ORIGINAL RESEARCH

Nutrafoods (2018) 17:27-32
DOI 10.17470/NF-017-1003-1

Received: February 09, 2017
Accepted: March 22, 2018

Assessment of nutritional risk factors predisposing to autism among Saudi children

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ABSTRACT

Introduction: Autism is a neurodevelopmental condition of unknown aetiology which is usually diagnosed in the first 3 years of life. Several studies have linked reduced intake of some nutrients with autism and autism spectrum disorder (ASD).

Objective: To identify nutritional risk factors that predispose to autism among preschool and school children living in Al-Madinah Al-Monawarah city in Saudi Arabia.

Method: Thirty children with autism/ASD aged 2–12 years and 36 matched control children were compared regarding BMI and food intake, using 24-hour recall and a food frequency questionnaire.

Results: Both groups consumed similar amounts of carbohydrates, protein and other nutrients, many of which were below the international recommendations for children of their age. However, children with autism/ASD also consumed significantly less omega-3 and iron than the control group.

Conclusions: Children with ASD, like other children in Saudi Arabia, consume less than the recommended amounts of some nutrients. Autistic children have reduced intake of omega-3 and iron, together with limited intake of many food varieties which could be linked to autism in susceptible children.

Keywords

Autism
Autism spectrum disorder
Diet
Omega-3
Iron

Introduction

Autism is a neurodevelopmental condition which is usually diagnosed in the first 3 years of life.

Its features include abnormal or impaired social interaction and communication and a restricted repertoire of activity and interests. Manifestations of the disorder vary greatly depending on the developmental level and age of the individual [1].

Genetic factors seem to be important in the aetiology of autism. However, genetics alone cannot explain the 870% increase in the number of autism cases between 1990 and 2000 [2]. This leaves nutrients and toxins interacting with genetic factors as the most likely causes of this condition.

Deficiency in several nutrients including omega-3 fatty acids, vitamin D, folic acid and vitamin B12, has been implicated in causing autism [3].

Autism was unknown in ancient times and was first described only in 1943. Prevalence estimates have increased over the last two decades and range from 0.7 per 10,000 population to 72.6 per 10,000 with a mean of 20.6 per 10,000. The mean male:female ratio is 4.2:1 [4].

In the Arab world, prevalence ranges from 1.4 per 10,000 children in Oman and 4.3 per 10,000 in Bahrain, to 29 per 10,000 in the United Arab Emirates. These rates are lower than those in the developed world, which are 39 per 10,000 for autism and 77 per 10,000 for autism spectrum disorders (ASD). In Saudi Arabia, autism affects 60 in every 10,000 individuals [5–8].

Methods

We hypothesize that insufficiency of some nutrients in genetically predisposed children may be a risk factor in the aetiology of ASD. Our objective was to identify nutritional risk factors that predispose to autism among preschool and school children living in Al-Madinah Al-Monawarah city in Saudi Arabia.

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Recruitment

This was a case–control study conducted at Al-Amal psychiatric hospital, Al-Madinah Al-Monawarah. The study included 30 children diagnosed with autism or ASD and attending the paediatric psychiatry outpatient clinic and autism day care centre from February to April 2014. Autism or ASD was diagnosed by a paediatric psychiatry consultant according to the diagnostic criteria of DSM 5. All children attending the clinic or centre during the working day who met the inclusion criteria were enrolled. The inclusion criteria were as follows: (1) parental consent, (2) age 2–10 years, and (3) a diagnosis of autism or ASD. Exclusion criteria were as follows: (1) autism associated with a genetic syndrome, (2) patients following a special diet such as a gluten- and casein-free diet, (3) known food allergy leading to avoidance of certain foods, and (4) mother or primary caretaker not available to provide a detailed diet history. Thirty-six children matched for age, sex and socioeconomic status were recruited from the university and Nabaa Al-Maref Nursery and served as the control group. As it was not possible to recruit control boys aged 7–10 years from male primary schools, these children were selected from the family members of the researchers. The mean (range) ages of the autism and control groups were 58.66±19.87 months (29–108) and 59.38±20.11 months (24–108), respectively. There was no significant difference in age between the two groups (p=0.884).

Dietary study

Mothers were asked about their children's early feeding practices and sun exposure. Before a diet history was taken, the mothers of all autistic children were asked about food habits and dietary intake before autism diagnosis. All reported that their children followed the same diet before and after autism onset. Eleven mothers (36.6%) reported trying to get their children to eat healthier food after diagnosis, but all children resisted change, so these results represent typical patterns of food intake.

Dietary history using 24-hour recall

Mothers were asked to recall the exact foods and beverages consumed during the previous 24-hour period. As autism is associated with behaviors that can impact on food intake, the mothers were also asked in detail about the family's usual diet with special focus on the child's eating pattern before onset of the condition as well as his/her current diet. The quantities of foods and beverages consumed was estimated in household measures, which were then were converted to grams. Food analysis was conducted using the software Arab Food Analysis Programme, Version 1 (Arab Center for Nutrition).

Food frequency questionnaire

The target foods possibly associated with a reduced or increased risk of autism were grouped into categories and the frequency of intake of those food items was assessed.

Anthropometry

The weight and standing height of each subject was measured using standard techniques.

Statistical analysis

Descriptive analysis (mean, standard deviation and Student's t test) was carried out using SPSS Statistics 17. Anthropometric, clinical and dietary data were compared using the χ^2 test for categorizing data. The level of significance was set at $p<0.05$.

Ethical issues

The research was explained to parents in simple language and all data were collected from mothers. Consent was obtained and all data were confidential.

Results

Sun exposure

Table 1 shows that there was a significant difference in sun exposure between the two groups.

Assessment of dietary intake using 24-hour recall

There was no significant difference in mean energy, carbohydrate, protein or total fat consumption between the two groups (Table 2). However, the autism group had significantly lower omega-3 intake than the control group (mean 0.029±0.03 g/day and 0.26±0.49 g/day, respectively; p=0.01).

	Subjects	Frequency of sun exposure				p Value
		Daily	Weekly	Monthly	Never	
First 2 years	Autism	11 (36.7%)	4 (13.3%)	3 (10%)	12 (40%)	0.03*
	Control	7 (19.4%)	16 (44.4%)	5 (13.9%)	8 (22.2%)	
Current exposure	Autism	8 (26.7%)	5 (16.7%)	1 (3.3%)	16 (53.3%)	0.02*
	Control	15 (41.7%)	9 (25%)	5 (13.9%)	7 (19.4%)	
*Significant difference						

Table 1 - Sun exposure among children of both groups

	Autism (n=30)	Control (n=36)	*p* Value
Energy (kcal/day)	1330±541	1576±463	0.051
Protein (g/day)	38±20	48±25	0.091
Omega-3 (g/day)	0.029±0.036	0.268±0.498	0.011*
Total fat (g/day)	46±24	54±21	0.159
Carbohydrates (g/day)	199±87	234±67	0.076
Iron (mg/day)	6.66±4.00	10.23±6.01	0.007*
Calcium (mg/day)	538±332	331±560	0.797
Folic acid (µg/day)	173±128	203±97.9	0.440
Vitamin B12 (µg/day)	0.45±2.27	0.55±1.9	0.365
Vitamin D (µg/day)	1.31±1.91	1.60±1.60	0.515
*Significant difference			

Table 2 - Mean daily dietary intake among normal children and children with autism

Minerals

There was a highly significant difference in iron consumption between both groups, but no significant difference in calcium intake, with consumption of both iron and calcium in both groups below the recommended levels.

Vitamins

There was no significant difference in consumption of water-soluble and fat-soluble vitamins between the two groups. The diet of most children in both groups contained less than 50% of the recommended amounts of vitamin D.

Food frequency

Dairy products and eggs

Milk and dairy products were consumed daily by significantly more control children than autistic children (Table 3). Approximately 33% and 20% of autistic children reported no milk or dairy product consumption, respectively, compared with only 5.6% and 11.1% of the control group. One-third of autistic children reported no egg consumption in comparison with 0.0% of the control group.

Vegetables and fruit

There was no significant difference in the consumption of fruit (dried and fresh) or vegetables (fresh and cooked) between the groups. Less than half of the studied children consumed fresh fruit each day. Consumption of fresh and cooked vegetables followed this low pattern, with only four children in each group consuming cooked vegetables daily.

Food choices among autistic children

Table 4 shows the number of children refusing particular food items. More autistic than control children excluded food items from their diet.

Food items	Subjects	Frequency of intake				*p* Value
		Daily	Weekly	Monthly	Never	
Milk	Autism	17 (56.7%)	3 (10.0%)	0 (0%)	10 (33.3%)	0.011*
	Control	22 (61.1%)	11 (30.6%)	1 (2.8%)	2 (5.6%)	
Dairy products	Autism	15 (50.0%)	9 (30.0%)	0 (0%)	6 (20%)	0.269
	Control	25 (69.4%)	7 (19.4%)	0 (0)%	4 (11.1%)	
Eggs	Autism	7 (23.3%)	11 (36.7%)	2 (6.7%)	10 (33.3%)	0.001*
	Control	7 (19.4%)	28 (77.8%)	1 (2.8%)	0 (0%)	
Fresh fruit	Autism	13 (43.3%)	13 (43.3%)	1 (3.3%)	3 (10.0%)	0.542
	Control	17 (47.2%)	15 (41.7%)	3 (8.3%)	1 (2.8%)	
Cooked vegetables	Autism	4 (13.3%)	9 (30%)	3 (10%)	14 (46.7%)	0.506
	Control	4 (11.1%)	15 (41.7%)	6 (16.7%)	11 (30.6%)	
Fresh vegetables	Autism	6 (20%)	11 (36.7%)	3 (10%)	10 (33.3%)	0.082
	Control	12 (33.3%)	17 (47.2%)	4 (11.1%)	3 (8.3%)	
Tuna	Autism	0 (0%)	7 (23.33%)	5 (16.7%)	18 (60%)	0.059
	Control	2 (5.56%)	17 (47.2%)	6 (16.7%)	11 (30.6%)	
Other fish types	Autism	0 (0%)	5 (16.7%)	9 (30%)	16 (53.3%)	0.016*
	Control	0 (0%)	11 (30.6%)	18 (50%)	7 (19.4%)	
Liver	Autism	0 (0%)	1 (3.3%)	5 (16.7%)	24 (80%)	0.027*
	Control	0 (0%)	2 (5.6%)	18 (50%)	16 (44.4%)	
Meat (including chicken)	Autism	10 (33.3%)	11 (36.7%)	0 (0%)	9 (30%)	0.017*
	Control	18 (50%)	16 (44.4%)	1 (2.8%)	1 (2.8%)	
Butter	Autism	4 (13.3%)	4 (13.3%)	3 (10%)	19 (63.3%)	0.003*
	Control	4 (11.1%)	10 (27.7%)	14 (38.8%)	8 (22.2%)	
Olive oil	Autism	5 (16.6%)	4 (13.3%)	3 (10%)	18 (60%)	0.020*
	Control	8 (22.2%)	11 (30.5%)	9 (25%)	8 (22.2%)	
Sweetened Juice	Autism	21 (70.0%)	5 (16.7%)	1 (3.3%)	3 (10.0%)	0.164
	Control	29 (80.5%)	7 (19.4%)	0 (0.0%)	0 (0.0%)	
Soft drinks	Autism	16 (53.3%)	2 (6.7%)	10 (33.3%)	2 (6.7%)	0.140
	Control	3 (8.3%)	13 (36.1%)	9 (25%)	11 (30.5%)	
Fast-food	Autism	1 (3.3%)	9 (30.0%)	6 (20.0%)	14 (46.6%)	0.010*
	Control	3 (8.3%)	13 (36.1%)	16 (44.4%)	4 (11.1%)	
Sweets	Autism	13 (43.3%)	9 (30.0%)	2 (6.7%)	6 (20.0%)	0.094
	Control	23 (63.8%)	11 (30.5%)	1 (2.7%)	1 (2.7%)	
Processed meat	Autism	0 (0.0%)	1 (3.3%)	1 (3.3%)	28 (93.3%)	0.082
	Control	0 (0.0%)	2 (5.5%)	2 (5.5%)	32 (88.8%)	
*Significant difference						

Table 3 - Statistical comparison between the autistic and the control group regarding the frequency of food item consumption

	Autism	Control
Milk	10 (33.3%)	2 (5.6%)
Other dairy products	6 (20%)	4 (11.1%)
Eggs	10 (33.3%)	0 (0%)
Fresh fruit	3 (10.0%)	1 (2.8%)
Dried fruit	21 (70%)	25 (69.4%)
Cooked vegetables	14 (46.7%)	11 (30.6%)
Fresh vegetables	10 (33.3%)	3 (8.3%)
Tuna	18 (60%)	11 (30.6%)
Salmon	27 (90%)	28 (77.8%)
Other fish types	16 (53.3%)	7 (19.4%)
Ghee	21 (70%)	15 (41.6%)
Butter	19 (63.3%)	8 (22.2%)
Olive oil	18 (60%)	8 (22.2%)
Sweetened juice	3 (10.0%)	0 (0.0%)
Soft drinks	2 (6.7%)	11 (30.5%)
French fries	3 (10.0%)	2 (5.5%)
Fast food	14 (46.6)	4 (11.1%)
Sweets	6 (20.0%)	1 (2.7%)
Processed meats	28 (93.3%)	32 (88.8%)

Table 4 - Proportion of children excluding food items from their diet

Discussion

Parents of children with ASD often report that their children are highly selective eaters and consume very restricted diets that may be limited to as few as five foods. Picky eating, also referred to as food selectivity, is a significant problem because it may result in inadequate nutrition. We found that this diet behaviour started long before diagnosis in autistic children [9]. Food selectivity was revealed by the higher prevalence of food groups never eaten by autistic children compared with controls, exposing these children to poor nutrition. Although we found no significant difference in BMI between the groups, the prevalence of overweight and underweight was higher among autistic children than among controls (Figure 1). Obesity and overweight have been reported among autistic children in other studies [10,11].

The obesity among our autistic children may be related to food selectivity. Food selectivity refers to picky eating, frequent food refusal and a limited repertoire of foods, and also includes excessive intake of a few foods, and selective intake of certain food categories such as carbohydrates [12]. The presence of obesity does not exclude nutritional deficiency, especially of micronutrients. Interestingly, vitamin and mineral deficiency may occur in both under- and overeating. For example, globalized high-energy and low-nutrient Western diets, typified by snacking, skipping breakfast, fast foods, soft drinks and convenience foods, are nutritionally unbalanced, and intake of micronutrients fails to meet recommended daily allowances [13].

Although only a minority of the studied children were underweight, we found that the intake of many micronutrients in both groups was below international recommendations for health and especially for healthy brain and bones. A recent study indicates that the dietary intake of some nutrients by an apparently healthy Saudi population is imbalanced [14].

Consistent with previous findings on food selectivity in children with autism/ASD, we found that the children consumed more servings of sweetened non-dairy beverages and soft drinks and significantly fewer servings of milk, eggs, tuna, fish, meat and liver than the control children [15,16]. The latter foods provide abundant nutrients.

Omega-3 polyunsaturated fatty acids (PUFAs) are required for normal neural development and maintenance of neural health [17]. However, we found nearly 10 times less omega-3 consumption among the autistic children compared with controls. Omega-3 fatty acids are found in fish and our results indicate that autistic children had significantly lower fish consumption compared with control children. The autistic children in this study also consumed significantly less milk and eggs than the control group. The apparent increase in the prevalence of autism over the last 20 years has corresponded with increasing medical advice to avoid the sun, advice that has probably lowered vitamin D levels and would theoretically greatly lower activated vitamin D (calcitriol) levels in developing brains [18,19]. In our study

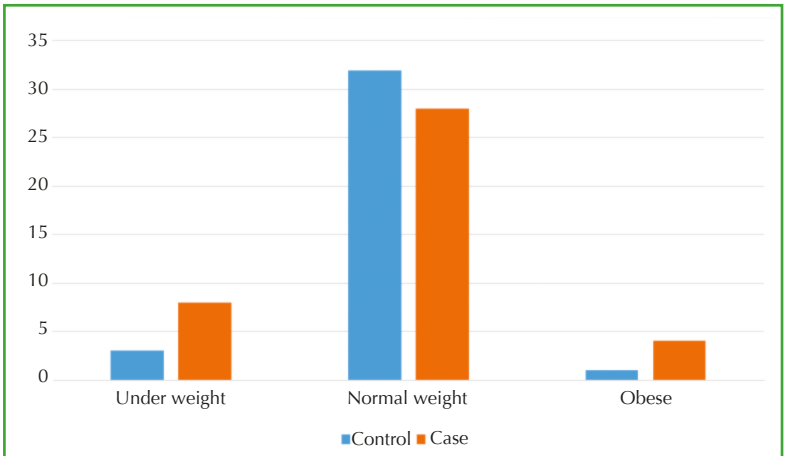

Figure 1 - Distribution of BMI categories between the two groups. χ^2=4.64; p=0.098

we demonstrated very low dietary vitamin D consumption among all children in both groups. The low vitamin D levels in autistic children may be compounded by the significantly lower sun exposure compared with the control group.

The autistic children had significantly lower iron consumption. This may be related to significantly less animal meat and liver intake compared with control children. Evidence suggests that brain iron deficiency at any time in life may disrupt metabolic processes and affect cognitive and behavioural functioning. Non-haematological manifestations of iron deficiency include decreased cognitive performance and behavioural disturbance [20]. There is strong evidence that iron deficiency anaemia is associated with poorer performance on developmental ratings in infants and with lower scores on cognitive function tests and educational achievement tests in children [21–23].

Conclusions

The study revealed that children with autism have many nutrient deficiencies, some of which may be a risk factor in genetically susceptible children. Supplementation may be the key to improving brain impairment in such children. Widespread vitamin D deficiency affects Saudi children and needs timely diagnosis and management in order to lessen its impact on health. Deficiencies of other nutrients such as folic acid, vitamin B12 and calcium, also need to be addressed. Professional dietitians should be included in the health team managing children with autism. The mothers of autistic children should be educated about the importance of proper nutrition and nutrients required for optimal behaviour and brain function. Nutrition education and counselling regarding child nutrition should be established, preferably within the existing premarital, prenatal and vaccination programmes. A campaign should also be launched on social platforms to highlight the role of vitamin D in preventing many diseases which are common in Saudi Arabia.

Contributions

AAl-T, SF, GA-H, MA, RA-R and GA-J collected the data; IH had the idea for the research, conducted the statistical analysis and contributed to writing the manuscript; AAEAa discussed the research with the other authors and contributed to writing the manuscript.

Conflicts of Interest

The authors declare they have no conflicts of interest.

Patient consent

Informed consent was obtained from all parents.

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