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ORIGINAL ARTICLE

Food preferences and YFAS/YFAS-C scores in schoolchildren and university students

Mikhail F. Borisenkov[1] · Tatyana A. Tserne[1] · Sergey V. Popov[1] · Larisa A. Bakutova[1] · Anna A. Pecherkina[2] · Olga I. Dorogina[2] · Ekaterina A. Martinson[3] · Valentina I. Vetosheva[4] · Denis G. Gubin[5,6] · Svetlana V. Solovieva[5] · Elena F. Turovinina[5] · Elvira E. Symaniuk[2]

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Abstracts

Purpose Food addiction (FA) is one of the causes of widespread obesity in modern society. It was shown that there is an age-associated increase in incidence rate of FA in adolescents/young adults. The purpose of this study was to analyze food preferences in schoolchildren and university students with FA.

Methods High school and university students ($N = 1607$; age: 17.8 ± 2.7 years; girls: 77.0%) located in four settlements of Russia anonymously took part in the study. Study participants provided personal data (age, sex, height, and weight) and completed the Yale Food Addiction Scale, the Zung Self-Rating Depression Scale and the Munich ChronoType Questionnaire. In addition, they indicated food products with which they had problems.

Results The frequency of detection of FA among university students was twice as high as among schoolchildren. University students with FA were 20.2% more likely than schoolchildren to report the symptom 'use continues despite knowledge of adverse consequences,' and 13.7% more likely to report the symptom 'tolerance.' Schoolchildren and university students with FA most often noted that foods high in sugar and fat were problematic. University students with FA also reported that foods with a high carbohydrate content were problematic.

Conclusion In university students with FA, in comparison with schoolchildren with FA, there is an increase in list of problematic food products, mainly due to products with a high carbohydrate content.

Level of evidence Level V, cross-sectional descriptive study.

Keywords Food addiction · Obesity · Depression · Social jetlag · Schoolchildren · University students · Food preferences

Introduction

In the course of evolution, people's food preferences were formed in conditions of food scarcity and irregularity of their receipt due to differences in the number of animals that people hunted and the instability of crop yield. The most

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✉ Mikhail F. Borisenkov
borisenkov@physiol.komisc.ru

[1] Department of Molecular Immunology and Biotechnology, Institute of Physiology of Komi Science Centre of the Ural Branch of the Russian Academy of Sciences, Syktyvkar, Russia

[2] Ural Institute of Humanities, Ural Federal University, Yekaterinburg, Russia

[3] Institute of Biology and Biotechnology, Vyatka State University, Kirov, Russia

[4] Institute of Pedagogy and Psychology, Pitirim Sorokin Syktyvkar State University, Syktyvkar, Russia

[5] Department of Biology, Tyumen Medical University, Tyumen, Russia

[6] Tyumen Cardiology Research Centre, Tomsk National Research Medical Center, Russian Academy of Science, Tyumen, Russia

important properties of food products that people preferred in these conditions were a high caloric content and rapid absorption of components, and an important feature of eating behavior, digestion and metabolism that people sought after was the ability to consume food after full saturation and store an excessive amount of food components in the form of fat deposits [1]. In modern conditions, where, in most countries, there is an abundance of cheap, high-calorie foods, these food preferences and eating behaviors have caused an extremely widespread proliferation of cases of obesity, which has become an epidemic [2]. In 2014, 1.9 billion overweight people and 900 million obese people were identified worldwide [3]. Moreover, this problem is equally relevant for both industrialized and developing countries. A recent, pooled analysis of 2416 population-based studies involving 128.9 million children, adolescents, and adults found that rising trends in the body mass index (BMI) of children and adolescents have plateaued in many high-income countries—albeit at high levels. However, the trend for increasing BMI in youth has accelerated in parts of Asia, and frequently fails to correlate with that of adults [4]. Russia has also seen an increased prevalence of adolescent obesity in recent years. Between 2002 and 2014, the prevalence of obesity in the Russian Federation increased by fourfold among girls and threefold among boys [5]. The increased risk of obesity is due to a number of reasons, including genetics, explaining 70% of the indicator variability [6]. At the same time, it is assumed that external factors make a significant contribution to the risk of obesity. It has been suggested that the active advertising and easy availability of cheap, high-calorie foods with a high content of fats and sugars (the so-called "obesogenic environment") is an important factor in the spread of obesity among the population in modern society [7].

Data have been obtained that indicate the existence of the psychophysiological mechanisms underlying obesity. It has been shown that the consumption of certain foods can lead to persistent activation of the nerve centers that make up the dopamine reward system [8]. This can lead to the formation of dependence on certain food products, which has similarities with nicotine, alcohol and drug addiction. On this basis, the concept of food addiction (FA) was proposed [8]. The Yale Food Addiction Scale (YFAS) was developed [9] to detect FA in accordance with the diagnostic criteria of the Diagnostic and Statistical Manual on Psychological Disorders for Drug Dependence [10]. The YFAS has been translated into many languages [11–16], passed extensive testing in different countries, and generally given comparable results in the frequency of detection of FA in different groups of healthy populations [17] and in specific groups of people with eating disorders [18].

Numerous similarities between substance use disorder (SUD) and FA have now been described. Individuals with SUD [10] and FA [19] are unable to control the consumption of problematic substances/products and continue to consume them, despite the negative physical and emotional consequences they experience. Problematic substances [20] and food products [21] can cause craving and addictive behavior in humans. Problematic substances/food products activate the dopamine reward system [8]. Repeated consumption of problematic substances [22] and food products [23] increases the sensitivity of the dopaminergic system.

The unresolved question is what specific components of problematic food products cause FA. Since the avalanche-like spread of obesity in society began relatively recently, over several decades, the attention of scientists has been focused on food products that appeared relatively recently but take a significant place in the diet of modern men. Modern food products are usually subjected to deep processing, which increases their digestibility. At the same time, the modern food industry is characterized by the widespread use of food additives, various flavors and flavor enhancers, as a result of which food acquire enhanced taste. In this regard, it was suggested that FA is caused by food products with very high palatability [24], as well as deeply processed foods [25]. However, in these cases, it is difficult to talk about any specific food components that cause FA. The most likely candidates for the role of food components that cause FA are sugars and fats [26, 27]. Sugars and fats are currently most often used as food additives; thus, modern foods are characterized by a high content of these components. People who prefer foods high in sugars and fats are exposed to high doses of these substances. As is known, a gradual increase in the dose of a problematic substance is a key condition for the formation of any dependence (nicotine, alcohol, etc.) [28, 29]. Studies using functional MRI showed that foods with a high content of fats and sugars lead to the activation of the dopamine reward system [30, 31]. A recent review [32] summarized neuroimaging data and found that there was significant overlap in the areas of the brain that were activated in association with food and drug addiction. These experimental data provide convincing evidence for the roles of sugar and fat in the formation of FA.

It has been repeatedly noted that the FA concept has a number of drawbacks [25]. In particular, it was shown that the diagnostic criteria used in the YFAS do not always accurately distinguish FA from other eating disorders [33, 34]. An insufficiently strong association was noted between FA and the anthropometric indicators of obesity (BMI, waist circumference) [35, 36]. Moreover, FA is sometimes detected in individuals with normal body weight [16, 23]. Recent findings indicate that the relationship between FA and BMI could be non-linear [37–39]. The correlation between FA and depression [16, 17], as well as between FA and sleep–wake rhythm characteristics [40, 41], was repeatedly noted. It can be assumed that in some cases, the respondents' choice of problematic food products may be caused not only

by their FA but also by the accompanying psychophysiological problems. Therefore, the urgent task is the identification of specific food preferences in people with FA.

Recently, the incidence of FA has been shown to be age dependent. The highest frequency of detection of FA was observed in young adults, while the indicator was found to be lower in children [16] and the elderly people [37, 42]. We have previously shown [16, 43] that the frequency of detection of FA more than doubles at the age of 16-18 years. The reasons for such significant changes in eating behavior are unknown. One of the possible factors may be the fact that at the age of about 18, young people strive to gain social independence and the associated greater freedom of food choice [44, 45]. It can be assumed that significant changes in food preferences occur at this age.

The aim of this study was to curry out retrospective comparative analysis of food preferences in schoolchildren and university students with FA.

Materials and methods

The study was conducted from March 2017 to March 2019. The research program was approved by the Ethics Committee of the Institute of Physiology of the Komi Scientific Center, Ural Branch of the Russian Academy of Sciences. Informed parental consent from the parents of students of secondary schools located in the city of Syktyvkar and informed consent from students of universities located in Syktyvkar, Kirov, Yekaterinburg and Tyumen was obtained to participate in the study. The participation in the study was voluntary and anonymous. High school students were informed of the study by school psychologists and filled out paper forms in their classrooms. University students were informed of the study by university professors and received course credit for completing the study. These students filled out an online battery of tests.

Participants

A total of 2722 questionnaires were administered. Inclusion criteria were as follows: students of 6–11-th grades of secondary schools and students of 1–5-th grades of universities were recruited, informed consent or parental informed consent to participate in the study was obtained. Of these, 372 (13.7%) had errors or omissions and were excluded from the analysis (Step 1, Fig. 1). An additional 753 questionnaires failed to indicate any product as being problematic (see below) and were also excluded from the analysis (Step 2, Fig. 1). The final dataset included the responses from 1607 questionnaires, of which 658 corresponded to school-aged subjects and 949 corresponded to university students (Table 1). The average age of the survey participants was

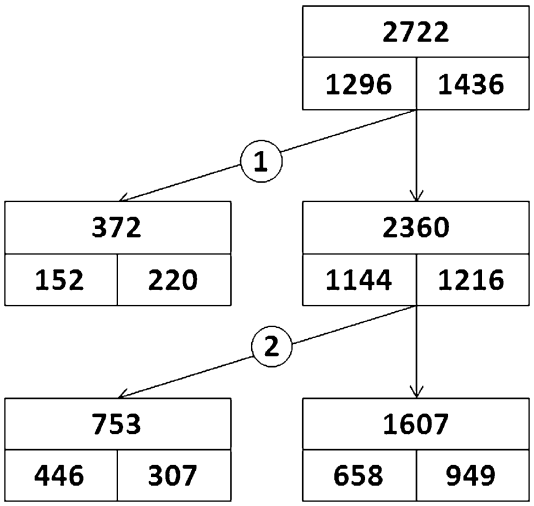

Fig. 1 Selection of study participants (see text for details). Questionnaires filled out with errors or omissions (Step 1) or no products from items 36 and 37 of the YFAS were identified as being problematic (Step 2) were excluded from the final sample. At each stage of selection, the number indicated above is the total number of participants, and the bottom left and right numbers are the numbers of schoolchildren and university students in the study, respectively

17.8 ± 2.7 years, range: 12-30 years, and female: 77.0%. Each survey participant indicated their personal data (date of completion of the questionnaire, place of residence, sex, age, height, weight) and filled out three questionnaires: the YFAS, the Zung Self-Rating Depression Scale (ZSDS) and the Munich ChronoType Questionnaire (MCTQ). Their BMIs were evaluated using their self-reported heights and weights. According to World Health Organization (WHO) criteria [46], all survey participants were assigned to one of the following BMI groups: (1) underweight; (2) normal weight; (3) overweight and (4) obese. Socio-demographic and psycho-emotional characteristic of study participants presented in Table 1.

Measures

To assess FA in university students and schoolchildren, the YFAS [9] and the children's version of the YFAS (YFAS-C) [47] were translated into Russian and subsequently used. The Cronbach's α for these samples were 0.862 and 0.909 for YFAS-C and YFAS, respectively.

In addition, the study participants were asked to answer two questions:

1. "Please circle ALL of the following foods you have problems with:

Ice cream, white bread, pretzels, pizza, chocolate, rolls, French fries, soda pop, apples, lettuce, carrots, doughnuts,

Table 1 Socio-demographic and psycho-emotional characteristics of study participants

Parameters	Units	All	Schoolchildren	University students	χ^2/F	ν	P	η^2
Total	*N*	1607	658	949				
Sex					28.0	1	0.000	
Females	*N* (%)	1238 (77.0)	453 (70.4)	775 (81.7)				
Males	*N* (%)	369 (23.0)	195 (29.6)	174 (18.3)				
Age, years	*M* (SD)	17.8 (2.7)	15.5 (1.8)	19.4 (2.1)	1515.9	1	0.000	0.486
BMI, percentiles	*M* (SD)	46.5 (23.3)	47.5 (22.4)	45.8 (23.9)	6.1	1	0.014	0.004
BMI, categories					3.7	3	n.s.	
Underweight	*N* (%)	116 (7.2)	38 (5.8)	78 (8.2)				
Normal weight	*N* (%)	1329 (82,7)	555 (84.3)	774 (81.6)				
Overweight	*N* (%)	121 (7.5)	48 (7.3)	73 (7.7)				
Obese	*N* (%)	41 (2.5)	17 (2.6)	24 (2.5)				
SJL, h	*M* (SD)	1.9 (1.3)	2.2 (1.5)	1.7 (1.2)	8.0	1	0.005	0.005
SJL, categories					14.6	1	0.001	
SJL < 1 h	*N* (%)	336 (20.9)	107 (16.3)	229 (24.1)				
SJL ≥ 1 h	*N* (%)	1271 (79.1)	551 (83.7)	720 (75.9)				
ZSDSI, scores	*M* (SD)	48.2 (10.3)	49.0 (10.8)	47.8 (10.0)	0.3	1	n.s.	
ZSDSIr, categories					2.8	3	n.s.	
No depression	*N* (%)	844 (52.5)	358 (54.4)	486 (51.2)				
Minimal depression	*N* (%)	486 (30.2)	184 (28.0)	302 (31.8)				
Moderate depression	*N* (%)	201 (12.5)	84 (12.8)	117 (12.3)				
Severe depression	*N* (%)	76 (4,7)	32 (4.9)	44 (4.6)				
SC, units	*M* (SD)	2.4 (1.7)	1.9 (1.6)	2.8 (1.6)	53.0	1	0.000	0.032
FA, categories					24.1	1	0.000	
NoFA	*N* (%)	1404 (87.4)	607 (92.2)	797 (84.0)				
FA	*N* (%)	203 (12.6)	51 (7.8)	152 (16.0)				
YFAS symptoms[a]								
1 NoFA	*N* (%)	149 (10.6)	59 (9.7)	90 (11.3)	0.9	1	n.s.	
FA	*N* (%)	83 (40.9)	20 (39.2)	63 (41.4)	0.1	1	n.s.	
2 NoFA	*N* (%)	1047 (74.6)	295 (48.6)	752 (94.4)	380.4	1	0.000	
FA	*N* (%)	199 (98.0)	50 (98.0)	149 (98.0)	0.01	1	n.s.	
3 NoFA	*N* (%)	256 (18.2)	108 (17.8)	148 (18.6)	0.1	1	n.s.	
FA	*N* (%)	98 (48.3)	27 (52.9)	71 (46.7)	0.6	1	n.s.	
4 NoFA	*N* (%)	222 (15.8)	117 (19.3)	105 (13.2)	9.6	1	0.005	
FA	*N* (%)	112 (55.2)	31 (60.8)	81 (53.3)	0.9	1	n.s.	
5 NoFA	*N* (%)	476 (33.9)	103 (17.0)	373 (46.8)	136.8	1	0.000	
FA	*N* (%)	174 (85.7)	36 (70.6)	138 (90.8)	12.7	1	0.000	
6 NoFA	*N* (%)	515 (36.7)	191 (31.5)	324 (40.7)	12.5	1	0.000	
FA	*N* (%)	168 (82.8)	37 (72.5)	131 (86.2)	5.0	1	0.05	
7 NoFA	*N* (%)	247 (17.6)	121 (19.9)	126 (15.8)	4.0	1	0.05	
FA	*N* (%)	120 (59.1)	37 (72.5)	83 (54.6)	5.1	1	0.025	
8 NoFA	*N* (%)	56 (4.0)	17 (2.8)	39 (4.9)	3.9	1	0.05	
FA	*N* (%)	203 (100)	51 (100)	152 (100)	0	1	n.s.	

SJL social jetlag, *ZSDSI* depression scores, *ZSDSIr* depression categories, *SC* number of FA symptoms, *FA* food addiction categories, *N* number or study participants in different groups, *SD* standard deviation, χ^2/F Chi squared/Fisher statistics for qualitative and quantitative variables, respectively, ν number of degrees of freedom, *P* level of significance, η^2 effect size

[a]Symptom 1: Substance taken in larger amount and for longer period than intended; Symptom 2: Persistent desire or repeated unsuccessful attempts at quitting; Symptom 3: Much time/activity to obtain, use, recover; Symptom 4: Important social, occupational, or recreational activities given up or reduced; Symptom 5: Use continues despite knowledge of adverse consequences (e.g., failure to fulfill role obligation, use when physically hazardous); Symptom 6: Tolerance (marked increase in amount; marked decrease in effect); Symptom 7: Characteristic withdrawal symptoms; substance taken to relieve withdrawal; Symptom 8: Use causes clinically significant impairment or distress

pasta, steak, broccoli, strawberries, bananas, cookies, rice, bacon, cake, crackers, hamburger, candy, chips, cheeseburger, none of the above."

2. "Please list any other foods that you have problems with that were not previously listed."

The level of depression was assessed using the ZSDS [48]. Schoolchildren filled out the ZSDS adapted for children. The ZSDS consists of 20 statements describing the symptoms of depression. The sum of raw ZSDS scores ranging from 20 to 80 was converted to ZSDS indices (ZSDSIs) varying from 25 to 100, as described by Zung [49] and Passik et al. [50]. The ZSDSIs were used to evaluate four levels of depression: I, no depression (ZSDSI ≤ 50); II, from minimal to mild depression (ZSDSI 51–59); III, moderate to significant depression (ZSDSI 60–69); and IV, severe to extreme depression (ZSDSI ≥ 70). The Cronbach's α for this sample was 0.865.

Circadian misalignment or social jetlag (SJL) was assessed using the MCTQ as described previously [51]. The test contains questions about sleep and wakefulness on school days and on weekends. Each respondent, in particular, was asked to indicate the times at which he goes to bed and gets out of bed, the time needed to completely fall asleep and to wake up, and whether he uses an alarm clock on school days and on weekends. SJL was calculated as the difference in hours between the middle of the sleep phase on school days and that on weekends. Respondents with SJL ≥ 1 h were assigned to the circadian misalignment group.

Statistical analyses

The statistical software package SPSS was used for statistical analyses. Chi squared test was used to evaluate significance of difference between categorical variables. One way analysis of covariance was used to evaluate significance of differences between continuous variables using age and sex as covariates. Eta-squared (η^2) was used as a measure of effect size. Small, medium, and large effects would be reflected in values of η^2 equal to 0.0099, 0.0588, and 0.1379, respectively [52].

Only food products that were mentioned at least 100 times were used in the analysis. We performed a series of binary logistic regression analyses for schoolchildren and university students separately, where "food products" (codes: 0—no problems; 1—there are problems) were used as dependent variables; "sex" (codes: 0—males, 1—females), "BMI" (codes: 0—underweight/normal weight, 1—overweight/obese), "ZSDSI" (codes: 0—no to mild depression; 1—moderate to extreme depression), "FA" (codes: 0—NoFA, 1—FA), "SJL" (codes: 0—SJL < 1 h, 1—SJL ≥ 1 h) as independent variables. Only significant factors were included in the final model using the procedure 'stepwise inclusion'. Bonferroni correction of P value was performed as follows, 0.05/5 = 0.01, where 5 is a number of predictors. Regression coefficients B, Odds Ratios (OR) and 95% Confidence Intervals (95% CIs) were calculated for all problematic food products. For each model goodness of fit was evaluated by the Hosmer–Lemeshow test and Omnibus tests of model coefficients.

Results

Schoolchildren and university students did not differ in the incidence of obesity ($\chi^2 = 3.7$; $P > 0.05$) or depression ($\chi^2 = 2.8$; $P > 0.05$; Table 1). The group of university students in this study comprised 11% more girls ($\chi^2 = 28.0$; $P < 0.0001$), 7.8% fewer people with SJL ($\chi^2 = 14.6$; $P < 0.001$), and twice as many people with FA ($\chi^2 = 24.1$; $P < 0.00001$; Table 1) compared with the group of schoolchildren. The pooled responses from university and school-aged children most frequently reported the following symptoms of FA: 'persistent desire or repeated unsuccessful attempts at quitting,' 'use continues despite knowledge of adverse consequences,' and 'tolerance.' University students without FA reported these symptoms 45.8%, 29.8%, and 9.2% more often than schoolchildren, respectively (Table 1). University students with FA were 20.2% and 13.7% more likely than schoolchildren to report symptoms of 'use continues despite knowledge of adverse consequences' and 'tolerance,' respectively (Table 1).

Most often, the respondents, regardless of their FA status, overweight status, level of depression and SJL, noted the following food products as problematic (the first 10 products, in decreasing order of frequency): chocolate, candy, chips, rolls, soda, pizza, cookies, cheeseburgers, hamburgers, and cake (Fig. 2). Sex differences in food preferences were noted. Females were significantly more likely to report chocolate, candy, rolls, cookies, ice cream, cake, white bread, and doughnuts as problematic. Males were significantly more likely to report soda as problematic product (Table 2). Age-related differences in food preferences were also observed. Specifically, university students indicated that soda, white bread, doughnuts, crackers, bacon, and steak were problematic (Table 2; Fig. 3).

The list of problematic food products for persons with FA included chocolate, candy, pizza, cookies, ice cream, French fries, rolls, cake, white bread, and crackers. Overweight/obese university students indicated bacon, and steak as problematic. University students who have symptoms of FA and overweight/obesity referred to ice cream, and French fries as problematic. Schoolchildren with depression regarded cake

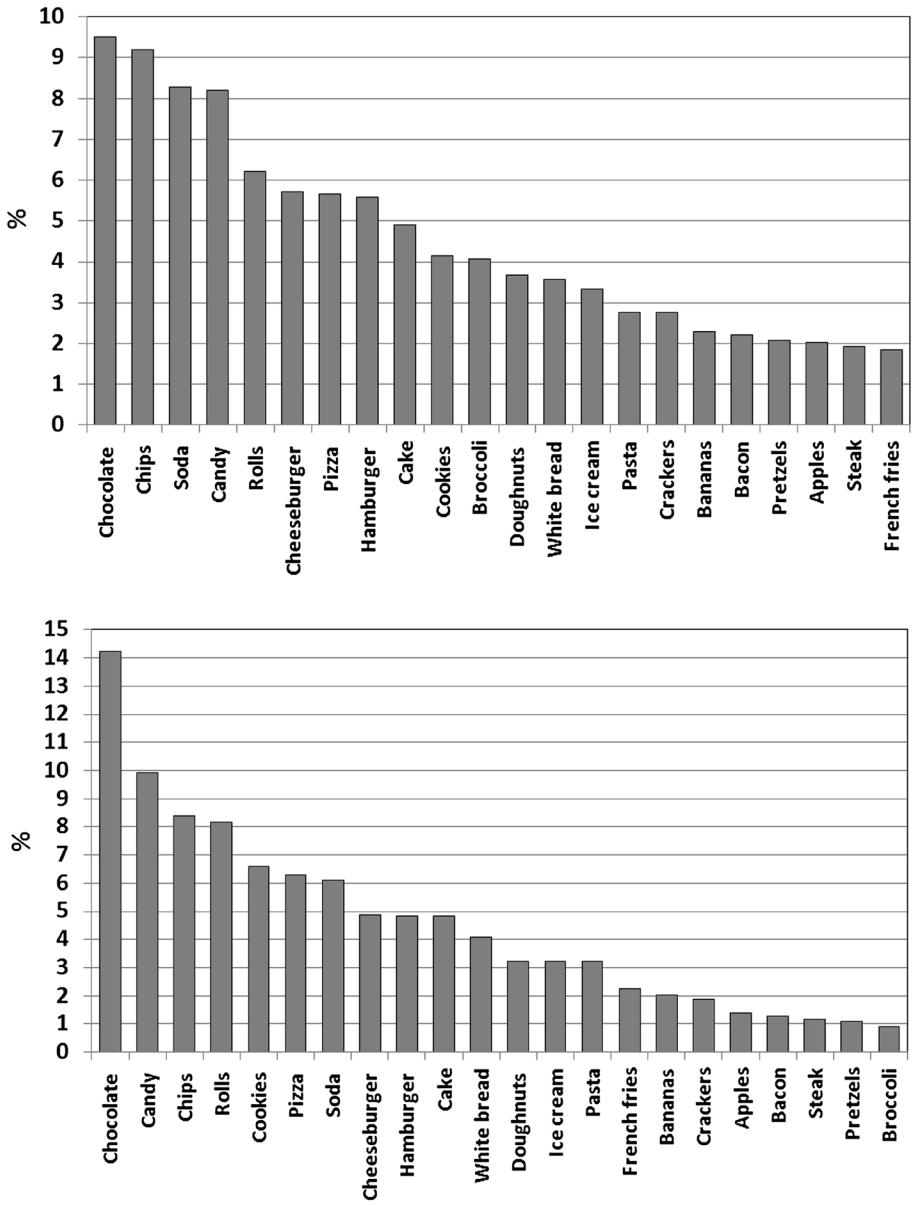

Fig. 2 The products that schoolchildren (upper panel) and university students (lower panel) have problems with. Frequencies (%) of marked products were noted

as problematic. Schoolchildren and university students with SJL indicated chips as problematic (Table 2; Fig. 3).

Food products that people of both sexes with symptoms of FA regarded as problematic included pizza, and crackers. Female respondents with symptoms of FA indicated chocolate, candy, cookies, ice cream, rolls, cake, and white bread as problematic (Table 2; Fig. 3).

Discussion

In our study, we first evaluated the food preferences of schoolchildren and university students from Russia who have symptoms of FA. The most frequently detected symptoms of FA in the school children in this study were 'persistent desire or repeated unsuccessful attempts at quitting,' 'use continues despite knowledge of adverse consequences', and 'tolerance.' These results are similar to those previously reported [47, 53]. Of note, the frequency of all three of these symptoms increased with age in the NoFA group, and the frequency of the latter two symptoms increased with age in the FA group. It is possible, that the change in the frequency of detection of these symptoms is associated with a 2–3-fold increase in the detection of FA in adolescents at the age of 18–19 (this study and [43]). Despite a significant increase in FA, we did not observe a corresponding significant increase in weight disorders in adolescents. This finding could be explained by the fact that the consumption of high-calorie foods is compensated for by an increased energy expenditure due to growth that ends at this age [54].

Table 2 Logistic regression analyses of the associations between food preferences and variables characterizing food addiction, weight, depression, circadian misalignment, and sex in

Food product‡	Factor†	*B*	OR	95% CI	*P*&	Omnibus test		Hosmer–Lemeshow test	
						χ^2	*P*	χ^2	*P*
School children									
Chocolate	Sex	0.863	2.369	1.629–3.447	0.000	40.619	0.000	1.677	0.947
	FA	1.019	2.770	1.493–5.138	0.001				
Chips	SJL	0.490	1.632	1.185–2.248	0.003	18.408	0.002	2.958	0.814
Candy	Sex	0.753	2.122	1.456–3.095	0.000	35.102	0.000	1.662	0.948
	FA	0.999	2.717	1.475–5.004	0.001				
Rolls	Sex	1.061	2.890	1.828–4.567	0.000	30.585	0.000	1.239	0.941
Pizza	FA	1.201	3.323	1.798–6.140	0.000	27.405	0.000	2.282	0.892
Cake	ZSDSI	0.657	1.929	1.220–3.050	0.005	20.410	0.001	4.271	0.511
Cookies	Sex	0.906	2.474	1.447–4.228	0.001	25.252	0.000	2.611	0.856
	FA	1.034	2.813	1.467–5.394	0.002				
Ice cream	Sex	0.860	2.364	1.344–4.159	0.003	24.928	0.000	9.199	0.163
	FA	1.226	3.408	1.744–6.660	0.000				
French fries	FA	1.519	4.566	2.130–9.788	0.000	22.826	0.000	1.823	0.935
University students									
Chocolate	Sex	0.988	2.687	1.993–3.622	0.000	62.590	0.000	1.435	0.488
	FA	0.646	1.908	1.319–2.759	0.001				
Candy	Sex	0.827	2.287	1.663–3.143	0.000	69.113	0.000	3.956	0.412
	FA	0.972	2.644	1.870–3.738	0.000				
Chips	SJL	0.426	1.531	1.152–2.034	0.003	13.679	0.018	1.144	0.950
Rolls	Sex	0.799	2.222	1.576–3.133	0.000	44.021	0.000	3.308	0.653
	FA	0.645	1.907	1.366–2.661	0.000				
Cookies	FA	0.943	2.569	1.825–3.615	0.000	39.025	0.000	0.452	0.978
Pizza	FA	0.518	1.678	1.187–2.373	0.003	17.039	0.004	3.188	0.671
Soda	Sex	−0.510	0.600	0.439–0.820	0.001	18.081	0.003	5.826	0.324
Cake	Sex	0.597	1.817	1.207–2.735	0.004	25.004	0.000	9.229	0.100
	FA	0.698	2.011	1.389–2.892	0.000				
White bread	Sex	0.644	1.903	1.217–2.975	0.005	25.522	0.000	8.396	0.211
	FA	0.631	1.880	1.284–2.752	0.001				
Doughnuts	Sex	0.664	1.943	1.169–3.230	0.010	13.890	0.016	1.933	0.748
Ice cream	BMI	0.852	2.345	1.512–3.635	0.000	35.416	0.000	2.222	0.695
	FA	0.788	2.199	1.471–3.287	0.000				
French fries	BMI	0.697	2.008	1.214–3.322	0.007	34.919	0.000	1.629	0.804
	FA	0.968	2.632	1.680–4.122	0.000				
Crackers	FA	1.044	2.840	1.730–4.661	0.000	17.406	0.004	2.097	0.836
Bacon	BMI	0.859	2.362	1.309–4.261	0.004	20.242	0.001	5.588	0.348
Steak	BMI	1.191	3.289	1.810–5.980	0.000	21.530	0.001	6.440	0.367

ZSDSI depression, *FA* food addiction, *SJL* social jetlag; a series of binary logistic regression analyzes were performed, where: "food product" (codes: 0—no problems; 1—problematic) were used as dependent variables, "age" (codes: 0—schoolchildren, 1—university students), "sex" (codes: 0—males, 1—females), "BMI" (codes: 0—underweight/normal weight, 1—overweight/obese), "ZSDSI" (codes: 0—no to mild depression; 1—moderate to extreme depression), "FA" (codes: 0—no FA, 1—FA), "SJL" (codes: 0—SJL < 1 h, 1—SJL ≥ 1 h) as independent variables; ‡code "0" was used as "group of comparisons"; †only significant factors ($P < 0.01$) were included in the final model using the procedure 'stepwise inclusion'; *B* regression coefficient (the sign at the coefficient was used to assess the direction of the association between variables); *OR* odds ratios; *95% CI* 95% confidence interval; &*P*—Bonferroni-corrected significance of the regression coefficient. For each model goodness of fit was evaluated by the Hosmer–Lemeshow test and Omnibus tests of model coefficients

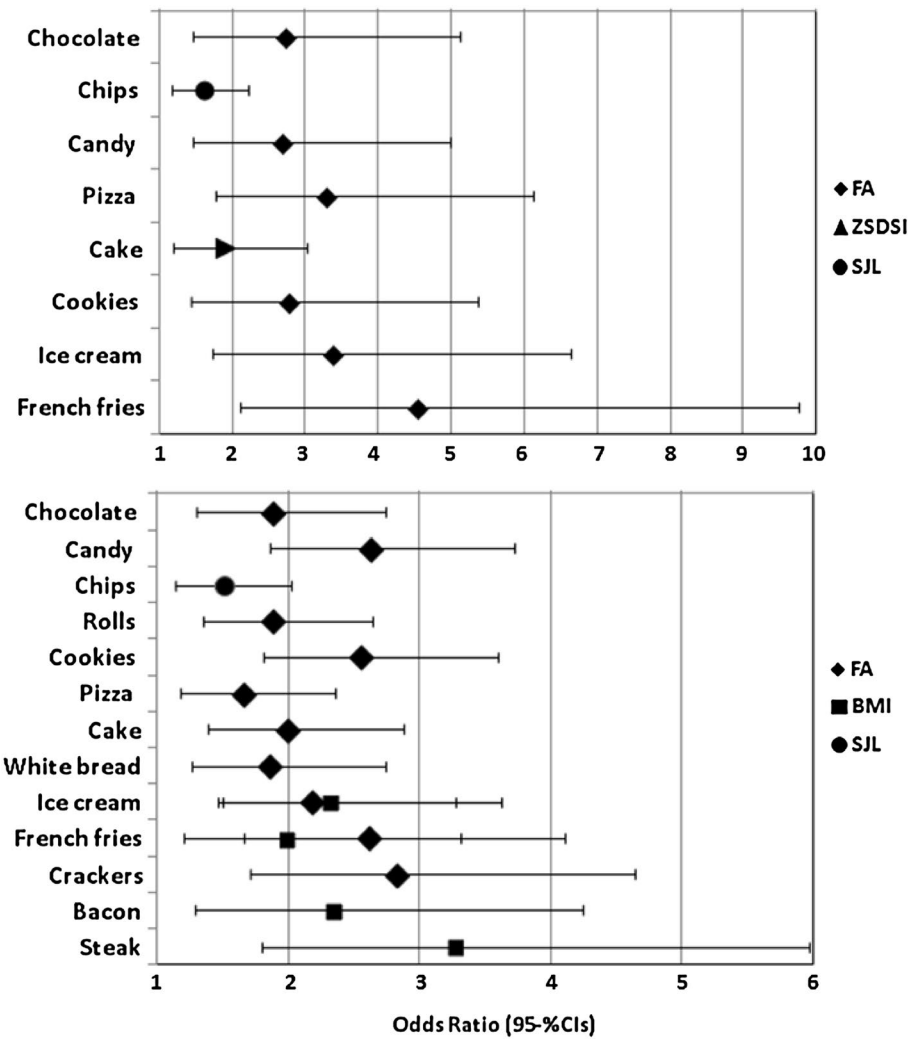

Fig. 3 Odds Ratio and 95% confidence intervals (CIs) of food preferences in schoolchildren (upper panel) and university students (lover panel) with food addiction (FA), overweight/obese (BMI), depression (ZSDSI), and social jetlag (SJL) according to logistic regression analyses. The results of the analyses are presented in Table 2

We confirmed previous data that people with FA most often call high-calorie foods high in carbohydrates and fats as problematic [55–57]. It has been previously shown that the currently widely used YFAS has several disadvantages. The group of people with FA includes people with depression [17] and those with sleep–wake rhythm disorders [40], and there is no strict association between FA and obesity [35]. Therefore, the respondents' choice of some problematic products is determined not only by FA but also by concomitant psychophysiological and weight disorders. We tried to identify problematic products that are specific to individuals with FA.

The inclusion of a wider range of food preference predictors in the analysis allowed us to show for the first time that some foods (i.e., chips) are associated with SJL, a circadian misalignment most frequently observed in 18-year-olds [58]. A food product (i.e., cake) was also found to be associated with depression in schoolchildren. Some food products (i.e., ice cream and French fries) were associated with FA and weight disorders in university students. Foods high in protein and fat (i.e., bacon, steak) were only associated with being overweight/obese. The relationship between FA and depression is well known [16, 17]. However, obesity is influenced by complex genetic, behavioral, and environmental factors [59]. Therefore, it is necessary to adjust for indicators characterizing circadian misalignment, depression, and weight disorders to more robustly identify the food preferences of adolescents with FA.

Significant age-related differences in food preferences were observed between our two study groups. Some products, mainly sweets, were problematic for both schoolchildren and university students. However, the university students also reported other products, mainly flour products, as being problematic. Age-related differences in the food preferences of people with FA could be explained by the fact that university students tend to live separately from their parents and are free from parental control when choosing food. Previous research has shown that the diet of university students is characterized by a predominance of high-sugar, high-fat foods [44, 45].

We observed sex-related differences in the food preferences of individuals with FA. Females more often identified foods with a high sugar content as being problematic. Previously, it was shown that females are more likely to have unhealthy food preferences associated with FA [57, 60].

Strengths and limitations

The food preferences of schoolchildren and university students were assessed in two independent studies, and university students from four settlements were examined simultaneously and independently. The similar associations between problematic food products and emotional state in subjects from different age groups and geographic locations indicates that our results may be generalized to the Russian population. However, this study included a significantly greater proportion of female subjects; therefore, the finding regarding sex-related differences in food preferences should be taken with caution. It was also not possible to infer cause-and-effect relationships between the indicators in the study because of the cross-sectional nature of the study design.

Conclusions

The frequency of detection of FA among university students was twice as high as among schoolchildren. University students with FA were 20.2% more likely than schoolchildren to report the symptom 'use continues despite knowledge of adverse consequences,' and 13.7% were more likely to report 'tolerance.' Schoolchildren and university students with FA most often indicated foods high in sugar and fat as being problematic. However, university students with FA also reported that products with a high carbohydrate content were problematic.

What is already known on this subject?

The concept of FA postulates the existence of certain food products that can cause addiction, similar to nicotine, alcohol and drug addiction. There is currently no consensus on which food products and their components cause FA. The main problem is the low specificity of the YFAS test in the assessment of FA symptoms.

What your study adds?

To overcome the low specificity of the YFAS, we used a procedure in which we identified foods that are problematic for persons with symptoms of FA and some other related psychophysiological disorders. Then, from this list, food products were selected that were called problematic only by individuals with symptoms of FA without concomitant psychophysiological disorders. Thus, from our point of view, a higher specificity was achieved in identifying foods with high addictive potential.

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Compliance with ethical standards

Conflict of interest The authors declare no conflict of interest.

Ethical approval This study was approved by the ethics committee of the Institute of Physiology of Komi Science Center, Ural Branch of RAS, and was conducted in accordance with the ethical standards of the Helsinki declaration.

Informed consent Informed consent was obtained from all participants and parents of minors included in the study.

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