STUDYING THE RELATIONSHIP BETWEEN MALNUTRITION AND COGNITIVE PERFORMANCE FOR SCHOOL-AGE CHILDREN IN THE RURAL AREAS OF MOROCCO'S GHARB PLAIN

Abdelkader Chibani [1]* and Yousef Aboussaleh [2]

[1,2] Nutrition, Health and Environment, Department of Biology, Faculty of Sciences,
University Ibn Tofail, Kenitra, Morocco.
*Corresponding Author Email: aker.chibani@gmail.com

DOI: 10.5281/zenodo.13734739

Summary

Detecting and managing neurocognitive disorders in children early and promoting effective rehabilitation allows them to develop their neurocognitive abilities in a normal manner. This study aims to identify such neurocognitive issues in students attending public schools and living in the rural area of Morocco's Gharb plain. This study therefore evaluates the short-term memory and visual attention performance for a group of public school students. The psychometric tests include applying the digit span test in forward and backward order and the bells test for test on a sample of 235 students aged between 10 years 2 months and 14 years. The average age of the students was 11.99±0.95. According to the results of these tests, 63.4% and 16.6% of the students succeeded in the forward and backward digit span tests, respectively. The study also found a significant correlation between the students' nutritional status and their performance in digit memorization, suggesting that malnutrition negatively impacts working memory performance, because only 37.1% gave correct answers with forward order of memorization and 14.3% when the order was reversed. When evaluating visual attention, the average score was 29 bells out of 35, with 37.8% of students having attention difficulties. Nevertheless, the children's performance did not significantly differ based on their nutritional status.

Keywords: Neurocognitive, Memory, Visual Attention, Nutritional, Anthropometric.

1. INTRODUCTION

Malnutrition in all its forms is a major factor deteriorating human health around the world (Swinburn et al., 2019). Several studies have shown that the prevalence of child malnutrition is directly related to various interacting factors, such as family size, birth order, access to food and its consumption, social equity, parental education level, and health and hygiene practices (Ansuya et al., 2018; De & Chattopadhyay, 2019; Islam & Biswas, 2020; Chibani et al., 2020; Agarwal et al., 2021). Malnutrition in children has a number repercussions at the individual, family, and community levels, such as reduced resistance to diseases, diminished cognitive abilities leading to academic failure, poor health care, and reduced productivity at work (Ndamobissi, 2017). Various studies have also highlighted how children's cognitive development is affected by various factors, including chronic malnutrition (Grantham-McGregor et al., 1991; Georgiadis et al., 2016; Crookston et al., 2011). Malnutrition also has a negative impact on their working memory capacity (Agarwal, 1990) and level of attention (Lopez et al., 1993). By "working memory," we refer to a person's ability to temporarily maintain information at a highly accessible level and use it to perform complex tasks, such as following instructions, reading a text, or mentally solving an arithmetic problem (Monnier, 2008). In Baddeley's model, this memory comprises three elements (see Figure 1): the phonological loop, the visuospatial sketchpad, and the central executive. The phonological loop temporarily stores verbal data, while the visuospatial sketchpad stores temporary visual and spatial data. These two components are supervised by

ISSN 1462 2815

the central executive during the various cognitive operations (Deschamps & Moulinier, 2005).

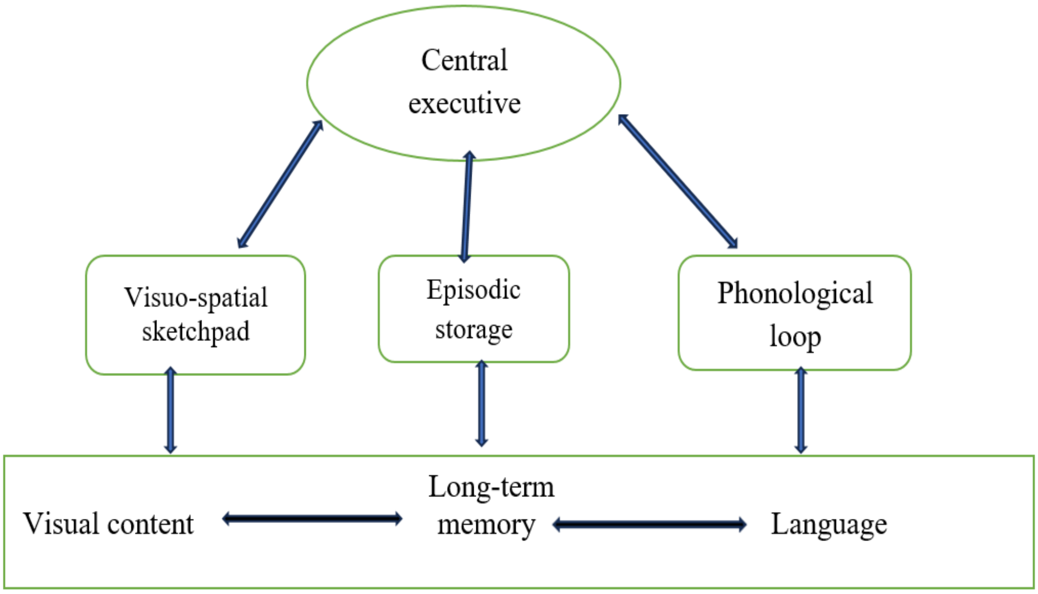

Figure 1: The components of working memory according to Baddely (2000)

The objective of this research is to investigate any potential correlation between malnutrition and working memory capacity (WM) in children attending schools in the rural Kenitra Province of Morocco.

2. MATERIALS AND METHODS

2.1 Study area

The commune of Kariat Ben Aouda in Kenitra Province has a rural character. It is located 90 km from the city of Kenitra on the road leading to the city of Ouazzane. According to the most recent population census, the commune has 11,087 inhabitants, 48.4% of whom are illiterate, with 61% being women and 36.5% being men. In addition, 65.26% of the population is inactive, with 18.2% of the total population being aged 6 to 14 years. In terms of basic infrastructure, 93.7% of households have access to mains electricity, but access to drinking water and sanitary wastewater disposal remains extremely limited (RGPH, 2014)

2.2 Inclusion and exclusion criteria

Public primary schools in the Kariat Ben Aouda rural commune were selected using a simple random sampling method. Judgment sampling was then used to recruit students in the 4th, 5th, and 6th grades of primary school. All were in good health with no signs of illness and/or ongoing medical treatment during the study, and their parents consented for them to be interviewed.

Students were excluded from the survey if they were absent at the time of the survey, reported being under medical treatment, withdrew from participation, or lacked parental consent to participate in the study. Students were selected by referring to the nominal list of male and female students at each selected school based on the pre-established inclusion criteria. The study was undertaken from the beginning of May to the end of June 2022 for a group of 235 students from the study population.

ISSN 1462 2815

2.3 Nutritional assessment

Anthropometric data, such as weight and height measurements, were collected in accordance with the standards established by the World Health Organization (WHO, 1995). Body weight was recorded at an accuracy of 0.1 kilogram using a digital scale, while height was measured at an accuracy of 0.1 cm using a height rod. The age of each participant was known precisely from dates of birth recorded and provided by the schools' administrative services. The three measured variables were combined to derive reference values in the form of the height-for-age (H/A) index and the body mass index for age (BMI/A) (Sbaibi et al., 2014). The Z-scores for these indexes were calculated based on the WHO 2007 growth references for the 5–19 years age group according to weight, height, sex, age, and date of measurement.

The tests used

The digit span test

This is a subtest of the WISC (Wechsler Intelligence Scale for Children) III verbal scale for assessing children's short-term verbal memory abilities. The digit span measures the maximum number of digits that a child can repeat in the order in which they were presented. When the child is asked to repeat the digits in the reverse order to which they were presented, it is called the backward digit span test. This allows working memory skills to be assessed (Wechsler, 1991; D'Amico & Guarnera, 2005; Deforge et al., 2006; Azzaoui et al., 2010).

Bells Test

The bells test was developed by Gauthier et al. (1989) to assess visual impairment in adults with brain damage. It is used in this study to assess the visual–attentional skills (BSEDS 5-6, 2003; ODEDYS, 2005) of the students through a target search test in the presence of distractors. In the test, the child is presented a sheet containing 112 drawings of objects (i.e., house, car, horse, saw, cloud, etc.), with 35 of these being bells. The child had to identify as many bells as possible on the test sheet within two minutes, after which the score (i.e., the number of crossed-out bells) was recorded.

RESULTS

The distribution of the means of the anthropometric indexes that were measured for all participants, according to their gender, is given in Table 1, as are the statistical characteristics of the anthropometric parameters, again according to gender. A t-test revealed no significant differences between genders for the variables of age, weight, height, and body mass index (BMI) for age.

Table 1: The statistical characteristics of the anthropometric parameters according to sex (N = 235). NS indicates that the p-value is not significant.

	Girls (N=128); 54.5%	Boys (N= 107); 45.5%	Total		
			N = 235	t-test	p-value
	Avg±σ	Avg±σ	Avg±σ		
Height (cm)	146.28±6.15	146.59±6.75	146,±6.42	-0.370	0.71 (NS)
Weight (kg)	37.69±3.89	37.61±3.59	37.66±3.75	0.15	0.87 (NS)
Age	11.93±0.89	12.05±1.01	11.99±0.94	-0.94	0.34 (NS)
BMI/A Zscore (kg/m2)	-0.56±1.41	-0.23±1.22	-0.40±1.34	-1.89	0.59 (NS)

The t-test showed no significant differences between the two sexes for the variables of age, weight, height, and BMI/A, nor did it for the scores achieved in the bells test.

Table 2: Students' performance in the digit span tests by gender

		Forward span		Backward span	
		Normal	Pathological	Normal	Pathological
Sex	Female	76 (59.4%)	52 (40.6%)	17 (13.3%)	111 (86.7%)
	Male	73 (68.2%)	34 (31.8%)	22 (20.6%)	85 (79.4%)
All		149 (63.4%)	86 (36.6%)	39 (16.6%)	196 (83.4%)
Meaning according to chi-square test		χ2 = 1.96 P= 0.16 (NS)		χ2 = 2.23 P= 0.13 (NS)	

Pearson's chi-square test revealed that the association between the categorical variables and front and back span performance, on the one hand, and gender on the other hand was not significant.

Table 3: Students' performance in digit span tests according to nutritional status.

		Forward span		Backward span	
		Normal	Pathological	Normal	Pathological
Nutritional status	Malnourished	13 (37.1%)	22 (62.9%)	5 (14.3%)	30 (85.7%)
	Normal	128 (67.7%)	61 (32.3%)	31 (16.4%)	158 (83.6%)
	Overweight	8 (72.7%)	3 (27.3%)	3 (27.3%)	8 (72.7%)
All		149 (63.4%)	86 (36.6%)	39 (16.6%)	196 (83.4%)
Meaning according to chi-square test		χ2 = 12.3 P= 0.002 (S)		χ2 =1.04 P= 0.59 (NS)	

Table 4: Results of the bell test according to gender.

		Bells test scores	
		Average	Standard deviation
	Female	29.23	2.643
	Male	29.52	3.136
All		29 ± 2.87 with a max. score of 35 bells and a min. of 19	
Student's t-test		-0.767, p = 0.44 (NS)	

Table 5: Students' results in the bells test according to their nutritional status

		Number of omissions	
		Normal	Pathological
Nutritional status	Malnourished	18 (12.3%)	17 (19.1%)
	Normal	119 (81.5%)	70 (78.7%)
	Overweight	9 (6.2%)	2 (2.2%)
All		146	89
Meaning according to chi-square test		χ2 = 3.571;	p= 0.168 (NS)

The results of the chi-square test are presented in Tables 3 and 5, and these show that there are no significant differences in the categorical variables and the performance in the reverse span and bells test based on the BMI/A index. In contrast, the study revealed a significant correlation between performance in the forward span test and the BMI index for age (p = 0.002).

DISCUSSION

The neurocognitive assessment revealed significant disparities in children's outcomes based on their nutritional status. Children with a better nutritional status generally scored higher in the test, while those who were malnourished scored lower. The results of the digit span memory tests revealed that 63.4% of the students obtained a normal score for the forward memorization order, but only 16.6% of the answers were correct for the reverse order, which is very low.

ISSN 1462 2815

In an urban environment, Aboussaleh et al. (2006) presented a much lower pass rate of 39% for children taking the forward order test, but the score with the reverse order was 22%, which is similar to what we observed. On the other hand, another study carried out in an urban area found that 100% of the participants passed the forward span test, with only 21.05% failing the reverse span test (Azzaoui et al., 2010). Yet another study carried out among students in urban schools found that 91.4% and 57.8% of students achieved normal scores for the front and reverse span tests, respectively (Talhaoui et al., 2017).

The chi-square test revealed a correlation between the categorical variables and performance in the place-to-place span, on the one hand, and the BMI-for-age index on the other hand ($p < 0.05$). The results of the bells test, which is used to assess a child's concentration and visual attention, revealed that the average score was 29 bells out of 35, with 62.12% of students passing this test. This study's result is similar to that of the previous study conducted in the same region, with it revealing a success rate of 61.29% for children living in rural areas (Azzaoui, 2010).

In addition, the average score observed for our sample is very close to the average of 29.86 recorded by the ODYDES 2005 study. Nevertheless, this study's average score is lower than the average score of 33.3 obtained by Gauthier et al. (1989) and those recorded by Rousseaux et al. (2001) and El Azmy et al. (2014), who obtained average scores of 32.94 and 31.79, respectively. Nevertheless, these differences in recorded values may well be explained by various factors, such as varying socioeconomic, nutritional, and/or environmental situations.

Indeed, the neurocognitive outcomes of students differ significantly depending on their place of residence, with children living in rural or peri-urban areas generally achieving lower scores (Azzaoui et al., 2010). Moreover, various studies have highlighted the linkage between socioeconomic status and cognitive performance, with cross-cultural research showing that socioeconomic criteria are closely related to cognitive development from early to middle childhood (Bradley et al., 1996).

Moreover, several researchers have also highlighted the detrimental impact of malnutrition in early childhood (Agarwal et al., 1995) in terms of protein and calorie deficiency (Nwuga, 1977; Brown & Politt, 1996) and iron-deficiency anemia (Sungthong et al., 2002; Walker, 1998; Hurtado et al., 1999; Elhioui, 2008), on children's intellectual skills. Several studies have also shown that certain pollutants—such as lead, mercury, and certain pesticides— also have an impact on neurocognitive function in children (Muñoz et al., 1993; Grandjean et al., 1997; Lizardi et al., 2008).

CONCLUSION

This study's results have revealed a level of neurocognitive disorder among the students in the study area. It is hoped this will stimulate further efforts from scientific researchers and other stakeholders with an interest in ensuring the health of school-age children. From the perspective of gender, no significant differences were identified between girls and boys in the results of the psychometric tests. Nevertheless, all stakeholders in the fields of health, education, scientific research, and so on are called upon to investigate and identify the source of this neurocognitive deficit, so appropriate measures can be taken to resolve the problem.

ISSN 1462 2815

References

1) Aboussaleh, Y., Ahami, A. O. T., Bonthoux, F., Marendaz, C., Valdois, S., & Rusinek, S. (2006). "Cognitive Performance of Anemic Children Aged 6 to 11 Years in Urban Areas of North-West Morocco." Journal of Behavioral and Cognitive Therapies, 16(2), 49-54.
2) Agarwal, K. N. 1990. Effects of Malnutrition and iron Deficiency on Mental Functions and Study of Possible Mechanisms in Animal Model. In Proc. Indian Natn. Sci. Acad. 856(1), 42-50.
3) Agarwal K.N., Agarwal D.K., Upadhyay S.K., 1995, Impact of chronic undernutrition on higher mental functions in Indian boys aged 10–12 years. Acta Pædiatrica, 84(12), 1357-1361.
4) Agarwal, A. K., Sarswat, S., Mahore, R., Saraswat, S., Kuity, P., & Tripathi, A. (2021). Malnutrition prevailing trend study among under five children of urban slum area of Gwalior city Madhya Pradesh. International Journal of Community Medicine and Public Health, 8(2), 623.
5) Ansuya et al., 2018; De & Chattopadhyay, 2019; Islam, & Biswas, 2020; Chibani et al., 2020; Agarwal et al., 2021).
6) Azzaoui, F. Z., Ahami, A. O. T., & Khadmaoui, A. (2010). "Study of the Impact of the Surrounding Environment on the Cognitive Functions of Moroccan Children from the Gharb Region." Antropo, 21, 9-25.
7) Baddeley, A. D. (2000). The episodic buffer: A new component of working memory? Trends in Cognitive Sciences, 4(11), 417–423. https://doi.org/10.1016/S1364-6613(00)01538-2
8) Bradley R.H., Corwyn R.F. et Whiteside-Mansell L., 1996, Life at home: same time, different places. Early Dev Parent, 5, 251-69
9) Brown JL. et Pollitt E., 1996, Malnutrition, poverty and intellectual development. Sci Am., 274(2), 38-43.
10) BSEDS, Health Assessment: Evaluation of Development for School Entry Age 5 to 6 Years, 2003, Version 3. Pierre Mendès-France University.
11) Chibani, A., Ahami, A., & Azzaoui, F. Z. (2020). Assessment of Nutritional Status of Students in the Public Schools in Rural Area in the Province of Kenitra.
12) Crookston B.T, Dearden K.A et al. (2011), « Impact of early and concurrent stunting on cognition », Matern Child Nutr, Vol. n° 7, pp. 397-409
13) D'Amico A. et Guarnera, M., 2005, exploring working memory in children with low arithmetical achievement. Learning and Individual Differences, 15(3), 189-202
14) Deforge H., Andre M., Hascoët JM., Toniolo AM., Demange V., Fresson J., 2006, Développement cognitif et performances attentionnelles de l'ancien prématuré «normal» à l'âge scolaire. Archives de pédiatrie, 13(9), 1195-1201.
15) Deschamps, R., & Moulignier, A. (2005). "Memory and Its Disorders." EMC - Neurology, 2(4), 505-525.
16) De, P., & Chattopadhyay, N. (2019). Effects of malnutrition on child development: Evidence from a backward district of India. Clinical Epidemiology and Global Health, 7(3), 439-445.
17) El Azmy, J., Ahami, A. O., Badda, B., Aboussaleh, Y., El Hessni, A., & Rusinek, S. (2014). Screening for attention deficit disorder (unilatéral spatial neglect) in a sample of junior high school students of M'rirt (Middle Atlas-Morocco)]. International Journal of Innovation and Applied Studies, 9(2), 937.
18) Elhioui M., Ahami AOT., Aboussaleh Y., Rusinek S., Dik K., Soualem A., Azzaoui FZ., Loutfi H., Elqaj M., 2008, Risk factors of anaemia among rural school children in Kenitra, Morocco. East Afr J Public Health, 5(2), 62-6.
19) Gauthier L., Dehaut F. et Joanette Y., 1989, The bells test: a quantitative and qualitative test for visual neglect. Int J Clin Neuropsychol, 11, 49-54.
20) Georgiadis A, Benny L. et al. (2016), « Growth trajectories from conception through middle childhood and cognitive achievement at age 8 years: Evidence from four low-and middle income countries », SSM –Population Health, Vol. n° 2, pp. 43-54.
21) Grandjean P., Weihe P., White R.F., Debes F., Araki S., Yokoyama K., Murata K., Sørensen N., Dahl R., Jørgensen P.J., 1997, Cognitive deficit in 7-year-old children with prenatal exposure to methylmercury. Neurotoxicol Teratol., 19(6), 417-28

22) Grantham-McGregor, S. M., Powell, C. A., Walker, S. P., & Hines, J. H. (1991). "Nutritional Supplementation, Psychosocial Stimulation, and Mental Development of Children with Growth Retardation: The Jamaica Study." The Lancet, Vol. 338, pp. 1-5

23) Hurtado E.K., Claussen A.H. et Scott K.G., 1999, Early childhood anemia and mild or moderate retardation. Am J Clin Nutr., 69, 115-9

24) Islam, M. S., & Biswas, T. (2020). Prevalence and correlates of the composite index of anthropometric failure among children under 5 years old in Bangladesh. Maternal & child nutrition, 16(2), e12930.

25) Lizardi P.S., O'Rourke M.K. and Morris R.J., 2008, The Effects of Organophosphate Pesticide Exposure on Hispanic Children's Cognitive and Behavioral Functioning. J Pediatr Psychol., 33(1):91-101.

26) Lopez I, DE Andraca I, Perales CG, Heresi E, Castillo M. et coll. 1993. Breakfast omission and cognitive performance of normal, wasted and stunted schoolchildren. European Journal of Clinical Nutrition; 47, 533-542

27) Monnier, C. (2008). "Working Memory: Theoretical Approach and Development." French Psychology, 53(3), 279-280.

28) Morocco, R. (2014). General Census of Population and Housing 2014. Retrieved from https://rgph2014.hcp.ma/downloads/Publications-RGPH-2014_t18649.html.

29) Muñoz H., Romiew I., Palazuelos E., Mancilla-Sanchez T., Meneses-Gonzalez F., HernandezAvila M., 1993, Blood lead level and neurobehavioral development among children living in Mexico City. Arch Environ Health., 48(3), 132-9.

30) Ndamobissi, R. (2017). The Sociodemographic and Political Challenges of Child Malnutrition in Sahel and Horn of Africa Countries (Doctoral dissertation, University of Bourgogne Franche

31) Nwuga VC., 1977, Effect of severe kwashiorkor on intellectual development among Nigerian children. Am J Clin Nutr., 30(9), 1423-30.

32) ODEDYS, Dyslexia Screening Tool, Version 2, 2005. Laboratory of Psychology and Neurocognition, Pierre Mendès-France University.

33) Rousseaux M., J.M. Beis, P. Pradat-Diehl, Y. Martin, P. Bartolomeo, T. Bernati, S. Chokron, M. Leclercq, A. Louis-Dreyfus, F. Marchal, P. Perennou, C. Prairial, G. Rode, C. Samuel, E. Sieroff, L. Wiart, P. Azouvi. (2001). A battery for assessing spatial neglect: norms and effects of age, educational level, sex, hand, and laterality. Rev Neurol (Paris); 157: 11, 1385

34) Sbaibi, R., Aboussaleh, Y., Achouri, I., Ahami, A. O. T., & Ateillah, K. (2014). "Exploration of the Links between Stature-Weight Status and Certain Socio-Economic Factors among Middle School Students in the Rural Municipality of Sidi El Kamel (North-West Morocco)." Antropo, 31, 9-16.

35) Sungthong R., Mo-Suwan L., Chongsuvivatwong V., Geater A.F., 2002, once weekly is superior to daily iron supplementation on height gain but not on hematological improvement among schoolchildren in Thailand. J Nutr., 132(3), 418-22

36) Swinburn, B. A., Kraak, V. I., Allender, S., Atkins, V. J., Baker, P. I., Bogard, J. R., ... & Dietz, W. H. (2019). The global syndemic of obesity, undernutrition, and climate change: the Lancet Commission report. The lancet, 393(10173), 791-846.

37) Talhaoui, A., Aboussaleh, Y., Ahami, A. O. T., Sbaibi, R., & Zeghari, L. (2017). "Study of the Relationship between Malnutrition and Working Memory in School-Aged Children in the City of Kenitra, North-West Morocco." Antropo, 38, 67-73.

38) Walker AR., 1998, The remedying of iron deficiency: What priority should it have?. Br. J. Nut, 79, 227-35.

39) Wechsler D. Echelle d'Intelligence de Wechsler pour Enfants WISC-III, 1991. 3ème Ed. ecpa, Les editions du Centre de Psychologie Appliqué.Paris, 294p

40) WHO (1995). "Use and Interpretation of Anthropometry." Technical Report Series 854, 498 pp.http://www.who.int/childgrowth/publications/physical_status_fr/en/index.html.

41) WHO (World Health Organization), 2007. "Growth Reference Data for 5-19 Years." Retrieved from http://www.who.int/growthref/en/.