meta-analysis of longitudinal studies. Arch Gen Psychiatry 67:220–229. https://doi.org/10.1001/archgenpsychiatry.2010.2
63. Mannan M, Mamun A, Doi S, Clavarino A (2016) Is there a bi-directional relationship between depression and obesity among adult men and women? Systematic review and bias-adjusted meta analysis. Asian J Psychiatr 21:51–66. https://doi.org/10.1016/j.ajp.2015.12.008
64. Speed MS, Jefsen OH, Børglum AD, Speed D, Østergaard SD (2019) Investigating the association between body fat and depression via Mendelian randomization. Transl Psychiatry 9:184. https://doi.org/10.1038/s41398-019-0516-4
65. Tyrrell J, Mulugeta A, Wood AR, Zhou A, Beaumont RN, Tuke MA et al (2018) Using genetics to understand the causal influence of higher BMI on depression. Int J Epidemiol 48:834–848. https://doi.org/10.1093/ije/dyy223
66. Goluza I, Borchard J, Kiarie E, Mullan J, Pai N (2017) Exploration of food addiction in people living with schizophrenia. Asian J Psychiatr 27:81–84. https://doi.org/10.1016/j.ajp.2017.02.022
67. Kucukerdonmez O, Urhan M, Altin M, Haciraifoglu O, Yildiz B (2019) Assessment of the relationship between food addiction and nutritional status in schizophrenic patients. Nutr Neurosci 22:392–400. https://doi.org/10.1080/1028415X.2017.1392429
68. Fountaine RJ, Taylor AE, Mancuso JP, Greenway FL, Byerley LO, Smith SR et al (2010) Increased food intake and energy expenditure following administration of olanzapine to healthy men. Obesity (Silver Spring) 18:1646–1651. https://doi.org/10.1038/oby.2010.6
69. Knolle-Veentjer S, Huth V, Ferstl R, Aldenhoff JB, Hinze-Selch D (2008) Delay of gratification and executive performance in individuals with schizophrenia: putative role for eating behavior and body weight regulation. J Psychiatr Res 42:98–105. https://doi.org/10.1016/j.jpsychires.2006.10.003
70. Teasdale SB, Ward PB, Samaras K, Firth J, Stubbs B, Tripodi E et al (2019) Dietary intake of people with severe mental illness: systematic review and meta-analysis. Br J Psychiatry 214:251–259. https://doi.org/10.1192/bjp.2019.20
71. Volkow ND (2009) Substance use disorders in schizophrenia—clinical implications of comorbidity. Schizophr Bull 35:469–472. https://doi.org/10.1093/schbul/sbp016
72. Danish Health Authority (2017) Danskernes sundhed—den nationale sundhedsprofil 2017. https://www.sst.dk/-/media/Udgivelser/2018/Den-Nationale-Sundhedsprofil-2017.ashx?la=da&hash=421C482AEDC718D3B4846FC5E2B0EED2725AF517. Accessed 24 Sept 2020

73. Statistics Denmark (2020) StatBank Denmark population and elections. https://www.statistikbanken.dk/statbank5a/default.asp?w=1920. Accessed 30 Sept 2020
74. Ziauddeen H, Fletcher PC (2013) Is food addiction a valid and useful concept? Obes Rev 14:19–28. https://doi.org/10.1111/j.1467-789X.2012.01046.x
75. Ziauddeen H, Farooqi IS, Fletcher PC (2012) Food addiction: is there a baby in the bathwater? Nat Rev Neurosci 13:514. https://doi.org/10.1038/nrn3212-c2
76. Fletcher PC, Kenny PJ (2018) Food addiction: a valid concept? Neuropsychopharmacology 43:2506–2513. https://doi.org/10.1038/s41386-018-0203-9
77. Schulte EM, Wadden T, Allison K (2020) An evaluation of food addiction as a distinct psychiatric disorder. Int J Eat Disord. https://doi.org/10.1002/eat.23350