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Foods and dietary profiles associated with 'food addiction' in young adults

Kirrilly M. Pursey [a,b], Clare E. Collins [a,b], Peter Stanwell [a,c], Tracy L. Burrows [a,b,]*

[a] School of Health Sciences, Faculty of Health and Medicine, University of Newcastle, Callaghan, NSW, Australia
[b] Priority Research Centre in Physical Activity and Nutrition, University of Newcastle, Callaghan, NSW, Australia
[c] Priority Research Centre for Translational Neuroscience and Mental Health, University of Newcastle, Callaghan, NSW, Australia

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ABSTRACT

Background: It has been suggested that addictive behaviors related to consumption of specific foods could contribute to overeating and obesity. Although energy-dense, hyper-palatable foods are hypothesized to be associated with addictive-like eating behaviors, few studies have assessed this in humans.
Objective: To evaluate in young adults whether intakes of specific foods are associated with 'food addiction', as assessed by the Yale Food Addiction Scale (YFAS), and to describe the associated nutrient intake profiles.
Design: Australian adults aged 18–35 years were invited to complete an online cross-sectional survey including demographics, the YFAS and usual dietary intake. Participants were classified as food addicted (FAD) or non-addicted (NFA) according to the YFAS predefined scoring criteria.
Results: A total 462 participants (86% female, 73% normal weight) completed the survey, with 14.7% ($n = 68$) classified as FAD. The FAD group had a higher proportion of females ($p = .01$) and higher body mass index ($p < .001$) compared to NFA. Higher YFAS symptom scores were associated with higher percentage energy intake (%E) from energy-dense, nutrient-poor foods including candy, take out and baked sweet products, as well as lower %E from nutrient-dense core foods including whole-grain products and breakfast cereals. These remained statistically significant when adjusted for age, sex and BMI category ($p = .001$).
Conclusions: Statistically significant associations were identified between YFAS assessed food addiction and dietary intake, specifically intakes of energy-dense, nutrient-poor foods. However, the effect sizes were small limiting clinical applications. Further examination of the relationship between addictive-like eating and intake of specific foods in a nationally representative sample is warranted.

1. Introduction

The prevalence of obesity has increased in parallel with dramatic changes in the food environment including an increase in the number of food service outlets and availability of hyper-palatable foods and beverages (Swinburn et al., 2011; Ng et al., 2014). Globally, 36.9% of males and 38.0% of females were classified as overweight or obese in 2013 (Ng et al., 2014). Obesity is associated with a greater risk of chronic conditions including type 2 diabetes and cardiovascular disease (World Health Organization, 2014; Guh et al., 2009) as well as poorer psychological and social wellbeing (Luppino et al., 2010; Jia & Lubetkin, 2005; McLaren, 2007). While obesity is complex and multifaceted, the majority of treatments have primarily focused on behavior change including caloric restriction and increased physical activity. The success of these behavioral approaches has been variable, with many failing to achieve significant weight loss and individuals regaining some or all of their lost body weight (Appel et al., 2011). Thus, there is a pressing need to better understand the underlying determinants of obesity and to subsequently develop interventions that provide more effective weight treatment and maintenance approaches to reduce the obesity burden.

A growing body of research is exploring whether addictive-like eating behaviors could contribute to overeating and subsequent obesity in susceptible individuals (Meule & Gearhardt, 2014a). Although there is no universally accepted definition of 'food addiction', it has been suggested that specific eating behaviors share similarities with the Diagnostic and Statistical Manual of Mental Disorders (DSM) diagnostic criteria for substance dependence (Gearhardt et al., 2009; Avena et al., 2011; Hone-Blanchet & Fecteau, 2014; Marcus & Wildes, 2014). These include: loss of control over consumption, continued overeating despite negative consequences and significant distress related to eating behaviors. While 'food addiction' is not yet a clinically recognized disorder, for the remainder of this paper the term is used as a construct to describe these addictive-like eating tendencies. Neurobiological parallels have been widely described between addictive-like eating patterns and traditional forms of substance abuse in dopaminergic reward-related pathways

Abbreviations: FAD, food addicted; NFA, not food addicted.

* Corresponding author at: School of Health Sciences, Priority Research Centre for Physical Activity and Nutrition, University of Newcastle, Callaghan, NSW, Australia.
E-mail addresses: Kirrilly.pursey@newcastle.edu.au (K.M. Pursey), Clare.collins@newcastle.edu.au (C.E. Collins), Peter.stanwell@newcastle.edu.au (P. Stanwell), Tracy.burrows@newcastle.edu.au (T.L. Burrows).

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(Hone-Blanchet & Fecteau, 2014; Jauch-Chara & Oltmanns, 2014; Volkow & O'Brien, 2007). More recently, with the inclusion of non-substance disorders such as gambling in the DSM-5 (American Psychiatric Association, 2013), it has been postulated that addictive-like eating may more closely resemble behavioral addictions (Meule & Gearhardt, 2014b; Pai et al., 2014; Hebebrand et al., 2014; Konkoly Thege et al., 2015; Davis & Loxton, 2013). Consequently, debate within the scientific community remains as to the classification of food addiction as a clinical disorder (Hebebrand et al., 2014; Ziauddeen & Fletcher, 2013).

The Yale Food Addiction Scale (YFAS) was developed in 2009 to evaluate addictive-like eating behaviors and has facilitated an increase in the number of studies seeking to assess this construct (Gearhardt et al., 2009). The YFAS operationalizes food addiction according to the DSM-IV diagnostic criteria for substance dependence, modeling these to eating behaviors (American Psychiatric Association, 2000). In a recent review with meta-analysis (Pursey et al., 2014a) of studies using the YFAS, the weighted mean prevalence of food addiction across populations studied was 19.9%, and ranged from 5.4% in the general community (Pedram et al., 2013) to 56.8% in a clinical population of individuals with binge eating disorder (Gearhardt et al., 2012). Of note, the majority of population samples across the reviewed articles were female, overweight or obese individuals recruited from clinical settings and thus may not be representative of the general population (Pursey et al., 2014a).

Few studies have explored possible associations between dietary intake and food addiction, as assessed by the YFAS (Pedram et al., 2013; Pedram & Sun, 2014). One study investigated the relationship between addictive-like eating behaviors and macronutrient intakes, and found that daily intakes of protein and fat were significantly higher in individuals meeting the YFAS criteria for food addiction (Pedram et al., 2013). A second study reported significantly higher intakes of fat and sugar, as well as a range of micronutrients, in those identified as food addicted according to the YFAS (Pedram & Sun, 2014). This study, however, was conducted in an obese population sample. In addition, the aforementioned studies only reported intakes of specific components of food including nutrients (e.g. calcium) and their association with addictive-like eating, rather than actual types of food (e.g. milk). The assessment and reporting of intake of everyday foods are important as the general population consume foods rather than individual nutrients or ingredients. Therefore, identifying specific foods associated with addictive-like eating is essential to inform the potential development of interventions to target these behaviors.

It is likely that foods have varying capacities to elicit an addictive-like response based on their ingredient composition and processing. One recent study reported that the degree to which a food has been processed is the most influential attribute for whether a food is associated with addictive eating behaviors (Schulte et al., 2015). In addition, in a qualitative study of self-identified 'food addicts', calorie-laden 'junk' foods such as chocolate and cookies were identified as the most common foods associated with addictive-like eating behaviors (Curtis & Davis, 2014). High-calorie, highly processed foods, which are ubiquitous in the modern food environment, are widely hypothesized as those that are most likely to be associated with addictive-like eating behaviors in humans (Ifland et al., 2009; Corsica & Pelchat, 2010). This hypothesis may be attributed in part to pre-clinical studies which have demonstrated that foods high in sugar and fat can elicit addictive-like behaviors in rodents (Avena et al., 2009). While preliminary research has emerged to identify whether similar food characteristics could potentially facilitate addictive-like eating in humans (Schulte et al., 2015), further research is required in this area.

To date, no studies have reported associations between food addiction, as assessed by the YFAS, and intakes of specific foods across a range of weight categories. This study aimed to determine if specific foods are associated with YFAS food addiction 'diagnosis' or 'symptom scores' and to subsequently describe the nutrient intake profiles and diet quality associated with these addictive-like eating behaviors. It was hypothesized that higher intakes of energy-dense, nutrient-poor foods would be more likely to be associated with food addiction, as assessed by the YFAS.

2. Materials and methods

Australian adults were recruited from March to May, 2013. Participants were eligible if they were aged 18 to 35 years, currently living in Australia and proficient in English. Participants were ineligible if they were currently pregnant. This study was compliant with the Health Insurance Portability and Accountability Act (HIPAA) Privacy Rule (National Institutes of Health, 2004) and was approved by the Human Research Ethics Committee, the University of Newcastle, Australia.

Participants were recruited via advertisements on the University of Newcastle's social media sites, posters, and emails to staff and students. To increase sample size and population representativeness, respondents were encouraged to 'share' the study web link with others by using 'virtual snowballing' via social media sites including Facebook and Dietitian Connection, a networking website.

2.1. Food addiction survey

A 174-item online survey was designed by the authors using the tool Survey Monkey (https://www.surveymonkey.com/). This consisted of eligibility questions, demographics, self-reported anthropometrics, the YFAS, the Australian Eating Survey food frequency questionnaire (AES FFQ) (Collins et al., 2013), and an optional contact details section with participant details known only to the researchers. The survey was designed to align with the Strobe Guidelines, a recognized checklist of items that aim to strengthen the reporting quality of observational studies (von Elm et al., 2007).

Participants were presented with an information statement on the first survey screen and interested individuals were invited to proceed, which was taken as their informed consent to participate. Participants who did not elect to proceed were exited from the survey. The first survey screen determined eligibility, with those who were ineligible redirected out of the survey. As an incentive to complete all survey questions, a prize draw was offered.

2.1.1. Demographic and self-reported anthropometric data

Participants reported demographic data including age, sex, postal code, marital status, and current employment. Socio-economic status (SES) was determined using the Socio-Economic Indexes for Areas (SEIFA) deciles (Census of Population and Housing, 2011), an indicator of advantage and disadvantage based on the participants place of usual residence. The index is based on Australian census data and takes into account factors that may affect SES including income, education, employment, occupation and housing (Australian Bureau of Statistics, 2008). Postal codes are allocated a score from 1 to 10 with a score of 1 denoting the most disadvantaged areas and 10 the most advantaged. Participants were also asked to self-report their current height and weight. The online self-report of anthropometric data were previously validated using a subsample of the survey participants (Pursey et al., 2014b). Self-reported body mass index (BMI) was calculated from online self-reported height and weight using standard equations.

2.1.2. Yale Food Addiction Scale

The YFAS is a 25-item survey which quantifies addictive-like eating behaviors in the previous twelve months (Gearhardt et al., 2009). The YFAS uses Likert and dichotomous questions on eating behaviors mapped to the DSM-IV diagnostic criteria for substance dependence. The tool has been previously demonstrated to have sound psychometric properties (Gearhardt et al., 2009; Gearhardt et al., 2012). The YFAS includes two scoring outputs giving a total 'symptom score' and a 'diagnosis' of food addiction. The total 'symptom score' ranges from zero to seven, corresponding with the number of DSM-IV diagnostic criteria reported with respect to food. Participants may also be allocated a 'diagnosis' of food addiction if they report ≥3 symptoms and they also satisfy the clinical impairment or distress criteria.

The authors acknowledge that food addiction is not a clinically diagnosable condition, but for the purposes of the current paper, the terms 'diagnosis' and 'symptom score' are used in subsequent sections in the context of the YFAS predefined scoring outputs. The YFAS diagnosis was used to define 'food addicted' (FAD) and 'non-addicted' (NFA) individuals and these terms are used for brevity in subsequent sections of the paper.

2.1.3. Dietary intake via the Australian Eating Survey food frequency questionnaire

Dietary intake was measured via the adult AES, a self-administered, validated, 120-item semi-quantitative FFQ used to collect information about usual dietary intake over the previous six months (Collins et al., 2013; Burrows et al., 2012; Burrows et al., 2009; Burrows et al., 2015). An additional fifteen questions are included to assess food behaviors, such as breakfast consumption, and daily time spent sedentary, including television and computer use. Respondents are required to report frequency of consumption of specific foods and non-alcoholic beverages. Portion sizes for the AES were derived from unpublished data from the National Nutrition Survey (Australian Bureau of Statistics, 1998), supplied by the Australian Bureau of Statistics, or the standard serving size for items such as a slice of bread (Collins et al., 2013).

The AES categorizes items according to food groups to calculate an individual's total energy intake (Collins et al., 2013). Foods are classified into one of two broad categories, *(a)* nutrient-dense core foods or *(b)* energy-dense, nutrient-poor foods, and the proportion of energy consumed from these two broad categories is subsequently calculated (Collins et al., 2013). Core foods included breads, cereals (breakfast cereals, savory crackers, whole-grain products such as rice and pasta), dairy products, meat, fruit, and vegetables. Energy-dense, nutrient-poor foods included sweetened drinks (e.g. soda), savory packaged snacks (e.g. snack bars, potato chips, savory combination snacks), candy (e.g. sweets, chocolate), baked sweet products (e.g. cakes, pastries, cookies), and take-out (e.g. pizza, burgers, fries).

Intake from each of the food groups is subsequently used to calculate an individual's macronutrient and micronutrient intake. The micronutrients analyzed were thiamin, riboflavin, niacin equivalents, Vitamin C, folate, retinol, sodium, potassium, magnesium, calcium, phosphorus, iron and zinc. A validated diet quality index score, the Australian Recommended Food Score (ARFS), was also calculated for each participant based on their responses to the FFQ. The ARFS reflects overall diet quality and has a maximum score of 73, with higher scores corresponding with a more optimal nutrient intake profile (Collins et al., 2015).

2.2. Statistics

Data sets with >5 missing responses were excluded from analysis ($n = 207$). Food frequency data were checked for potential reporting errors, with no participants excluded due to implausible total energy intake. Participants were classified by BMI category using the World Health Organization cut-points (World Health Organization, 2013).

Chi squared tests were used to test associations between categorical demographic variables and YFAS food addiction diagnosis. Continuous demographic, anthropometric and AES nutrient intake variables were assessed using *t*-tests to identify any differences between the FAD and NFA groups. Additional subgroup analyses were undertaken to explore differences in dietary intakes according to BMI category in the FAD group only. For this analysis, the FAD group was divided into two broad weight status categories: underweight/normal weight and overweight/obese, and the two groups were compared using *t*-tests.

Logistic regression models were used to calculate the odds ratios of YFAS assessed food addiction diagnosis according to dietary intake and linear regression used to calculate the change in symptom scores according to dietary intake. The models were adjusted using the variables age, sex and BMI category. Crude and adjusted *p*-values are given for both the logistic and linear models to test for associations between dietary intake and food addiction outcomes. As each of the nutrient intake variables is presented on different scales, Cohen's *d* was calculated to compare effect sizes across the linear regression models (Cohen, 1988). Effect sizes were interpreted as small (Cohen's $d = .2$), moderate (Cohen's $d = .5$), or large (Cohen's $d = .8$).

Significance level was set at $p = .05$. Due to the large number of dietary intake variables tested, an adjusted *p*-value for the nutrient data was calculated using a Bonferroni correction factor by dividing the *p*-value by the number of tested variables (i.e. $n = 40$). The adjusted *p*-value for dietary data was therefore set at $p = .00125$. Unless otherwise specified, data are presented as means ± standard deviations. All analysis was undertaken using Stata V11 (StataCorp LP, Texas).

3. Results

A total of 669 respondents entered the survey with 462 participants (69.3%) completing all questions. Age and BMI did not differ significantly between survey completers and non-completers; however, the non-completers were more likely to be male ($p = .006$), report higher symptom scores ($p < .001$) and were less likely to be classified as FAD ($p < .001$). Participant demographic characteristics are summarized in Table 1. The mean age of participants was 25.1 ± 4.0 years and 86% were female. The participants were from a range of socioeconomic backgrounds (SEIFA range 1–10) with the eighth SEIFA decile the most commonly reported corresponding to a relatively high SES. The mean BMI was 23.2 ± 4.5 kg/m^2 (range 15.9–54.0 kg/m^2, males 24.5 ± 4.1 kg/m^2, females 23.0 ± 4.5 kg/m^2) and the majority of participants were classified as of a normal weight BMI (72.9%), followed by overweight (13.9%) and obese (7.8%). The majority of the sample had attained a university qualification (50.7%) and had never been married (63.6%). The most common duration of time spent in sedentary behaviors was 0–1 h per day for television watching (47.8%) and 2–3 h per day for computer time (35.3%).

Sixty-eight respondents met the YFAS predefined criteria for FAD (14.7%). The FAD group had a significantly higher proportion of females compared to the NFA group ($p = .01$) and a significantly higher proportion of NFA were university educated compared to FAD ($p = .003$). Weight and calculated BMI were significantly higher in FAD compared to NFA ($p < .001$). No significant differences were identified between FAD and NFA for any other demographic or anthropometric variables including duration of sedentary behaviors ($p > .05$).

The mean number of symptoms for the whole sample was 2.4 ± 1.8 out of possible score of seven. The FAD group reported a significantly higher mean symptom score of 5.2 ± 1.5 compared to 1.9 ± 1.4 in NFA ($p < .001$). A total of 435 respondents (94.2%) reported at least one food addiction symptom, with the most common symptoms being *Persistent desire or unsuccessful attempts to cut down or control eating* (91.6%) and *Continued eating despite physical or psychological problems* (37.2%). The least commonly reported symptom was *Social, occupational or recreational activities given up due to eating behavior* (16.9%). Each of the seven YFAS food addiction symptoms was reported by a significantly higher proportion of the FAD group compared to NFA ($p < .05$).

3.1. Food and nutrient intake according to food addiction diagnosis

Dietary intakes are reported in Table 2. There were no differences in energy intake between the FAD and NFA groups ($p = .59$). Mean percentage energy intake (%E) from protein, carbohydrate and total fat was within the recommended acceptable macronutrient distribution ranges, although saturated fat intakes were higher than recommended in both groups (National Health and Medical Research Council, 2006). Mean %E from whole-grain products was associated with lower odds of classification as FAD, with an odds ratio of .93, 95%CI (.90, .97). In addition, %E from total fat and monounsaturated fat was associated with higher odds of classification as FAD, with odds ratios of 1.11, 95%CI

Table 1
Demographic and anthropometric characteristics of the total sample, non-addicted (NFA) and food addicted (FAD) groups.

Participant characteristics	Total sample	NFA	FAD	p
Number of participants	462	394 (85.3%)	68 (14.7%)	
Female	395 (85.5%)	330 (83.8%)	65 (95.6%)	.01[a]
Age (years) [mean (SD)]	25.1 (4.0)	25.1 (4.1)	25.1 (4.4)	.96[b]
Indigenous	6 (1.3%)	5 (1.3%)	1 (1.5%)	.89[a]
Self-reported height (cm) [mean (SD)]	168.5 (8.1)	168.6 (8.2)	168.3 (7.7)	.79[b]
Self-reported weight (kg) [mean (SD)]	66.1 (14.4)	64.6 (11.6)	75.0 (23.4)	<.001* [b]
Self-reported BMI (kg/m^2) [mean (SD)]	23.2 (4.5)	22.7 (3.5)	26.4 (7.6)	<.001* [b]
BMI category				
Underweight	25 (5.4%)	23 (5.8%)	2 (2.9%)	
Normal weight	337 (72.9%)	302 (76.7%)	35 (51.5%)	
Overweight	64 (13.9%)	49 (12.4%)	15 (22.1%)	
Obese	36 (7.8%)	20 (5.1%)	16 (23.5%)	<.001* [a]
Highest qualification				
No formal qualifications	1 (0.2%)	1 (0.3%)	0 (0%)	
School certificate or Higher school certificate	168 (36.7%)	136 (34.5%)	32 (47.1%)	
Trade or Diploma	59 (12.8%)	44 (11.2%)	15 (22.1%)	
University degree or Higher university degree	234 (50.7%)	213 (54.1%)	21 (30.9%)	.003[a]
Mean number of YFAS symptoms reported				
Mean symptoms [mean (SD)]	2.4 (1.8)	1.9 (1.4)	5.2 (1.5)	<.001* [b]
Percentage of participants reporting specific YFAS symptoms				
Larger amounts consumed than intended	90 (19.5%)	48 (12.8%)	42 (61.8%)	<.001* [a]
Persistent desire or unsuccessful attempts to cut down or control eating	423 (91.6%)	356 (90.4%)	67 (98.5%)	.03[a]
Much time spent obtaining food or eating or recovering from consumption	113 (24.5%)	64 (16.2%)	49 (72.1%)	<.001* [a]
Social, occupational or recreational activities given up	78 (16.9%)	37 (9.4%)	41 (60.3%)	<.001* [a]
Continued eating despite physical or psychological problems	172 (37.2%)	111 (28.2%)	61 (89.7%)	<.001* [a]
Tolerance	120 (26.0%)	72 (18.3%)	48 (70.6%)	<.001* [a]
Withdrawal symptoms	91 (19.7%)	45 (11.4%)	46 (67.7%)	<.001* [a]
Clinically significant impairment or distress	79 (17.1%)	11 (2.8%)	68 (100.0%)	<.001* [a]

Unless otherwise specified, data are presented as *count* (%).[a] = Chi squared test, [b] = t-test. BMI = body mass index, FAD = 'Food addicted' (≥3 symptoms + satisfying clinical impairment/distress criteria), NFA = non-addicted, YFAS = Yale Food Addiction Scale. * = $p < .05$.

(1.04, 1.18), and 1.22, 95%CI (1.08, 1.38), respectively. These remained statistically significant when adjusted for age, sex and BMI category ($p = .001$).

While there was some evidence that mean %E from candy, take-out and breakfast cereal was significantly associated with odds of FAD classification, this did not remain significant when adjusted for age, sex and BMI category. No significant associations were identified between the odds of classification as FAD and %E from protein, carbohydrate or any of the micronutrients (all $p > .00125$). Although there was a trend towards higher odds of FAD classification with higher %E intake of energy-dense nutrient-poor foods ($p = .06$) and lower ARFS diet quality scores ($p = .05$), these were not statistically significant.

Analyses of the FAD group alone indicated that individuals classified as overweight/obese ($n = 31$) had significantly higher intakes of take-out ($p = .001$) and energy-dense, nutrient-poor foods ($p < .001$); as well as lower intakes of vegetables and core foods ($p < .001$) compared to those classified as underweight/normal weight ($n = 37$) (Supplementary Table 1). Although there were trends towards higher intakes of sweet drinks, savory packaged snacks, saturated fat and sodium; as well as lower intakes of fruit, polyunsaturated fat, vitamin C, and lower diet quality in the overweight/obese FAD group compared to underweight/normal weight FAD group, these were not statistically significant.

3.2. Relationships between symptom scores and food and nutrient intake

A non-significant trend was found between symptom scores and energy intake ($p = .06$) (Table 3). Positive relationships were identified between YFAS symptom scores and %E from candy, total fat, saturated fat, and intake of energy-dense, nutrient-poor foods ($p \le .001$); while negative relationships were identified with %E from whole-grain products, breakfast cereals and core foods ($p < .001$). All variables remained significant when adjusted for age, sex and BMI category. Additionally, when adjusted for demographic variables, a positive relationship was identified between symptom scores and %E from baked sweet products and take-out ($p \le .001$). Despite reaching statistically significant thresholds, analysis using Cohen's d indicated that only small effect sizes existed for each of the dietary variables (Cohen's d range .15–.21). While there was a trend for higher symptom scores to be associated with lower diet quality, this was not statistically significant ($p = .08$).

4. Discussion

This study examined whether intakes of specific foods, nutrients and diet quality were associated with food addiction diagnosis and symptom scores as assessed by the YFAS. In line with our hypothesis, higher YFAS symptom scores were found to be associated with higher intakes of energy-dense, nutrient-poor, processed foods including candy, take-out and baked sweet products. Higher symptom scores were also related to lower intakes of nutrient-dense core foods including whole-grain products and breakfast cereals. Although there was a trend towards higher intakes of energy-dense, nutrient-poor foods in the FAD group, these did not reach statistical significance, which is in contrast to our original hypothesis. In addition, no significant relationships were identified between diet quality and food addiction diagnosis or symptom scores.

Approximately fifteen percent of the sample met the YFAS predefined criteria for food addiction diagnosis. This is slightly higher than previous research conducted in the Australian population (Lee et al., 2014) and may be attributable to differences in sample characteristics between the two studies. The self-selected nature of the current sample may also have led to an overestimate of the prevalence of food addiction with those individuals displaying addictive-like eating behaviors more interested and motivated to complete the survey. The FAD group was comprised of a higher proportion of females compared to NFA, consistent with previous research (Pursey et al., 2014a). Unlike other studies (Flint et al., 2014), no associations between age and food addiction outcomes were identified in the current study, but this may have been limited by the homogenous sample comprised of predominantly female, young adults.

Weight status assessed via BMI was significantly higher in the FAD group compared to NFA, aligning with previous international studies

Table 2
Mean daily nutrient intake and odds ratios for the total sample ($n = 462$), non-addicted (NFA) and food addicted (FAD) groups. Data are presented as mean (standard deviation).

Nutrients	Total sample ($n = 462$)	NFA ($n = 394$)	FAD ($n = 68$)	p unadjusted[a]	p adjusted[b]	Adjusted odds of FAD diagnosis[b]	(95%CI)
Total energy (kcal)	2007 (620)	2009 (624)	1997 (602)	.88	.59	1.00	(1.00, 1.00)
Total energy (kJ)	8399 (2595)	8407 (2611)	8355 (2518)	.88	.59	1.00	(1.00, 1.00)
Percentage energy from food groups (%)							
Vegetables (%)	8.5 (3.9)	8.5 (3.9)	8.2 (4.1)	.50	.71	.99	(.92, 1.06)
Fruit (%)	8.5 (6.0)	8.4 (5.6)	8.6 (8.1)	.83	.37	1.02	(.98, 1.07)
Meat (%)	14.8 (8.1)	14.7 (8.0)	15.4 (9.0)	.56	.99	1.00	(.97, 1.04)
Grains (%)	18.9 (7.8)	19.5 (7.6)	15.4 (7.6)	<.001*	.001*	.93	(.90, .97)
Dairy (%)	11.1 (6.6)	11.3 (6.6)	10.0 (6.4)	.12	.27	.98	(.93, 1.02)
Sweet drink (%)	2.9 (4.9)	3.1 (5.1)	1.9 (3.4)	.08	.05	.91	(.83, 1.00)
Savory packaged snacks (%)	2.4 (2.6)	2.3 (2.4)	3.2 (3.5)	.01	.06	1.10	(1.00, 1.21)
Candy (%)	6.3 (5.9)	5.8 (5.3)	8.9 (8.2)	<.001*	.01	1.06	(1.01, 1.10)
Baked sweet products (%)	5.0 (4.3)	4.9 (4.0)	5.6 (5.8)	.18	.69	1.01	(.95, 1.08)
Take-out (%)	7.6 (5.9)	7.2 (5.1)	9.8 (9.1)	<.001*	.03	1.05	(1.00, 1.09)
Breakfast cereal (%)	6.2 (4.8)	6.5 (4.9)	4.1 (4.1)	<.001*	.003	0.91	(.85, .97)
Nutrient intake							
Protein (%)	19.6 (3.7)	19.6 (3.6)	19.4 (3.9)	.75	.45	.97	(.90, 1.05)
Carbohydrate (%)	45.2 (6.9)	45.4 (6.9)	44.1 (6.8)	.17	.19	.97	(.93, 1.01)
Fat (%)	33.3 (4.6)	33.0 (4.5)	35.3 (5.1)	<.001*	.001*	1.11	(1.04, 1.18)
Saturated fat (%)	13.5 (2.5)	13.4 (2.4)	14.4 (3.1)	.002	.08	1.11	(.99, 1.24)
Polyunsaturated fat (%)	4.3 (1.2)	4.3 (1.2)	4.6 (1.4)	.07	.01	1.31	(1.06, 1.61)
Monounsaturated fat (%)	12.5 (2.3)	12.3 (2.2)	13.2 (2.3)	.001*	.001*	1.22	(1.08, 1.38)
Alcohol (%)	2.1 (2.7)	2.2 (2.7)	1.5 (2.3)	.03	.17	.92	(.81, 1.04)
Cholesterol (mg)	288.5 (124.2)	288.1 (124.1)	290.5 (125.5)	.88	.55	1.00	(1.00, 1.00)
Sugars (g)	115.9 (50.5)	116.5 (51.4)	112.2 (45.5)	.52	.99	1.00	(.99, 1.00)
Fiber (g)	26.1 (8.3)	26.3 (8.3)	24.9 (7.9)	.21	.95	1.00	(.97, 1.04)
Thiamin (mg)	1.5 (0.6)	1.5 (0.6)	1.4 (0.5)	.06	.12	.64	(.37, 1.13)
Riboflavin (mg)	2.3 (0.8)	2.3 (0.8)	2.0 (0.8)	.03	.21	.79	(.55, 1.14)
Niacin equivalent (mg)	42.0 (13.8)	42.2 (13.9)	40.7 (12.8)	.39	.77	1.00	(.97, 1.02)
Vitamin C(mg)	152.4 (63.2)	152.5 (61.9)	151.5 (70.7)	.90	.34	1.00	(1.00, 1.01)
Folate (μg)	312.0 (99.7)	316.4 (100.8)	286.7 (89.5)	.19	.33	1.00	(1.00, 1.00)
Vitamin A (μg)	1168.4 (440.9)	1179.2 (445.6)	1105.3 (410.1)	.20	.49	1.00	(1.00, 1.00)
Sodium (mg)	2014.6 (756.7)	2015.0 (745.7)	2011.8 (823.5)	.97	.99	1.00	(1.00, 1.00)
Potassium (mg)	3367.2 (966.0)	3373.5 (976.7)	3300.5 (907.3)	.73	.52	1.00	(1.00, 1.00)
Magnesium (mg)	391.8 (105.7)	394.6 (106.1)	375.6 (102.6)	.17	.87	1.00	(1.00, 1.00)
Calcium (mg)	1117.5 (409.8)	1124.3 (406.3)	1078.0 (430.8)	.39	.99	1.00	(1.00, 1.00)
Phosphorus (mg)	1580.6 (496.8)	1587.0 (499.1)	1543.0 (485.1)	.50	.94	1.00	(1.00, 1.00)
Iron (mg)	13.0 (3.9)	13.2 (4.0)	12.2 (3.3)	.06	.27	.96	(.88, 1.04)
Zinc (mg)	12.6 (4.2)	12.7 (4.3)	12.2 (4.0)	.35	.51	.98	(.91, 1.05)
Percentage energy from broad food categories (%)							
Core foods (%)	67.0 (13.6)	67.8 (12.9)	62.3 (16.5)	.002	.06	.98	(.96, 1.00)
Energy-dense, nutrient poor foods (%)	33.0 (13.6)	32.2 (12.9)	37.7 (16.5)	.002	.06	1.02	(1.00, 1.04)
Diet quality							
ARFS (score out of 73)	35.4 (9.3)	35.9 (9.2)	32.6 (9.5)	.008	.05	.97	(.94, 1.00)

[a] = unadjusted p value, [b] = adjusted for age, sex and body mass index category. ARFS = Australian Recommended Food Score, FAD = 'Food addicted' (≥3 symptoms + satisfying clinical impairment/distress criteria), NFA = non-addicted. * = significant at $p < .00125$.

(Pursey et al., 2014a; Flint et al., 2014; Gearhardt et al., 2014). However, the majority of participants classified as FAD were categorized as of a normal weight BMI. Although online self-reported anthropometrics have been shown to be a valid method of data collection (Pursey et al., 2014b), the self-reported nature may have led to some discrepancies in BMI classification. This may have resulted in a larger proportion of normal weight individuals classified as FAD in the current study compared to previous studies where anthropometrics were measured (Pedram et al., 2013). In addition, while there was a statistically significant relationship between BMI and addictive-like eating behaviors as assessed by the YFAS, food addiction is not synonymous with obesity and the two can occur independently (Pursey et al., 2014a).

There were no significant differences between the groups for total energy intake or duration of sedentary behaviors. The observed differences in BMIs between the groups may indicate possible underreporting of food intake by the FAD group or higher levels of energy expenditure through physical activity in the NFA group, which was not assessed in this study. It is well documented that young adults have the steepest weight gain trajectory of any age group (Ng et al., 2014; Australian Bureau of Statistics, 2012). Significant life transitions that occur during young adulthood may result in changes in eating behaviors and environmental factors (Hebden et al., 2012), including increased access to high-calorie, hyper-palatable foods, and these could be problematic for some individuals who are vulnerable to displaying addictive-like eating behaviors. Therefore, while some survey participants reported addictive-like eating tendencies as assessed by the YFAS, these maladaptive eating patterns may not yet have manifested as clinical presentations such as obesity. Due to age-related variation in eating behaviors and dietary profiles, future studies are required across a broader range of ages, particularly children and adolescents (Burrows & Meule, 2014).

Scientific evidence supporting the classification of any specific food, nutrient or additive (excluding caffeine) as addictive in humans is presently lacking (Hebebrand et al., 2014). The current study extended previous research by investigating associations between YFAS assessed food addiction and detailed dietary intake profiles including the percentage of total energy derived from specific food groups, diet quality and total macronutrient and micronutrient intakes across all BMI categories. Total dietary fat intake was identified as the primary nutrient associated with increased odds of FAD diagnosis, which is similar to the studies conducted by Pedram et al. (Pedram et al., 2013; Pedram & Sun, 2014). However, Pedram et al. also reported that obese individuals identified as food addicted according to the YFAS criteria reported higher intakes of other subtypes of fat including saturated fat (Pedram & Sun, 2014). These differences between studies may be due to the variation between population samples.

Dietary intake of total carbohydrates or sugars was not significantly associated with FAD or symptom scores in the current study. Notably, dietary intake of whole-grain products was found to be somewhat

Table 3
Associations between food addiction symptom scores and mean daily nutrient intake for the total sample.

Nutrients	Adjusted change in symptom score[b]	(95%CI)	*p* unadjusted[a]	*p* adjusted[b]	Cohen's *d*
Total energy (kcal)	$2.6\ e^{-4}$	$(-1.3\ e^{-5}, 5.4\ e^{-4})$	.23	.06	.09
Total energy (kJ)	$6.3\ e^{-5}$	$(-3.1, 1.3\ e^{-4})$	.23	.06	.09
Percentage energy from food groups (%)					
Vegetables (%)	−.04	(−.08, .003)	.05	.07	−.08
Fruit (%)	.003	(−0.3, 0.2)	.37	.82	−.01
Meat (%)	−.007	(−.03, .01)	.80	.48	−.03
Grains (%)	−.04	(−.06, −.02)	<.001*	<.001*	−.17
Dairy (%)	−.03	(−.05, −.002)	.02	.04	−.09
Sweet drink (%)	−.02	(−.05, .01)	.24	.21	−.06
Savory packaged snacks (%)	.06	(−.002, .12)	.01	.06	.09
Candy (%)	.06	(.04, .09)	<.001*	<.001*	.20
Baked sweet products (%)	.06	(.02, .10)	<.001*	.001*	.15
Take-out (%)	.06	(.03, .09)	<.001*	<.001*	.19
Breakfast cereal (%)	−.07	(−.10, −.03)	<.001*	<.001*	−.17
Nutrient intake					
Protein (%)	−.03	(−.07, .01)	.34	.19	−.06
Carbohydrate (%)	−.01	(−.03, .01)	.30	.40	−.04
Fat (%)	.06	(.03, .10)	<.001*	<.001*	.16
Saturated fat (%)	.11	(.05, .18)	<.001	.001*	.16
Polyunsaturated fat (%)	.06	(−.07, .18)	.76	.38	.04
Monounsaturated fat (%)	.10	(.03, .17)	.004	.01	.12
Alcohol (%)	−.04	(−.10, .02)	.05	.20	−.06
Cholesterol (mg)	.002	$(2.7\ e^{-4}, .003)$	.07	.02	.11
Fiber (g)	−.004	(−.2, .02)	.14	.71	−.02
Sugars (g)	.002	(−.002, .005)	.74	.36	.04
Thiamin (mg)	−.21	(−.51, .08)	.10	.16	−.07
Riboflavin (mg)	−.07	(−.27, .12)	.12	.48	−.03
Niacin equivalent (mg)	.003	(−.01, .01)	.88	.70	.02
Vitamin C (mg)	$4.0\ e^{-4}$	(−.002, .003)	.57	.76	.01
Folate (μg)	−.001	$(-.003, 4.4\ e^{-4})$	.01	.15	−.07
Vitamin A(μg)	$-1.7\ e^{-4}$	$(-5.3\ e^{-4}, 2.0\ e^{-4})$	.15	.36	−.04
Sodium (mg)	$1.2\ e^{-4}$	$(-1.1\ e^{-4}, 3.4\ e^{-4})$	.29	.30	.05
Potassium (mg)	$6.6\ e^{-5}$	$(-1.1\ e^{-4}, 2.4\ e^{-4})$	.99	.45	.03
Magnesium (mg)	$-3.2\ e^{-4}$	(−.002, .001)	.11	.69	−.02
Calcium (mg)	$-1.7\ e^{-5}$	$(-4.1\ ^{e\text{-}4}, 3.8\ e^{-4})$	.48	.93	−.003
Phosphorus (mg)	$1.4\ e^{-4}$	$(-2.0\ e^{-4}, 4.8\ e^{-4})$	.86	.40	.04
Iron (mg)	−.01	(−.06, .03)	.19	.59	−.03
Zinc (mg)	.005	(−.04, .04)	.95	.81	.01
Percentage energy from broad food categories (%)					
Core foods (%)	−.03	(−.04, −.02)	<.001*	<.001*	−.21
Energy-dense, nutrient-poor foods (%)	.03	(.02, .04)	<.001*	<.001*	.21
Diet quality					
ARFS	−.02	(−.03, .002)	.01	.08	−.08

[a] = unadjusted *p* value, [b] = adjusted for age, sex and body mass index category. ARFS = Australian Recommended Food Score. * = significant at $p < .00125$.

protective against addictive-like eating behaviors, decreasing odds of FAD classification by 7%. This is an interesting finding, and may suggest that specific subtypes of carbohydrates may have different effects on addictive-like behaviors based on their degree of processing and glycaemic load (Ifland et al., 2009). Glycaemic load has been shown to predict the types of problematic foods associated with addictive eating behaviors more than sugars or net carbohydrate content and thus warrants further investigation (Schulte et al., 2015).

Higher intakes of energy-dense, nutrient-poor foods including candy, baked sweet products, and take-out foods were associated with higher YFAS symptom scores. These foods typically contain large quantities of added fat, sugar and salt (sodium) to increase their palatability; hence it is not surprising that a positive relationship was identified between dietary intakes of fat, particularly saturated fat, and symptom scores. Interestingly, no significant relationships were identified between symptom scores and other key nutrients including sugar and sodium, unlike previous research in the area (Pedram & Sun, 2014). The YFAS does not assess the actual frequency of addictive-like eating episodes and therefore periodic or infrequent episodes of addictive eating may not impact dietary intake in such a way that statistically significant differences in nutrient intake profiles can be detected according to food addiction status. Future research should assess the frequency and quantity of food consumed during these periods of addictive-like eating, as well as binge eating behavior to determine the long term effects on dietary intake profiles.

Higher symptom scores were related to lower intakes of nutrient-dense core foods, which is significant given that lower intakes of these foods carry an increased risk of chronic conditions (Rice et al., 2013; Boeing et al., 2012; Jonnalagadda et al., 2011; National Health and Medical Research Council, 2013). Although statistically significant, the effect sizes for the relationships between symptom scores and dietary variables were small, therefore the clinical effect of these relationships may be limited. No significant associations were identified between food addiction outcomes and any of the micronutrients analyzed or diet quality. This is likely to have been influenced by the sample size limiting statistical power. As poorer diet quality is associated with chronic disease as well as risk of all-cause morbidity and mortality (Wirt & Collins, 2009; Kant, 1996), future studies are required to evaluate the long-term health implications of diet profiles associated with addictive-like eating behaviors.

It has previously been shown that bulimic symptomology is strongly associated with addictive-like eating behaviors as measured by the YFAS (Meule et al., 2014). It is possible that some individuals within the FAD group classified as underweight or normal weight may have displayed bulimic symptomology. Additional analyses of the FAD group alone revealed that overweight/obese individuals reported lower intakes of core foods and higher intakes of energy-dense, nutrient-poor foods compared to underweight/normal weight individuals in this group. Therefore, even within the FAD group, individuals report differences in dietary profiles that can contribute to differences in weight status over time. The current study did not assess compensatory behaviors such as purging or exercising, which may also explain differences in BMI.

This study provides preliminary evidence to inform a study using a larger, more representative sample to assess the clinical implications of addictive-like eating behaviors on food intake and diet quality. Future studies may also investigate the clinical applications of the YFAS including its use as screening tool to identify those displaying addictive-like eating behaviors and to subsequently develop more effective treatment approaches tailored to these individuals.

This study was limited by the predominantly female, well-educated, convenience sample, reducing the generalizability of findings to the broader population. The cross-sectional nature of the survey also precludes inferences regarding causality between addictive-like eating and food intake and diet quality. It is possible that the retrospective, self-reported nature of the FFQ led to underreporting of total energy and nutrient intakes, particularly in those classified as overweight and obese (Rennie et al., 2007; Macdiarmid & Blundell, 1998). However, the AES has been previously shown to be a reproducible and reliable estimate of dietary intake compared to weighed food records and dietary biomarkers (Collins et al., 2013; Burrows et al., 2015). A further limitation of the study is the use of the SEIFA deciles as a proxy for SES, where measures of advantage and disadvantage are assigned to areas, not to individuals. Thus, although SEIFA is considered a standard measure and is commonly used in Australia, it should be considered a proxy of SES based on area of residence, and future studies should assess SES at the individual level. As the survey questions were presented in the same sequence for all participants, it is possible that the order of questions may have affected the responses of participants and future studies should control for order effects by counterbalancing the order of questions. A further limitation of the study was that presence of eating disorders was not assessed, therefore it is possible that individuals with disordered eating may have been present in the sample and influenced findings. Despite these limitations, this study provides important exploratory data regarding potential relationships between dietary intake profiles and YFAS defined food addiction.

5. Conclusions

This study used validated tools in a novel analysis to characterize foods and nutrient intakes associated with addictive-like eating behaviors, as assessed by the YFAS. Approximately fifteen percent of participants were classified as FAD and YFAS food addiction diagnosis was associated with higher BMIs. Higher intakes of whole-grain products were related to lower odds of classification as FAD while higher intakes of fat were associated with higher odds of FAD. Additionally, higher intakes of energy-dense, nutrient-poor foods were related to higher symptom scores. However, the effect sizes were small, limiting the clinical significance of these findings. Future studies investigating larger, more nationally representative samples are required to substantiate the findings of this study and explore further associations between YFAS food addiction outcomes and diet profiles.

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Conflicts of interest

The authors declare no conflicts of interest.

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