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BRIEF REPORT

Food Addiction Features Are Related to Worse Academic Performance in Adolescents

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Although it has not yet been included in the Diagnostic Manual of Mental Disorders (DSM-V) (Cooper, 2014), there is still a debate about the real significance of food addiction (FA), both as an independent mental disorder or as an addictive behavior (Lemeshow et al., 2016). To differentiate between a pleasantness and an addictive conduct, it is necessary a loss of control associated with such conduct, which is maintained despite negative consequences (Wise & Koob, 2014). Therefore, FA was defined as hedonic eating behavior involving the consumption of highly palatable foods in quantities beyond homeostatic energy requirements (Gold & Shriner, 2013). An important question arises from these statements, and that is, can certain foods take over the brain in ways like drugs of abuse and alcohol?

To reinforce this hypothesis, previous works have described common neurobiological alterations in subjects with FA and substance abuse. For instance, both addictive behaviors increase extracellular dopamine while there is a decrease in D2-receptor in the mesolimbic dopaminergic circuit (Avena et al., 2008), and a downregulation of opioid receptors and acetylcholine release in the nucleus accumbens (Berridge et al., 2010).

Although many reports have previously described an inverse association between the use of drugs of abuse and cognitive performance (Bjørnebekk et al., 2019; Gouzoulis-Mayfrank & Daumann, 2009), few studies have related cognitive performance and FA (Franken et al., 2018), and to our knowledge, no previous studies have been conducted on adolescents and academic performance; however, a recent report has shown that individuals with elevated FA symptoms have lower structural brain connectivity in several regions like the insula, the anterior cingulate cortex, and the ventromedial prefrontal cortex (Peng-Li et al., 2020).

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In humans, highly processed foods (e.g., pizza, chocolate) have been related to FA in a greater extent than minimally processed foods (e.g., fruit, vegetables) (Schulte et al., 2019). High fat and high sugar foods lead to alterations in brain regions involved in learning, memory, and behavioral control, which seem to be especially profound in the immature brain (Boitard et al., 2016; Gainey et al., 2016). In this regard, specific problems with any of these highly palatable foods could be also involved in alterations of cognitive performance; unfortunately, to our knowledge, there are no previous studies that have evaluated these aspects.

Therefore, based on the hypothesis that adolescents with FA may present an impaired cognitive functioning, the aim of the present work was to evaluate and characterize the association between FA diagnostic and its associated symptoms with academic performance. Moreover, as a secondary objective, we aimed to identify those foods with high addictive potential that could be related to academic performance.

Methods

Design and Participants

A cross-sectional study was designed to evaluate possible associations between food addiction and academic performance. Through a clustering sampling method, two different High Schools of Andalusia (Spain) took part in the study. The unique eligibility criterion was to be previously allowed by their parents or legal representatives to take part in the study. Students who declared that they did not understand the test and those that rejected to take part in the study were excluded. Students with metabolic pathologies and behavioral disorders (Asperger syndrome or autism spectrum symptoms) were also excluded. Of all students, 317 Caucasian adolescents (15 ± 3 years, 139 boys and 178 girls) agreed to participate. After completing the study, certain questionnaires were inadequately fulfilled, so the final sample comprised 268 students.

The survey was carried out with previous written authorization from the ethics committee of the university and the approval of the Andalusian Education Service. Subjects were informed about the design of the study orally and in written form. An explanation of the research was also given, informing about the aim, the need for confidentiality and anonymity of the data, and respecting the Helsinki Declaration Agreement.

Data Acquisition

Academic performance was employed as a surrogate measurement of cognitive performance, in the same way as other previous works (Alloway & Alloway, 2010; Best et al., 2011), and considering its Mesh definition: "A quantitative or qualitative measure of intellectual, scholarly, or scholastic accomplishment." Marks were qualified from 0 to 10 points, where a mark of 10 points represents the most outstanding student, and a mark of 5 points is the minimum mark to pass the academic year (see Supplementary Table 1). The mean academic performance was the arithmetic mean of 7 subjects depending on the high school modalities (Technology/Science or Humanities and Social Sciences).

Yale Food Addiction Scale (YFAS) was employed to evaluate food addiction, as is considered the gold-standard method to evaluate food addiction (Gearhardt et al., 2009). This self-report questionnaire was designed by Gearhardt et al. in 2009, based upon substance dependence criteria in the DSM-IV-TR (e.g., withdrawal, tolerance, continued use despite problems, and vulnerability in social activities) and other scales to assess behavioral addictions (gambling, exercise, and sex). In this version of the test, questions were adapted to assess the diagnostic criteria related to the consumption of high-fat and high-sugar foods (Gearhardt et al., 2009). The Spanish version of the test was adapted in the work of Granero et al. in 2014 and had a good internal consistency (α = 0.71) for an eating disorder sample and excellent for the whole population (Cronbach's α = 0.95) (Granero et al., 2014). A "diagnosis" of FA was assigned to participants who endorse three or more symptoms plus satisfying the clinical impairment criteria, in line with the DSM-IV diagnosis of traditional substance dependence (Gearhardt et al., 2009).

YFAS contains 16 items scored trough a Likert scale of five options, ranging from "never" (with a score of 0) to "4 or more times per week or daily" (with a score of 4), which refers to behaviors that can occur occasionally in people with addiction problems; 8 items with a dichotomous score (yes/no; with a value of 0 or 1 point), which is used for questions that show more severe food consumption problems; and one additional Likert-like item scored from 1 to 5, depending on the number of times in the last year that the participant has tried to reduce or stop eating certain foods (see Supplementary Table 2). YFAS also asks if a person is having problems with certain foods. This section of the scale contains 26 food items (ice cream, chocolate, apples, doughnuts, broccoli, cookies, cake, goodies, white bread, rolls, lettuce, pasta, strawberries, rice, crackers, chips, pretzels, fried potatoes, carrots, steak, bananas, bacon, hamburgers, cheeseburgers, pizza, and sugary drinks).

Statistical Analysis

Data are presented as mean ± SD and 95% confidence interval (CI). Correlation coefficients were used to analyze the relationships between academic performance and YFAS score. Partial correlation analysis was also conducted to exclude the effect of age, sex, and BMI. A step forward multivariate regression analysis was also conducted to further establish the actual relationships between the variables and their predictive values. Student's *t*-test was used to compare data attending to the presence or not of FA diagnosis, as well as with each specific food. All statistical analyses were carried out using SPSS (24.0; SPSS Inc., Chicago, USA).

Results

Baseline Participants' Characteristics

The first step of the data analysis was to establish the academic performance and food addiction. Our data showed that the mean academic mark of the students was 5.7 ± 1.8 points (range: 1.0–9.8 points). Most of the students did not fail any subject, while 2% of the students failed all the subjects. Regarding the anthropometric characteristics, our data showed an average weight of 53.8 ± 11.7 kg (CI 95% = 52.3–55.3) and an average height of 1.6 ± 0.1 m (CI 95% = 1.60–1.62). From these data, an average BMI value of 20.64 ± 3.39 kg/m^2 (CI 95% = 20.21–21.08) was estimated, which, according to the WHO growth standards, corresponds approximately to the 50th BMI percentile.

Mean YFAS test score was of 18 ± 9 points (CI 95% = 16–19). The food addiction (FA) diagnosis prevalence was of 8.8%. Supplementary Figure S1 shows the prevalence of FA diagnosis and each of FA symptoms. The most prevalent symptom was the symptom 2: *persistent desire or repeated unsuccessful attempt to quit*, which was present in 84% of the students, followed by the symptom 6: *tolerance* and the symptom 3: *much time/activity to obtain*, *use*, *recover*.

Relationship Between Food Addiction and Academic Performance

To evaluate the relation between FA and cognitive performance, a Pearson's correlation coefficient analysis was conducted between the YFAS score and the mean mark of the academic record of the participants (Fig. 1). Attending to this analysis, our data revealed an inverse and statistically significant relation between both variables ($r = -0.245$, $p < 0.001$). This relation was independent of BMI and sex, as indicated by the partial correlation coefficients ($r = -0.240$, $p < 0.001$; $r = -0.256$, $p < 0.001$, respectively). These results were reinforced by the regression analysis, since YFAS score was the unique variable included in the predictive model (see Supplementary Table S3).

To reinforce this result, we compared the mean academic marks attending to the FA diagnosis. As shown in Fig. 2, students meeting the FA diagnosis showed a statistically significant lower mark that those students that did not meet the FA diagnosis ($p = 0.002$, $d = 0.812$) (Fig. 2). When the academic performance was compared based on each FA symptom, the data showed statistically significant differences in symptom 3 (much time/activity to obtain, use, recover), 4 (important social, occupational, or recreational activities given up or reduced), 6 (tolerance), and 7 (characteristic withdrawal symptoms) (Supplementary Figure S2).

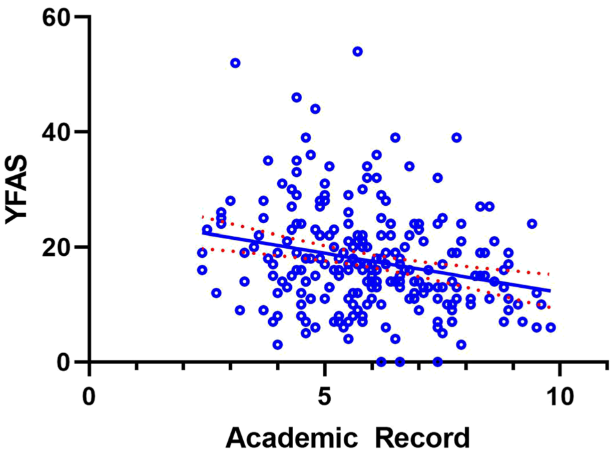

Fig. 1 Scatter plot showing the relation between YFAS test score and the academic mean record of the subjects studied. Blue line shows adjusted linear regression curve ($R = 0.246$, $p < 0.001$) and dotted red lines represent 95% confidence bands of the best-fit line

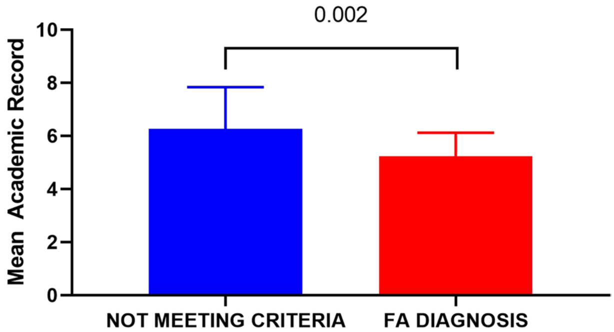

Fig. 2 Mean academic performance of students depending on the FA diagnosis. Data represent mean ± sd. Statistical differences were analyzed by a Student's *t*-test

Effect of Addiction to Specific Foods on Academic Performance

Regarding those specific foods with addictive properties, the data obtained in the present work revealed that the prevalence of students with specific food problems was higher in foods with high sugar content, like chocolate (38.0%), goodies (38.2%), and sugary drinks (33.6%). Other high-fat foods like pizza and chips also showed a high prevalence (32.0% and 31.1%, respectively). From these specific foods, those students with addiction to sugary drinks showed a statistically significant lower academic performance that their counterparts without specific addictive symptomatology with this food (5.6 ± 1.6 vs 6.1 ± 1.6, $p = 0.024$, $d = 0.311$), while no statistically significant difference was observed with any high-fat food.

Discussion

Given the evidences that have suggested an alteration of certain neurological pathways in subjects with food addiction (FA) (Peng-Li et al., 2020), the present study was conducted to evaluate a possible relation between FA and academic performance. The initial hypothesis was that FA may negatively affect cognitive functioning, and therefore the academic performance. The data obtained confirmed this hypothesis, since those students with higher FA symptomatology had lower academic performance. Our data have shown that this inverse relation between FA symptomatology and academic performance was independent of confounding variables like age, sex, or BMI. This situation indicates that even in a healthy environment, some individuals may be more susceptible to develop FA, which seems to impair their school achievement. Previous studies have shown an inverse relationship between other types of addiction and cognitive performance. Grant et al. (2019) have shown that adults with smartphone addiction had lower academic performance and higher impulsivity. In adolescents, instant messaging addiction has also been related to an academic performance decrement (Huang & Leung, 2009). Using traditional addictive substances like alcohol was also associated with the perception of academic failure (Bergen et al., 2005). Previous studies have also shown that smoking, both actively and passively, is associated with mental and neuro-behavioral developmental disorders and lower academic performance (Chen et al., 2013; Yamada et al., 2019). Similarly, the use of marijuana has been significantly associated with increased health problems, neurocognitive problems, and lower academic achievement and functioning (Bray et al., 2000; Brook et al., 2008). In general, addictions are associated with poorer cognitive and academic functioning. Therefore, it is possible to affirm that in the studied population, FA affects cognitive functions similarly to other addictions.

It is important to comment that most studies regarding FA and other addictions have been conducted in adults, but not in adolescents, while this group have a higher psychological and neurobiological vulnerability (Chambers et al., 2003; Garrison et al., 2017). Moreover, adolescents tend to seek for emotions and sensations that make them look for pleasant behaviors, although in the absence of control, they become more annoying than pleasant (Olszewski et al., 2019).

Focusing on each FA symptom, those students with *much time/activity to obtain food and those students with reduced social interactions* (symptoms 3 and 4) exhibited lower academic performance. In the same way, those students with higher *tolerance* and *withdrawal* symptomatology got lower academic marks (symptoms 6 and 7). To our knowledge, this is the first study describing the relation between FA symptoms and academic performance, but several psychological characteristics may explain these observations. Previous reports have shown that individual differences in sensitivity to reward and punishment modulate cognitive control, as suggested by Anderson and Good (2017). The inverse association between FA and academic performance can be also related to psychological features, like body image distortion, depressive symptoms, and low self-esteem (Swami et al., 2010), as well as to physiological factors like metabolic syndrome, risk factors of diabetes, or cardiovascular diseases (Pal et al., 2018; Yates et al., 2012), although considering the adolescent sample of the present work, the influence of these latter factors should be superfluous.

In the light of our data and that of other authors, it will be necessary to evaluate and determine risk factors of academic decline to implement prevention programs. Many efforts have been made for the prevention of tobacco use or alcohol consumption in adolescents (Bugbee et al., 2019), including for the prevention of obesity and eating disorders such as anorexia nervosa or bulimia nervosa (Golden et al., 2016), but not with FA. Perhaps, as suggested by Hauck et al., additional studies are needed to examine and establish orthogonal diagnostic criteria specific to FA, and still it is too early to draw conclusions about the clinical significance of FA (Hauck et al., 2020). However, based on the present data, the detection of FA in adolescents could be very useful to an early detection of academic difficulties.

In the present work, those students with addiction to sugary drinks presented a significantly lower academic performance. Øverby et al. showed that a high intake of foods representing a poor diet (sugar-sweetened soft drinks, sweets, etc.) was associated with increased odds of mathematical difficulties (Øverby et al., 2013), in accordance with the current observations. In the present work, foods with high-sugar content (goodies, chocolate, and sugary drinks) had the greatest addictive potential. On the contrary, a work conducted in adults described fat as the primary nutrient associated with FA diagnosis (Pursey et al., 2015). Apparently, in the early stages, there is a preference for high sugar foods, but as becoming adults, preferences shift towards high-fat foods, which may happen because the brain of a 13–15 years adolescent has not been fully developed (Vijayakumar et al., 2018), which could explain, at least in part, why addiction to high sugar foods was negatively associated with academic performance.

There were several limitations in the present work that deserve consideration. The number of subjects was limited compared with other large population studies (Grant et al., 2019), although similar to other previous cross-sectional works (Peng-Li et al., 2020; Pursey et al., 2015). On the other hand, it would have been interesting to examine whether the influence of

FA on academic performance was maintained at long term, especially according to the participants' food preferences, which will have to be corroborated in future studies.

Conclusions

In summary, food addiction (FA) was inversely associated with academic performance. Several symptoms of FA addiction like *tolerance*, *withdrawal*, or *reduced social interactions* were also indicators of worse performance. FA is associated with an alteration of certain neural circuits, which, as it has been shown in this work, negatively affects academic performance. Furthermore, those adolescents with addictive problems to sugary drinks were also characterized by a worse academic performance. Due to the cross-sectional design of the study, we cannot conclude that food addiction is generating the lower academic performance, but this issue will have to be confirmed in further studies. Nevertheless, the present work highlights the need for an early detection of FA, as with alcohol or tobacco use, which could allow an early detection of academic difficulties.

Supplementary Information The online version contains supplementary material available at https://doi.org/10.1007/s11469-021-00724-7.

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Declarations

Research Involving Human Participants and/or Animals All procedures followed were in accordance with the ethical standards of the responsible committee on human experimentation (institutional and national) and with the Helsinki Declaration of 1975, as revised in 2000.

Informed Consent Informed consent was obtained from all parents or persons in charge of the participants before being included in the study.

Data Deposition Information The data derived from the present study is available at: Hernandez Morante, Juan Jose (2021), "YFAS-ACADEMIC RECORD," Mendeley Data, v1. http://dx.doi.org/10.17632/z2774zth4g.1

Conflict of Interest The authors declare no competing interests.

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