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Dietary Pattern of Children with Attention Deficit Hyperactivity Disorder in Ismailia City

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Abstract

Background: **The dramatic increase in the diagnosis of Attention Deficit Hyperactive Disorder among children has become a public health concern since school-age children –which are in a critical period of rapid development and growth- are markedly vulnerable to malnutrition and unhealthy diet that negatively affects their brain development.** ***Aim:*** **To identify and assess the association between dietary patterns and ADHD in children.** ***Subjects and Methods:*** **A case-control study was carried out in child psychiatry clinics in Suez Canal University and Suez Canal Authority hospitals in Ismailia city. A total of 433 children 6 to 10 years old: 146 ADHD cases, 141 control siblings, and 146 community control children were studied. A semi-quantitative food frequency questionnaire was used to collect data. Principal component analysis was used to extract dietary patterns from the 116 investigated food items. Logistic regression was used to estimate the Odds Ratios of ADHD across tertiles of dietary patterns.** ***Results:*** **Three dietary patterns were extracted: "unhealthy diet", "unsaturated-fat diet" and "traditional diet". All the cases were in the 3rd tertile of the "unhealthy diet" pattern, while the "unsaturated-fat diet" pattern was more consumed by controls. The lowest consumption tertile of this pattern was associated with an OR 4.30 (1.16-15.85) for ADHD. Increasing the intake of the "traditional diet" pattern, after energy adjustment, was associated with reduced OR for ADHD (p=0.001).** ***Conclusion:*** **There is an association between consumption of "unhealthy diet" dietary pattern and ADHD. Also, the "Traditional diet" dietary pattern is protective against ADHD.**

Keywords: Food, consumption, mental

Introduction

Attention Deficit Hyperactive Disorder (ADHD) has become a growing public health problem. The dramatic increase in its incidence made it an epidemic. The disorder is one of the most commonly diagnosed childhood mental illnesses that continue throughout adulthood. It causes functional impairment in academic, family, and social settings and contributes significantly to the global burden of disease[(1)]. The global prevalence of ADHD among children has increased from 7.2% in 2015 to 12% in 2016[(2,3)]. Additionally, the reported prevalence is similar between Arab populations and other cultures[(4)]. ADHD's prevalence in the United States, Korea, Jordan, and Egypt is 9.4%, 8.5%, 9.5%, and 5-12% respectively[(4-8)]. In Egypt, the reported

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prevalence of ADHD is variable. The highest reported rate was in El- Fayoum city where the prevalence was 20.5%[9]. In the Al-Qalyubia governorate, the prevalence was about 16.2%, whereas a 7.1% prevalence rate was recently reported in Ismailia city[10,11]. The impact of ADHD during childhood is highly variable. This includes impaired school performance; about half of children with ADHD have a learning disorder, impaired socialization, and suffer from psychiatric manifestations such as conduct disorders and bipolar manifestations[12]. Since ADHD is a lifespan disorder and continues through adulthood, it was found that adults suffering from ADHD have an increased risk of substance abuse and antisocial behavior when compared to adults without ADHD[13]. Recent studies have pointed out an association between specific diet and food patterns in children with ADHD where a study by *Azadbakht and Esmaillzadeh* reported four major dietary patterns - named as healthy, western, sweet, and fast food – from which only two major dietary patterns – "sweet" and "fast food" – were found to be significantly associated with ADHD in children[14]. "Traditional-healthy dietary pattern"; includes increased consumption of grains, bonefish, and decreased intakes of beverages and fast food, to be protective and is associated with reduced risk of developing ADHD[15]. School children are a vulnerable group of the community due to their rapid affection by malnutrition and unhealthy diet that generally affects their body's development, specifically, their brain development during that critical period of rapid development, which makes them susceptible to multiple morbidities that would continue with them throughout their lives such as developing ADHD[16]. To the best of our knowledge, there is a lack of studies investigating the association between dietary patterns and ADHD among Egyptian children. As a result of the above-mentioned controversies and concerns and given that suggesting a dietary pattern possibly associated with ADHD would provide an opportunity for interventional research to act and decrease the childhood morbidity resulting from ADHD as well as improve their quality of life. This study aimed at assessing the dietary consumption pattern among children with ADHD in Ismailia City.

Subjects and Methods

Study setting and Study population
The current study was a matched case-control study, carried out in child psychiatry clinics in Suez Canal University and Suez Canal Authority hospitals in Ismailia city on 433 children ranging from 3 to 13 years of age that were divided into 3 groups as follows: 146 ADHD cases, 141 control siblings, and 146 community control children were studied.

Cases: Children (6-10 years old) newly diagnosed with ADHD by psychiatrists based on the ADHD 10th revision of the International Statistical Classification of Diseases and Related Health Problems (ICD-10 codes F90, 208-210), and having a lifetime medical history that fulfilled the Diagnostic and Statistical Manual of Mental Disorders, 4th Edition., revised (DSM-IV-R) criteria. The long-form of Conner's Rating Scale was used to confirm the diagnosis.

Controls: Involved two groups: I. Control I (Community) group was recruited from children attending the study settings. II. Control II (Siblings) group: was recruited from the siblings of the cases. For both control groups, testing using the long form of Conner's Rating Scale was carried out to exclude a history of ADHD. They were sex- and age- (6-45-month difference)

matched. Children were excluded from being recruited in the study sample if they had severe chronic diseases that interfere with dietary intake such as Diabetes Mellitus, cardiovascular disease, hematological disorders, food allergies, malabsorption syndromes, hepatic disorders, cancer, and chronic renal diseases. A history of any related mental disorder such as anxiety, depression, and learning disabilities. Certain medications, for at least 3 months, can affect body weight such as anti-histaminic, beta-blockers, antipsychotics, and hormonal therapy[17].

Study design

This was a matched case-control study. The sample size was calculated based on the following: 0.2 probability of sweet pattern among controls[18], Odds ratio of 2.2 between the case group and control group (I)[15], Odds ratio between the case group and control group (II), calculated based on an effect size 0.4, which gave odds ratio 2.06[18]. The smallest odds ratio of the two groups was used. Using Epi Info 6.04 software[19], at a 95% level of confidence, and 80% study power, a sample size of 133 per group was needed. After adding around 10% of the calculated sample size to compensate for the non-response rate, the required sample size was 145 per group. However, 146 cases were recruited, among which 5 were single children. Therefore, the control (II) group had only 141 children (siblings) while the control (I) group consisted of 146 children. Eventually, a total of 433 children were recruited.

Data Collection

An interview questionnaire, a semi-quantitative food frequency questionnaire, portion sizes atlas, and long-form Conner's Scale and anthropometric measurements were used for data collection. The interview questionnaire consisted of 3 main parts: a semi-structured interview questionnaire, a semi-quantitative food frequency questionnaire, and an anthropometric measurements sheet. The questionnaire used both closed and open-ended questions and it was developed by the researcher based on a literature review[20-23] and proposed study variables.

Results

The socio-demographic characteristics varied among the three studied groups as demonstrated in Table 1. The mean age was significantly lower in control group II (siblings) compared with the ADHD and control I group. Regarding gender, males represented the majority in the 3 groups, with no statistically significant differences among the three groups. As regards the birth order, 63% of the cases were first-borns, compared to 39% of the control I, and 23.4% of the sibling's control. These differences were statistically significant. Most of the surveyed children live in nuclear families with no statistically significant differences among groups as illustrated in Table 2. Concerning parents' education, significantly more fathers and mothers were having university education in the control I group ($p<0.001$). This group also had significantly fewer fathers who were unemployed or had professional jobs, and fewer housewife mothers ($p<0.001$). Most fathers among the three groups did not smoke indoors, while 24% of the fathers in the ADHD group usually or always smoked indoors. Moreover, the difference in the overall observed pattern of indoor paternal smoking was statistically significant across each pair of groups. Furthermore, all the prenatal complications

were significantly abundant among the mothers of the cases. The statistical significance was detected between the ADHD group and the control I group regarding all of the prenatal complications, while only gestational diabetes and prenatal infections in the 1st trimester were significant between the ADHD and siblings' groups.

Table 1: Comparison of Children's characteristics in the three studied groups

Characteristic	ADHD (*n=146*)	Control (I) (Community) (*n=146*)	Control (II) (Siblings) (*n=141*)	Test (*p-value*)
	n (%)	n (%)	n (%)	
Matched Factors				
Gender:				
Male	89 (61.0)	89 (61.0)	89 (63.1)	0.18[a] (0.910)
Female	57 (39.0)	57 (39.0)	52 (36.9)	
Age (years):				
Range	6 – 10	6 - 10	3 – 13	28.21[b] (**<0.001***)
Mean (±SD)	7.71 (±1.48)	7.78 (1.46)	6.72 (±2.58)	
Median	8	8	6	
Unmatched Factors				
Birth order:				
First	92 (63.0)	57 (39.0)	33 (23.4)	57.03 [a] (**<0.001***)[1]
Middle	36 (24.7)	75 (51.4)	53 (37.6)	21.88 [a] (**<0.001***)[2]
Youngest	13 (8.9)	14 (9.6)	55 (39.0)	34.46 [a] (**<0.001***)[3]
Residence:				
Urban	91 (62.3)	100 (68.5)	90 (63.8)	0.19 [a] (0.890)[1]
Rural	55 (37.7)	46 (31.5)	51 (36.2)	1.22 [a] (0.268)[2] 0.92[a] (0.337)[3]

*****Statistically significant p-values are indicated in bold*

[a] Chi square test, [b] Kruskal-Wallis Test

[1] p-value from comparing between ADHD group and Control II (siblings) group

[2] p-value from comparing between ADHD group and Control I (community) group

[3] p-value from comparing between Control I (community) and Control II (siblings) group

Based on the obtained anthropometric measurements, the mean BMI percentiles were statistically significantly higher in the ADHD group in comparison with each of the control groups (Table 3). It is also observed that none of the children in the study was underweight. On the other hand, only 53.4% of the cases had normal weight in contrast with 88.4% and 94.3% in control I and control II groups, respectively. The differences were statistically significant. After calculating the daily intakes of each of the 116 food items for each child, 15 food groups were generated; the "low-fat dairy" group was omitted because none of the recruited children consumed it as well as 4 food items which are salted fish, salmon, dried figs, and diet soda drinks. Furthermore, the canned fruit juice item was omitted from further analysis because all the children recruited reported consuming it. PCA was performed and generated 3 dietary patterns that had Eigen values ≥1 and explained 57.7% of the

total variance. Varimax rotation was carried out and the final components containing factor loadings of absolute values >0.3 (Table 5). Each pattern was labeled according to the food groups with the highest absolute loadings. The 1st dietary pattern was named "unhealthy diet" and was characterized by increased intakes of sugar-sweetened beverages, unhealthy snacks, French fries, and additives.

Table 2: Comparison of the parents and family characteristics in the three studied groups

Characteristic	ADHD (*n=146*)	Control (I) (Community) (*n=146*)	Control (II) (Siblings) (*n=141*)	Test (*p-value*)
	n (%)	**n (%)**	**n (%)**	
Family type:				
Nuclear family	127 (87.0)	122 (83.6)	124 (87.9)	0.63[a] (0.969)[1]
Single-parent family	11 (7.5)	13 (8.9)	10 (7.1)	0.74[a] (0.690)[2]
Step/blend family	8 (5.5)	11 (7.5)	8 (5.5)	1.21[a] (0.546)[3]
Father Education:				
Illiterate	10 (6.8)	0 (0)	10 (7.1)	20.50[a] (<**0.001***)[2]
Reads and writes	3 (2.1)	1 (0.7)	3 (2.1)	
Basic	25 (17.1)	21 (14.4)	24 (17.0)	
High school	49 (33.6)	34 (23.3)	46 (32.6)	
University or higher	59 (40.0)	90 (61.6)	58 (41.1)	
Father Occupation:				
Unemployed	6 (4.1)	0 (0)	5 (3.5)	46.01[a] (**<0.001***)[2]
Unskilled manual work	18 (12.3)	57 (39.0)	18 (12.8)	
Skilled manual work	54 (37.0)	63 (43.2)	52 (36.9)	
Clerks, technicians, or sales	28 (19.2)	9 (6.2)	27 (19.1)	
Professional	40 (27.4)	17 (11.6)	39 (27.7)	
Mother Education:				
Illiterate	7 (4.8)	0 (0)	7 (5.0)	21.28[a] (**<0.001***)[2]
Reads and writes	5 (3.4)	5 (3.4)	5 (3.5)	
Basic	3 (2.1)	16 (11.0)	3 (2.1)	
High school	69 (47.3)	48 (32.9)	65 (46.1)	
University and higher	62 (42.5)	77 (52.7)	61 (43.3)	
Mother Occupation:				
Housewife	85 (58.2)	29 (19.9)	83 (58.9)	57.35[a] (**<0.001***)[2]
Unskilled manual work	13 (8.9)	40 (27.4)	12 (8.5)	
Skilled manual work	26 (17.8)	62 (42.5)	24 (17.0)	
Clerks, technicians, or sales	5 (3.4)	3 (2.1)	5 (3.5)	
Professional	17 (11.6)	12 (8.2)	17 (12.1)	

** Statistically Significant p values are indicated in bold.*

[a] Chi-square, [b] Fisher's exact test

[1] p-value from comparing between ADHD group and Control II (siblings) group

[2] p-value from comparing between ADHD group and Control I (community) group

[3] p-value from comparing Control I (community) and Control II (siblings) group

Table 3. Comparison of BMI percentiles among the studied groups				
BMI Percentiles	ADHD (*n=146*)	Control (I) (Community) (*n=146*)	Control (II) (Siblings) (*n=141*)	Test (*p-value*)
	n (%)	**n (%)**	**n (%)**	
Normal weight (5th - <85th)	78 (53.4)	129 (88.4)	133 (94.3)	61.65 [a] **(<0.001*)**[1]
Overweight (85th - <95th)	53 (36.3)	13 (8.9)	6 (4.3)	43.17 [a] **(<0.001*)**[2]
Obese (≥95th)	15 (10.3)	4 (2.7)	2 (1.4)	(0.181) [3] [c]
Range of percentiles	10 – 98	5 – 99	6 – 95	56.62[b] **(<0.001*)**
Mean (± SD)	70.16 (±24.63)	51.69 (±23.09)	49.70 (±18.26)	-6.87 [d] **(<0.001*)**[1]
Median	82	50	50	-6.06 [d] **(<0.001*)**[2] -0.82 [d] (0.407) [3]

* *Statistically Significant p values are indicated in bold.*
[a] *Chi-square test,* [b] *Kruskal-Wallis Test,* [c] *Fisher's exact test,* [d] *Mann-Whitney U test.*
[1] *p-value from comparing between ADHD group and Control II (siblings) group*
[2] *p-value from comparing between ADHD group and Control I (community) group*
[3] *p-value from comparing Control I (community) and Control II (siblings) group*

Table 4. Factor loadings for the major dietary patterns derived from principal component analysis			
Food Group	Dietary patterns*		
	Unhealthy Diet	Unsaturated-fat rich Diet	Traditional Diet
Sugar-sweetened beverages	**0.752**		
Unhealthy snacks	**0.671**		
French Fries	**0.671**		
Additives	**0.611**		
Nuts		**0.860**	
Fish		**0.738**	
Vegetables			**0.755**
Meats			**0.745**

* *Factor loadings written in bold represent the food items that contribute the most in each pattern.*
* *Factor loadings with absolute values > 0.3 are listed in the table.*

The 2nd dietary pattern was named "unsaturated-fat rich diet" and was composed of an increased intake of nuts and fish. The 3rd dietary pattern was named "Traditional diet" and consisted of increased intake of both vegetables and meats. Table 6 demonstrates a comparison between the mean factor scores of each dietary pattern among the ADHD group and each of the control groups separately. Compared with control I, the ADHD group had higher means in both unhealthy and traditional diets, and these differences were statistically significant. Meanwhile, Control I scored higher in the unsaturated-fat-rich diet, and this difference was statistically significant. On the other hand, the control II group scored higher in the unsaturated-fat-rich diet but scored lower in the unhealthy and traditional diets when compared to the ADHD group. The differences were statistically significant in the unhealthy and the unsaturated-fat-rich diet only. In Table 7, binary logistic regression

analysis was carried out between the ADHD group and the Control I group to test if dietary patterns significantly predicted ADHD occurrence. Regarding the first dietary pattern, the scores of the individuals in the ADHD group were all grouped in the third tertile only, therefore the unhealthy dietary pattern was not eligible for regression analysis.

Table 5. Comparisons of factor scores of dietary patterns in ADHD and control groups

Dietary Pattern	ADHD	Control 1 (Community)	Test [a] *(p-value)*	ADHD	Control 2 (Siblings)	Test [a] *(p-value)*
	Mean (±SD)	Mean (±SD)		Mean (±SD)	Mean (±SD)	
I	0.98 (±1.07)	-0.77 (±0.22)	-14.36 **(<0.001*)**	0.98 (±1.07)	-0.21 (±0.39)	-11.15 **(<0.001*)**
II	-0.37 (±0.55)	-0.32 (±0.30)	-2.81 **(0.005*)**	-0.37 (±0.55)	0.72 (±1.36)	-7.88 **(<0.001*)**
III	0.18 (±1.30)	-0.24 (±0.48)	-2.17 **(0.030*)**	0.18 (±1.30)	0.05 (±0.99)	-0.88 (0.378)

** Statistically Significant p values are indicated in bold.*

[a] Mann-Whitney U test.

Table 6. Comparison of odds ratio by tertiles of dietary pattern scores between ADHD group and Control I (community) group

Dietary Pattern		n (%) Control/Case	Crude Model	OR (95% CI) Multivariate Model 1[1]	OR (95% CI) Multivariate Model 2[2]
Unsaturated-fat rich diet	T1	48 (32.9) / 75 (51.4)	1.66 (0.96 – 2.86)	1.97 (0.92 – 4.20)	4.30 (1.16 – 15.85)
	T 2	49 (33.6) / 25 (17.21)	0.54 (0.29 – 1.01)	0.53 (0.21 – 1.29)	0.14 (0.01 – 1.24)
	T3	49 (33.6) / 54 (37.0)	1	1	1
	P trend		**(0.042*)**	(0.066)	**(0.008*)**
Traditional Diet	T1	48 (32.9) / 54 (37.0)	1	1	1
	T 2	49 (33.6) / 20 (13.7)	0.36 (0.19 – 0.69)	0.67 (0.28 – 1.62))	0.16 (0.03 – 0.83)
	T3	49 (33.6) / 72 (49.3)	1.30 (0.76 – 2.22)	2.01 (0.95 – 4.24)	0.05 (0.01 – 0.30)
	P trend		(0.254)	(0.050)	**(0.001*)**

** Statistically Significant p values are indicated in bold.*

[1] Adjusted for indoor paternal smoking before childbirth, prenatal folic acid supplementation, prenatal acetaminophen administration, category of birth weight, and daily water consumption.

[2] Model 1 + additional adjustment for total energy intake.

Concerning the unsaturated-fat-rich diet, in all models, the higher the tertile, the fewer ORs detected. However, this was statistically insignificant except for model 2, where children in the lowest tertile had 4 times more risk for developing ADHD when compared with those in higher tertiles and this was statistically significant. Regarding the traditional diet, in the crude model and model 1, consuming more of the traditional diet increased the risk of ADHD occurrence by 1.3 and 2 times. However, this association was not statistically significant. Meanwhile, upon adjusting for energy intake in model 2, the increased consumption of this pattern became significantly protective against ADHD, where individuals categorized in the third tertile

were less likely by 95% to develop ADHD when compared with individuals lying in the first tertile (p for trend = 0.009). In Table 8, binary logistic regression analysis was carried out between the ADHD group and the Control II group to test if dietary patterns significantly predicted ADHD occurrence. Regarding the unsaturated-fat-rich diet, in models 1 and 2 the higher the tertile, the fewer ORs detected. However, this was statistically insignificant. Regarding the traditional diet, in the crude model and model 1, higher tertiles demonstrated an increased risk of ADHD occurrence; OR (95%CI): 1.08 (0.65-1.80) and OR (95% CI): 1.55 (0.72-3.35) respectively, although this was statistically insignificant. However, upon adjusting for total energy intake in model 2, this pattern became a statistically protective factor against ADHD, where individuals lying in both the second and third tertiles had a reduced risk of developing ADHD; OR (95% CI): 0.15 (0.03-0.74) and OR (95% CI): 0.30 (0.09-0.95) respectively.

Table 7: Comparison of odds ratio by tertiles of dietary pattern scores between ADHD group and Control II (Siblings) group

Dietary Pattern		n (%) Control / Case	Crude Model	OR (95% CI) Multivariate Model 1[1]	OR (95% CI) Multivariate Model 2[2]
Unsaturated-fat rich diet	T1	33 (23.4) / 75 (51.4)	4.84 (2.82 – 8.29)	2.00 (0.82 –4.85)	3.01 (1.11 – 8.18)
	T 2	10 (7.1) / 25 (17.21)	5.32 (2.36 – 12.00)	1.95 (0.68 – 5.62)	2.56 (0.65 – 10.04)
	T3	98 (69.5) / 54 (37.0)	1	1	1
	P trend		**(<0.001*)**	(0.110)	(**0.028***)
Traditional Diet	T1	52 (36.9) / 54 (37.0)	1	1	1
	T 2	25 (17.7) / 20 (13.7)	0.77 (0.38 – 1.55)	0.91 (0.29 – 2.85)	0.15 (0.03 – 0.74)
	T3	64 (45.4) / 72 (49.3)	1.08 (0.65 – 1.80)	1.55 (0.72 – 3.35)	0.30 (0.09 – 0.95)
	P trend		(0.723)	(0.248)	(0.071)

* *Statistically Significant p values are indicated in bold.*

[1] *Adjusted for indoor paternal smoking before childbirth, prenatal folic acid supplementation, prenatal acetaminophen administration, prenatal complications, number of daily snacks, presence of family conflicts*

[2] *Model 1 + additional adjustment for total energy intake.*

Discussion

Attention Deficit Hyperactive Disorder is one of the most diagnosed childhood mental illnesses that continues throughout adulthood and causes functional impairment in academic, family, and social settings. Furthermore, it is now being regarded as an epidemic due to the dramatic increase in its global incidence, where its prevalence kept on rising from 7.2% in 2015 till it reached 17.8% in 2020[3,6,24]. Studies highlighted multiple risk factors for developing ADHD, but their results and findings remain controversial. Recent studies have demonstrated the role of dietary patterns of children in increasing the risk of ADHD occurrence [10,25]. Nevertheless, there is a lack of evidence regarding the association between both diet and the occurrence of ADHD in Egypt. Additionally, detecting dietary patterns that are possibly associated with ADHD would provide an opportunity for interventional research to act and decrease the childhood morbidity resulting from ADHD as well as improve their quality of life. Therefore, this study was aimed at assessing the dietary pattern among

children with ADHD in Ismailia City and was conducted in Ismailia City Hospitals, specifically Suez Canal University hospital and Suez Canal Authority hospital. The aim of the study was met upon extracting the dietary patterns, three patterns were obtained. The first dietary pattern which was named "unhealthy diet" was consumed the most by the cases. What is more, is that all the cases were in the third tertile of this dietary pattern. The second dietary pattern was named "unsaturated-fat diet" and constituted a high intake of nuts and fish. This pattern was consumed the most by the controls and its increased consumption was found to protect against ADHD. The third dietary pattern was named "traditional diet" and included an increased intake of meats and vegetables. Although this pattern was found to be consumed the most by the cases, after adjustment of energy intake in this pattern, it was found to be strongly protective against ADHD development. Regarding the general characteristics of the ADHD group of this current study, most of the groups were males, firstborns, and lived-in urban areas among nuclear families. These characteristics are similar to those described by several studies investigating children diagnosed with ADHD [8,15,26]. The fathers of most of the children received a university education and worked as skilled manual workers, while most of the mothers received high school education and were housewives. The main objective of the present study was the identification of dietary patterns related to ADHD. Three dietary patterns were identified. The first pattern which was named "unhealthy diet", consists of high consumption of sugar-sweetened beverages, unhealthy snacks, french fries, and additives. The mean intake of this pattern was found to be the highest among the ADHD cases, with significantly lower intake by children in both control groups. Additionally, upon dividing the consumption scores of this dietary pattern into tertiles, it was observed that the scores of all of the cases were located in the third tertiles. Even though this pattern was excluded from the regression analysis due to this result, a suggestion emerges and assumes that the increased consumption of this dietary pattern could be associated with ADHD. This finding agrees with previous studies that reported an association between the higher consumption of the unhealthy food products contained under each of the food groups of the "unhealthy diet" and ADHD risk[9,13,27]. In further support of the association between this dietary pattern and ADHD is the fact that increased risk of ADHD occurs upon increasing the consumption of additives, artificial dyes, and refined sugars present in unhealthy food products, as well as the saturated and trans fatty acids present in fast food and unhealthy snacks[26,27]. All of these were investigated in our study, particularly in the "unhealthy diet" pattern. The second dietary pattern that was retained included a high intake of two food groups, namely nuts and fish; accordingly, this pattern was named "unsaturated-fat rich diet". The highest mean intake of this dietary pattern was observed among the two control groups, with significantly reduced intake among the ADHD cases. The multivariate logistic regression analysis revealed that with increasing intake of this pattern, the risk of ADHD decreases as evident by the trend analysis. However, this finding was statistically insignificant. The mere statistically significant association was noticed in the lowest tertile of consumption which showed decreased odds of ADHD, and this is what *Hernandez et al.*

also concluded[28]. These foregoing present study results are also similar to several previous research that concluded that intake of fish and nuts significantly reduces the risk of ADHD among children[29-31]. The mechanism that strengthens our results is that fish, nuts, and seeds contain a variety of healthy fats, whereas fish, especially fatty fish, contains polyunsaturated fatty acids, while nuts contain monounsaturated fatty acids as well as polyunsaturated fatty acids. All these types of fats are known for their beneficial and essential role in brain development and the protection against neurobehavioral disorders such as ADHD as in our case[32-34]. The final dietary pattern extracted in our study was the "vegetable-meat" pattern, which consisted of increased consumption of various types of vegetables and meats. Despite that the mean intake of this pattern was found to be significantly increased among the ADHD cases, upon the performance of the regression analysis after adjusting for energy intake, this pattern was found to be a significant protective factor against ADHD. This paradoxical finding could be attributed to two possibilities. The first one is that the meats group includes sausages that have considerable amounts of fats, which could mask the effect of other essential beneficial nutrients in the red meat and alter the role of the whole pattern in ADHD development. The second possibility is that in our Egyptian culture, the primary method of cooking most of the vegetables is through using different sorts of fats and oils, which could distort the role of this pattern in ADHD development given that vegetables contain vital nutrients for the protection against ADHD, while trans fatty acids and saturated fatty acids predispose to ADHD. In conclusion, since fat produces a considerable amount of energy, therefore, upon adjusting for this effect, the true protective role of the "vegetable-meats diet" pattern emerges. Our findings regarding this pattern are also consistent with the previous body of research[35,36].

Conclusion

The study findings lead to the conclusion that the "Traditional diet" dietary pattern possesses protective effects on ADHD. Additionally, the consumption of "unhealthy diet" dietary patterns is higher with ADHD.

References

1. Crittenden, P., Dallos, R., Landini, A. and Kozlowska, K., 2014. EBOOK: Attachment and Family Therapy. McGraw-Hill Education (UK).
2. El Baza F, AlShahawi HA, Zahra S, et al. (2017) Magnesium supplementation in children with attention deficit hyperactivity disorder. Egy J Med Human Genet. 17(1):63–70.
3. Casey M, Thom A, Peaceman M. (2017) Treatment of Subclinical Hypothyroidism or Hypothyroxinemia in Pregnancy. N Engl J Med 376:815–25.
4. Zhang T, Sidorchuk A, Sevilla-Cermeño L, et al. (2019) Association of Cesarean Delivery with Risk of Neurodevelopmental and Psychiatric Disorders in the Offspring: A Systematic Review and Meta-analysis. JAMA Netw open. 2(8).
5. Geier DA, Mumper E, Gladfelter B, et al. (2008) Neurodevelopmental disorders, maternal Rh-negativity, and Rho(D) immune globulins: a multicenter assessment. Neuro Endocrinol Lett. 29(2):272–80.
6. Mahmoud M, El-Mazary M, Maher M, et al. (2011) Zinc, ferritin, magnesium and copper in a group of Egyptian children with attention deficit hyperactivity disorder. Ital J Pediatr. 37(1):1–7.
7. Sarris J, Logan AC, Akbaraly TN, et al. (2015) Nutritional medicine as mainstream in psychiatry. The Lancet Psychiatry. 2(3):271-4.

8. Ketzer R, Gallois C, Martinez L, et al. (2012) Is there an association between perinatal complications and attention-deficit/hyperactivity disorder-inattentive type in children and adolescents? Rev Bras Psiquiatr. 34(3): 321–8.
9. van Egmond-Fröhlich A, Weghuber D, de Zwaan M. (2012) Association of Symptoms of Attention-Deficit/Hyperactivity Disorder with Physical Activity, Media Time, and Food Intake in Children and Adolescents. PLoS One. 7(11).
10. Aboul-ata M, Amin F. (2018) The Prevalence of ADHD in Fayoum City (Egypt) Among School-Age Children: Depending on a DSM-5-Based Rating Scale. J Atten Disord. 22(2):127–33.
11. Danielson L, Bitsko H, Ghandour M, Holbrook R, Kogan D, Blumberg J. (2018) Prevalence of Parent-Reported ADHD Diagnosis and Associated Treatment Among U.S. Children and Adolescents, 2016. J Clin Child Adolesc Psychol. 47(2):199–212.
12. Gómez-Pinilla F. (2008) Brain foods: The effects of nutrients on brain function. Nat Rev Neurosci. 9(7): 568–78.
13. Stergiakouli E, Thapar A, Davey Smith G. (2016) Association of Acetaminophen Use During Pregnancy with Behavioral Problems in Childhood: Evidence Against Confounding. JAMA Pediatr. 170(10):964–70.
14. Azadbakht L, Esmaillzadeh A. (2012) Dietary patterns and attention deficit hyperactivity disorder among Iranian children. Nutrition. 28(3):242–9.
15. World Health Organization. (2018) International statistical classification of diseases and related health problems, 11th revision. Geneva: World Health Organization.
16. Centers for Disease Control and prevention (CDC). (2018) International Micronutrient Malnutrition Prevention and Control (IMMPaCt). Available from: https://www.cdc.gov/immpact/micronutrients/index.html.
17. Agnoli C, Pounis G, Krogh V. (2019) Dietary pattern analysis. In: Pounis G, 1st ed. Analysis in nutritional research. Cambridge: Academic Press. 74-101.
18. Arnsten F, and Pliszka R. (2011) Catecholamine influences on prefrontal cortical function: relevance to the treatment of attention-deficit/hyperactivity disorder and related disorders. Pharmacol Biochem Behav. 99:211-216.
19. Center for Disease Control and Prevention (CDC). (2010) Epi Info. Version 6.04. Atlanta, Georgia: CDC; Available from: https://wwwn.cdc.gov/epiinfo/html/ ei6_downloads.htm
20. Bruin JE, Gerstein HC, Holloway AC. (2010) Long-term consequences of fetal and neonatal nicotine exposure: a critical review. Toxicol Sci;116(2):364-74.
21. Julvez J, Fortuny J, Mendez M, et al. (2009) Maternal use of folic acid supplements during pregnancy and four-year-old neurodevelopment in a population-based birth cohort. Paediatr Perinat Epidemiol. 23(3):199–206.
22. National Institute for Health and Care Excellence. (2018) attention deficit hyperactivity disorder: diagnosis and management. NICE Guideline.
23. Blumenthal S, Castro V, Clements C, et al. (2014) An Electronic Health Records Study of Long-Term Weight Gain Following Antidepressant Use. JAMA Psychiatry. 71(8):889–896.
24. Yu R, Jiang H, Wang J, et al. (2008) Copper (Cu2+) induces degeneration of dopaminergic neurons in the nigrostriatal system of rats. Neurosci Bull. 24(2):73–8.
25. San Mauro Martín I, Blumenfeld Olivares JA, Garicano Vilar E, et al. (2018) Nutritional and environmental factors in attention-deficit hyperactivity

disorder (ADHD): A cross-sectional study. Nutr Neurosci. 21(9):641–7.
26. Guney E, Cetin H, Iseri E. (2015) The Role of Environmental Factors in Etiology of Attention- Deficit Hyperactivity Disorder. In: Norvilitis J, ed. ADHD - New Directions in Diagnosis and Treatment. Intech Open.
27. Collett BR, Ohan JL, Myers KM. (2003) Ten-year review of rating scales. V: scales assessing attention-deficit/hyperactivity disorder. J Am Acad Child Adolesc Psychiatry; 42(9):1015-37.
28. Hernández-Castellano LE, Hernandez LL, Weaver S, et al. Increased serum serotonin improves parturient calcium homeostasis in dairy cows. J Dairy Sci. 2017 Feb;100(2):1580-1587.
29. Konofal E, Lecendreux M, Deron J, Marchand M, Cortese S, Zaïm M, et al. (2008) Effects of iron supplementation on attention deficit hyperactivity disorder in children. Pediatr. Neurol. 38: 20–26.
30. Zukier Z, Solomon A, Hamadeh J. (2010) The role of nutrition in mental health: attention deficit hyperactivity disorder (ADHD). Nutrition ADHD. 1-8.
31. Perna R, and Cooper D. (2012) Perinatal cyanosis: Long-term cognitive sequelae and behavioral consequences. Appl Neuropsychol Child. 1(1):48–52.
32. Ellio-Martin JA, Ledikwe JH, Rolls BJ. (2005) The influence of food portion size and energy density on energy intake: implications for weight management. Am J Clin nutrition. 82:236S-41S.
33. Thompson J, Waldie K, Wall C, et al. (2014) Associations between acetaminophen use during pregnancy and ADHD symptoms measured at ages 7 and 11 years. PLoS One. 9(9):e108210.
34. Morrill M. (2011) The effects of maternal employment on the health of school-age children. J Health Econ. 30(2):240–57.
35. Kim JH, Nam CM, Kim JW, et al. Relationship between attention-deficit/hyperactivity disorder and trans fatty acids intake in female adolescents. Acta Paediatr. 2012 Sep;101 (9): e431-3.
36. Araujo JSA, Delgado IF, Paumgartten FJR. Antenatal exposure to antidepressant drugs and the risk of neurodevelopmental and psychiatric disorders: a systematic review. Cad Saude Publica. 2020 Jan 31;36(2): e00026619.