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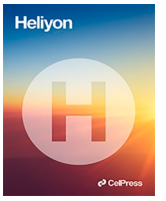

Research article

Food insecurity and academic performance in Spanish adolescents: Results from the EHDLA study

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ABSTRACT

Introduction: Food insecurity is a growing global issue that affects both developed and developing nations, and mounting evidence suggests that decreased consumption of healthy foods has been linked to lower academic performance in adolescents. The present study aimed to examine the relationship between food insecurity and academic performance in a sample of Spanish adolescents aged 12–17 years from the *Valle de Ricote* (Region of Murcia, Spain).

Methods: The present study analyzed data from the Eating Healthy and Daily Life Activities study, which included a sample of 777 adolescents (55.3 % girls). The Spanish Child Food Security Survey Module was used to assess food insecurity, and academic performance was evaluated using school records provided by the schools. Linear regression models (fitted by robust methods) were used to compare the relationships between food insecurity status and academic performance-related indicators.

Results: Adolescents with the highest levels of food insecurity reported the lowest academic performance in language (mean [*M*] = 4.7; 95 % confidence interval [CI] 3.6 to 5.7), math (*M* = 4.6; 95 % CI 3.5 to 5.8), foreign language (*M* = 4.8; 95 % CI 3.8 to 5.8), and grade point average (*M* = 5.7; 95 % CI 4.9 to 6.5). Conversely, adolescents with the lowest levels of food insecurity reported the highest academic performance in language (*M* = 6.2; 95 % CI 6.0 to 6.5), math (*M* = 5.9; 95 % CI 5.5 to 6.2), foreign language (*M* = 6.2; 95 % CI 5.9 to 6.4), and grade point average (*M* = 6.7; 95 % CI 6.5 to 6.9) compared to those with higher food security.

Conclusions: Living in a more food-insecure household could explain the lower academic performance of adolescents. Food insecurity should always be on the agenda of public policies. The availability of quality basic food essentials must be ensured in permanently satisfactory quantities without compromising access to other fundamental needs.

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1. Introduction

Food insecurity is a growing global issue that affects both developed and developing nations [1]. The Food and Agriculture Organization of the United Nations (FAO) defines food insecurity as a situation in which individuals lack regular access to sufficient nutritious food [2]. Currently, millions of people face varying levels of food insecurity, ranging from moderate to severe [3]. The causes of food insecurity are complex and multifaceted [4]. Poverty and inequality are two significant factors that contribute to food insecurity, as impoverished families may lack access to healthy food and instead resort to unhealthy alternatives [5], such as processed food, which tends to be less costly [6]. Moreover, the recent COVID-19 pandemic has caused economic difficulties and further complicated the achievement of food security [7].

Abbreviations

B	unstandardized beta coefficient
CFSSM–S	Child Food Security Survey Module in Spanish
CI	confidence interval
EHDLA	Eating Healthy and Daily Life Activities
FAO	Food and Agriculture Organization of the United Nations
FAS–III	Family Affluence Scale–III
GPA	grade point average
IQR	interquartile range
M	mean
YAP–S	Spanish Youth Activity Profile

A previous systematic review pointed out that individuals who had food insecurity had greater odds of depressive symptoms and low global cognition than those who had food security [8]. More specifically, food insecurity can induce psychological distress and behavioral issues in young individuals [9]. Furthermore, malnutrition can cause developmental delays [10], stunted growth [11], and compromised immune systems [12]. Therefore, it seems essential to guarantee good basic foods in consistently adequate quantities without compromising access to other fundamental needs, such as study and academic performance.

Mounting evidence suggests that dietary factors, such as consuming certain types of food (e.g., fish, vegetables, and fruits), are associated with greater academic performance [13–18]. Food provides nourishment for the body and mind, promoting optimal cognitive functioning [19]. Thus, a balanced and nutritious diet can increase energy levels and mental functioning [20], which ultimately might lead to improved academic performance [21]. Similarly, a systematic review conducted by Burrows et al. [22] revealed a relationship between dietary intake characterized by lower nutrient-poor and energy-dense foods, as well as higher overall diet quality, and greater academic achievement. Supporting this notion, López-Gil et al. [18] observed that a higher frequency of vegetable and fruit consumption and a lower frequency of soft drink consumption and sweets (among others) were related to higher and lower perceived academic performance in adolescents, respectively. Conversely, a low consumption of healthy foods such as fish, fruit, and vegetables, along with a high consumption of unhealthy foods, such as fast and ultra-processed foods, has been linked to lower academic performance in young people [25].

Previous studies have reported an inverse association between food insecurity and academic performance in the young population [23,24]. However, some research gaps have been identified in the previously published literature on this topic, including a lack of studies that considered several potential confounding factors, such as sociodemographic, lifestyle, and anthropometric measures [26]. These variables can contribute to a more comprehensive understanding of the association between food insecurity and academic performance among adolescents. Measuring academic performance objectively, since studies typically use self-reported measures, can also contribute to the scientific knowledge in this research field. Therefore, given the potential impact of food insecurity on development and academic achievement as adolescents and the gaps found in the current literature, the present study examined the relationship between food insecurity and academic performance in a sample of Spanish adolescents aged 12–17 years from the *Valle de Ricote* (Region of Murcia, Spain).

2. Materials and methods

2.1. Study design and population

This is a secondary examination utilizing data from the Eating Healthy and Daily Life Activities (EHDLA) study, encompassing a diverse group of adolescents from the *Valle de Ricote* in the Region of Murcia, Spain. Data were collected during the 2021–2022 academic year from all three secondary schools in that region. The methodology of the EHDLA study has been previously published [27]. The present study included 777 (55.3 % girls) adolescents.

2.2. Procedures

2.2.1. Food insecurity

To assess food insecurity in households, the Child Food Security Survey Module in Spanish (CFSSM–S) was used [28]. This survey was designed to measure participants' perceptions of food insecurity, including concerns about running out of food, relying on inexpensive food, being unable to eat a balanced diet, eating less, reducing portion sizes, going hungry, skipping meals, and going without food for an entire day. The CFSSM–S questionnaire comprises nine questions that are evaluated using a 3-point Likert scale. If the response was affirmative, indicating moderate or high food insecurity ("sometimes" or "a lot"), one point was given. Conversely, negative responses ("never") are scored as zero points. To determine the level of food security, the scoring system was based on the criteria established by the original research [29] and the US Department of Agriculture [30]. Participants from households with 0–1 point are classified as "food secure", 2–5 points indicate "low food security", and 6–9 points signify "very low food security".

2.2.2. Academic performance

The evaluation of academic performance included an assessment of grades achieved in mathematics, language, and foreign language (English), as well as the overall grade point average (GPA). To calculate the GPA, the sum of the numerical grades for each subject was divided by the total number of subjects included, resulting in a final average score between zero and 10, with zero representing the lowest possible score and 10 representing the highest possible score.

2.2.3. Covariates

2.2.3.1. Sociodemographic. The adolescents' age and sex were self-reported. Socioeconomic status was determined using the Family Affluence Scale (FAS–III) [31]. The FAS-III score was computed based on six different items, including whether the family owned a car, whether the adolescents had their own bedroom, the number of computers in the household, the number of bathrooms, whether the family had a dishwasher, and the number of holidays taken outside of Spain in the previous year. The FAS-III score can range from 0 to 13 points.

2.2.3.2. Lifestyle. To gather data on sedentary behavior and physical activity among adolescents, the Spanish version of the Youth Activity Profile (YAP–S) was used [32]. Scores for physical activity and sedentary behavior were calculated by adding up the scores of each section. Participants' sleep duration was also evaluated by inquiring about their weekday and weekend bedtime and wake-up time. The average daily sleep duration was calculated for each participant as follows: [(average nocturnal sleep duration on weekdays $\times$ 5) + (average nocturnal sleep duration on weekends $\times$ 2)]/7. Energy consumption was assessed via a self-reported dietary habits survey, which was previously confirmed for its applicability within the Spanish population [33].

2.2.3.3. Anthropometric. Waist circumference was measured to the nearest 0.1 cm using constant tension tape, following the guidelines of the International Society for the Advancement of Kinanthropometry [34].

Table 1
Descriptive data of the study participants, globally and according to food insecurity (N = 777).

Variables	Total[b]	Food secure	Low food security	Very low food security
Total, n (%)	777 (100.0)	663 (85.3)	93 (12.0)	21 (2.7)
Sociodemographic				
Age	14.0 (2.0)	14.0 (2.0)	13.0 (3.0)	15.0 (2.0)
Female sex, n (%)	430 (55.3)	367 (55.4)	53 (57.0)	10 (47.6)
FAS-III (score)	8.0 (3.0)	9.0 (3.0)	7.0 (3.0)	9.0 (5.0)
Anthropometric				
Waist circumference (cm)	70.8 (13.2)	70.6 (12.7)	70.9 (17.6)	71.7 (14.6)
Lifestyle				
YAP-S PA (score)	2.6 (0.8)	2.6 (0.8)	2.7 (0.8)	2.4 (1.1)
YAP-S SB (score)	2.6 (0.8)	2.4 (0.8)	2.6 (1.0)	2.8 (0.8)
Sleep duration (hour)	8.3 (1.1)	8.3 (1.1)	8.4 (1.4)	8.0 (1.1)
Energy intake (kcal)	2589.0 (1477.5)	2520.2 (1394.9)	3025.5 (2363.4)	3965.6 (3812.6)
Academic performance				
Language (score)	7.0 (3.0)	7.0 (3.5)	6.0 (3.0)	5.0 (3.0)
Math (score)	6.0 (4.0)	6.0 (4.0)	5.0 (3.0)	4.0 (3.0)
Foreign language (score)	6.0 (3.0)	7.0 (3.0)	6.0 (3.0)	5.0 (2.0)
GPA (score)[a]	6.7 (1.9)	6.8 (1.9)	6.1 (1.6)	5.6 (1.6)

FAS-III, Family Affluence Scale – III; GPA, grade point average; PA, physical activity; SB, sedentary behaviors; YAP-S, Spanish Youth Active Profile.
[a] Computed as the average of the school records of the total number of subjects taken by each participant.
[b] Values are the median (interquartile range), except where otherwise indicated.

2.3. Statistical analysis

To evaluate the normal distribution of the variables, visual techniques such as density and quantile–quantile plots, along with the Shapiro–Wilk test, were used. This study reported the median and interquartile range (IQR) for quantitative variables and frequencies (*n*) and percentages (%) for qualitative variables, both for the overall sample and stratified by food security categories. Linear regression models were constructed to determine the relationship between food insecurity and academic performance. These models were fitted using robust methods (i.e., "SMDM" method, which includes an S-estimation, an M-step, a D-estimation, and another M-step) because they offer several advantages in the context of dealing with heteroscedasticity and outliers [35]. Furthermore, the estimated marginal mean (*M*) and 95 % confidence interval (CI) of each academic performance-related indicator based on food security status were determined. Age, sex, socioeconomic status, waist circumference, physical activity, sedentary behavior, sleep duration, and energy intake were included as covariates. All the statistical analyses were carried out using R statistical software (version 4.3.2) from the R Core Team in Vienna, Austria, and RStudio (version 2023.12.1 + 402) from Posit in Boston, Massachusetts, USA, and the statistical significance was set at $p < 0.05$.

3. Results

Table 1 presents data on food security in relation to sociodemographic, anthropometric, lifestyle, and academic performance covariables. Of the total sample of 777 individuals, 21 (2.7 %) had very low food security, 93 (12.0 %) experienced low food security, and 663 (85.3 %) were food secure. Concerning academic performance, the highest median grades for language, math, foreign language, and GPA were identified in adolescents with food security (language: median = 7.0; IQR = 3.5; math; median = 6.0; IQR = 4.0; foreign language: median = 7.0; IQR = 3.0; GPA: median = 6.8; IQR = 1.9). Conversely, the lowest median grades for the same indicators were observed in those with very low security (language: median = 5.0; IQR = 3.0; math; median = 4.0; IQR = 3.0; foreign language: median = 5.0; IQR = 2.0; GPA: median = 5.6; IQR = 1.6).

Table 2 displays the outcomes of the linear regression models for each dependent variable (language, math, foreign language, and GPA) considering the associations with food insecurity and covariates in each model. The analysis revealed that for each additional point in the CFSSM–S, academic performance was lower for language (unstandardized beta coefficient [*B*] = −0.243; 95 % CI –0.357 to −0.128), math (*B* = −0.269; 95 % CI –0.398 to −0.140), foreign language (*B* = −0.212; 95 % CI –0.324 to −0.101), and GPA (*B* = −0.192; 95 % CI –0.280 to −0.104).

Fig. 1 shows the predicted means of academic performance according to food insecurity status after adjusting for several covariates. Adolescents with the highest levels of food insecurity reported the lowest academic performance in language (*M* = 4.7; 95 % CI 3.6 to 5.7), math (*M* = 4.6; 95 % CI 3.5 to 5.8), foreign language (*M* = 4.8; 95 % CI 3.8 to 5.8), and GPA (*M* = 5.7; 95 % CI 4.9 to 6.5). Conversely, adolescents with the lowest levels of food insecurity reported the highest academic performance in language (*M* = 6.2; 95 % CI 6.0 to 6.5), math (*M* = 5.9; 95 % CI 5.6 to 6.2), foreign language (*M* = 6.2; 95 % CI 5.9 to 6.4), and GPA (*M* = 6.7; 95 % CI 6.5 to 6.9) compared to those with higher food security. For all academic performance-related indicators, significant differences were identified between food-secure adolescents and those with very low food security ($p < 0.05$ for all comparisons).

Table 2
Linear regression models (fitted by robust methods) of the relationship between food insecurity and different academic performance indicators among adolescents.

Predictor	Language				
	B	SE	LLCI	ULCI	p
CFSSM–S (per one point)	−0.243	0.059	−0.357	−0.128	**<0.001**
	Math				
CFSSM–S (per one point)	−0.269	0.066	−0.398	−0.140	**<0.001**
	Foreign language				
CFSSM–S (per one point)	−0.212	0.057	−0.324	−0.101	**<0.001**
	GPA[a]				
CFSSM–S (per one point)	−0.192	0.045	−0.280	−0.104	**<0.001**

B, beta coefficient (unstandardized); CFSSM–S (Child Food Security Survey Module in Spanish); GPA, grade point average; LLCI, lower limit confidence interval; SE, standard error; ULCI: upper limit confidence interval.
Adjusted for age, sex, socioeconomic status, waist circumference, physical activity, sedentary behavior, sleep duration and energy consumption [35].
Bold indicates a *p*-value < 0.05.
Models fitted by robust methods (i.e., "SMDM" method).
[a] Computed as the average of the school records of the total number of subjects taken by each participant.

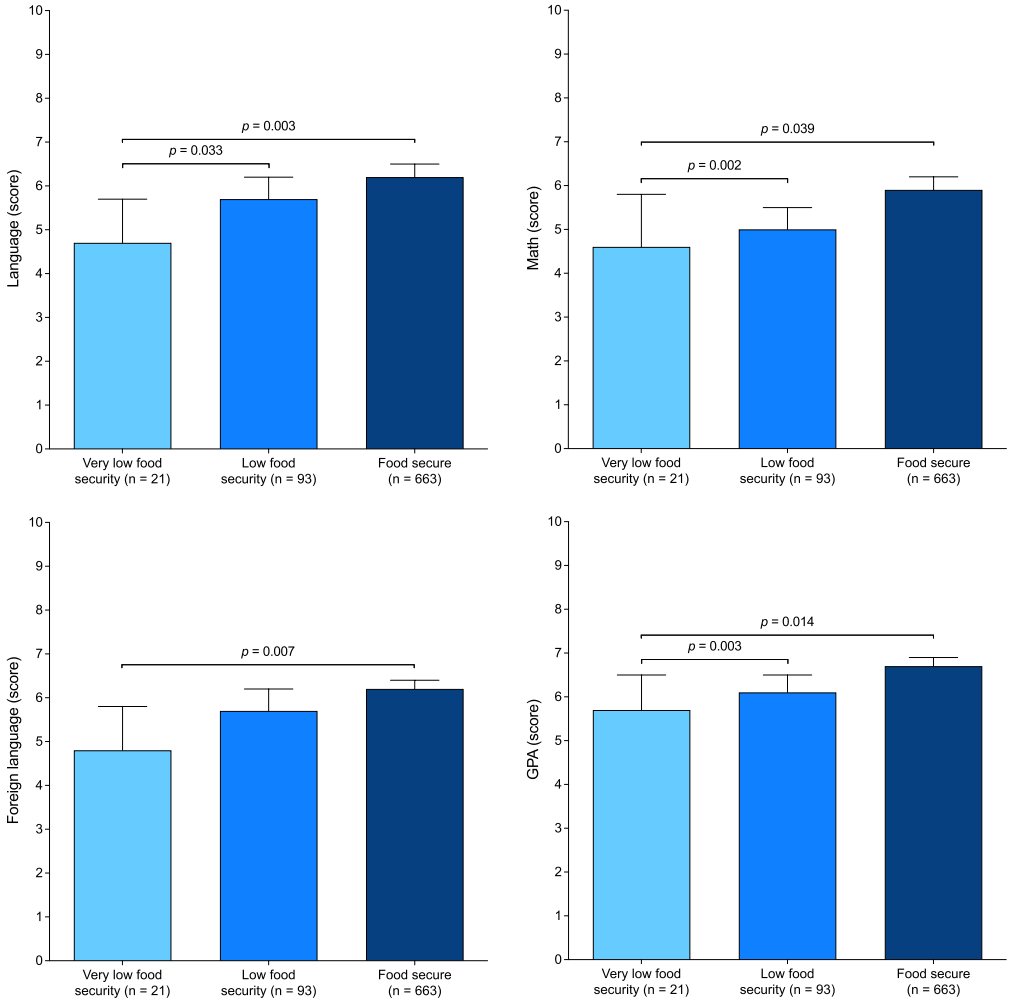

Fig. 1. Estimated marginal means of academic performance according to the food insecurity status among adolescents. Grade point average computed as the average of the school records of the total number of subjects taken by each participant. Models fitted by robust methods (i.e., "SMDM" [35] method). GPA, grade point average.

4. Discussion

4.1. Main findings and comparison with previous studies

Overall, the findings of this study suggest that adolescents reporting lower levels of food insecurity have greater academic performance, with higher grades in math, language, and GPA. The results of the present study are in line with the literature among children and adolescents [23,24,26,36–38]. For instance, in a study carried out in Ghana by Masa and Chowa [26], adolescents in food-insecure households were more likely to experience lower school attendance, poorer academic performance, and higher dropout rates than their counterparts in food-secure households. Furthermore, a study carried out in adolescents from Iceland with 6346 participants reported that there is a relationship between food insecurity and academic performance [38]. Although the mechanisms by which food insecurity can cause lower academic performance have not been previously established, several factors could contribute to the relationship between food insecurity and academic performance in adolescents.

4.2. Disrupted family environment and limited access to educational resources

A possible explanation for our results could be related to the disrupted family environment and limited access to educational resources inherent to food-insecure households. Food insecurity often arises from socioeconomic challenges, such as poverty or

financial instability [39]. A disrupted home environment characterized by increased family stress, limited resources for educational support, and reduced access to learning materials can create educational disadvantages and hinder academic progress [40]. In addition, households struggling with food insecurity may have limited financial resources available for educational expenses such as books, school supplies, tutoring, or extracurricular activities [41]. Therefore, addressing the root causes of food insecurity, such as low wages and adverse social and economic conditions, could be crucial for reducing its prevalence and improving health outcomes [39].

4.3. Stress, anxiety, and emotional well-being

Food insecurity can result in negative self-perception and reduced self-esteem, which may cause students to doubt their abilities, disengage from school, and underperform academically [42]. In addition, psychological causes that have been related to food insecurity, such as heightened stress, anxiety, and depression, can result in lower academic performance [43]. Thus, increased stress due to food insecurity can lead to cognitive impairments, including diminished attention, memory, and problem-solving abilities [44]. Likewise, this stress can exacerbate anxiety, which, in turn, may cause students to struggle with concentration and maintain focus in the classroom [45]. Furthermore, depression, which is more prevalent among food-insecure individuals, can negatively influence motivation and engagement in educational activities [46]. Moreover, food-insecure students may experience feelings of helplessness and hopelessness, which can further intensify depressive symptoms (stress, anxiety and depression) and impede academic success [47].

4.4. Nutritional deficiencies

On the other hand, food insecurity often leads to inadequate intake of essential nutrients, such as proteins, vitamins, and minerals. Malnutrition can impair cognitive function, memory, attention span, and overall brain development, which in turn can affect academic performance. For instance, iron deficiency anemia, which affects oxygen transport in the body, has been associated with decreased cognitive function due to the high demand for oxygen in the brain [48]. Similarly, inadequate intake of certain fatty acids, which are essential for brain development and function, has been associated with reduced cognitive performance and attention deficit hyperactivity disorder when consumed in insufficient amounts [49]. In addition, zinc deficiency can influence cognitive function, as it plays a critical role in neuronal development, neurotransmitter function, and synaptic plasticity [50]. Moreover, the importance of a balanced diet is further highlighted by the impact of vitamin B deficiencies, particularly B6, B9 (folate), and B12, which can result in elevated homocysteine levels, a factor associated with cognitive decline and low academic achievement [51]. Deficiencies in antioxidants such as vitamins A, C, and E can also impair cognitive function by increasing oxidative stress in the brain, leading to neuronal damage [52]. Therefore, each of these essential nutrients plays a vital role in maintaining optimal brain function, and their deficiencies can have negative consequences on cognitive abilities and academic achievement [4].

4.5. Methodological considerations

There are some limitations in this study that must be recognized. First, given its cross-sectional nature, it is not possible to draw causal inferences; consequently, future longitudinal observational studies are needed to determine whether lower food insecurity results in enhanced academic achievement among adolescents. Second, the use of self-reported measures may introduce differential bias due to potential inaccuracies and overestimation by adolescents. Third, although the analyses were adjusted for several covariates (i.e., anthropometric, sociodemographic, and lifestyle variables), residual confounding is still possible. On the other hand, some strengths can be highlighted in this study. For instance, this study included a large sample of Spanish adolescents, which is an understudied population. Similarly, academic performance was measured objectively, including a comprehensive evaluation of school records for all grades and not only examining language and/or math, which is common in most studies (studies have typically used these self-reported measures). Furthermore, grades were provided by the schools and not self-reported by the adolescents, which could have led to certain biases (i.e., social desirability, recall). Finally, we adjusted for several potential confounding variables, enhancing the robustness of the findings and providing an accurate representation of the relationship between food insecurity and academic performance.

5. Conclusion

Living in a more food-insecure household could explain the lower academic performance of adolescents. Our findings remained constant despite considering other sociodemographic, lifestyle or anthropometric variables, thus highlighting the relevant role of food insecurity on academic performance in young people. Food insecurity should always be on the agenda of public policies. Ensuring the availability of quality basic food essentials in permanently satisfactory quantities without compromising access to other fundamental needs, such as study and academic performance, is crucial.

Ethics statement

The study obtained ethical approval from the Bioethics Committee of the University of Murcia (ID 2218/2018), as well as the Ethics Committee of the Albacete University Hospital Complex and the Albacete Integrated Care Management (ID 2021-85). Similarly, this study adhered to the guidelines outlined in the Helsinki Declaration.

Informed consent statement

All subjects included in the study provided informed consent signed by parents. Written informed consent was obtained from all participants.

Data availability statement

The data used in this study are available from the corresponding authors after reasonable request, since they pertain to minors, and privacy and confidentiality must be respected.

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CRediT authorship contribution statement

Edina Maria de Camargo: Writing – original draft. **Sitong Chen:** Conceptualization. **Estela Jiménez-López:** Writing – review & editing, Conceptualization. **Desirée Victoria-Montesinos:** Writing – review & editing. **Lee Smith:** Writing – review & editing. **José Francisco López-Gil:** Writing – review & editing, Writing – original draft, Project administration, Formal analysis, Data curation, Conceptualization.

Declaration of competing interest

The authors declare that they have no known competing financial interests or personal relationships that could have appeared to influence the work reported in this paper.

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Appendix A. Supplementary data

Supplementary data to this article can be found online at https://doi.org/10.1016/j.heliyon.2024.e29489.

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