



Effect of Eating Habits on Attentional and Memory Performance and Academic Success in High School Students in the Tiznit Region in Southern Morocco



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ABSTRACT

Aims This study aimed to investigate the impact of specific socio-economic factors and eating habits on attention, working memory, and academic performance among high school students.

Instrument & Methods The sample of this quantitative study comprised high school teenagers aged 15 to 22 years from both rural and urban areas. Eating habits were assessed using a questionnaire covering student demographics and dietary behaviors. Attention and working memory were evaluated using the computer-based Rey complex figure (RCF) test, while academic achievement was determined based on students' overall grades.

Findings The results revealed correlations between certain dietary habits and RCF test parameters. Specifically, we observed a correlation between breakfast consumption frequency and attentional performance ($\chi^2=6.599$; $p=0.037$), as well as working memory ($\chi^2=6.053$, $p=0.048$). Additionally, we found associations between weekly consumption of fish and attentional performance, as well as between the consumption of milk and its derivatives, Argan oil, and attentional performance. Furthermore, a correlation was observed between weekly fruit consumption and students' memory performance.

Conclusion Our findings underscore the significant impact of dietary habits on students' attention and working memory capacities. Adopting healthy eating habits enhances these neurocognitive skills, thereby contributing to improved academic success among adolescents.

Keywords Feeding Behavior; Attention; Memory; Students; Morocco

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Introduction

In late 2030, the United Nations established one of its initial goals for sustainable development: ensuring that all children have access to quality education. This is pivotal for enhancing living conditions and investing in sustainable progress, as it facilitates social and economic mobility and serves as a means to break free from poverty [1].

This realization sparked interest in identifying factors that impact academic success. [2, 3]. To pinpoint factors associated with poor academic performance, studies have delved into lifestyle aspects such as eating habits, sleep quality, substance abuse, and physical activity. Regarding eating habits, research suggests that regular breakfast consumption enhances school performance [4, 5]. Nutrition indeed plays a crucial role as one of the most significant environmental factors influencing cognitive performance by providing the necessary building blocks for neuronal formation and brain development. Given the link between academic success and learners' cognitive abilities, such as attention and working memory, investigating the effects of food on these parameters is increasingly vital [6, 7]. Inadequate eating habits or nutritional intake during developmental stages can detrimentally affect cognitive abilities. Glucose, in particular, serves as the primary energy source for the human brain [9], and a deficiency in glucose can lead to a significant decline in mental function [10].

Ensuring adequate nutrient intake to support development and cognitive performance poses a challenge as children grow older and gain more control over their food choices and eating habits [11]. Indeed, the world is undergoing significant shifts in eating habits and lifestyles, often leading to overeating and exceeding daily energy requirements. Adolescents are frequently the first to adopt these dietary changes.

This study aimed to underscore the importance of nutrition and eating habits in the cognitive and academic performance of students. This is achieved by examining the correlation between high school students' eating habits and cognitive performance (specifically attention and working memory) measured using the computerized version of the Rey Complex Figure (RCF) test (ELIAN software). Additionally, the study explored the influence of eating habits on students' academic performance.

Instrument and Methods

This quantitative study evaluated the impact of students' eating habits on their academic performance. The research was based on an anonymous questionnaire addressing students' eating habits, including breakfast consumption and the weekly frequency of certain foods commonly consumed in Morocco. These eating habits were analyzed alongside parameters of attention, working

memory, and the academic performance of the students.

Study Zone

The province of Tiznit was the site of the study. It is a sub-Saharan area located in the southern region of Morocco. This region is economically poor; the population relies on agricultural activity and traditional livestock to ensure its income.

Sample

In this study carried out in March and April 2018, we targeted 121 high school students at the three levels (common core, first and second baccalaureate). Although the survey was limited to a geographical area and a specific period of time, it was based on a relatively representative sample of establishments; it covered a sample of rural and urban high schools belonging to various socio-economic strata. These students come from the ALMARGHITI high school in the Mireght region on the outskirts of the city of Tiznit, as a rural environment, and also in the Sidi Hassine high school in the Lakhsas region, which is an urban environment. These two high schools have boarding facilities for students from neighboring regions to reside in.

Research Tools

Socio-Economic Parameters

Age, sex, parents' educational attainment and occupation, location, and family size were among the socioeconomic factors that were examined.

Eating Habits

A 24-hour dietary recall was used to gather information on dietary diversity. Participants were asked to recall all food and drinks consumed in the 24 hours preceding the interview. An anonymous questionnaire was used to collect information on students' eating habits, including breakfast consumption, as well as the daily and weekly frequency of consumption of certain foods commonly eaten in Morocco.

Cognitive Performance

The cognitive performances considered in our study were attention and working memory. These parameters were measured using the computerized version of the Rey complex figure (RCF) test by the ELIAN software.

The goal of this particular neuropsychological assessment was to evaluate an individual's perceptual and memory organization. Additionally, it enables differentiation between subjects experiencing perceptual disorders and those with memory disorders. The test consisted of 1) replication of a complex geometrical shape, devoid of inherent significance, due to its ability to challenge the observer's perceptual analysis and organizational capabilities and 2) reproduction of delayed memory, which requires the use of working memory to recall various elements accessed a few minutes earlier

A recent technique for gathering RCF tracings was developed and implemented [13, 14]. This technique utilizes the digital pen of the "Logitech" system.

During the tracking process, the subject uses a grid-coated paper that appears a light gray color to the naked eye, specifically CREDAGE A4 paper. Using the pen, the subject records the dynamics of each stroke as a sequence of x and y coordinates, along with instantaneous pressures. Both the copy and reproduction proofs are located on the same A4 format CREDAGE paper, folded in half to avoid overlap, with a small piece of cardboard inserted between the halves. The duration of this process is not limited. The pen's memory, capable of storing around 50 to 100 traces depending on the model, retains the data to be transferred later to a computer via a USB base. To analyze the data, specialized software called "ELIAN" or "Expert Line Information ANalyser" is employed, displaying the line dynamics on the screen in various modes and providing numerical parameters.

The results will be presented by categorizing the scores into percentiles and organizing them into three classes. This classification will diagnose the subject's orientation. Subjects with central values falling between the 25th and 75th percentiles will be considered to have a "normal" cognitive and neuropsychological profile. Those with central values between the 10th and 25th, or 75th and 90th percentiles will be classified as "tangent" or "to be monitored." Finally, subjects with values outside the 10th or 90th percentile will be classified as "abnormal or pathological" cases. In summary, a subject is deemed normal if its values fall between the 25th and 75th percentiles. Subjects with central values between the 10th and 25th, or 75th and 90th percentiles will be categorized as tangent or to be monitored. Any subjects with values outside the 10th or 90th percentile will be considered abnormal or pathological cases.

Academic Success

The academic success of students was assessed based on the grades obtained during the current year; a score below 10/20 is deemed insufficient, a score between 10/20 and 12/20 is considered fair, a score between 12/20 and 14/20 is regarded as fairly good, a score between 14/20 and 16/20 is seen as good, and a score above 16/20 is considered very good.

Ethical Considerations

To ensure the confidentiality and privacy of participants' information, all necessary precautions consistent with the Declaration of Helsinki were implemented. Prior to commencing the research, comprehensive information about the goals and procedures was provided to the guardians, who gave their informed consent. Permission to conduct the survey in public schools within the Tiznit province was obtained from the Ministry of National Education's provincial delegation. School directors were notified one week before the survey visit.

Statistical Analysis

Statistical analysis was conducted using SPSS 20.0 and the Excel spreadsheet (version 2007). The

Pearson Chi-square test was employed to examine the association between the different parameters of the FCR test and the dietary habits considered on the one hand, and the correlation between the parameters of the FCR test and academic success on the other hand.

Findings

Regarding breakfast intake, 80.99% reported eating and 19.01% reported not taking breakfast. A statistically significant correlation was found between consuming breakfast and the numerical rating score in both the copying phase ($\chi^2=6.599$; $p=0.037$) and the memory recall phase ($\chi^2=6.053$; $p=0.048$) of the computerized Rey test.

Table 1 presents the frequency of weekly consumption of some foods.

Concerning the weekly frequency of fish consumption, the majority of pupils consumed fish once a week (47.1%) or rarely (38%), while the percentage of pupils who consumed fish 2 to 3 times a week or every day remained low (13.2% and 1.7%, respectively).

The results showed a significant relationship between the place of habitat and the frequency of weekly fish consumption ($\chi^2=7.923$; $p=0.048$).

Statistical analysis also showed a significant relationship between the frequency of weekly fish consumption and the duration of drawing the RCF at the level of the copy phase ($\chi^2=16.645$; $p=0.011$) and the memory recall phase ($\chi^2=15.235$; $p=0.019$).

Concerning the weekly frequency of consumption of fruit, the highest percentage was that of learners who consumed fruit every day (47.9%) and 2 to 3 times a week (36.4%), followed by those who consumed fruit rarely (9.9%) and once a week (5.8%).

The results indicated a highly significant relationship between the frequency of weekly fruit consumption and the place of residence ($\chi^2=20.649$; $p=0.0001$) on the one hand and between the size of households and the frequency of weekly fruit consumption ($\chi^2=10.712$; $p=0.013$) on the other hand.

The existence of a significant relationship between the weekly frequency of fruit consumption and the score obtained in numerical scoring in the memory recall phase ($\chi^2=14.907$; $p=0.021$), whereas there was no significant link with the dynamic parameters of the RCF test.

Considering the weekly frequency of consumption of milk and its derivatives, we found that 53.7% of pupils consumed milk and its derivatives daily, while 29.8% consumed it 2 to 3 times a week. Then we found the learners consuming milk and derivatives once a week (9.1%) and rarely by the lowest percentage (7.4%). Statistical analysis showed a significant relationship between the frequency of weekly consumption of milk and its derivatives and the duration of production of the FCR drawing in the copying phase ($\chi^2=16,750$; $p=0.010$).

With regard to the weekly frequency of consumption of Argan oil, the highest frequency of Argan oil consumption was found in students who rarely consumed Argan oil (64.5%), followed by consumption once a week and 2 to 3 times per week (12.4% each), and finally, the pupils consuming Argan oil every day presented 10.7% of the sample studied.

We observed a significant correlation between the frequency of Argan oil consumption and the gender of the subjects tested ($\chi^2=8.284$; $p=0.04$), as well as an almost significant correlation ($\chi^2=7.638$; $p=0.054$) between the place of residence and this frequency.

The analysis revealed a statistically significant correlation between the weekly frequency of Argan oil consumption and the duration of drawing the RCF during the copying phase ($\chi^2=16.196$; $p=0.013$).

Regarding the academic success of learners, we found an almost significant correlation between school performance and eating breakfast ($\chi^2=7.957$; $p=0.093$).

There was no significant correlation between other eating habits and school performance. The results obtained are illustrated in Table 2.

Regarding the relationship between academic success and the parameters of the RCF test, we found statistically significant correlations between academic success and the score obtained during the copying phase of the RCF test ($\chi^2=15.758$; $p=0.046$), as well as the score obtained during the memory recall phase ($\chi^2=21.465$; $p=0.006$). Additionally, there was a significant correlation between academic success and the height of the tracing in the memory recall phase ($\chi^2=21.294$; $p=0.006$).

Table 1. Frequency of weekly consumption of some foods

	Weekly Fish Consumption	Weekly Fruit Consumption	Weekly Milk and Its Derivates Consumption	Weekly Argan Oil Consumption
Rarely	38	9.9	7.4	64.5
Once a week	47.1	5.8	9.1	12.4
Two or three times a week	13.2	36.4	29.8	12.4
Every day	1.7	47.9	53.7	10.7

Table 2. Relationship between academic success and eating habits

Academic success	Red meats and Pisces chicken	Eggs	Vegetables	Fruits	Cereals	Milk and Tea derivatives	Olive Oil	Argan Oil		
χ^2	13.949	7.713	15.759	14.051	14.755	6.239	13.383	15.992	14.211	10.619
p-value	0.304	0.807	0.203	0.297	0.255	0.904	0.342	0.192	0.287	0.562

Discussion

The aim of this work was to detect attention and working memory disorders in high school students considering the socio-economic determinants and eating habits of these learners.

With regard to taking breakfast, the vast majority of students (81%) reported eating breakfast before coming to school. This is because all the students who stay at the boarding school, which constitute a significant percentage of the total sample, are required to have breakfast at a certain time before returning to class.

The frequency of weekly fish consumption was generally low, with 38% of respondents rarely eating fish and 47.1% consuming it only once a week. This low level of fish consumption is attributed to the region's mountainous terrain, which is far from the sea and, more specifically, from ports. The limited consumption of fish is closely tied to the region's weekly market (held every Tuesday), which is the only time fish is supplied, with no availability for the rest of the week. Additionally, the notable association between the place of residence (either boarding school or with the family) and the frequency of weekly fish consumption can be explained by the fact that meals at the boarding school more frequently include fish.

Regarding the frequency of weekly fruit consumption, the majority of learners exhibit a high frequency, attributed to the plentiful supply of fruit

and the local habit of consuming fruit, particularly after lunch. This aligns with studies recommending daily fruit consumption due to the health benefits of consuming vegetables and fruits daily [15, 16]. It is advised that all students consume at least one piece of fruit daily, especially as a snack or dessert. The significance of adopting such dietary habits lies in the fact that this life stage presents an opportunity to develop independence in making healthy lifestyle choices, including dietary decisions [17]. During these critical developmental phases, dietary habits play a crucial role in determining adult health status [18, 19]. The significant relationship between the frequency of weekly fruit consumption and the place of residence is explained by the school cafeteria offering fruit at every lunch and dinner, accounting for the higher frequency of fruit consumption among students living at the boarding school.

Regarding the weekly consumption frequency of milk, its derivatives, and tea, it is observed that the majority of students consume these products frequently (daily for half of them and two to three times a day for a significant portion). Globally, tea consumption ranks second only to water [20], a trend attributed to milk and tea being the primary beverages consumed during breakfast and snack times.

As for the weekly consumption frequency of Argan oil, it is noted that a majority of the surveyed students rarely consume it (64.5%) or only do so once a week

(12.4%). This limited consumption can be attributed to the high selling price of Argan oil, despite the region being known for producing it. Moreover, the correlation between the frequency of weekly Argan oil consumption and the place of residence is explained by the boarding school not providing this type of oil in its meals for students.

The results indicated a statistically significant association between eating breakfast and the scores achieved during the copying phase and the memory recall phase. Given that these scores reflect attentional performance in the copying phase and memory performance in the recall phase, it suggests that eating breakfast positively affects these abilities. This finding is in line with research demonstrating that regular breakfast consumption beneficially influences attention, concentration, and working memory [21]. The energy provided by breakfast is particularly crucial since the last meal typically occurred at least twelve hours prior, and the brain requires glucose for optimal functioning [22].

Regarding the impact of breakfast consumption on academic performance, our findings demonstrate that regular breakfast intake positively affects students' school performance; those who consistently eat breakfast perform better than those who do not. This outcome aligns with earlier studies. Indeed, researchers have shifted focus to internal factors related to individuals' lifestyles, such as dietary habits, following investigations into the causes of poor academic performance. They argue that regular breakfast consumption enhances specific cognitive functions like memory and results in academic tests [23]. Dietary habits significantly influence academic achievement [24]. Malnutrition and food insecurity are identified as more critical factors affecting academic success than merely inadequate nutrition [25-27]. Furthermore, the statistically significant relationship between academic achievement and RCF parameters during the copying and memory recall phases indicates that attentional and working memory performance, as engaged during classes and lessons, influences academic outcomes and the educational trajectory of students.

In terms of weekly fish consumption frequency, we observed a significant correlation with the time taken to complete the RCF drawing in both the copy and memory recall phases. This may be attributed to the nutrients found in fish enhancing alertness in students who consume fish regularly. Specifically, fish are rich in iodine, which plays a crucial role in the development of the brain and nervous system in fetuses [28, 29].

Regarding weekly fruit consumption frequency, a significant correlation was observed with the scores achieved during the memory recall phase. This association may be attributed to the observation that students who consume more fruits exhibit improved working memory performance.

In terms of the weekly consumption frequency of milk and its derivatives, a significant relationship was found with the time taken to complete the FCR drawing during the copying phase. This effect can be linked to the presence of certain vitamins in milk (B1, B6, and B12), whose deficiency can impair students' attentional performance.

As for the weekly tea consumption frequency, no significant association was identified between this frequency and the attention and working memory parameters of the FCR test, contradicting findings from other studies [30-32]. Research focusing on the impact of black tea on attention performance [33, 34] has suggested preliminary evidence that tea may positively affect tasks requiring attention. It is important to highlight that these benefits are not solely due to caffeine. Instead, it is proposed that other components, such as flavonoids and theanine, play a role in enhancing attention-related performance.

Regarding the frequency of olive oil consumption, a nearly significant association ($p=0.065$) was noted with the time required to complete the RCF drawing during the memory phase. This suggests that olive oil may influence the memory capabilities of the subjects tested.

Regarding the weekly consumption frequency of Argan oil, a significant correlation was found with the duration of the FCR test in the copying phase, suggesting Argan oil's impact on attentional skills.

Both olive oil and Argan oil contain a substantial amount of lipids, considered beneficial fats that are necessary or even crucial for brain development and behavioral influence. Essential fats of the Omega-3 type are significantly lower in children experiencing attention deficit and hyperactivity disorder [34]. Our findings underscore the significance of dietary habits in the cognitive development of students and the enhancement of their attention and working memory performances, aiming for healthier school environments and improved academic achievements among adolescents.

Conclusion

There is an association between certain socio-economic factors and dietary habits and the parameters of the RCF test. There is a link between the habit of eating breakfast and the frequency of weekly fish consumption with attention and working memory performances. Similarly, There is a correlation between the weekly consumption frequency of milk, its derivatives, and Argan oil with attentional performance, while the weekly consumption frequency of fruits is associated with the working memory performances of students.

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Ethical Permissions: To ensure the safeguarding of confidential and private information of participants in the study, all necessary precautions consistent with the declaration of Helsinki [12] have been taken. Prior to the commencement of the research, the tutors were provided with comprehensive information regarding the goals and procedures and gave their informed consent. Permission to carry out the survey in public schools within the Tiznit province was granted by the Ministry of National Education's provincial delegation. One week prior to the visit of the school, the directors were informed.

Conflicts of Interests: The authors reported no conflicts of interests.

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