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Original article

Comparison of dietary macro and micronutrient intake with physical activity levels among children with and without autism: a case-control study

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Summary. *Background:* Physical activity is an important part of healthy lifestyle especially for autistic children. A few studies have previously compared the differences of diet intake and physical activity patterns in autistic and healthy children. This study was aimed to compare the macro-and micronutrient intake and physical activity patterns between children with and without autism. *Materials and Methods:* The present case-control study was conducted on 59 boys aged 6 to 13 years with autism and healthy children. Dietary intake of subjects was measured by Food Frequency Questionnaire (FFQ). The physical activity level was recorded for seven days using an ActiGraph accelerometer which categorized by the time of each participant spent, in sedentary, moderate and vigorous activity. *Results:* The findings revealed that there were significant differences in intake of many dietary factors including energy ($p < 0.05$), carbohydrate ($p<0.05$), sugar ($p<0.05$), fructose ($p<0.01$), vitamin D ($p<0.05$), Vitamin C ($p<0.01$), Calcium ($p<0.01$), Iron ($p<0.05$), Magnesium ($p<0.05$) and Manganese ($p<0.05$) between autistic and healthy children. Furthermore, sedentary and moderate activity levels were significantly higher in children with autism compared with healthy children ($p < 0.05$). Percent calories from fat was positively associated with heavy physical activity ($r = 0.258$, $p<0.05$). multivariate linear regression analysis showed that after control for change in BMI and dietary energy intake the calorie from fat, vitamin C and caffeine were negatively associated with physical activity level ($r = -0.571$, $p < 0.05$ Vs. $r = -0.573$, $p<0.05$ Vs. $r = -0.371$, $p<0.01$, respectively). *Conclusion:* It is concluded that there is a significant difference in food intake and physical activity levels in children with autism compared with healthy children. The potential role of diet especially calorie from fat, vitamin C, and caffeine should be considered to have applicable physical activity recommendations for children with ASD.

Key words: actigraph, autism, children, dietary intakes, micronutrient, physical activity

Abbreviations

ASD: Autism spectrum disorders
FFQ: Food frequency questionnaire
BMI: Body mass index
CPM: Count per minute

Introduction

Autism spectrum disorders (ASD) is a group of heterogeneous neurodevelopmental disabilities characterized by impaired emotional functioning, social and behavioral interaction that manifest during childhood (1, 2). Worldwide, the prevalence of this disability increasing annually which has become a relatively common neurodevelopmental disorder (3). Increased risk of being overweight/obese is one of the problems affecting the children with ASD (4, 5). It is well established that the type of diet, physical inactivity and side effects of antipsychotic medications that these children used may contribute to more body weight gain than healthy children (6, 7).

In addition to obesity, recent studies have shown that some of the associated behaviors and symptoms of ASD are related to dietary intake (8, 9). In children with ASD limited diets due to the food selectivity, dietary habits, chewing problems, family food choices, aberrant eating, gastrointestinal symptoms and mealtime behavior may affect dietary intake (10, 11). Therefore, we accomplished that in comparison to healthy children, nutritional status of children with ASD may be endangered due to the insufficient intake of vitamins and minerals. However, unlike the studies investigating the dietary intake of children with ASD, there are limited numbers of studies have compared them to age-matched healthy children (12-14).

The social and behavioral impairments experienced by these children appear to make participation in physical activity more difficult (15). There are still some methodological problems among studies measuring physical activity levels. Children with ASD have difficulties in completing self-report questionnaires and completing them by parents is not an accurate procedure. In addition, these questionnaires cannot use to monitor physical activity behavior (16). The lack of an appropriate method to record exercise activity in individuals with ASD causes impossibility to compare them with healthy children in accurate way (17). Nevertheless, ActiGraph activity monitor which can collect data such as body movements over extended periods of time may be a useful and more user-friendly method versus other methods to record exercise activity especially for children with autism (18).

There are relatively rare studies regarding physical activity and dietary intake in children with ASD. Therefore, this case- control study firstly aimed to investigate macro-and micronutrients intake and physical activity levels among children with and without ASD, Secondly, to determine the impact of macro-and micronutrients intake on the physical activity levels of these subjects. The interaction of dietary intake and physical activity levels on body mass index was also assessed.

Materials and methods

Participants

A group of 59 boys (aged 6 to 13 years), including 30 autistic subjects and 29 healthy ones were selected by the cluster sampling method from two autistic schools, and four healthy children's schools located in Tehran, Iran from December to March 2014. Subject with autism who participated in the study diagnosed according to the diagnostic and statistical Manual of Mental Disorders (19). Children who have mental retardation and severe behavior problems were excluded. The study was ethically approved by the ethics committee of Tehran University of Medical Sciences, Tehran, Iran (Reference no.: tums 91022717958).

Anthropometric measurements

All participants (n=59) were weighed and measured in light clothing without shoes using a digital scale (Seca Hamburg, Germany) with accuracy nearest to 0.05 kg, and by Seca stadiometer, with accuracy about 0.1 cm. The body mass index (BMI) was calculated as the weight (kg) divided by the square of the height (m).

Physical activity determination

Physical activity was assessed using an accelerometer (ActiGraph, GTX3, USA). This 25-gram device was closed around the wrist of subjects, and information on physical activity levels was recorded. Validity and reliability of this method was determined by previous studies (15). Physical activity was measured by ActiGraph accelerometers during walking hours for 7 consecutive days. At the end of this time the physical activity levels summarized as sedentary (counts/min 25-250), moderate (counts/min 250-499), and heavy (counts/min ≥500) (20).

Dietary assessment

The food frequency questionnaire (FFQ), validated for children with autism was used (21), in order to evaluate the pattern of food intake and also energy intake in children. The parents of study participants reported their children mean frequency of consumption of each food item in a day, week, month, or year and the portion size during the past year. Then mean weekly consumption of food items was calculated. The data were analyzed by Nutritionist IV software.

Statistical analysis

For data analysis, descriptive statistics (mean, standard deviation), as well as inferential statistics (independent t-test, Kolmogorov-Smirnov, Pearson correlation coefficient), were applied using SPSS 19 software (SPSS Inc. IL, Chicago, USA). The normal distribution of the samples was determined by the Kolmogorov–Simonov test. Independent student t-test was used to compare case and control groups. Bivariate Pearson correlations were assessed between physical activity levels and dietary variables. Multivariate linear regression analysis was used to assess significant correlation among the physical activity and dietary factors. In this study a *P* value of less than 0.05 was considered significant.

Results

One of the 30 subjects participated in the control group of current study was excluded because of lack of cooperation, and ultimately 59 subjects were included in the study. Independent t-test results showed that there were no significant differences in mean age, BMI, height, and weight between two study groups (p >0.05). In line with the study purposes, the average intake of macro-and micronutrients in children with autism and healthy children was evaluated. There were significant differences in energy (p <0.05), carbohydrate (p<0.05), sugar (p<0.05), fructose (p<0.01), vitamin D (p<0.05), Vitamin C (p<0.01), Calcium (p<0.01), Iron (p<0.05), Magnesium (p<0.05) and Manganese (p<0.05) intake between autistic and healthy children. The intakes of the presented nutrients were higher in healthy children (Table 1). We also evaluated the average level of physical activity in children with autism and healthy children. According to the table 2, moderate activity level was significantly lower in children with autism versus healthy children (p = 0.035), while sedentary physi-

Table 1. Demographic and micronutrients and macronutrients intake in case and control groups

Variables	Cases (n = 30) (Mean ± SD)	Controls (n = 29) (Mean ± SD)	P-value
Age (year)	10.3± 2.37	9.83 ± 1.97	0. 410
Height (cm)	140.16 ± 16	138.2 ± 11.12	0. 582
Weight (kg)	36.12 ± 14.63	37.94 ± 10.18	0.550
BMI (kg/m2)	18.85 ± 4.03	19.49 ± 3.12	0.500
Energy (kcal)	2148.21 ± 668.61	1806.54 ± 555.25	0.045
Carbohydrate (16)	279.01 ± 80.31	242.26 ± 56.71	0.032
Protein(16)	68.78	57.03	0.063
Fat(16)	86.10	71.02	0.139
Sugar (16)	70.16 ± 37.08	52.82 ± 24.54	0.010
Fructose (16)	11.63 ± 9.78	5.85 ± 4.13	0.008
Linolenic acid (16)	0.40 ± 0.72	0.31 ± 0.28	0.054
Vitamin D (μg)	1.39 ± 1.28	0.95 ± 1.47	0.025
Vitamin C (mg)	91.34 ± 68.08	60.80 ± 37.03	0.005
Calcium (mg)	688.86 ± 286.40	547.53 ± 286.04	0.006
Iron (mg)	13.56 ± 4.67	11.75 ± 3.96	0.013
Magnesium (mg)	228.12 ± 81.22	182.63 ± 54.13	0.021
Zinc (mg)	8.32 ± 3.92	7.04 ± 2.89	0.180
Manganese (mg)	2.30 ± 1.68	1.73 ± 0.70	0.021

BMI, body mass index; data are presented as mean ± SD; p <0.05 is significant

Table 2. The comparison of physical activity levels* in case and control groups.

Activity level	Cases (n = 30) (mean ± SD)	Controls (n = 29) (mean ± SD)	p-value
Sedentary (7th day)	331.84 ± 117.37	286.61 ± 104.43	0.124
Sedentary (5th day)	341.98 ± 119.99	309.58 ± 117.03	0.280
Sedentary (2th day)	313.06 ± 122.47	254.75 ± 100.36	0.047
Moderate (7th day)	180.67 ± 105.46	217.98 ± 111.78	0.190
Moderate (5th day)	181.51 ± 121.606	203.06 ± 114.35	0.058
Moderate (2th day)	178.73 ± 109.815	243.51 ± 120.26	0.035
Heavy (7th day)	20.06 ± 27.113	17.94 ± 21.01	0.073
Heavy (5th day)	21.40 ± 31.133	16.13 ± 18.25	0.413
Heavy (2th day)	18.61 ± 26.521	20.96 ± 26.50	0.073

Data are presented as mean ± SD and p <0.05 is significant. Physical activity was measured by ActiGraph accelerometers worn during 7 consecutive days: 7th day (Activity recorded in seven days), 5th day (Activity recorded in five days), and 2nd day (Activity recorded in two days)

Table 3. Pearson correlation coefficients between physical activity with demographic characteristics, dietary intakes, and BMI

Variables		BMI	Kilocalories	Carbohydrate*	Protein*	Fat*	Iron	Zinc	Manganese
PA 2day	r	-0.20	.094	-0.135	-0.173	0.233	0.033	.157	-0.080
	P	0.167	0.508	0.339	0.220	0.096	0.817	0.265	0.573
PA 5day	r	-0.186	0.061	-0.121	-0.175	.209	-0.25	.125	0.014
	P	0.188	0.667	0.395	0.216	0.137	0.860	0.378	0.920
PA 7day	r	-0.190	0.079	-0.159	-0.191	.258	-0. 12	0.138	-0.030
	P	0.178	0.577	0.261	0.175	0.045	0.935	0.329	0.830

*PA: physical activity, r: Pearson correlation coefficients, p: p value; p <0.05 is significant. * Percent calories from fat, Carbohydrates, Protein*

cal activity was higher in autistic children (p = 0.047). About heavy physical activity, there was no any significant difference between groups (P>0.05).

Bivariate Pearson correlation coefficients between physical activity, which measured by mean daily CPM (counts per minute), and demographic characteristics, dietary factors, and BMI were shown in Table 3. In all subject, there was a significantly positive correlation between heavy physical activity level and dietary fat intake (r = 0.258, p = 0.045). Other dietary factors were not correlated with physical activity levels (P>0.05).

Multivariate linear regression was used to assess the correlation of five factors (caffeine intake, vitamin C, percent calorie from fat, protein and carbohydrates) with physical activity (total sum of physical activity), after controlling for the influence of total energy intake and BMI in all boys. It was shown that the calorie from fat, vitamin C and caffeine were negatively associated with physical activity level (r = -0.571, p <0.05 vs. r= -0.573, p<0.05 vs. r= -0.371, p<0.01, respectively) (Table 4).

Table 4. Multivariate linear regression analysis for relationship between physical activity and some dietary intakes

Variable	Coefficient	95% C.I		P value
		Lower	Upper	
percent calorie from fat	-0.571	0.93	7.83	0.040
percent calorie from carbohydrate	-0.169	-2.81	1.53	0.550
percent calorie from protein	0.208	-1.624	6.37	0.237
vitamin C	-0.573	-4.039	-1.46	0.001
Caffeine	-0.371	-1.96	-0.37	0.008

p <0.05 is significant. Values were adjusted for energy intake and BMI

Discussion

This study was aimed to compare the dietary intake and physical activity levels between children with autism and healthy children. In addition, we assessed the association of dietary intake with physical activity levels in these two groups. This study revealed that the level of moderate physical activity is lower in autistic children than in healthy children, while sedentary physical activity was higher in autistic children. From the perspective of the authors, this finding could explain the differences in physical activity levels between autistic and healthy children.

By reviewing previous studies in the literature, it can be found that the activity level of children with autism might have some differences with the healthy children. In line with the present study, Pan et al (22) and Ghaheri et al (23) indicated that activity levels in children with autism is lower than healthy children. Nevertheless, Sandt et al (24) reported that there is no significant difference in physical activity between autistic and normal children. Bandini et al (15) reported that the moderate and severe activity in children with autism is equal to other children. However, this finding was different from the perspective of children's parents, which they reported their autistic children have a low level of physical activity.

Interestingly there was no correlation between physical activity levels and BMI of subjects. In contrast, Must et al described that autistic children tend to engage in lower level of physical activity during the weekend, which may be related to a subsequent increase of their BMI (25).

We also found that there is a significant clinical deficiency in nutrients intake of children with autism. There are several studies have examined the micronutrients intake of autistic patients. In agreement with our study, they have reported that the intake of micronutrients in these patients is lower than normal controls (26, 27). However, some other studies have reported that there are not any differences in nutrients intake between normal and autistic children (28). Micronutrients are essential components in the production of neurotransmitters, and people who suffered from mental illnesses need more micronutrients, therefore, it is suggested that higher intake of nutrients may improve mental performance in these patients (29). Recent studies have proposed that adenosine triphosphate level (ATP) in patients with mental disorders is influenced by the proportion of micronutrients they consume (29). Therefore, regardless of the subclinical insufficiency, adequate intake of micronutrients is associated with better mental performance.

The comparison of micronutrients intake in autistic children with dietary recommended intake (DRI) has revealed that intakes of calcium, magnesium, vitamin C, and vitamin D are lower than the required amounts. Blaurock-Busch et al (30) demonstrated that in children with autism, the intake of arsenic, cadmium, barium, lead, cerium, magnesium, and zinc is lower than DRI (30, 31). Furthermore, in a study that was conducted by Elder and colleagues, it has been shown that autistic children have a low intake of zinc, selenium, vitamin D and omega-3 fatty acids(11). Micronutrients intake may have a positive impact on the level of physical activity. The results of Rucklidge's study (32) showed that higher intake of micronutrients in adults with autism is associated with a reduction in tension and stress caused by the tremor. In our study, healthy children who had a better status in term of micronutrients intake had a higher physical activity level.

Intake of toxic metals such as mercury and arsenic might effect on the pathogenesis of autism and physical activity level in children with this disorder. Since children have higher absorption levels, they are more susceptible to the risk of toxic metals associated autism; meanwhile, nutrients deficiencies such as iron, zinc, and copper could exacerbate this state (33-35). Yasuda et al (36) in a study emphasized on the positive role of these micronutrients in the ASD. In agreement with their study, in the present study, intake of the essential trace element 'copper' was significantly different in autistic and healthy children, which might contribute to the observed differences in physical activity level between these two groups.

In some studies, consumption of a high-fructose diet has been reported to be in association with occurrence of the negative symptoms of autism (11, 37, 38, 39). In this study, there was a significant difference in fructose consumption between the two groups, which could be considered as one of the involving factors in activity level differences between children with and without autism. However, some studies have not found any relationship between dietary fructose limitation and reduction in negative symptoms of autism (40).

The study limitations

A number of caveats need to be considered in the interpretation of the present findings. Briefly, the relatively small sample size might limit the power to detect very moderate associations and also limit the generalizability of the results. In addition, the study subjects were limited to male students, and thus replication of our results using larger samples in both genders is necessary. Finally, the case-control design of our study, in which we could not determine the causality or mechanism of the relationship between macro-and micronutrients intake and autism could be considered as study's limitations.

Conclusion

This study revealed inadequate intake of several important nutrients in autistic children compared with healthy ones. Moreover, our findings showed that there was a significant positive correlation between calorie from fat intake and heavy physical activity level in children. It could be recommended that in order to increase the level of physical activity in children with autism, the potential role of diet especially calorie from fat, vitamin C, and caffeine should be considered.

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