

# Is good dietary diversity a predictor of academic success?

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**Abstract.** *Background and aim:* Interest in identifying factors influencing educational success is growing. Many studies have examined factors that may affect academic performance. It is often observed that a group of students sharing the same external variables (school environment) yet have different results, which states that individual variables have more impact on the determination of academic performance. Therefore, the present study aims to substantiate this controversy by investigating the association between dietary habits and academic performance in a population of adolescents attending school in Eastern Morocco. *Methods:* Cross-sectional study based on a self-administered questionnaire. Items included sociodemographic variables, eating and sleeping habits, physical activity practice and the last semester's grade point average of Mathematics (GPAm) and first foreign language (GPaf) subjects. *Results:* Dietary diversity score (DDS) is a significant predictor of academic performance. Weight status and sleep duration was found to be strongly associated with academic achievement. Absenteeism and smoking are negatively associated with school achievement. *Conclusions:* The results reveal associations between dietary diversity and the academic performance of students in Eastern Morocco, which supports the creation of effective nutrition education policies to overcome the double burden of malnutrition by promoting healthy diets and encouraging physical activity. The results of these actions are likely to be healthier schools and improved behavioral development and academic performance of children ([www.actabiomedica.it](http://www.actabiomedica.it))

**Key words:** Dietary habits, Dietary Diversity Score, Academic Achievement, Education, Schoolchildren

## Background

Ensuring access to high-quality education for all children is at the top of the list of sustainable development goals that the United Nations have set towards the end of the year 2030 (1). According to this organization, quality education is a key to allow individuals to improve their living conditions and to invest in sustainable development, it promotes socio-economic mobility and is a pathway to escape poverty. It is from this observation that the interest in identifying the factors influencing educational success is growing. Many studies have examined factors that may affect academic performance. Among these works are those emphasizing the school environment namely the effect

of teaching practice, in this context Taştan et al. conducted a study in two countries Iran and Russia and concluded that when the teacher's self-efficacy is high in science classrooms, students show good attractiveness, better motivation and higher achievement (2). In a similar context, Maria Iacovou, in her paper measuring the effects of class size on student test scores, found that smaller classes were associated with higher reading scores but not mathematics scores (3), and the attractiveness of the school environment was also explored; Li and al. found that students with a view of a green space performed better on tests of attention and stress recovery (4). For family environment factors such as socioeconomic status. A recent meta-analysis by Liu et al. found a significant association

between SES (parents' education, employment status, and income) and students' academic performance (5). The research on the explanatory factors of the inadequacy of school performance has led researchers, not convinced of the determinants of external factors to focus on internal factors related to the lifestyles of individuals namely eating habits, quality of sleep, substance abuse as well as the practice of physical activity, they argue that regular consumption of breakfast enhances academic performance (6) Healthy eating behaviors are predictive factors of academic success (7). Physical activity does not appear to be detrimental to academic achievement in school-aged children and adolescents. On the opposite it might be beneficial (8). Good quality, longer duration and greater regularity of sleep are strongly associated with better academic performance (9). It is often observed in our classrooms that a group of students sharing the same external variables (school environment) yet have different results, which states that the variables related to the individual have more impact on the determination of academic performance. Therefore, the present study aims to substantiate this controversy by investigating the association between dietary habits and academic performance in a population of adolescents attending school in Eastern Morocco. After

reviewing the literature, we identified factors that may influence academic performance and formulated the hypotheses summarized in Table 1.

## Material and methods

### *Study design*

The present research is a cross-sectional study based on a self-administered questionnaire. Eight public and three private schools were randomly selected, and then classes were randomly drawn from each school. The survey was conducted from May 13, 2021, to October 21, 2021. The questionnaire was anonymous and was distributed by a previously trained team and was filled in individually by the students in the presence of a dietician.

### *Variables measured during the interview*

Dietary diversity data were collected using a 24-hour dietary recall. Participants were asked to recall all foods and beverages consumed in the twenty-four hours prior to the interview. A scale of nine food groups was used to assess subjects' individual dietary

**Table 1.** Description of the hypothetical explanations for academic performance.

Hypothesis	Description
H1	Higher Dietary Diversity Score (DDS) has positive impact on academic performance.
H2	Quarter of the year of birth is associated with academic performance.
H3	A higher number of household members negatively affects academic performance.
H4	Owning IT tools can improve academic performance.
H5	Females have higher academic performance than males.
H6	The intake of food additives could improve academic performance.
H7	Missing meals during the day affects negatively academic performance.
H8	Substance abuse (smoking) negatively affects the academic performance.
H9	Students who have benefited from preschool perform well in school.
H10	Absenteeism negatively affects the academic performance
H11	Sex of the teacher is associated with academic performance.
H12	Exercising is positively associated with academic performance.
H13	Students with abnormal weight have poorer academic performance.
H14	Sufficient sleep duration has positive impact on academic performance.

diversity. The food groups were: starchy foods, dark green leafy vegetables, vitamin A-rich fruits and vegetables, other fruits and vegetables, organ meats, meat and fish, eggs, legumes, nuts and seeds, and milk and dairy products. Foods consumed by participants were classified into food categories and individual dietary diversity scores were calculated using FAO guidelines for measuring household and individual dietary diversity. The minimum and maximum dietary diversity scores were 1 and 9, respectively. (10). In addition to socio-demographic information, our items included eating and sleeping habits, physical activity practice and the last semester grade point average of mathematics (GPAm) and first foreign language (GPAf) subjects.

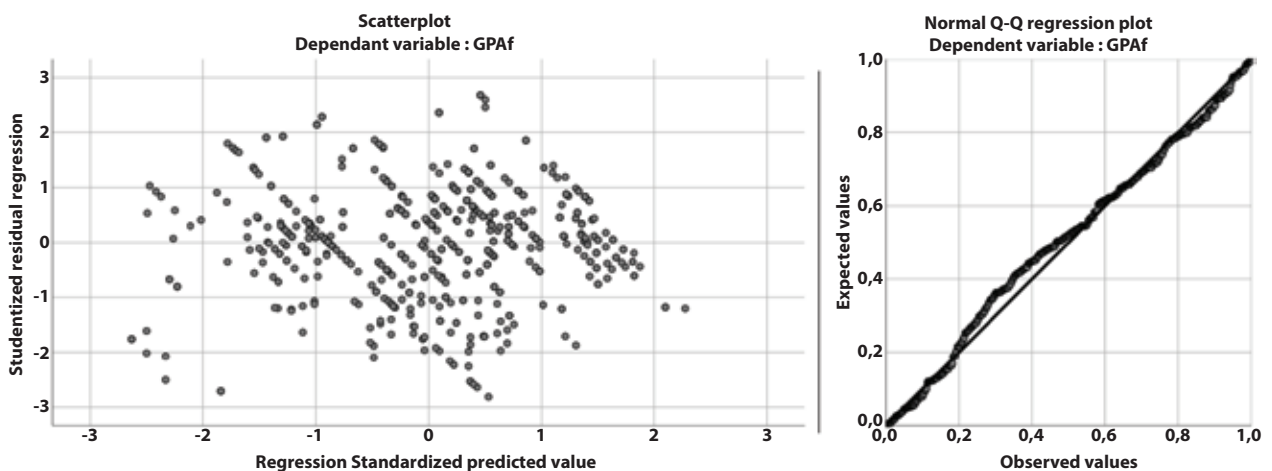
#### *Ethical considerations*

All precautions according to the Declaration of Helsinki (Finland, June 1964) were taken to protect the privacy and confidentiality of the personal information of those involved in the research. Informed consent was obtained from the guardians, who were properly informed of the objectives, methods, and institutional affiliations of the researchers and assured that their responses would be kept anonymous and confidential. Authorization to conduct the survey in public schools in the province of Taza (Morocco) was obtained from the provincial delegation of the

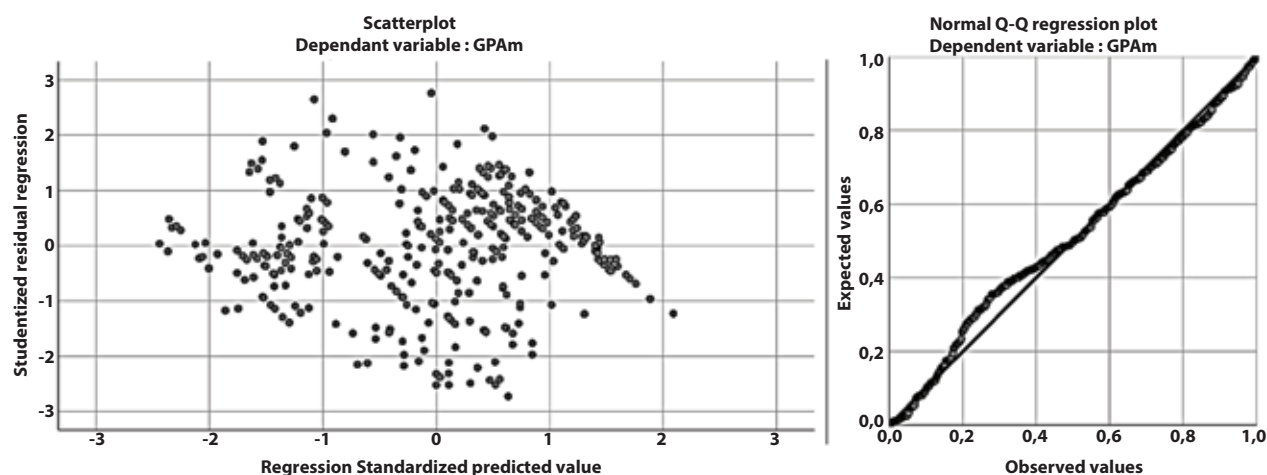
Ministry of National Education. The headmasters of the institutions were informed one week before the visit. The interview took place during a Day-Off for students.

#### *Statistical analysis*

Data analysis was performed using SPSS version 26 software. Quantitative variables were expressed as means and standard deviations, and qualitative variables were expressed as frequencies (percentages). The study used linear regression to test the underlying hypotheses and predict good academic performance. The GPAm and GPAf from the last semester was used separately as the dependent variable in the proposed models. The GPA ranges from 0 to 20. For better linear regression outputs, categorical variables was converted in dummy variables (dichotomized). The exploration of outliers was carried out, it appeared that all values of residuals was randomly distributed between  $-3$  and  $3$  z-scores (11). The premises of the linear regression were validated graphically. As shown in Figure 1, there were no problems with linearity and homoscedasticity because the plot of residuals versus fitted values was a random pattern with values around zero. The normality assumption was also plausible because the straightness of the normal Q-Q plot was pronounced. The analysis of the residuals is indicated in figures 1 and 2.



**Figure 1.** Residual diagnosis: First model with GPAf as dependent variable.



**Figure 2.** Residual diagnosis: Second model with GPAm as dependent variable.

## Results

### *Descriptive statistics*

After statistical processing we noted that 528 students completed the questionnaire, 43.6% of which were females. The average age was  $14.70 \pm 1.92$  year. Most respondents (40.9 %) were born on the first quarter of the year (from January to March), 85.6% of students lived in a larger family with more than three people sharing the same residence, among these students, 58.1% reported that they do not own information and telecommunication (IT) tools, such as a computer and an Internet connection. Only a few students (11%) did not attend pre-school classes and 15.3% were repeating the current class (failed to reach to the following class level last year). 72.7% of the students were indifferent to the sex of the teacher while 10.6% preferred to be taught by females and 16.7% preferred male teachers. 15% of students report having been absent from class more than 4 times per academic year. Only 1.9% of students were smokers. The dietary diversity score appeared to vary a little between students (Mean = 5.79, SD = 1.48). 35% of the respondents have the habit of taking their meals regularly, while 34.1% skip breakfast and 22.5% do not take dinner and only 8.3 skip the main meal being lunch. Daily sleep time was estimated at 7.58 hours with a standard deviation of 1.59. Almost half of the respondents practiced regular physical activity in fitness centers or

outdoors (42.4%). For weight status, the prevalence of overweight and obesity combined was estimated at 6.6%; however, 62.7% had a normal weight and 30.7% were underweight. Concerning academic performance, the GPA seems to vary considerably from one student to another for the French subject (Mean = 13.44, SD = 4.27). This was also the case for mathematics (Mean = 12.88, SD = 5.57). The results of the descriptive statistics are summarized in Table 2.

### *Multivariate linear regression analysis*

The GPA of French and Mathematics were used as dependent variables for the conduction of the linear regression. The model was generated by including all variables of the hypotheses; however, for reasons of collinearity, the following modalities were excluded: First semester of birth, regular consumer, preferred male sex as teacher, underweight. The outputs analysis of the linear regression reveals that the model has good explanatory power of the dependent variable variance (For GPAm as dependent variable adjusted R square = 0.714 and for GPAf adjusted R square=0.773). Table 3 presents the obtained results.

Results of multivariate linear regression analyses in Table 3 indicated that dietary diversity score is a significant predictor of academic performance (P value < 0.01) both for GPAm and GPAf. This result supports hypothesis (H1). Missing a meal during the day was statistically significant for breakfast (P value < 0.01) with a

**Table 2.** Descriptive statistics.

Variable	Percentage (%)		Mean	SD
Age		-	14,70	1,92
Sex	Male	56,4	-	-
	Female	43,6	-	-
Quarter of the year of birth	1 <sup>st</sup>	40,9	-	-
	2 <sup>nd</sup>	20,1	-	-
	3 <sup>rd</sup>	20,5	-	-
	4 <sup>th</sup>	18,6	-	-
Cohabiting family members	Less than 3	14,4	-	-
	More than 3	85,6	-	-
Owning IT tools	Computer	4,9	-	-
	Computer and an internet connection	36,9	-	-
	No IT tools	58,1	-	-
Preschool	No	11,0	-	-
	Yes	89,0	-	-
Absenteeism	Never	44,5	-	-
	Rarely	40,2	-	-
	Occasionally	14,0	-	-
	Very often	1,3	-	-
Teacher's preferred sex	Female	10,6	-	-
	Male	16,7	-	-
	No difference	72,7	-	-
Current class repetition	No	84,7	-	-
	Yes	15,3	-	-
Smoking	No	98,1	-	-
	Yes	1,9	-	-
GPAf		-	13,44	4,27
GPA <sub>m</sub>		-	12,88	5,57
DDS	-	-	5,79	1,48
Skipped meals	None	35	-	-
	Breakfast	34,1	-	-
	Lunch	8,3	-	-
	Dinner	22,5	-	-
Sleeping		-	7,58	1,59
Regular physical activities	No	57,6	-	-
	Yes	42,4	-	-
BMI	Underweight	30,7	-	-
	Normal	62,7	-	-
	Overweight	4,5	-	-
	Obesity	2,1	-	-

Note: BMI is Body Mass Index, GPAf and GPA<sub>m</sub> are Grade point average in french and math subjects respectively, IT tools: Information and Telecommunication tools, DDS: Dietary diversity score.

**Table 3.** Multivariate linear regression analysis.

Predictors	Dependent variable: GPAf			Dependent variable: GPAm		
	Beta	SE	t-value	Beta	SE	t-value
<b>Sex (0=male;1=female)</b>	-0.445	0.208	-2.138	-0.366	0.275	-1.331
<b>DDS</b>	0.830**	0.112	7.398	0.990**	0.147	6.715
<b>Quarter of birth</b>						
2 <sup>nd</sup>	-0.214	0.141	-1.517	-0.239	0.187	-1.281
3 <sup>rd</sup>	-0.277**	0.092	-3.027	-0.352**	0.121	-2.907
4 <sup>th</sup>	-0.218**	0.073	-2.99	-0.24**	0.096	-2.497
<b>Owning IT tools</b>						
No IT tools	-0.513	0.815	-0.629	-0.065	1.062	-.061
Computer and internet	3.847**	0.807	4.765	5.560**	1.052	5.283
<b>Food additive intake (0=No;1=Yes)</b>	0.33	0.238	1.39	0.452	0.314	1.441
<b>Skipped meal</b>						
Breakfast	-1.062**	0.251	-4.228	-1.149**	0.332	-3.465
Lunch	0.218	0.387	0.563	0.808	0.511	1.581
Diner	-0.766	0.28	-2.739	-0.661	0.369	-1.791
<b>Smoking</b>	-3.006**	0.369	-8.156	-2.54**	0.487	-5.22
<b>Preschool</b>	-0.645	0.316	-2.042	-0.699	0.417	-1.676
<b>Absenteeism</b>	-3.508**	0.289	12.131	-4.214**	0.382	11.036
<b>Teacher's preferred sex</b>						
Female	-0.565	0.385	-1.469	-0.591	0.508	-1.164
Indifferent	-0.346	0.278	-1.245	-0.305	0.367	-0.831
<b>Regular physical activity</b>	0.582*	0.221	2.632	0.683*	0.292	2.339
<b>BMI</b>						
Normal weight	4.633**	0.234	19.791	7.074**	0.309	22.886
Overweight	6.292	0.522	12.053	8.299	0.689	12.041
Obesity	-0.027**	0.734	-0.036	-1.008**	0.969	-1.041
<b>Sleeping</b>	0.349**	0.067	5.177	0.425**	0.089	4.777

Note: Beta(s) are regression coefficients, SE(s) are standard errors, \* p-value < 0.05, \*\* p-value < 0.01.

negative coefficient, which means that the student who skips breakfast is one time more susceptible to getting bad grades, the association was not significant for other meals. Thus, hypothesis (H7) is supported. Weight status was found to be strongly associated with academic performance (P-value < 0.01), Indeed, obesity is negatively associated with academic performance, while students with a normal weight status are four times more likely to excel in French and seven times more likely to have good grades in math. Thus, hypothesis

(H13) is supported. Term of birth is significantly associated with academic performance; this implies that students born between July and December are likely to have low grades in both French and Math. Therefore hypothesis (H2) was also supported. The presence of information and telecommunication (IT) tools at home is positively associated with academic performance. In fact, students with a computer connected to the internet in their homes are three times more likely to excel in French and five times more likely to excel in math

which confirms hypothesis (H4). Smoking was another significant factor ( $P$ -value  $< 0.01$ ) and negatively associated with academic performance, smokers will score three times lower than their non-smoking peers. This confirms the hypothesis (H8). Sleep duration was significant ( $P$ -value  $< 0.01$ ) then hypothesis (H14) was confirmed. Absenteeism is significant and negatively associated with academic performance ( $P$ -value  $< 0.01$ ). Consequently, students who are missing more than 10 school sessions per year are 3 times less likely to perform well in French and 4 times less likely to perform well in math than students who attend school regularly, and this retains hypothesis (H10). Physical activity was significantly and positively associated with academic performance in both french and math ( $P$ -value  $< 0.05$ ). Therefore, the hypothesis H12 is retained. Sex, number of family members sharing the same residence, Gender of teacher, dietary additives intake, preschooling, are non-significant predictors ( $P$ -value  $> 0.05$ ) of academic performance. Therefore, hypotheses (H3), (H5), (H6), (H9), (H11) and were not supported.

## Discussion

The present study aims to elucidate the synergistic and antagonistic effects that dietary diversity, lifestyle, and some school environment variables might have on academic performance in a developing country context as summarised in Table 4. The impact of every factor was examined by testing the appropriate hypothesis in its association with academic performance. It was found that a diverse diet has a positive influence on academic performance. The higher the students' dietary diversity score, the better their academic performance will be. This finding is consistent with several studies in the literature, Burrows et al., MacLellan et al. have shown that the consumption of a diverse diet from animal sources (meat and dairy) and vegetarian sources (vegetables and fruit) is associated with better academic achievement (12,13), specifically in a similar context Taras H. and Meyers AF. have shown that undernourished children have decreased attention and academic performance compared to well-nourished children (14,15). Evidence from other several studies states that healthier diets with more vegetables and

cereals and less processed foods are associated with better academic performance (16,17). The implication is that nutrients from different foods may affect cognitive function and memory. Tan and Norhaizan indicated that consumption of High Fat Diet HFD can lead to cognitive disorder (18). Kennedy et al. state that both fat-soluble (A, D, E) and water-soluble (B, C) vitamins contribute directly to optimal brain function via a specific biochemical mechanism (19). There may also be a socioeconomic link to this finding, as those with higher socioeconomic status are more likely to have access to protein-rich foods such as red meat and fish (20,21). The current study relied on the availability of a computer and internet connection in the student's household to assess socioeconomic status; in the past, census authorities relied on the presence of a television and refrigerator to estimate socioeconomic status, which are no longer luxuries today, and the presence of new IT tools seems to reflect medium to high socioeconomic status. In our sample, 58.1% of students reported the absence of IT tools, which reveals a minimal socioeconomic status. This could explain the low score of dietary diversity by the limited access to a varied diet, especially meat and fish. Moreover, the presence of information and telecommunication tools at home through MOOCs available on different platforms could help students to better do their homework, this is proven in our context as students with a computer connected to the internet are 3 times more likely to excel in French and 5 times more likely to have good GPAs in mathematics compared to students with no computer or internet connection. Our results are in harmony with those of Kim et al, on a sample of Korean students, who demonstrated the existence of a positive association between regular meal intake and academic success, which could ensure the regular administration of micronutrients necessary for the proper execution of cognitive functions (22). In a review article, Pollitt P and Mathews R focus on the breakfast meal and summarize that skipping breakfast impairs cognition and learning, an effect that is more pronounced in nutritionally at-risk children than in well-nourished children, whereas eating breakfast improves school attendance and learning (23). The link between breakfast consumption and the decrease in school absences could be explained by

**Table 4.** Studies on association between dietary habits, owning IT tools, regular breakfasting intake, sleep, month of birth, regular physical activity and academic performance.

Reference	Characteristics of study	Main results	Our study
<b>Dietary diversity</b> (Burrows et al., 2017) (MacLellan et al., 2008)	Systematic review Cross-sectional study	Small to moderate significant positive associations were found between diverse diet and academic achievement	A diverse diet has a positive influence on academic performance, the higher the student's dietary diversity score, the better their academic performance Student who skips breakfast is one time more susceptible to getting bad grades, the association was not significant for other meals
(Meyers et al., 1988) (Taras, 2005)	Case-control study Systematic review	Undernourished children have decreased attention and academic performance compared to well-nourished children	
(Correa-Burrows et al., 2016) (Florence et al., 2008)	A cohort study beginning in infancy (4months aged children) Cross-sectional study	An unhealthy diet at age 16 years was associated with reduced academic performance Students with decreased overall diet quality were significantly more likely to perform poorly	
(Tan & Norhaizan, 2019) Kennedy & Haskell, 2011)	Review	Dietary intake was also found to induce cognitive dysfunction The administration of broader ranges of vitamins, or multivitamins, suggest potential efficacy in terms of cognitive and psychological functioning	
<b>Socioeconomic status as a moderator of dietary diversity</b> (Kearney, 2010) (Sirin, 2005)	Review	Students with higher socioeconomic status are more likely to have access to protein-rich foods such as red meat and fish	
<b>Owning IT tools</b> (Asif et al., 2022)	Cross-sectional study	A positive impact of technology tools on academic performance	Students with a computer connected to the internet in their homes are three times more likely to excel in French and five times more likely to excel in Math
<b>BMI</b> (He et al., 2019) (Miller et al., 2015)	Systematic review Review	BMI is weakly and negatively associated with academic achievement Childhood obesity is associated with poor school performance	Obesity is negatively associated with academic performance, while students with a normal weight status are four times more likely to excel in French and seven times more likely to have good grades in Math
<b>Sleep duration</b> (Okano et al., 2019)	Cross-sectional study	Better quality, longer duration, and greater consistency of sleep were correlated with better grades	Shorter sleep duration is associated with lower GPAs
<b>Quarter of birth</b> (Bedard & Dhuey, 2006)	Cohort study	Initial maturity differences have long-lasting effects on student performance	Students born between July and December are likely to have low grades in both French and Math
<b>Physical activity</b> (Singh et al., 2012)	Review	Participation in physical activity is positively related to academic performance	Physical activity was significantly and positively associated with academic performance



Reference	Characteristics of study	Main results	Our study
<b>Sex</b> (Woodfield et al., 2006)	Review	Female students had significantly higher overall percentage scores for their degree program	No sex differences in academic performance
<b>Absenteeism</b> (Khan et al., 2019)	Cross-sectional study	Positive and significant impact of attendance coefficient on academic performance	students who are missing more than 10 school sessions per year are 3 times less likely to perform well in French and 4 times less likely to perform well in Math than students who attend school regularly

the improvement of the quality of the diet of adolescents, which translates into a good health status and subsequently the reduction of absences due to health problems (illnesses). Regarding the relationship between BMI and academic performance, Jinbo He et al., in a review article comprising 60 studies examining the association between body mass index (BMI) and academic performance, reported that BMI had a negative correlation with academic achievement, suggesting that being overweight is inversely related to academic achievement. In addition, moderators such as region and grade level contributed significantly to the observed heterogeneity of associations between BMI and academic achievement (24). Moderators of cultural and psychological origin could explain the low academic performance among obese students in developing countries where obesity records low prevalence, so the obese student is often criticized by peers which impacts his mental health and implicitly his school results. There is ample evidence from research that adipose tissue is metabolically active. It produces various substances with biological functions associated with obesity and communicates with multiple tissues and organ systems, including the brain, to regulate metabolism. These substances are present in children, and have been found to be associated with executive function skills in animals and adults. In addition to this, hormones that regulate metabolism also appear to contribute significantly to cognitive processing, particularly to skills such as working memory and learning, which are key components of executive functions or (25). Shorter sleep duration is associated with lower

GPA's, and this is in harmony with the findings of Okano K. Sleep is a biological need and an essential component of learning and memory consolidation. It has been shown that after a night characterized by reduced sleep duration, students will obtain poor memorization scores compared to those who have slept enough (26). The month of birth appears to be a determinant of school performance. The effect seems to be related to the age of the child when first attending school, thus the issue of maturity in relation to peers is raised, Bedard and Dhuey found a positive effect of relative age in academic achievement (27). Our study is in line with the literature review conducted by Singh et al. which found a positive association between regular physical activity and academic achievement, according to this study regular participation in physical activity is related to improved brain function and cognition, which has a positive influence on achievement (28). While Woodfield et al. found differences between girls and boys in terms of academic achievement (29), our study did not identify a significant association. Similarly, there was no significant relationship with academic achievement for the sex of teacher, attending preschool classes, food additive intake, and number of family members sharing the same residence.

## Conclusions

The findings indicate associations between dietary diversity (DDS) and academic performance of students in eastern Morocco. The results of our survey

support the creation of effective nutrition education policies to overcome the double burden of malnutrition on the one hand to eradicate leanness and ensure food security in terms of quality and quantity and to fight against obesity which is a public health risk factor through the promotion of physical exercise. On the other hand, to ensure dietary and nutritional diversification responsible for a large part of academic excellence. It is also essential to review the lifestyle of adolescents by raising awareness against the scourge of smoking near schools. The results of these actions are likely to be healthier schools and improved behavioral development and academic performance of children.

A limitation of this study was the use of GPA scores which may not reflect the true performance of the students. Self-reported sleep duration is subjective and does not provide any insight into the quality of sleep. The 24 hours recall period before the survey took place, does not provide an indication of the student's usual diet but allows for a one-time assessment of diet, and the use of a recall period that spans days as in the Food Frequency Questionnaire (FFQ) that spans a year could confirm the present results. The 24-hour recall period was chosen because it is less error-prone, requires less effort on the part of respondents, and is also the recall period used in many dietary diversity studies (30–32). Future replication of the study should be based on objective standardized tests such as Raven's Progressive Matrices as well as using wearable gadgets available on the market that measure sleep duration or even provide information on the number of times awake per night. Longitudinal follow-up of a cohort could better clarify the significant associations found between diet, lifestyle and academic performance.

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## References

1. United Nations Educational, Scientific and Cultural Organization. Meeting commitments: are countries on track to achieve SDG 4? Published online 2019. Accessed November 13, 2022. <https://unesdoc.unesco.org/ark:/48223/pf0000369009>
2. Taştan SB, Davoudi SMM, Masalimova AR, et al. The impacts of teacher's efficacy and motivation on student's academic achievement in science education among secondary and high school students. *Eurasia Journal of Mathematics, Science and Technology Education*. 2018;14(6):2353-2366. doi:10.29333/ejmste/89579
3. Iacovou M. Class size in the early years: Is smaller really better? *Educ Econ*. 2002;10(3):261-290. doi:10.1080/09645290210127499
4. Li D, Sullivan WC. Impact of views to school landscapes on recovery from stress and mental fatigue. *Landsc Urban Plan*. 2016;148:149-158. doi:10.1016/j.landurbplan.2015.12.015
5. Liu J, Peng P, Luo L. The Relation Between Family Socioeconomic Status and Academic Achievement in China: A Meta-analysis. *Educ Psychol Rev*. 2020;32(1):49-76. doi:10.1007/s10648-019-09494-0
6. Adolphus K, Lawton CL, Dye L. The effects of breakfast on behaviour and academic performance in children and adolescents. *Front Hum Neurosci*. 2013;(JUL). doi:10.3389/fnhum.2013.00425
7. Wald A, Muennig PA, O'Connell KA, Garber CE. Associations between healthy lifestyle behaviors and academic performance in U.S. undergraduates: A secondary analysis of the American college health association's national college health assessment ii. *American Journal of Health Promotion*. 2014;28(5):298-305. doi:10.4278/ajhp.120518-QUAN-265
8. Barbosa A, Whiting S, Simmonds P, Moreno RS, Mendes R, Breda J. Physical activity and academic achievement: An umbrella review. *Int J Environ Res Public Health*. 2020;17(16):1-29. doi:10.3390/ijerph17165972
9. Okano K, Kaczmarzyk JR, Dave N, Gabrieli JDE, Grossman JC. Sleep quality, duration, and consistency are associated with better academic performance in college students. *NPJ Sci Learn*. 2019;4(1). doi:10.1038/s41539-019-0055-z
10. Food and Agriculture Organization. Guidelines for measuring household and individual dietary diversity. *Fao*. Published online 2010:1-60. doi:613.2KEN

11. Pituch KA, Stevens J, James P. Applied multivariate statistics for the social sciences : analyses with SAS and IBM's SPSS. Published online 2016.
12. Burrows T, Goldman S, Pursey K, Lim R. Is there an association between dietary intake and academic achievement: a systematic review. *Journal of Human Nutrition and Dietetics*. 2017;30(2):117-140. doi:10.1111/jhn.12407
13. MacLellan D, Taylor J, Wood K. Food intake and academic performance among adolescents. *Canadian Journal of Dietetic Practice and Research*. 2008;69(3):141-144. doi:10.3148/69.3.2008.141
14. Meyers AF, Sampson AE, Weitzman M, et al. School Breakfast Program and School Performance.; 1988. <http://archpedi.jamanetwork.com/>
15. Taras H. Nutrition and Student Performance at School. Vol 75.; 2005.
16. Correa-Burrows P, Burrows R, Blanco E, Reyes M, Gahagan S. Nutritional quality of diet and academic performance in Chilean students. *Bull World Health Organ*. 2016;94(3):185. doi:10.2471/BLT.15.161315
17. Florence MD, Asbridge M, Veugelers PJ. Diet quality and academic performance. *J Sch Health*. 2008;78(4):209-215. doi:10.1111/J.1746-1561.2008.00288.X
18. Tan BL, Norhaizan ME. Effect of High-Fat Diets on Oxidative Stress, Cellular Inflammatory Response and Cognitive Function. *Nutrients*. 2019;11(11). doi:10.3390/NU11112579
19. Kennedy DO, Haskell CF. Vitamins and cognition: what is the evidence? *Drugs*. 2011;71(15):1957-1971. doi:10.2165/11594130-000000000-00000
20. Sirin SR. Socioeconomic status and academic achievement: A meta-analytic review of research. *Rev Educ Res*. 2005;75(3):417-453. doi:10.3102/00346543075003417
21. Kearney J. Food consumption trends and drivers. *Philosophical Transactions of the Royal Society B: Biological Sciences*. 2010;365(1554):2793-2807. doi:10.1098/rstb.2010.0149
22. Kim HYP, Frongillo EA, Han SS, et al. Academic performance of Korean children is associated with dietary behaviours and physical status. *Asia Pac J Clin Nutr*. 2003;12(2):186-192. <https://apjcn.nhri.org.tw/server/APJCN/12/2/186.pdf>
23. Connors, Blouin. Breakfast and cognition summary 805s. <https://academic.oup.com/ajcn/article-abstract/67/4/804S/4666123>
24. He J, Chen X, Fan X, Cai Z, Huang F. Is there a relationship between body mass index and academic achievement? A meta-analysis. *Public Health*. 2019;167:111-124. doi:10.1016/j.puhe.2018.11.002
25. Miller AL, Lee HJ, Lumeng JC. Obesity-associated biomarkers and executive function in children. *Pediatr Res*. 2015;77(1-2):143-147. doi:10.1038/PR.2014.158
26. Okano K, Kaczmarzyk JR, Dave N, Gabrieli JDE, Grossman JC. Sleep quality, duration, and consistency are associated with better academic performance in college students. *NPJ Sci Learn*. 2019;4(1). doi:10.1038/s41539-019-0055-z
27. Bedard K, Dhuey E. The persistence of early childhood maturity: international evidence of long-run age effects\*; 2006. <http://qje.oxfordjournals.org/>
28. Singh A, Uijtewilligen L, Twisk JWR, van Mechelen W, Chinapaw MJM. Physical activity and performance at school: a systematic review of the literature including a methodological quality assessment. *Arch Pediatr Adolesc Med*. 2012;166(1):49-55. doi:10.1001/ARCHPEDIATRICS.2011.716
29. Woodfield R, Jessop D, McMillan L. Gender differences in undergraduate attendance rates. *Studies in Higher Education*. 2006;31(1):1-22. doi:10.1080/03075070500340127
30. Arimond M, Wiesmann D, Becquey E, et al. Simple food group diversity indicators predict micronutrient adequacy of women's diets in 5 diverse, resource-poor settings1-7. *Journal of Nutrition*. 2010;140(11). doi:10.3945/jn.110.123414
31. Steyn N, Nel J, Nantel G, Kennedy G, Labadarios D. Food variety and dietary diversity scores in children: are they good indicators of dietary adequacy? *Public Health Nutr*. 2006;9(5):644-650. doi:10.1079/phn2005912
32. Kennedy GL, Pedro MR, Seghieri C, Nantel G, Brouwer I. Dietary diversity score is a useful indicator of micronutrient intake in non-breast-feeding Filipino children. *J Nutr* 2007;137(2):472-477. doi:10.1093/JN/137.2.472

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