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Desequilibrio de nutrientes y obesidad en niños con trastorno del espectro autista

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Desequilibrio de nutrientes y obesidad en niños con trastorno del espectro autista

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ABSTRACT

Introduction: children with ASD have a higher percentage of obesity compared to neurotypical children of the same age. Diet problems can lead to excesses or deficiencies in the consumption of macro and micronutrients.

Objectives: to rigorously and serially evaluate the anthropometric and dietary data of ASD patients of preschool and school age over a period of 6 months.

Methods: a longitudinal study that included 34 children diagnosed with ASD of both sexes, from 4 to 11 years of age, recruited at convenience in the Mental Health Service of the National Institute of Pediatrics in Mexico City. The variables considered were: age, body mass index with Z-score and intake of macro and micronutrients.

Results: at the end of the follow-up, 25 of 34 patients concluded the study and their nutritional status showed changes that did not have statistical significance, where 4 % were underweight, 56 % were normal weight, 12 % were overweight and 28 % were obese. Macronutrients, such as energy and fiber, and micronutrients, such as zinc, vitamin D, omega-3 and omega-6, and tryptophan, showed imbalances in consumption by patients without statistical significant changes in time.

Conclusions: there is an imbalance in the consumption of macro and micronutrients in children with ASD and the prevalence of obesity is higher compared to other studies.

Keywords: Autistic spectrum disorders. Diet. Micronutrients. Macronutrients. Overweight and obesity.

RESUMEN

Introducción: la prevalencia del trastorno del espectro autista es mayor en los hombres que en las mujeres. Los niños con TEA presentan un mayor porcentaje de obesidad comparados con los niños neurotípicos de la misma edad. Los problemas de alimentación pueden llevar a excesos o deficiencias en el consumo de macro y micronutrientes.

Objetivos: evaluar de forma rigurosa y seriada los datos antropométricos y dietéticos de pacientes con TEA en edad preescolar y escolar durante un período de 6 meses.

Métodos: estudio longitudinal que incluyó a 34 niños con diagnóstico de TEA de ambos sexos, de 4 a 11 años, reclutados a conveniencia en el Servicio de Salud Mental del Instituto Nacional de Pediatría de la Ciudad de México. Las variables consideradas fueron: edad, índice de masa corporal con *score* Z e ingesta de macro y micronutrientes.

Resultados: al término del seguimiento, 25 de 34 pacientes concluyeron el estudio y su estado de nutrición presentó cambios que no tuvieron significancia estadística, en donde el 4 % presentaron bajo peso, el 56 % presentaron peso normal, el 12 % sobrepeso y el 28 % obesidad. Los macronutrientes como la energía y la fibra, y los micronutrientes como el zinc, la vitamina D, los omegas 3 y 6 y el triptófano presentaron desequilibrios de consumo por los pacientes, sin significancia estadística en el tiempo.

Conclusiones: existe un desequilibrio en la ingesta de macro y micronutrientes en los niños con TEA, y la prevalencia de obesidad es mayor comparada con otros estudios.

Palabras clave: Trastornos del espectro autista. Dieta. Micronutrientes. Macronutrientes. Sobrepeso y obesidad.

INTRODUCTION

Autism spectrum disorder (ASD) is a behavioral syndrome of variable severity with neurodevelopmental effects that is characterized by communication and sociability alterations, repetitive behaviors, and resistance to change (1). The prevalence of ASD in 2018 revealed that it affects approximately 23 per 1,000 children in the United States (2). In particular, the prevalence of ASD in Mexico was 8.7 cases per 1,000 in 2016 (3).

The pathogenesis of ASD involves a causal interaction between genetic and environmental factors such as parental age, medication use during pregnancy, maternal immune activation, and others (4). The manifestations of ASD are correlated with gastrointestinal symptoms, language problems, hyperactivity, anxiety, food selectivity due to sensory sensitivity and persistence in routines (5). Atypical eating behaviors in patients with ASD are risk factors for nutritional problems (6).

Several studies have reported that obesity is more common in children with ASD than in neurotypical children (7,8). The worldwide prevalence of obesity in children with ASD is 21.8 %; 29.9 % in South America, 21.8 % in North America, 16.1 % in Europe, and 26.1 % in Asia, ranging in age from 2 to 5 (14.8 %) and 6 to 12 (23.5 %) years (9). In Mexico, a study reported that 12.9 % of its population aged 5-10 years suffered from obesity. However, there are no other studies with a larger number of participants that can help corroborate this prevalence (10).

The diet of children with ASD is characterized by high energy and fat consumption and low vegetable and fruit intake (11). To evaluate diet

behavior, the most used tools are: the brief evaluation scale for eating behavior in children (BAMBI) or its revised version (BAMBI-R), the 24-hour recall, food frequency questionnaires, and 3-day food records (12). However, most of the results of the diet analysis are representative of the food group and not of the macro- and micronutrients that these foods provide (13). More studies are needed to help report the consumption of macro- and micronutrients in the diet, and to determine how their deficiency or excess could harm the health of children with ASD in the long term.

The aim of this study was to rigorously and serially evaluate the anthropometric and dietary data of preschool and school-aged patients with ASD over a period of 6 months.

METHODS

This longitudinal study evaluated the nutritional status and macro- and micronutrient intake of children with ASD over 6 months. During the 6-month period, no intervention was made in the diet. The participants were recruited via convenience sampling from the Mental Health Service of the National Institute of Pediatrics (INP) in Mexico City. The diagnostic instruments used by the clinical psychologist were Autism Spectrum Disorder Diagnostic Interview (CRIDI-ASD) and the Childhood Autism Rating Scale (CARS).

All participants included in this project were 4 to 11 years old children of both sexes; those who had any syndromic comorbidity and those who did not complete the 24-h dietary recalls were excluded. Data were collected between May 2022 and November 2023. The parents or guardians of all participants accepted freely read and signed their informed consent in accordance with the Declaration of Helsinki as revised in 2013, and the Mexican regulations for clinical studies.

The analysis of anthropometric data was conducted at the beginning and at the end of the study, at 6 months. A comparison was performed for

those who completed the study. The anthropometric evaluation was performed by a single standardized dietitian. To perform measurements, a stadiometer (SECA 206, Germany) and Seca® pediatric digital scale (Hamburg, Germany) were used, following the anthropometric methodology recommended by the WHO (14). Weight and height measurements were used to calculate body mass index (BMI) (weight divided by the square of height), expressed in kg/m^2. The WHO Anthro Plus software (v.1.0.4) was used to determine BMI according to age using the Z-score (BMI/A). Nutritional diagnoses were evaluated according to the WHO (2007) standards, which consider: underweight < -2 SD, normal weight -2 to 1 SD, overweight > 1 SD and obesity > 2 SD (15).

The diet of the patients recruited at the beginning of treatment was described, and a comparison of the diet was made at 3 and 6 months among the patients who completed the study. To obtain the most representativeness of a patient´s diet, a two-day dietary recall was made, 3 times during follow-up: at the beginning of the study, at 3 months, and at 6 months. The two-day food records (2 weekdays or 1 weekday and 1 weekend) were obtained from trained dietitians at each follow-up. Through interviews, the dietitians used standard household measuring tools and food models to obtained information from parents about the portion size and help them estimate their children's consumption. To obtain more precise data on macronutrient and micronutrient intake, children were divided into two groups stratified by age (4-8 years old and 9-13 years old) and sex (female and male). The nutritional content of every food reported on the dietary recalls, was evaluated using the MetabolicPro® software (https://gmdi.org/MetabolicPro). The amount of macro- and micronutrients ingested was quantified as absolute intake and relative to the recommended daily intake (RDI) at baseline and at 3 and 6 months of follow-up. Individual intake of each nutrient was calculated as a

percentage of the age- and sex-specific RDA, which is defined as the amount of essential nutrients considered adequate to meet the nutritional needs of healthy children according to the Nutrient Ingestion Recommendations for the Mexican population (16).

For statistical analysis, absolute frequencies and percentages were determined for qualitative variables, and quantitative variables were expressed as means and standard deviations (SD). To identify changes in the amount consumption of macro and micronutrients along the study a repeated measures one-way ANOVA was performed, for variables where only two repeated measures were available a paired Student´s t test was performed. These tests were performed with the GraphPad Prism analysis package, version 9.5.1.

The present study is part of a research protocol with registration number 2021/058, which was approved by the research committee, research ethics committee, and biosafety committee of INP, Mexico City.

RESULTS

The general characteristics of the studied cohort, such as age, sex, and anthropometrical evaluation, are shown in table I. At the beginning of the project, 34 participants were included; but only 25 of 34 initial patients concluded the 6-month period.

The characteristics of the 34 patients included at the beginning of the project were the following: mean age was 7.12 ± 1.97 years. The greatest proportion of the population was comprised of males (26/34 patients). According to BMI/A Z-score, 32.4 % were underweight, 23.5 % were normal weight, 23.5 % were overweight, and 20.58 % were obese.

Their nutritional status changed to normal weight in more than half of all participants (56 %), underweight decreased to 4 %, and overweight (12 %) together with obesity (28 %) added up to 40 %; 5 of the 6 patients changed from underweight to normal weight (83.3 %) and 4

of the 6 patients changed from overweight to obesity (66.66 %). However, the Z-value of body BMI was compared at the initial intervention and at six months of intervention without statistically significant changes ($p = 0.10$).

Diet analysis in different ASD groups followed for 6 months revealed changes in macronutrient and micronutrient intake according to RDI by sex and age. At baseline ($n = 34$) (Table II), all age groups had increased protein, fat, and carbohydrate intake. Girls and boys aged 4-8 years and boys aged 9-11 years had high cholesterol intake. Girls and boys aged 4-8 years had higher energy intake than the other groups. All groups had low fiber intake below the RDI and high sugar intake. The women's group aged 9-11 years had high iron intake, whereas the other groups had low calcium, iron, and potassium intake. Groups of girls and boys aged 4-8 years had high zinc and sodium intake. With the exception of the group of girls aged 4-8 years who had a lower intake of vitamin A, the other groups had higher intakes of vitamins A, C, and B12. The group of girls aged 9-11 years had a higher vitamin D intake than the other groups that had lower vitamin D, E, and K intakes. All groups had a high niacin intake, and women had a higher folate intake. All groups had low omega-3 and omega-6 intakes and high intakes of amino acids such as tryptophan, phenylalanine, and tyrosine.

Comparing the consumption of macronutrients and micronutrients between the 3-month and 6-month follow-up groups, the following result was obtained: in the 3-month follow-up ($n = 25$) set of the diet analysis (Table III), it was found that proteins, fats, carbohydrates, cholesterol, and energy intakes were high, except in the group of female patients aged 9-11 years, who presented low cholesterol and energy intake. The groups aged 9-11 years had low fiber intakes, whereas the groups aged 4-8 years had dietary fiber intakes very close to the RDI value. All groups maintained a high sugar intake and low calcium and iron intake. Female patients aged 4-8 years had high potassium intake, whereas

groups of female and male patients of the same age had high zinc intake. Female patients aged 9-11 years had low sodium intake compared with the other groups. Female and male patients aged 4 to 8 years had high intakes of vitamin A. Female patients aged 9-11 years had a low intake of vitamin C. All groups had high vitamin B12 intakes. All groups had a low intake of vitamins D and E, except for female patients aged 4-8 years, who had a high intake of vitamin D. Male patients had a high vitamin K intake, whereas female patients aged 9-11 years had low niacin intakes. Female patients aged 4-8 years had high folate intakes. All groups maintained a low intake of omega-3 and omega-6 fatty acids. Tryptophan, phenylalanine, and tyrosine amino acids were mainly ingested in all groups, except in the group of female patients aged 9-11 years. who had a low intake of tryptophan.

At the end of the 6-month follow-up (n = 25) diet analysis (Table IV) all groups maintained high intakes of protein, fat, carbohydrates, cholesterol, energy, and sugar. The group of female and male patients aged 9-11 years maintained a low fiber intake, but female and male patients aged 4-8 years had fiber intake values slightly higher than the RDA. All groups maintained low calcium and iron intakes. Female patients aged 9-11 years had high potassium intakes and female patients aged 4-8 years had lower sodium intakes. Female patients aged 9-11 years and male patients aged 4-8 years had a high intake of vitamin A. Female patients had a high intake of vitamin C. All groups had a low intake of vitamin E. Female patients aged 4-8 years had a high intake of omega-3, whereas the other groups had low intakes of folate and omegas. All groups maintained high intakes of tryptophan, phenylalanine, and tyrosine.

In the statistical comparison of the baseline (n = 25), 3 months (n = 25), and 6 months (n = 25) time points of the consumption of macronutrients (energy and fiber) and micronutrients (zinc, vitamin D, omega 3 and 6,

and tryptophan), no statistically significant changes were found in any of them.

DISCUSSION

One of the consistent findings of ASD is the higher prevalence in men than in women, with approximately 70 % of ASD cases described in men. In our study sample, 84 % of the population was male, and in another study similar to ours 74.2 % were male, indicating that sex is a determinant of ASD (10,17).

Many studies have suggested that the ASD condition is related to the risk of overweight and obesity in this population because obesity is present in 8-32 % of children with ASD, and a recent study found that children with ASD were 8 times more obese (16.8 %) than children in the general population (2.0 %) (18). However, the results of other studies showed that there is a 41.1 % greater risk (p = 0.018) in children with ASD of developing obesity compared to children with typical development (19).

Compared with South America (29.9 %), the prevalence of obesity in Mexican children with ASD in this study (28 %) was lower and compared with the prevalence of obesity in children with characteristics similar to our study, (12.9 %) it was higher (9,10). These results differ from those reported by the National Health and Nutrition Survey 2022 (ENSANUT-2022), in which the prevalence of obesity in neurotypical schoolchildren was 18.1 % (20). However, at present, there are no national reports on preschool and school populations with ASD in Mexico.

Risk factors for developing obesity in children with ASD include eating behaviors such as sensory difficulties and food selectivity (21). During diet monitoring, changes were observed in the intake of essential macronutrients and micronutrients necessary for adequate development and nutritional status. Changes in nutritional status during follow-up were not statistically significant; although it was observed that there is a

tendency toward obesity in this population. In Western populations with ASD, it is common to find these weight gain trends related to the preference for ultra-processed foods with high energy values and poor in vitamins and minerals (22-24). Furthermore, the preference for this type of food can cause a decrease in fiber consumption, which is related to gastrointestinal problems such as constipation, causing an increase in pain and anxiety in ASD (25).

During follow-up, micronutrients such as zinc, vitamin D, omega-3 and omega-6, and tryptophan were consumed at lower levels according to the RDI. However, there was no statistical significance when comparing levels between patients during follow-up. Compared with other studies that studied zinc intake among children with ASD and NT aged 4-10 years, the current study showed a high daily zinc intake. There was low vitamin D consumption at baseline, which was maintained after three months. In the follow-up of intake at 6 months, there were fluctuations in consumption since it was high in the group of girls aged 9-11. Other studies have reported that children with ASD often showed vitamin D deficiency (26-28).

In our study, fatty acids, such as omega-3 and omega-6, were low in all groups, which was prevalent throughout the entire diet follow-up period. In another study, results showed a significant relationship between age and intake of omega-3 and omega-6 PUFAs (polyunsaturated fatty acids). The results also showed that participants aged 7-10 years had the lowest values of omega-3 consumption (29). These fatty acids and their metabolites have been linked to ASD because they contribute significantly to brain structure and function, neurotransmission, cell membrane composition, and organization within microdomains and play important roles in inflammation, immunity, and oxidative stress (30).

Our study revealed high tryptophan intake in all groups at all time points during diet follow-up; however, there was no statistical significance when comparing the groups. An analytical survey investigation with a

cross-sectional approach found an association between amino acid intake (phenylalanine and tryptophan) and hyperactivity in autistic children (31). In another study, researchers found an imbalance in tryptophan intake in children with ASD, which was related to the reported pattern of severity in ASD symptoms (32). Abnormal tryptophan values are implicated in irregularities in the serotonin pathway. The compounds that participate in this pathway play a fundamental role in the proper functioning of mental and physiological activities (33).

On the other hand, the results of a preclinical study in mice indicated that chronic deprivation of tryptophan, tyrosine, and phenylalanine (TTP) in the diet induces a decrease in monoamines and their metabolites specifically in the brain region. Altered activities of monoaminergic systems may contribute to increased locomotor activity (34). Among ASD conditions, repetitive and stereotyped movements may be related to an imbalance in tryptophan consumption in this population. Another condition with high co-occurrence in ASD is sleep problems such as insomnia, which may also be related to imbalances in the production of serotonin derived from tryptophan (35).

The detailed analysis of the nutrients consumed by children with ASD in this study allowed us to determine the amount of amino acids that have not been reported in previous studies of Mexican children with ASD. Previous studies on diet analysis in the Mexican population have reported only the types of foods consumed and their frequency of consumption. This study is the first to conduct a rigorous analysis of diet reminders in Mexican preschool and school populations with ASD. Another strength was the serial dietary recalls, which allowed us to see more realistically and at different times the characteristics of their diet and thus have a closer analysis of their usual diet.

Some of the limitations of our study were the sample size and the use of 24-h recalls as a tool for documenting the patients’ dietary reports

because it depends on memory and can overestimate or underestimate dietary intake (36). The percentage of fat and muscle were not measured, but they are some of the many variables that can be included in future studies to obtain better results. More studies with a larger sample size are needed to contribute to the creation of dietary and nutritional guidelines that can help generate individualized therapies aimed at improving the nutritional status of patients with ASD to improve their quality of life.

CONCLUSIONS

The prevalence of obesity was higher in this population than in another similar study of a Mexican population. It is difficult to establish a correct prevalence of obesity in Mexican children with ASD without the existence of other studies with larger populations. The rigorous dietary analysis of our study helped determine in more detail the imbalances of macro- and micronutrients, including some amino acids that have not been presented in any other study of Mexican children with ASD. Future studies should consider the dietary problems that lead to an imbalance in nutrient consumption and their possible relationship with the obesity suffered by children with ASD.

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Table I. General characteristics of the sample of female and male patients with autism spectrum disorder

	0 months ***n* = 25**	**6 months** ***n* = 25**
Characteristics	**Mean, ± ED, and %**	**Mean, ± ED, and %**
Age (years)	*6.72 ± 2.03*	*7.48 ± 2.02*
Sex		
Female	(4) 16.0	(4) 16.0
Male	*(21) 84.0*	*(21) 84.0*
Nutrition State		
Underweight	(6) 24	(1) 4.0
Normal weight	*(9) 36*	*(14) 56.0*
Overweight	(6) 24	(3) 12.0
Obesity	(4) 16	(7) 28.0

Values expressed as mean, standard deviation and percentage. The Z-score was calculated with the AntroPlus v1.0.4 software according to the reference values for sex and age (WHO, 2007).

Table II. Macronutrients and micronutrients intake in girls and boys with ASD (0 months)

Baseline			**ASD girls 4 to 8 years *n* = 7**		**ASD boys 4 to 8 years *n* = 17**		**ASD girls 9 to 13 years *n* = 1**		**ASD boys 9 to 13 years *n* = 9**	
Nutrient	**Unit**	**Category**	**Mean**	**RDA**	**Mean**	**RDA**	**Mean**	**RDA**	**Mean**	**RDA**
Protein	g	Macronutrients	*77.49*	22.00	*77.22*	22.00	*53.90*	39.00	*76.71*	39.00
Fat	g	Macronutrients	*73.33*	42.00	*66.36*	45.00	*35.70*	55.00	*73.76*	59.00
Carbohydrate	g	Macronutrients	*234.80*	130.00	*235.04*	130.00	*266.30*	130.00	*219.97*	130.00
Cholesterol	mg	Macronutrients	*184.93*	130.00	*302.49*	130.00	31.50	130.00	*260.98*	130.00
Energy	kcal	Macronutrients	*1908.19*	1376.00	*1931.01*	1512.00	1555.70	1830.00	1866.80	1967.00
Dietary fiber	g	Macronutrients	15.71	16.00	14.92	16.00	14.60	22.00	20.12	22.00
Sugars	g	Macronutrie	*66.07*	25.00	*71.25*	25.00	*81.10*	25.00	*59.34*	25.00

		nts								
Calcium	mg	Minerals	775.14	800.00	721.82	800.00	1169.00	1300.00	589.33	1300.00
Iron	mg	Minerals	12.10	15.00	9.68	15.00	*36.90*	20.00	9.76	20.00
Potassium	mg	Minerals	1951.00	2300.00	1617.47	2300.00	1957.00	2500.00	1932.44	2500.00
Zinc	mg	Minerals	*8.43*	6.60	*7.41*	6.60	8.00	11.60	8.78	11.60
Sodium	mg	Minerals	*2255.14*	1900.00	*2412.24*	1900.00	1646.00	2300.00	1852.50	2300.00
Vitamin A (RAE)	mcg	Vitamins	386.54	400.00	*1000.49*	400.00	*620.70*	580.00	*653.67*	580.00
Vitamin C	mg	Vitamins	*144.29*	25.00	*78.47*	25.00	*52.00*	45.00	*78.67*	45.00
Vitamin B12	mcg	Vitamins	*3.79*	1.20	*2.84*	1.20	*7.70*	1.70	*4.30*	1.70
Vitamin D	mcg	Vitamins	3.00	5.00	3.24	5.00	*8.00*	5.00	3.44	5.00
Vitamin E (alpha-TE)	mg	Vitamins	5.53	7.00	6.15	7.00	3.70	11.00	3.72	11.00
Vitamin K	mcg	Vitamins	41.86	55.00	46.82	55.00	33.00	60.00	29.44	60.00

Niacin	mg	Vitamins	*22.36*	8.00	*31.51*	8.00	*26.50*	12.00	*22.37*	12.00
Folate	mcg	Vitamins	*279.57*	230.00	214.65	230.00	*472.00*	360.00	206.00	360.00
Linoleic acid (omega-6)	g	Fatty acids	3.86	8.00	3.00	8.00	0.99	8.00	1.56	8.00
Docosahexaenoic acid (omega-3)	g	Fatty acids	0.17	2.00	0.08	2.00	0.00	2.00	0.27	2.00
Tryptophan	g	Amino acids	*0.59*	0.11	*0.55*	0.11	*0.39*	0.19	*0.64*	0.19
Phenylalanine	g	Amino acids	*2.51*	0.52	*2.27*	0.52	*1.81*	0.92	*2.70*	0.92
Tyrosine	g	Amino acids	*1.88*	0.52	*1.71*	0.52	*1.18*	0.92	*2.13*	0.92

RDA: Recommended Dietary Allowance; DRI: Dietary Reference Intake.

Table III. Macronutrients and micronutrients intake in girls and boys with ASD (3 months)

3-month			**ASD girls 4 to 8 years *n* = 3**		**ASD boys 4 to 8 years *n* = 14**		**ASD girls 9 to 11 years *n* = 1**		**ASD boys 9 to 11 years *n* = 7**	
Nutrient	**Unit**	**Category**	**Mean**	**RDA**	**Mean**	**RDA**	**Mean**	**RDA**	**Mean**	**RDA**
Protein	g	Macronutrients	*99.77*	22.00	*84.03*	22.00	*49.90*	39.00	*89.40*	39.00
Fat	g	Macronutrients	*99.08*	42.00	*69.40*	45.00	*62.90*	55.00	*77.93*	59.00
Carbohydrate	g	Macronutrients	*204.38*	130.00	*216.08*	130.00	*226.10*	130.00	*242.56*	130.00
Cholesterol	mg	Macronutrients	*293.40*	130.00	*260.23*	130.00	103.20	130.00	*309.96*	130.00
Energy	kcal	Macronutrients	*2078.43*	1376.00	*2079.51*	1512.00	1658.70	1830.00	*2089.63*	1967.00
Dietary fiber	g	Macronutrients	15.97	16.00	*16.14*	16.00	8.70	22.00	18.60	22.00
Sugars	g	Macronutrie	*53.85*	25.00	*55.97*	25.00	*121.9*	25.00	*72.88*	25.00

		nts					*0*			
Calcium	mg	Minerals	771.33	800.00	607.96	800.00	551.00	1300.00	486.21	1300.00
Iron	mg	Minerals	10.98	15.00	10.54	15.00	4.20	20.00	9.37	20.00
Potassium	mg	Minerals	*2368.83*	2300.00	1769.29	2300.00	983.00	2500.00	1828.50	2500.00
Zinc	mg	Minerals	*8.33*	6.60	*9.29*	6.60	7.00	11.60	9.21	11.60
Sodium	mg	Minerals	*1953.23*	1900.00	*2424.11*	1900.00	1931.00	2300.00	*2806.79*	2300.00
Vitamin A (RAE)	mcg	Vitamins	*519.48*	400.00	*440.66*	400.00	275.30	580.00	526.83	580.00
Vitamin C	mg	Vitamins	*70.33*	25.00	*113.79*	25.00	3.00	45.00	*57.14*	45.00
Vitamin B12	mcg	Vitamins	*3.82*	1.20	*3.48*	1.20	*4.30*	1.70	*3.52*	1.70
Vitamin D	mcg	Vitamins	*7.00*	5.00	3.11	5.00	5.00	5.00	3.21	5.00
Vitamin E (alpha-TE)	mg	Vitamins	4.90	7.00	5.04	7.00	1.70	11.00	3.15	11.00
Vitamin K	mcg	Vitamins	44.00	55.00	*56.46*	55.00	22.00	60.00	*84.14*	60.00

Niacin	mg	Vitamins	*24.78*	8.00	*31.64*	8.00	9.30	12.00	*59.60*	12.00
Folate	mcg	Vitamins	*248.33*	230.00	206.18	230.00	27.00	360.00	230.79	360.00
Linoleic Acid (omega-6)	g	Fatty acids	0.78	8.00	3.55	8.00	5.26	8.00	2.82	8.00
Docosahexaenoic acid (omega-3)	g	Fatty acids	0.49	2.00	0.12	2.00	0.00	2.00	0.05	2.00
Tryptophan	g	Amino acids	*0.87*	0.11	*0.57*	0.11	*0.31*	0.19	*0.51*	0.19
Phenylalanine	g	Amino acids	*3.13*	0.52	*2.38*	0.52	*1.11*	0.92	*2.28*	0.92
Tyrosine	g	Amino acids	*2.43*	0.52	*1.86*	0.52	0.87	0.92	*1.73*	0.92

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Table IV. Macronutrients and micronutrients intake in girls and boys with ASD (6 months)

6-month			**ASD girls 4 to 8 years *n* = 2**		**ASD boys 4 to 8 years *n* = 14**		**ASD girls 9 to 11 years *n* = 2**		**ASD boys 9 to 11 years *n* = 6**	
Nutrient	**Unit**	**Category**	**Mean**	**RDA**	**Mean**	**RDA**	**Mean**	**RDA**	**Mean**	**RDA**
Protein	g	Macronutrients	*87.35*	22.00	*92.76*	22.00	*105.65*	39.00	*113.55*	39.00
Fat	g	Macronutrients	*81.33*	42.00	*70.75*	45.00	*78.98*	55.00	*101.42*	59.00
Carbohydrate	g	Macronutrients	*223.58*	130.00	*209.04*	130.00	*229.03*	130.00	*249.36*	130.00
Cholesterol	mg	Macronutrients	*184.75*	130.00	*286.23*	130.00	*195.45*	130.00	*480.55*	130.00
Energy	kcal	Macronutrients	*1985.33*	1376.00	*2011.88*	1512.00	*2039.40*	1830.00	*2538.26*	1967.00
Dietary fiber	g	Macronutrients	*17.08*	16.00	*16.46*	16.00	19.60	22.00	14.91	22.00
Sugars	g	Macronutrie	*71.78*	25.00	*70.92*	25.00	*64.83*	25.00	*77.79*	25.00

		nts								
Calcium	mg	Minerals	389.25	800.00	651.04	800.00	685.25	1300.00	590.93	1300.00
Iron	mg	Minerals	10.05	15.00	10.60	15.00	11.55	20.00	12.27	20.00
Potassium	mg	Minerals	1551.50	2300.00	1772.96	2300.00	*2713.75*	2500.00	2094.57	2500.00
Zinc	mg	Minerals	5.25	6.60	*9.25*	6.60	9.25	11.60	*17.50*	11.60
Sodium	mg	Minerals	1895.75	1900.00	*2661.46*	1900.00	*3131.25*	2300.00	*2727.79*	2300.00
Vitamin A (RAE)	mcg	Vitamins	104.23	400.00	*573.52*	400.00	*737.38*	580.00	514.89	580.00
Vitamin C	mg	Vitamins	*41.50*	25.00	*82.86*	25.00	39.50	45.00	*74.07*	45.00
Vitamin B12	mcg	Vitamins	*3.38*	1.20	*3.18*	1.20	*5.43*	1.70	*6.12*	1.70
Vitamin D	mcg	Vitamins	*8.75*	5.00	2.39	5.00	*5.25*	5.00	3.07	5.00
Vitamin E (alpha-TE)	mg	Vitamins	3.10	7.00	5.81	7.00	4.90	11.00	3.95	11.00
Vitamin K	mcg	Vitamins	27.50	55.00	32.29	55.00	*188.25*	60.00	35.43	60.00
Niacin	mg	Vitamins	*16.63*	8.00	*42.75*	8.00	*30.25*	12.00	*135.4*	12.00

									4	
Folate	mcg	Vitamins	126.50	230.00	183.75	230.00	212.25	360.00	236.93	360.00
Linoleic acid (omega-6)	g	Fatty acids	0.00	8.00	3.07	8.00	7.21	8.00	5.15	8.00
Docosahexaenoic acid (omega-3)	g	Fatty acids	*8.91*	2.00	0.04	2.00	0.56	2.00	0.04	2.00
Tryptophan	g	Amino acids	*0.51*	0.11	*0.66*	0.11	*1.05*	0.19	*0.65*	0.19
Phenylalanine	g	Amino acids	*2.01*	0.52	*2.75*	0.52	*3.90*	0.92	*3.44*	0.92
Tyrosine	g	Amino acids	*1.59*	0.52	*2.21*	0.52	*3.16*	0.92	*2.71*	0.92

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