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Evaluation of Neurocognitive Performance and Its Association with Nutritional Status and Certain Determining Factors in Adolescents Attending School in the Khemisset Region (Northern Morocco)

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Abstract

The cognitive performance of adolescents is attracting growing interest in developmental psychology research. Various factors such as diet, education and socio-economic status have a direct or indirect impact on the cognitive health of pupils and, consequently, on their success at school. In this context, the aim of this research was to evaluate the neurocognitive performance (non-verbal intelligence) of adolescents attending school in Khemisset, northern Morocco. This cross-sectional study was carried out in public schools in Khemisset. It used a questionnaire to collect socio-demographic information, as well as Raven's standard progressive matrices, and a 24-hour dietary recall. This cross-sectional study was carried out in public schools in Khemisset. It used a questionnaire to collect socio-demographic information, as well as Raven's standard progressive matrices and a 24-hour dietary recall. In our sample of pupils (aged 12 to 19), the mean score obtained for non-verbal intelligence was 35±0.46, with a minimum of 13 and a maximum of 50. 61.4% of pupils had average intelligence and 37.7% had above-average intelligence. We also observed significant and positive correlations between non-verbal intelligence scores, age and school level. In addition, we found a relationship between Raven's categories and the dietary profile (BMI and DDS) of the adolescents surveyed. This study encourages all those involved in education, health and other sectors to take action to address the problem of poor cognitive performance among our pupils, and highlights the importance of promoting health factors that improve cognitive performance in adolescents.

Keywords: cognitive perfermence ; adolescents, dietary profile, factors socio-demographic , Morocco

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1. Introduction

Cognitive performance refers to the mental abilities that facilitate learning, reflection, problem-solving, and decision-making. They encompass skills such as concentration, memory, comprehension, logic, and problem-solving ability [1]. Cognitive performance can be affected by many factors, including age, health, education, and lifestyle [2-5]. Diet and lifestyle are factors that influence cognitive performance [6]. An analytical study based on articles published in 2019 shows that in a group of adolescents, it was observed that the consumption of fruit and vegetables is linked to better mental health. In particular, green vegetables, yellow vegetables, and fresh fruit appear to have positive effects on the mental health of adolescents [7]. Conversely, a diet low in nutrients, high in processed foods, and added sugars is associated with poorer cognitive performance [8].

The mechanisms by which diet affects cognitive performance are not fully understood, but it is possible that the nutrients found in healthy foods play a role in the development and maintenance of the brain. For example, fruits and vegetables are rich in antioxidants, which can protect brain cells from oxidative stress. Legumes and nuts are rich in plant-based protein, which is essential for the construction and repair of brain tissue. Whole grains are rich in fiber, which can help improve blood flow to the brain.

In Morocco, there are few studies that have sought to identify possible associations between the neurocognitive performance (non-verbal intelligence) of adolescents and sociodemographic and nutritional factors. The aim of the present research was to assess the neurocognitive performance of a sample of adolescents enrolled in the Khemisset region (northern Morocco) in order to determine the factors that may influence their intelligence.

2. Materials and Methods

This cross-sectional study was carried out in 2020 on a sample of 215 adolescent girls in the sidi allal el bahraoui region of morocco, and is based on a self-administered questionnaire that includes socio-demographic data such as the pupils' gender, age and school level. Cognitive performance is assessed using sixty standard Raven progressive matrices, first published in 1938, to measure non-verbal intelligence, with a time limit of 45 minutes to complete the test, which consists of five series (A to E) of 12 items, each with increasingly difficult problems in each series, requiring greater cognitive ability to analyse and solve them. In addition, the survey addresses the dietary profile of adolescents based on a 24-hour recall (the dietary survey is conducted in two samples separated by one month).

2.1. Ethical considerations

All necessary measures were taken to protect the privacy and confidentiality of the personal information of the research participants, in accordance with the 1964 Declaration of Helsinki. Authorisation to conduct the survey was obtained from the provincial delegation of the Ministry of National Education in the province of Khemisset. School headmasters were informed of this authorisation. In addition, informed consent was obtained from the tutors, who were fully informed that their responses would remain anonymous and confidential.

2.2. Statistical analysis

The data were entered and filtered in Excel before being transferred to SPSS. Quantitative variables were presented as means and standard deviations, while qualitative variables were expressed as frequencies and percentages. Joint analyses were performed, including a chi2 hypothesis test.

3. Results

3.1. Socio-demographic characteristics of participants

The table 1 presents the sociodemographics results of the surveyed children, of whom 61.86% are girls (sex ratio is not balanced). The distribution by school level shows that 61% are students of 3TC (Third Year College (3TC)) and 39% are students of 2SC (Second Year College (2SC)), and 73.02% of the children come from urban areas. However, the chi-square test shows a significant association between age and sex (chi2=4.18; p<0.041). The average age of the surveyed children is 14.75±0.94 years (min=13; max=19, Skewness=0.582). However, among children under 15 years old, 66.02% are girls compared to 50.84% who are over 15 years old. However, 39.04% of the children reported having a medical history. Table (1)

3.2. Anthropometric characteristics of participants

Based on the reference standards established by the International Obesity Task Force in 2007, according to sex and age, and using a WHO Anthro software macro for SPSS, the thresholds are based on the definitions of overweight (body mass index equal to or greater than 25 kg/m2) and obesity (body mass index equal to or greater than 30 kg/m2). Children were classified into 4 categories: underweight (Z Score < -2 standard deviations, SD), normal weight, overweight (> +1SD and 2SD), and obese (> +2SD) (T.J. Cole, 2000). Classification according to WHO BMI standards (Z score) and gender showed no significant difference (chi2 =1.95, p<0.38) (Table 2). Furthermore, no child had an underweight Z score < -2SD. However, 82.79% (n=178) were of normal weight, including 60.11% of girls and 39.89% of boys. On the other hand, 12.56% (n=27) of the children were overweight, over 74% of them girls. Finally, 4.65% were obese (6 girls and 4 boys).

3.3. Participants diversified diet

The average dietary diversity score of the schoolchildren surveyed was 5.67 ± 0.95. To identify the DDS (dietary diversity score) categories in the absence of a threshold defining the different classes of dietary diversity, we proposed converting the scores into standardised variables (Z score). Using the following classification:

- Category 1: Z score less than -1, low dietary diversity
- Category 2: Z score between -1 and +1, moderate dietary diversity
- Category 3: Z score greater than +1, high dietary diversity

The distribution of adolescents according to DDS category and Z score shows that 12% have a high DDS, 21% a low DDS and 67% a moderate DDS.

3.4. Assessment of non-verbal intelligence

a. Results of the Raven Standard Progressive Matrices (SPMR)

The figure 1 below shows the descriptive results of the Raven scores. The mean score was 35 ± 0.46, with a minimum of 13 and a maximum of 50, and a median of 35. The distribution was symmetrical (skewness=0.021 and kurtosis=0.015). The coefficient of variation was 19.22%, indicating homogeneity of 80.78%. (Figure 1). The table (3) below shows the results of the descriptive analysis for each series. The average scores for the series are also increasingly low. The breakdown of respondents' scores by intelligence category shows that 61.4% of students have average intelligence and 37.7% have above-average intelligence. However, none of the students had below-average or very low intelligence. Similarly, none of the students had very high intelligence. Table (3)

b. Distribution of Raven test scores by age

The table 4 presents the results of the chi-square test between age and Raven categories. The chi-square test shows a significant association between these two variables (chi2=7.04; p<0.008), with 67.30% of students under 15 years old having average intelligence and 32.7% having above-average intelligence. However, 47.37% of students over 15 years old have average intelligence and 52.63% have above-average intelligence (Table 4).

Table 1. Socio-demographic characteristics of adolescent children					
variables	modalities	Girls (n=133)	Boys (n=82)	Total	significance
Level of education	2SC	53	29	82	0,43 (p<0,51)
	3TC	80	53	133	
Living environment	Rural	38	20	58	0,45 (p<0,50)
	Urban	95	62	157	
Age	<15 years	103	53	156	4,18 (p<0,041)*
	> 15 years	30	29	59	
Medical history	No	114	73	187	0,49 (p<0,48)
	Yes	19	9	28	
* : Significant difference					

Table 2 Distribution of BMI categories by gender.				
Category	Girl (n=133)	Boys (n=82)	total	Chi2 (p-value)
Underweight Z-score < -2DS %.	0 (0%)	0 (0%)	0 (0%)	1,95 (p<0,38)
Normal weight	107 (60,11%)	71(39,89%)	178	
Overweight Z score > + 1DS and 2DS % %of total weight	20 (74,97%)	7 (25,03%)	27	
Obesity' Z score > + 2DS	6 (60%)	4 (40%)	10	
SD: standard deviation				

Table 3: Description of séries				
series	Mean ± SE	Median	minimum	maximum
A	10,02± 0,10	10	4	12
B	8,96± 0,14	9	3	12
C	7,22±0,15	7	1	12
D	6,43±0,17	6	1	12
E	2,33±0,11	2	0	8

Table 4. Chi-square test between age and intelligence qualities				
variable	modality	Score Raven		Total
		average intelligence	Above-average intelligence	
Age	<15 years	105	51	156
	> 15 years	27	32	59
Total		132	81	215

Table 5. Chi-square test between school level and intelligence qualities				
variable	modality	Score Raven		Total
		average intelligence	Above-average intelligence	
Level of education	2SC	59	22	81
	3TC	73	61	134
Total		132	81	215

Table 6. Chi-square test between IBM and intelligence qualities				
variable	modality	Raven Score		total
		average intelligence	Above-average intelligence	
BMI	Normal	104	73	177
	Overweight	19	9	28
	Obese	9	1	10
Total		132	81	215

Table7. Chi-square test between SDD and intelligence qualities				
variable	modality	Score Raven		TOTAL
		average intelligence	Above-average intelligence	
SDA	Low	12	13	25
	Medium	101	50	151
	Important	19	20	39
Total		132	81	215

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Table 8. Linear regression (dependent variable = Raven score)

Coefficients a						
Model		Non-standardised coefficients		Standardised coefficients	T	meaning
		B	Standard error	Beta		
1	(Constant)	25,135	4,562		5,509	,000***
	Drink	1,370	0,814	0,118	1,683	0,05*
	Sucrerie	1,329	0,956	0,098	1,391	0,166
	Dairy products	0,667	0,798	0,058	0,835	0,405
	Fruit & vegetables	-0,425	0,819	-0,036	-0,519	0,604
	fat	1,126	0,658	0,123	1,713	0,05*
	cereal	1,274	0,950	0,095	1,341	0,181
	meat	1,706	0,855	0,145	1,995	0,05*

a. Dependent variable : Total Raven , * : Significant difference

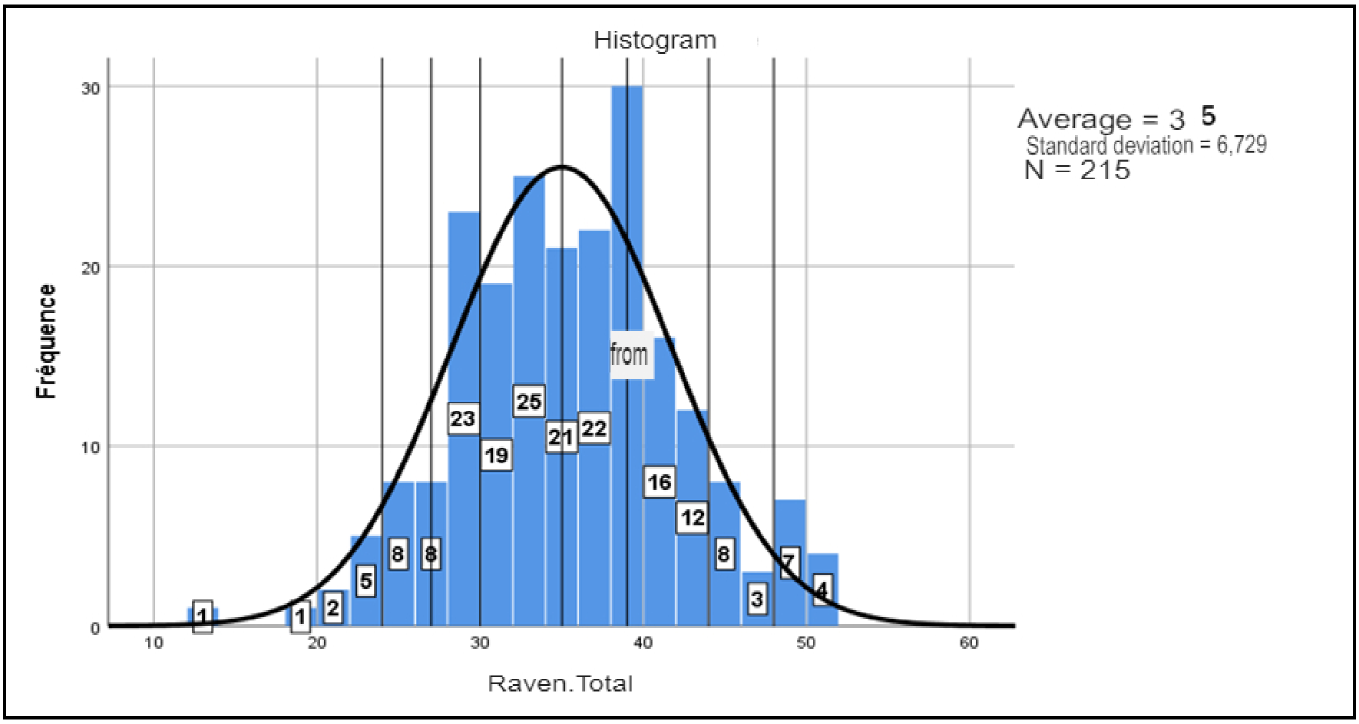

Figure 1: descriptive results of the Raven scores

c. *Distribution of Raven test scores by school level*

The table 5 shows the results of the chi-square test between school level and Raven's categories. The chi-square test shows a significant association between these two variables (chi2=6.55; p<0.01). 72.84% of the 2SC pupils had average intelligence and 27.16% had above-average intelligence. On the other hand, 55.30% of 3TC pupils had average intelligence and 44.7% above-average intelligence. (Table 5).

d. *Distribution of Raven test scores as a function of BMI*

The table 6 shows the results of the chi-squared test between BMI and the Raven categories. The chi-square test shows a significant relationship between these two variables (chi-square=4.76; p<0.032). 59.09% of students with a normal weight had average intelligence and 40.91% had above-average intelligence. Conversely, 70.37% of overweight pupils had average intelligence and 29.63% above average intelligence. Furthermore, 9 out of 10 obese pupils had average intelligence and only one pupil had above-average intelligence. (Table 6)**.**

Finally, the study revealed a significant difference between girls and boys: boys have an advantage in the Raven test, and girls perform well in school exams. The mechanisms behind this difference should be explored in future research.

e. Distribution of Raven's test scores as a function of SDD

The table 7 shows the results of the chi-squared test between SDD dietary diversity and Raven's categories. The chi-square test shows a significant association between these two variables (chi-square=5.39; p<0.05). 48% of students with low SDD had average intelligence and 52% had above-average intelligence. On the other hand, 66.89% of students with moderate SDD had average intelligence and 33.11% above-average intelligence. Finally, 51.35% of students with high SDD had average intelligence and 48.65% above-average intelligence. (Table 7). The table 8 below presents the results of the linear regression of intelligence as a function of dietary intake. This analysis shows that the variables that significantly explain the intelligence qualities of the pupils surveyed are the consumption of drinks (p<0.05), the consumption of fats such as olive oil and the consumption of meat as a source of protein. (Table 8)

4. Discussion

The aim of our study was to evaluate neurocognitive performance (non-verbal intelligence) in adolescents in northern Morocco. The results showed that the mean score on the Raven test, which measures non-verbal intelligence, was 35±0.46, with a minimum of 13, a maximum of 50 and a median of 35. The distribution of scores revealed that 61.4% of the students had average intelligence and 37.7% had above-average intelligence. No student was identified as having below-average or very low intelligence, and similarly no student demonstrated very high intelligence. Our results were similar to those obtained from 164 pupils aged 12 to 18 at a secondary school in Mrirt (Middle Atlas, Morocco), with a mean Raven test score of 34.29 and a standard deviation of 9.86. The highest score was 51, while the lowest was 5 [9].

Another study was carried out on 1,177 adolescents attending school, with mean ages ranging from 11.8 to 17.7 years, in the rural commune of Sidi El Kamel (north-west Morocco). The mean Raven score for all subjects was 29.80/60 (SD=12.92, median score 32), lower than the mean for our sample [10].

The results of our study show that the neurocognitive performance of the subjects tested is poorer than that of children from socio-economically developed countries, in particular in comparison with British (Ivanovic et al, 2000), Icelandic (Jorgen et al., 2003), Kuwaiti (Abdel-Khalek et al., 2008) and Slovenian (Boben., 2007) subjects [11-14]. In order to study the supposed association between non-verbal intelligence and certain socio-demographic factors, correlation tests were carried out. Our results show significant correlations between non-verbal intelligence, age and school level. Pupils under 15 studying at 2SC level have average intelligence, while most 3TC pupils over 15 have above-average intelligence.

Several studies have confirmed the link between intelligence and academic success (Mayes et al., 2009; Downey et al., 2014; Bouchefra et al., 2022) [15-17]. Indeed, students with high scores on the Raven test achieved better academic results. Similarly, an analysis of 240 studies by Roth et al. (2015) found correlations between intelligence and academic performance ranging from 0.30 to 0.70 [18]. L'analyse statistique à l'aide du test du chi-carré n'a pas révélé de différence statistiquement significative entre les moyennes des garçons et des filles. Ces résultats sont conformes à ceux obtenus par El Azmy (2013) à M'rirt, au Maroc [9], ainsi qu'aux résultats de recherches menées dans de nombreux pays occidentaux, tels que ceux d'Irwing (2004) and Syria [19-20]. All these results contradict the results of Bouchefra (2022) on schoolchildren in Taza (eastern Morocco), who showed a slight superiority of boys in Raven scores [17].

Our study revealed a significant correlation between Raven's categories and the dietary profile (BMI and SDA) of the adolescents surveyed. However, the majority of pupils with above-average intelligence had a normal weight (59.09%) and a high SDR (48.65%), whereas overweight pupils had average intelligence (70.37%) and an average SDR (66.89%). According to a study conducted by Akubuilo on children aged between 6 and 12 in 2020 in Nigeria, overweight and obesity are associated with a high IQ, even after controlling for factors such as gender and socio-economic status. The proportion of overweight and obese participants was higher in the high non-verbal intellegence group than in the normal non-verbal intellegence group. There is also a tendency to associate thinness with lower intelligence [21].

In 2013, Sandjaja et al. drew similar conclusions regarding the significant association between undernutrition and non-verbal intelligence in 6,746 school-age children (aged 6 to 12) from four South-East Asian countries: Indonesia, Malaysia, Thailand and Vietnam [22]. Bouchefra et al (2023) have also shown that the dietary diversity score (DDS) is an important predictor of school performance [23]. We can explain our results based on the conclusions of Agnieszka Wendołowicz (2018), which demonstrated that a balanced diet is essential for the proper functioning of the brain. Neurotransmitters, which are made from the foods we eat, play a crucial role. Agnieszka adds that a good diet is based on vegetables, fruits, whole grain products complemented by products providing quality proteins (dairy products, fish, lean meats) and quality fats (vegetable oils, fish fats), allowing us to avoid concentration, mood, and cognitive function problems such as intelligence [24].

5. Conclusion

Over the last century, data on non-verbal intelligence have been published in several countries, but rarely in Morocco. The aim of this article is to contribute to research on non-verbal intelligence by presenting results specific to Morocco. We conducted a study of school-age adolescents, aged 12 to 19, to determine their level of non-verbal intelligence. The results showed that Moroccan adolescents have a less developed non-verbal intelligence than pupils of the same age in socio-economically developed countries. This situation could have a negative impact on their school career, increasing failure and drop-out rates.

A correlation has been found between non-verbal intelligence and certain socio-demographic factors such as age and level of education. In addition, our study provides further evidence of the relationship between adolescents' diet and their cognitive abilities. These results underline the importance of parents and teachers helping adolescents to improve their cognitive performance by ensuring that they have a balanced diet, regular physical activity, sufficient sleep and a healthy environment.

In order to improve the quality of research in this field, it is recommended that this study be replicated and improved by using longitudinal surveys and more comprehensive assessment batteries.

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Conflict of interest

The authors declare that they have no conflicts of interest.

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