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Food selectivity, nutritional inadequacies, and mealtime behavioral problems in children with autism spectrum disorder compared to neurotypical children

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Abstract

Objective: To evaluate body composition, nutritional status through food selectivity and degree of inadequate intake, and mealtime behavior in children with autism spectrum disorder (ASD) compared to neurotypical children.

Method: A cross-sectional case–control study was carried out in 144 children ($N = 55$ with ASD; $N = 91$ with neurotypical children) between 6 and 18 years of age. Body composition, nutritional intake, food consumption frequency (FFQ), and mealtime behavior were evaluated.

Results: Results showed a greater presence of children with a low weight (18.4% ASD vs. 3.20% comparison group) and obesity (16.3% ASD vs. 8.6% comparison group) in the ASD group for body mass index (BMI) categories ($p = .003$; number needed to take [NNT] = 8.07). The presence of obesity in ASD children compared to the comparison group was even higher when considering the fat component (47.5% ASD vs. 19.4% comparison group, $p = .002$; NNT = 10.3). ASD children had greater intake inadequacy (50% ASD vs. 22% comparison group, $p = .014$; NNT = 3.58), high food selectivity by FFQ (60.6% ASD vs. 37.9% comparison group, $p < .037$; NNT = 4.41), and more eating problems (food rejection, limited variety, disruptive behavior), compared to neurotypical children ($p = .001$).

Conclusion: Children with ASD showed an unbalanced body composition toward both underweight and obesity, a greater degree of inadequate intake, high food selectivity as indicated by their consumption frequency, and more disturbed eating behavior than children with neurotypical development. We suggest monitoring nutritional inadequacies and implementing nutritional strategies to expand the variety of foods children with ASD consume.

KEYWORDS
anthropometric parameters, autism spectrum disorder, food selectivity, mealtime behavior, nutrient intake

1 | INTRODUCTION

Autism spectrum disorders (ASD) is a behaviorally defined complex neurodevelopmental syndrome characterized by impairments in social communication and restricted and repetitive behaviors, interests and activities, as well as abnormalities in sensory reactivity (American Psychiatric Association, 2013) that are frequently associated with different comorbidities such as disruptive behavior, gastrointestinal symptoms, and eating problems (Peverill et al., 2019). These atypical eating patterns are often governed by food rejection/denial or a preference for certain kinds of food (Bandini et al., 2017; Wentz, Björk, & Dahlgren, 2019), and may lie in a sensory-associated physiological alterations probably caused by their behavioral problems (Ashley, Steinfeld, Young, & Ozonoff, 2020; Peverill et al., 2019).

ASD children's atypical eating patterns include mealtime rituals (Hubbard, Anderson, Curtin, Must, & Bandini, 2014), food selectivity (Bandini et al., 2017; Sharp et al., 2018), and disruptive behavior at mealtimes (Dovey et al., 2019; Leader, Tuohy, Chen, Mannion, & Gilroy, 2020; Murphy, Zlomke, VanOrmer, & Swingle, 2020). Food selectivity is one of the most common eating problems in children with ASD and is an important cause of concern because of its negative impact upon nutritional adequacy (Kral et al., 2015; Sharp et al., 2013) and anthropometric parameters (Criado et al., 2018; Sharp et al., 2018), as well as the family stress generated at mealtime (Thullen & Bonsall, 2017). Severe forms of feeding concerns in ASD meet the diagnostic criteria for avoidant-restrictive food intake disorder (ARFID), a psychiatric diagnosis that recognizes ASD as a risk factor for nutritional concerns associated with food selectivity (Eddy & Thomas, 2019).

Previous review (Cermak, Curtin, & Bandini, 2010) and meta-analysis studies (Sharp et al., 2013) concluded a higher food selectivity and nutrient insufficiency in ASD children compared to control children. Nevertheless, they point out a lack of complete nutritional assessment in ASD child. Nowadays, there is still a need of analytical studies that cover all aspects involved in nutritional intake in children with ASD, including food intake frequency by groups, as well as the number of deficiencies and the dietary preferences in ASD that may explain conflicting results among past reports. To date, a few studies (Bandini et al., 2010; Hyman et al., 2012) have assessed in detail nutrient intake in children with ASD, based on 72-h food diaries describing insufficient intake of certain nutrients such as vitamins A, C, B6, B9 (folate), B12, D, E, and K, or minerals such as phosphorus, zinc, calcium (Ca), or iron (Fe). Very few studies (Marí-Bauset, Llopis-González, Zazpe, Marí-Sanchis, & Morales Suárez-Varela, 2017) have additionally analyzed food consumption habits through the application of the food frequency questionnaire (FFQ) to identify unbalanced diets due to excess or absence in terms of the consumption of certain food groups. It has been suggested that children with ASD could be at risk of suffering nutritional inadequacies (Sharp et al., 2018) resulting in negative middle- to long-term consequences for growth and development (Bandini et al., 2017; Graf-Myles et al., 2013). Moreover, the relative contribution of food selectivity and dietary disturbance to the increased risk of overweight and obesity that has been observed in ASD is still a prominent area of research, based on dietary preferences for processed foods, snacks, and sweets and the frequent rejection of fruits and vegetables (Sharp et al., 2013). Since the literature on the assessment of ASD children's nutritional status is limited, to our knowledge, there are few studies (Bandini et al., 2010; Hyman et al., 2012; Marí-Bauset et al., 2017) that have performed a detailed comprehensive assessment of intake using the reference technique of 72-h food diaries, complemented by food consumption frequency.

The existence of differences in anthropometric measurements between children with ASD and neurotypical children has been described as possibly related to severe food selectivity and mealtime behavioral problems, as well as to special diets and/or gastrointestinal problems in children with ASD (Kamal Nor, Ghozali, & Ismail, 2019). Although there are different methods by which to assess overweight and obesity in children and adolescents (Chan & Woo, 2010), body composition methods demonstrate high accuracy in the assessment of adiposity (Jensky-Squires et al., 2008). To date, very few studies have evaluated body composition in children with ASD, and the existing research has produced inconsistent or even contradictory results. On the one hand, Castro et al. (2017) concluded that a large percentage of children and adolescents with ASD had total overweight or obesity with truncal adiposity, and there was a significant percentage of underweight participants. In contrast, a recent study (Esteban-Figuerola, Morales-Hidalgo, Arija-Val, & Canals-Sans, 2021) revealed the absence of significant differences in bioelectrical impedance analysis in children and adolescents with ASD, compared to children with neurotypical development. Therefore, further studies are needed to analyze body composition imbalances in this concrete population, with a view to associating such alterations with atypical behavioral patterns and the intake inadequacy.

Based on the above, the present study was carried out to evaluate body composition, nutritional status through food selectivity and degree of inadequate intake, as well as mealtime behavior in children with ASD, compared to neurotypical children. We hypothesized that children with ASD would (a) present an unbalanced body composition, (b) have altered macro- and micronutrient food intake, (c) have food selectivity as indicated by their consumption frequency, and (d) exhibit more disruptive behavior than children with neurotypical development.

2 | METHOD

2.1 | Participants

The present cross-sectional, observational case–control study was carried out at Madrid Complutense University and the University of Granada (Spain) between January 2016 and December 2018. This was a multidisciplinary study involving specialists in dentistry, nutrition, physiology, and ASD. The study sample comprised 144 children (51 children with ASD and 93 neurotypical children) and convenience sampling was used to select participants attending special schools and primary schools. The neurotypical children were selected from the

same inclusive public centers that have specific classrooms for children with ASD. ASD children aged between 6 and 18 years were diagnosed based on the criteria in the Diagnostic and Statistical Manual of Mental Disorders V (DSM-V), but disorder severity was not considered. The comparison group members were selected from a geographical setting and socioeconomic context similar to that of the children with ASD. The exclusion criteria for both groups were as follows: use of dietary supplements, receiving treatment or following a special diet (e.g., gluten- and casein-free), any medical condition (endocrine, metabolic diseases, etc.) that could influence food intake, use of drugs (e.g., stimulants, atypical antipsychotics, tricyclic antidepressants, steroids, and mood stabilizers) that could affect food intake; not attending study interview appointments, and not completing nutritional records properly.

After contacting the school administration, the center notified the parents and coordinated an informative meeting. After the initial session, those parents who decided to allow their children to participate were given an informed consent form to sign. At the first appointment, before the study began, the parents received an explanation of the tests that would be applied, as well as data confidentiality in compliance with Spanish legislation, and informed consent for children's participation was obtained. The study was approved by the Ethics Committee of Hospital Clínico Universitario San Carlos (Madrid, Spain). The children's parents or legal representatives were scheduled to attend an informative meeting during which the study's objectives, the relevance of the expected results, and the study's significance to the children's health were explained. For both groups, we excluded families who declined to participate and those who we were unable or failed to provide complete nutritional records.

2.2 | Instruments and procedures

2.2.1 | Body composition and anthropometric measurements

Height was measured using a stadiometer (precision 0.1 cm, Secca 220, Spain) while the children remained static in the anatomical position with their heels together. The children were weighed (wearing light clothes) barefoot in the anatomical position with their feet and hands on the electrodes. Body composition measurements were obtained via multifrequency bioelectrical impedance (Tanita MC-980 MA Multifrequency Segmental Body Composition Analyzer, Barcelona, Spain). The analyzer complies with the applicable European standards (93/42EEC, 90/384EEC) for use in the medical industry. The impedance between each child's feet and hands, respectively, was measured while an alternating current (50 kHz, 90 mA) was passed through the entire body. The participants or their parents/legal representatives were informed in advance about the conditions that had to be observed prior to measurement: no vigorous exercise for at least 12 h before the test, no food or drink for at least 3 h before the test, and urination immediately before measurement. All anthropometric measurements were taken at the same time and recorded by the same researcher. The following measurements were obtained: weight, body mass index (BMI), and lean mass and fat mass expressed as a percentage of total body fat (fat mass index [FMI]).

2.2.2 | Seventy-two-h food diary

A 72-h recall questionnaire was used to record the participant's food and drink consumption over a 3-day period. This type of 3-day food diary is currently considered the gold standard among the methods for assessing diet (Barrett-Connor, 1991). The questionnaire was based on recall of food intake for 2 days of the week, in addition to one weekend day, in order to avoid weekly mean data registry bias attributable to special consumption habits on weekends. The food intake information was obtained from individual interviews with the children's parents or legal representatives, conducted by a registered dietitian. Experts on the research team held informative workshops before data collection and resolved any possible doubts through telephone support. The data collected on food and beverage consumption were finally converted to absolute values referring to energy consumption, macro and micronutrient intake, and percentage intake adequacy for each nutrient (recommended daily allowance [RDA]), using Nutriber software (version 1.1.5, Barcelona, Spain).

Nutritional data obtained were compared against the Spanish food composition tables (Mataix, 2011). Vitamin and mineral intake was also compared against the recommended dietary intake (DRI) for both the Spanish population and the European Union (Cuervo et al., 2009). Intake adequacy or inadequacy was determined by comparing each participant's real intake to the recommended intake for each nutrient, with two cut-off points: insufficient intake (less than 75% of the DRI) and excessive intake (above the DRI). In addition, to assess the children's specific degree of inadequate intake, we calculated the total number of macronutrients and micronutrients for which there was insufficient intake and established three cut-off points: mildly inadequate intake (insufficient intake of one to five nutrients), moderately inadequate intake (insufficient intake of 6 to 10 nutrients), and highly inadequate intake (insufficient intake of over 10 nutrients) (Marí-Bauset, Llopis-González, Zazpe-García, Marí-Sanchis, & Morales-Suárez-Varela, 2015).

2.2.3 | Food frequency questionnaire

The FFQ was used to determine the daily, monthly, and annual consumption frequency of each food groups, based on a list of over 200 foods. For each participant, we determined the percentage adequacy of the consumption for the different food groups in relation to the recommendations of the Spanish Society of Community Nutrition (SENC) (Aranceta Bartrina et al., 2016). The participants were classified into two categories: (a) an FFQ score below the recommended servings of a given food group, or (b) an FFQ score above the recommended servings based on the food pyramid proposed by the SENC for each food group (Aranceta Bartrina et al., 2016). Those

food groups without a recommendation were expressed as servings consumed per week. Food selectivity was assessed using the information reported on the FFQ, defined as the degree of adequacy, and used to classify the participants into two categories according to the percentage of foods each child refused among those offered, that is, showing no intake frequency: (a) nonfood selectivity (an FFQ food score of less than 33% of the total foods); or (b) high food selectivity (an FFQ score of over 33% of the total foods) (Chistol et al., 2018; Curtin et al., 2015).

2.2.4 | Brief assessment of mealtime behavior in children

Mealtime behavior was evaluated using the BAMBIC (Hendy, Seiverling, Lukens, & Williams, 2013). The questionnaire was administered to participants' parents to assess three common food problems: (a) limited variety of foods, (b) rejection of foods, and (c) disruptive behavior at mealtimes. The questionnaire comprised a total of 10 items, with scores for each BAMBIC subscale based on a 5-point Likert scale. Each item's scores were initially multiplied by the factor loadings (Hendy et al., 2013) and, subsequently, the mean scores for each dimension were calculated. Regarding alpha coefficients, 0.79 was found for the limited variety factor, 0.69 for the food refusal factor, and 0.69 for the disruptive behavior factor. The parents or legal representatives were asked to score the children's mealtime eating behavior according to the frequency of incidence of each situation in the last 6 months on a scale ranging from 1 to 5, where 1 = never, 2 = rarely, 3 = occasionally, 4 = often, 5 = almost always.

2.3 | Statistical analysis

The data were analyzed using the SPSS version 25.0 statistical package for MS Windows (SPSS Inc. Chicago, IL) and expressed as the mean and *SD* in the descriptive analysis. The variables were standardized using the Shapiro–Wilk test with Lilliefors correction. Homoscedasticity was determined with the Levene test. A comparative study of the sample characteristics in children with ASD and the comparison group was performed using analysis of covariance (ANCOVA) for continuous variables. The model was adjusted for age. Comparative analysis of daily energy, macronutrient and

TABLE 1 Main characteristics and body composition distribution of children with autism spectrum disorder and children with neurotypical children

	ASD children ($n = 51$)		Neurotypical children ($n = 93$)					
	Mean	*SD*	Mean	*SD*	*F*	Covariate age	*F*	*p*-Value (Cohen's *d*) [NNT]
Age	9.57	1.67	12.8	2.98	-	-	53.3	.001 (1.29)
BMI Z score	0.44	1.32	−0.25	0.63	17.8	.001	2.12	.147 (.246)
	n	% of children	*n*	% of children				
BMI percentile classification								
Underweight	9	18.4	3	3.2				.003[a] [8.07]
Healthy weight	22	44.9	65	69.9				
Overweight	10	20.4	17	18.3				
Obesity	8	16.3	8	8.6				
Fat mass percentile classification								
Healthy	18	45.0	52	55.9				.002[b] [10.3]
Overfat	3	7.50	23	24.7				
Obese	19	47.5	18	19.4				

Note: The continuous variables data were expressed as the mean and standard deviation (SD). The categorical variables were expressed number and percentage of subjects. ANCOVA analysis was used to compare values for ASD and the comparison group ($p < .05$ being considered significant). The model has been corrected by the age factor. Cohen's d coefficient for continuous variables were provided (.20: small effect; .50: intermediate effect; .80 and higher: large effect) (Lenhard & Lenhard, 2017). Number needed to take was also calculated for categorical variables as the number of children with altered body compartment relative to the total number of children for each group (NTT: < 4: strong effect; 4 to 9: moderate effect; > 9 weak effect) (Kraemer & Kupfer, 2006). The body mass index (BMI) was classified into four categories in accordance to the CDC growth charts for the BMI by age (for boys or girls) to obtain the percentile category: underweight, less than the 5th percentile; healthy weight, 5th percentile to 85th percentile; overweight, 85th to 95th percentile; obese, equal to or greater than the 95th percentile (Nagy et al., 2014). The fat mass index was classified into three categories in accordance to the TANITA healthy body fat ranges for children by age (for boys or girls): healthy, overfat and obese (McCarthy et al. 2006).
Abbreviations: ASD, Autism spectrum disorder; BMI, body mass index; ES, effect size.
[a]*p*-Value obtained in Chi-square test using the Bonferroni analysis. $\chi^2 = 13.754$, $df = 4$, p value < .003.
[b]*p*-Value obtained in Chi-square test using the Bonferroni analysis. $\chi^2 = 12.845$, $df = 2$, p value < .002.

TABLE 2 Comparative analysis of daily macro and micronutrient intake and adequacy in autism spectrum disorder children compared to neurotypical children

Daily nutrient intake	ASD children ($n = 51$)				Neurotypical children ($n = 93$)						
Macronutrients	Median	25th–75th quartile	Insufficient	Excess	Median	25th–75th quartile	Insufficient	Excess	χ^2 (NTT)	Z	*p*-Value (Cohen's d)
Energy (kcal/day)	1879.0	1,314.0–2,453.0	15 (34.9)	17 (39.5)	1,658.0	1,484.0–1947.0	9 (15.3)	27 (45.8)	*(7.92)	−1.06	.290 (.211)
Carbohydrates (% of total energy)	48.4	40.2–50.9	20 (46.5)	8 (18.6)	46.8	44.1–50.5	18 (30.5)	13 (22.0)	(11.9)	−.07	.943 (.014)
Proteins (% of total energy)	18.0	15.4–19.5	0 (0)	44 (93.0)	18.5	16.3–20.0	1 (1.7)	58 (98.3)	(−60.0)	−1.24	.214 (.248)
Fats (% of total energy)	33.6	31.1–38.2	15 (34.9)	17 (39.5)	36.5	32.7–40.2	6 (10.2)	40 (67.8)	*(6.01)	−1.81	.070 (.365)
Fiber (g/day)	15.9	10.4–21.6	16 (37.2)	19 (44.2)	15.1	13.4–19.7	5 (8.5)	38 (64.4)	*(5.18)	−0.09	.929 (.046)
Vitamins											
Thiamine (mg/day)	1.20	0.97–1.67	0 (0)	40 (93)	1.18	0.84–1.42	2 (3.4)	56 (94.9)	(−30.5)	−1.47	.140 (.295)
Riboflavin (mg/day)	1.50	1.11–1.94	5 (11.6)	27 (62.8)	1.56	1.21–1.74	4 (6.8)	51 (86.4)	*(24.5)	−.26	.792 (.052)
Niacin (mg/day)	21.3	16.2–25.5	1 (2.30)	42 (97.7)	20.6	16.8–25.7	2 (3.40)	51 (91.5)	(−99.4)	−.34	.732 (.068)
Vitamin B6 (mg/day)	3.20	2.34–4.87	22 (51.2)	13 (30.2)	3.29	2.39–4.11	19 (32.2)	23 (39)	(10.5)	−.27	.786 (.311)
Pantothenic acid (mg/day)	1.77	1.30–2.17	9 (20.9)	22 (51.2)	1.52	1.25–2.07	5 (8.5)	41 (69.5)	(10.5)	−1.55	.121 (.054)
Biotin (mg/day)	5.10	3.65–7.61	4 (9.30)	35 (81.4)	4.86	3.69–7.76	1 (1.70)	56 (94.9)	(14.6)	−.17	.863 (.034)
Folate (mg/day)	225.4	162.2–304.8	3 (7)	40 (93)	197.5	172.5–269.0	1 (1.70)	58 (98.3)	(20.5)	−.82	.412 (.163)
Vitamin B12 (mcg/day)	5.85	3.94–11.5	2 (4.70)	37 (86)	5.82	4.14–8.05	4 (6.80)	48 (81.4)	(19.1)	−.40	.687 (.080)
Vitamin C (mg/day)	115.5	74.9–153.6	41 (95.3)	0 (0)	91.9	59.6–129.3	56 (94.9)	3 (5.10)	(8.78)	−1.96	.050 (.396)
Retinol (mcg/day)	585.3	453.2–1,008.0	17 (39.5)	20 (46.5)	798.8	609.1–948.2	4 (6.80)	47 (79.7)	*(4.54)	−1.57	.117 (.314)
Vitamin D (mg/day)	4.35	2.60–6.33	20 (46.5)	17 (39.5)	7.06	4.34–10.0	18 (30.5)	32 (54.2)	(11.9)	−2.12	.034 (.429)
Vitamin E (mg/day)	8.18	5.42–11.7	20 (46.5)	17 (39.5)	6.91	5.25–9.39	17 (28.8)	23 (39)	(10.6)	−1.82	.069 (.366)
Minerals											
Sodium (mg/day)	2.87	2.34–3.76	0 (0)	14 (32.6)	3.08	2.51–3.75	0 (0)	19 (32.3)	(–)	−.71	.479 (.141)
Potassium (mg/day)	2,745.0	2,224.0–3,447.0	14 (32.6)	21 (48.8)	2,633.0	2,186.0–3,175.0	12 (20.3)	31 (52.5)	(13.0)	−.58	.565 (.115)
Calcium (mg/day)	940.0	684.4–1,206.0	9 (20.9)	21 (48.8)	1,007.0	900.3–1,135.0	5 (8.5)	48 (81.4)	*(10.5)	−.66	.507 (.132)
Magnesium (mg/day)	292.1	239.8–358.8	14 (32.6)	16 (37.2)	289.8	244.1–367.9	6 (10.2)	43 (72.9)	*(6.03)	−.31	.758 (.061)
Phosphorous (mg/day)	1,261.0	863.8–1702.0	2 (4.7)	33 (76.7)	1,282.0	1,090.0–1,478.0	3 (5.1)	47 (79.7)	(−253)	−.34	.735 (.067)
Iron (mg/day)	12.1	9.39–18.69	12 (27.9)	24 (55.8)	11.5	9.77–15.8	5 (8.5)	45 (76.3)	*(7.14)	−.88	.378 (.175)
Cooper (mg/day)	0.73	0.60–1.09	12 (27.9)	17 (39.5)	0.69	0.53–0.88	14 (23.7)	25 (42.4)	(37.8)	−1.14	.253 (.228)
Zinc (mg/day)	6.41	4.94–9.58	31 (72.1)	6 (14)	6.17	5.28–7.59	35 (59.3)	19 (32.2)	(9.59)	−.35	.727 (.069)
Selenium (mcg/day)	46.7	32.5–59.7	12 (28.6)	26 (61.9)	64.2	44.7–84.3	4 (6.80)	50 (84.7)	*(6.46)	−2.41	.016 (.491)
Iodine (mcg/day)	82.7	48.8–227.8	19 (44.2)	21 (48.8)	221.1	58.3–271.0	13 (22)	45 (76.3)	*(7.94)	−2.46	.014 (.502)

Note: Data for continuous variables were expressed as median and quartiles at the 25th and 75th. The categorical variables were expressed number and percentage of subjects. Wilcoxon rank-sum test analysis was used to compare values for ASD and neurotypical children. The model was corrected by the age factor. Bonferroni-corrected significance levels for multiple comparisons were calculated for nutritional analyses of macronutrients ($p = .05/5$, being considered significant if $p < .01$), vitamins ($p = .05/12$, being considered significant if $p < .004$) and minerals ($p = .05/10$, being considered significant if $p < .005$). Cohen's d coefficient for continuous variables were provided (.20: small effect; .50: intermediate effect; .80 and higher: large effect) (Lenhard & Lenhard, 2017), being calculated from the Z of the applied nonparametric test (Fritz et al., 2012). Number needed to take was also calculated for categorical variables (NTT: < 4: strong effect; 4 to 9: moderate effect; > 9 weak effect) (Kraemer & Kupfer, 2006). The DRI percentages were calculated according to the Spanish recommendations (Cuervo et al., 2009). The macronutrient distribution was expressed as percentage of total energy consumed. Intake inadequacy was determined by comparing each participant's real intake to the recommended intake for each nutrient, with two cut-off points: an intake below the 75% of DRI was classified as "insufficient intake"; an intake above the 100% of DRI was classified as "intake excess."

Abbreviations: ASD, autism spectrum disorder; DRI, dietary reference intake.

*p-value obtained in Chi-square test using the Bonferroni adjustment ($p < .05$).

TABLE 3 Food consumption frequency and adequacy in children with autism spectrum disorder and neurotypical children

		ASD children ($n = 51$)				Neurotypical children ($n = 93$)						
Food groups	**Reference**	**Median**	**25th–75th quartile**	**<R**	**>R**	**Median**	**25th–75th quartile**	**<R**	**>R**	**χ^2 (NTT)**	**Z**	***p*-Value (Cohen's *d*)**
Potatoes, rice, bread, wholemeal bread, pasta	4–6 s/d	2.36	2.00–2.75	100	-	2.29	1.86–2.57	100	-	-	−1.28	.201 (.265)
Vegetables	>2 s/d	2.38	2.10–3.57	14.7	35.3	2.00	1.50–2.96	46.7	25.0	*(−5.26)	−2.62	.009 (.575)
Fruits	>3 s/d	2.07	1.72–2.72	84.8	-	2.03	1.21–2.67	83.3	-	(−341)	−.40	.691 (.083)
Milk and dairy	2–4 s/d	2.29	1.73–2.58	42.4	3.0	2.30	2.12–2.64	40.0	0	(168)	−1.34	.180 (.281)
Fish	3–4 s/w	4.50	3.94–6.43	8.8	64.7	3.76	2.75–5.25	26.7	43.3	(−7.75)	−2.47	.014 (.485)
Lean meats, poultry and eggs	3–4 s/w	6.75	6.00–7.98	-	94.1	6.39	5.20–7.50	-	91.7	(−46.8)	−.47	.639 (.049)
Legumes	2–4 s/w	2.00	2.00–3.00	12.0	4.0	2.00	2.00–3.00	13.3	1.7	(−95.2)	−.86	.392 (.560)
Nuts	3–7 s/w	1.00	0.01–2.00	84.8	-	0.25	0.01–1.00	91.7	-	(−51.9)	−1.14	.253 (.235)
Sausages and meat fats[a]	Occasional	0.86	0.57–1.14	6.1	93.9	1.00	0.59–1.28	3.3	95.0	(40.1)	−.88	.378 (.183)
Sweets, snacks and soft drinks[a]	Occasional	1.82	1.16–1.88	-	93.9	1.99	1.53–2.53	-	100	(17.5)	−2.78	.006 (.601)
Butter, margarine and pastries[a]	Occasional	1.00	0.86–1.21	0	97.8	2.30	0.71–1.28	3.3	96.7	(−31.0)	−.99	.323 (.205)

Note: The continuous variables data were expressed as the median and quartiles at the 25th and 75th. The categorical variables were expressed number and percentage of subjects. Wilcoxon rank-sum test analysis was used to compare values for ASD and neurotypical children. The model was corrected by the age factor. Bonferroni-corrected significance levels for multiple comparisons were calculated for food consumption frequency ($p = .05/11$, being considered significant if $p < .004$). Cohen's d coefficient for continuous variables were provided (.20: small effect; .50: intermediate effect; .80 and higher: large effect) (Lenhard & Lenhard, 2017), being calculated from the Z of the applied nonparametric test (Fritz et al., 2012). Number needed to take was also calculated for categorical variables (NTT: < 4: strong effect; 4 to 9: moderate effect; > 9 weak effect) (Kraemer & Kupfer, 2006). Food frequency adequacy was expressed as servings/day and servings/week. Reference values for food consumption frequency were proposed by the Spanish Community Nutrition Society (SENC) (Aranceta Bartrina et al., 2016).

Abbreviations: ASD, autism spectrum disorder; s/d, servings/day; s/w, servings/week; < R = food frequency consumption below the reference recommendation; > R = food frequency consumption above the reference recommendation.

[a]If occasional servings are recommended or if there is no specific recommendation for a food group, intake is reported as servings/day.

TABLE 4 Nutritional inadequacy, food selectivity and mealtime behavior in children with autism spectrum disorder and neurotypical children

	ASD children ($n = 51$) Mean	Neurotypical children ($n = 93$) SD	Mean	SD	*F*	*p*-Value (Cohen's d) [NNT]
Nutritional inadequacy (number of nutrients)						
Macronutrients inadequacy	4.48	2.06	3.47	1.50	7.90	.010 (.588)
Micronutrients inadequacy	7.71	4.12	5.33	3.46	9.84	.003 (.637)
Total inadequate intake	11.9	5.84	8.81	4.72	8.29	.008 (.595)
FFQ adequacy	51.0	8.70	47.1	7.79	3.96	.048 (.478)
Frequency of problematic child mealtime behaviors						
Food rejection	3.05	1.13	2.37	0.53	16.7	.001 (.869)
Limited variety	−1.20	2.89	−3.05	1.76	15.4	.001 (.840)
Disruptive behavior	2.95	0.85	2.49	0.32	15.5	.001 (.827)
Degree of inadequate intake, *n* (percentage)						
Low inadequacy (1–5 nutrients)	4	10.5%	13	22.0%	-	.014[a] [3.58]
Moderate inadequacy (6–10 nutrients)	15	39.5%	33	55.9%	-	
High inadequacy (> 10 nutrients)	19	50.0%	13	22.0%	-	
Degree of FFQ adequacy, *n* (percentage)						
Nonselectivity (>33% of total items)	13	39.4%	36	62.1%	-	.037[b] [4.41]
High food selectivity (<33% of total items)	20	60.6%	22	37.9%	-	

Note: The continuous variables data were expressed as the mean and *SD*. The categorical variables were expressed number and percentage of subjects. ANCOVA analysis was used to compare values for ASD and the comparison group. The model has been corrected by the age factor. Bonferroni-corrected significance levels for multiple comparisons were calculated for nutritional inadequacy ($p = .05/4$, being considered significant if $p < .01$) and the frequency of problematic child mealtime behaviors ($p = .05/3$, being considered significant if $p < .02$). The BAMBIC classified the scores into three categories: food rejection, limited food variety, and disruptive behavior (Hendy et al., 2013). Cohen's d coefficient for continuous variables were provided (.20: small effect; .50: intermediate effect; .80 and higher: large effect) (Lenhard & Lenhard, 2017). Number needed to take was also calculated for categorical variables (NTT: < 4: strong effect; 4 to 9: moderate effect; > 9 weak effect) (Kraemer & Kupfer, 2006). For the categorical variable degree of inadequate nutrient intake, low and moderate inadequacy computed as unfortunate outcome. The nutritional inadequacy was classified into three categories according to the range of nutrients with inadequate intake (Mari-Bauset et al., 2015): low, inadequate intake of 1 to 5 nutrients; moderate, inadequate intake of 6 to 10 nutrients; high, inadequate intake greater than 10 nutrients. Food selectivity was assessed using the information reported on the FFQ, defined as the degree of adequacy, and used to classify the participants into two categories according to the percentage of foods each child refused among those offered, that is, showing no intake frequency: nonselectivity, an FFQ food score of less than 33% of the total foods; high food selectivity, an FFQ score of over 33% of the total foods (Chistol et al., 2018; Curtin et al., 2015).

[a]*p*-Value obtained in the Chi-square test using Bonferroni's analysis. $\chi^2 = 8.491$, df = 3, $p < .05$.

[b]*p*-Value obtained in the Chi-square test using Bonferroni's analysis. $\chi^2 = 4.351$, df = 1, $p < .05$.

micronutrient intake, FFQ score and adequacy in ASD children compared to neurotypical children was performed using the Wilcoxon rank-sum test, and the data were expressed as the median and interquartile ranges. Behavioral problems during meals were determined using ANCOVA to explore the differences between the mean scores obtained for the ASD children versus the comparison group, adjusting for age. A chi-squared test was used to analyze the sample distribution based on BMI and FMI, and proportions of ASD and neurotypical children who showed both insufficient intake and an excessive intake of vitamins or minerals. Bonferroni-corrected significance levels for multiple comparisons were calculated for nutritional analyses of macronutrients (being considered significant if $p < .01$), vitamins (being considered significant if $p < .004$) and minerals (being considered significant if $p < .005$), FFQ (being considered significant if $p < .004$), nutritional inadequacy (being considered significant if $p < .01$) and the frequency of problematic child mealtime behaviors (being considered significant if $p < .02$). Cohen's d coefficient for continuous variables were provided as a more standardized measure of effect size to indicate the magnitude of the between-group differences, being calculated from the Z of the applied nonparametric test according to Fritz, Morris, and Richler (2012) and classified as described by Lenhard and Lenhard (2017) (.20: small effect; .50: moderate effect; .80 and higher: large effect). The number needed to take (NNT) was performed to report the effect size of the categorical variables considering the prime rates of each of the variables of interest (NNT < 4: strong effect; 4 to 9: moderate effect; >9 weak effect). The NNT applied in the present study is the answer to the question "How many children with ASD do you have to see to find one more

'failure' (e.g., BMI disturbance, nutritional inadequacy, or food selectivity) than if you had sampled neurotypical children'' (Kraemer & Kupfer, 2006; Striegel-Moore et al., 2009).

3 | RESULTS

Table 1 reports the characteristics of the ASD and neurotypical children included in the study. Statistically significant age differences were observed; specifically, the children with ASD were younger than the comparison group. The group comparison of the mean z score for age-adjusted BMI was not statistically significant. However, the sample distribution analysis revealed significant between-group differences with a moderate effect for BMI categories; specifically, comparatively more children with ASD were in the low weight category (18.4% vs. 3.20% in the comparison group) and also in the obese category (16.3% vs. 8.6% in the comparison group). Significantly more children with ASD were also found to be in the obese category when stratifying by fat percentage (47.5% vs. 19.4% in the comparison group; small effect).

Table 2 shows the results of the comparative analysis referred to median energy, macro- and micronutrient intake, and intake adequacy in the study groups. Despite the fact that the median energy was similar in both groups, a larger percentage of children with ASD were below the RDA (34.9% versus 15.3% in the comparison group; moderate effect). Similarly, more children with ASD had greater inadequacy of fat and fiber (moderate effect). With regard to vitamins and minerals, although no differences between groups were observed in terms of the median intakes of the analyzed micronutrients after adjusting for multiple comparisons, more children with ASD presented greater inadequacy of vitamins such as vitamin B2 and retinol, and of minerals such as calcium (Ca) (20.9% vs. 8.5% in the neurotypical comparison group), magnesium (Mg) (32.6% vs. 10.2% in the comparison group), iron (Fe) (27.9% vs. 8.5% in the comparison group), selenium (Se) (28.6% vs. 6.8% in the comparison group) and iodine (I) (44.2% vs. 22.0% in the comparison group) (small to moderate effect).

Table 3 in turn shows the adequacy of mean food consumption frequency in the study population. After adjusting for multiple comparisons, no differences were observed between groups in the consumption of any of the analyzed food groups—though there was a trend toward statistical significance for the consumption of vegetables ($p = 0.009$) and sweets, snacks, and soft drinks ($p = 0.006$). Most of the children in both groups exceeded the recommended consumption of occasional foods such as sweets, snacks, and soft drinks, while they did not frequently consume recommended foods such as potatoes, rice, bread, wholemeal bread, pasta, fruit, or nuts. In addition, more children in the neurotypical comparison group showed a lower frequency of vegetable consumption than in the ASD group.

Table 4 reports nutritional inadequacy based on the number of nutrients with an inadequate intake, food selectivity according to the FFQ score, and the evaluation of mealtime eating problems. Children with ASD showed greater nutritional inadequacy for both macronutrients and micronutrients (moderate effect). When the children were classified according to the degree of inadequacy, one-half of the children with ASD were seen to present high nutritional inadequacy versus 22% of the comparison group (strong effect). Moreover, 60.6% of the children with ASD showed high food selectivity versus 37.9% of the neurotypical children (moderate effect). Lastly, the former showed greater food rejection, disruptive behavior, and limited variety (large effect).

4 | DISCUSSION

The present study compared body composition, nutritional status, and mealtime eating behaviors in children with ASD versus neurotypical children. The main findings were a prevalence of underweight and obesity of 18.4 and 16.3%, respectively, among the children with ASD on considering BMI. The figure in turn increased to 47.5% for the latter fat mass category on considering the body fat component. Furthermore, although no differences in median nutrient intake were observed between the groups, 50% of the children with ASD showed high inadequacy for nutrient intake due to inadequate intakes corresponding to more than 10 nutrients, high food selectivity, as well as more disruptive mealtime behavioral problems compared to neurotypical children.

In children with ASD, a number of studies have recorded contradictory data regarding anthropometrical measures. For instance, Neumeyer et al. (2018) evaluated children with ASD and neurotypical children, and recorded similar BMI values in both groups. This is consistent with the study of Malhi, Venkatesh, Bharti, and Singhi (2017) in children between 4 and 10 years of age, where BMI likewise was found to be similar in both groups. In contrast, in Spain, Marí-Bauset et al. (2015) recorded a greater prevalence of low weight in children with ASD. These authors observed no significant differences in food intake but suggested that the underlying cause could be atypical eating behavior or food selectivity—though they did not specifically investigate these factors. On the other hand, Hyman et al. (2012) found 5- to 11-year-old children with ASD to have a greater incidence of low weight, while those between 2 and 5 years of age showed a greater incidence of overweight and obesity, compared to neurotypical children. In our study, there was a greater presence of low weight as well as a higher frequency of children with obesity in the ASD group when BMI was considered (moderate effect). This is in agreement with the study published by Castro et al. (2017), who used bioelectrical impedance as a reference technique for body composition. Based on the above, it could be concluded that children with ASD might be characterized by a deviation toward both low weight and obesity, with a similar distribution of both extremes.

Evaluating food intake is a key element in nutritionally assessing a population. Several studies have reported on nutritional inadequacies in children with ASD (Sharp et al., 2018; Sharp, Berry, Burrell, Scahill, & McElhanon, 2020). In this regard, Adams, Johansen, Powell, Quig, and Rubin (2011) affirmed that insufficient protein intake, metabolic imbalances or alterations in protein digestion in children with ASD may be associated to increased gastrointestinal problems. In fact, these authors reported that nutritional status depends not only on

intake but also on digestion, absorption, metabolic processing and metabolic demand. Regarding dietary intake, children with ASD consume 16% less calories, a greater percentage of carbohydrates, 37% less protein, and 29% less fats (Neumeyer et al., 2018). Interestingly, from 34.9 to 39.5% of our children with ASD showed an altered consumption of calories—both insufficiency and excess—this being mainly due to an unbalanced intake of certain macronutrients such as fats and fiber, with a moderate effect and described by the homogeneous response despite the sample size in both groups. This fact could also be related to the abovementioned distribution of the children between extreme nutritional status categories (underweight and obese). In contrast to other studies, a high protein intake was observed in both groups—this being consistent with data previously reported in Spanish children (Serra-Majem, Ribas-Barba, Pérez-Rodrigo, & Bartrina, 2006). In relation to micronutrient intake, the adjustment of multiple comparisons showed the children with ASD to have no differences in absolute intake of all the assessed micronutrients versus the comparison group. These findings are in contrast to the observations of a recent meta-analysis (Esteban-Figuerola, Canals, Fernández-Cao, & Arija Val, 2019) that recorded lower intakes of certain vitamins and minerals in children with ASD compared to healthy controls. In our opinion there may be two explanations for this. First, our study applied a more conservative statistical analysis, avoiding overestimations or false positives of the differences between the two groups that could appear in other studies (Esteban-Figuerola et al., 2019). Second, the children with ASD would be less likely to suffer from insufficient nutrient intake, mainly because of greater parental control over food consumption (Hyman & Johnson, 2012).

Although used in routine practice, 72-h food diaries have a number of limitations that may result in the underestimation of food intake. The data they afford therefore must be interpreted with caution (Burrows, Martin, & Collins, 2010). The FFQ is considered to be an essential tool in the qualitative assessment of nutrient intake, taking into account our Mediterranean diet model based on the food pyramid proposed by the SENC (Aranceta Bartrina et al., 2016). Again, adjustment for multiple comparisons revealed similar food consumption in both groups, although there was an imbalance in the consumption of certain food groups such as potatoes, rice, bread, wholemeal bread, pasta, fruits, milk and dairy products, or nuts, where a high percentage of children showed consumption below the recommendations. In contrast, a moderate percentage of children over-consumed lean meats, poultry and eggs, and other foods where consumption should be occasional—which in the case of lean meats, poultry and eggs would be consistent with the recorded protein intake. Nevertheless, it should be taken into account that both the results published by Marí-Bauset et al. (2017) and our own findings suggest good adherence to the reference Mediterranean diet, albeit with shortcomings in the intake of certain fundamental food groups. Despite the methodological heterogeneity involved, other studies (Herndon, DiGuiseppi, Johnson, Leiferman, & Reynolds, 2009; Schreck, Williams, & Smith, 2004) have obtained results similar to our own. Although the findings of the present study are encouraging in that they reflect awareness on the part of the parents of children with ASD regarding the importance of an adequate diet, lower FFQ scores for certain essential foods were observed in the group of children with ASD, resulting in a more limited food variety.

Atypical mealtime behavior and food selectivity are common in children with ASD (Sharp et al., 2013, 2018). In a previous study, we reported altered mealtime eating behavior in relation to severe food selectivity and its association to oral health in children with ASD (Leiva-García, Planells, Planells Del Pozo, & Molina-López, 2019). Similarly, prior evidence (Chistol et al., 2018; Murphy et al., 2020; Peverill et al., 2019) would confirm such eating problems in these children, including food rejection, limited variety, unbalanced intake and food consumption frequency, and mealtime behavioral problems, where such food preferences would have been attributed to the influence of other factors such as sensory sensitivity and familial food preferences (Bandini et al., 2017). It has been highlighted that children with ASD exhibit poorer behavior during meals, as well as lower dietary quality, though food consumption questionnaires were not used to evaluate this aspect (Johnson et al., 2014). Other studies (Bandini et al., 2017; Zimmer et al., 2012) have also recorded a greater risk of nutritional insufficiency when children with ASD exhibit food selectivity. The assessment of intake alterations, the application of the FFQ, and the statistical adjustment for multiple comparisons are among the strengths of the present study, evidencing that although no differences between groups were observed in absolute values of intake and FFQ, a greater percentage of children with ASD presented highly inadequate intake (insufficient intake of 6–10 or more nutrients), as well as high food selectivity, as determined by the FFQ—though with a weak effect size. We therefore should be cautious when generalizing such differences. In line with our findings, Sharp et al. (2018) found that 78.5% of the children with ASD followed a diet with an inadequate intake of five or more nutrients. Additionally, these food selectivity and nutritional inadequacies were greater in the group of children with ASD, who were the children with the most altered mealtime behavior (moderate effect), explaining that these differences would stem from the greater alteration and homogeneous response of these behaviors in children with ASD.

From a holistic perspective, in order to provide an answer to the observed alterations in body composition in our children with ASD, a longitudinal study (Bandini et al., 2017) evaluating 18 adolescents with ASD found correlations between changes in weight and the variety of food consumed. Moreover, Sharp et al. (2018) evaluated 279 patients (70 of whom had ASD) over a 24-month period, and found those subjects that exhibited severe food selectivity and had five or more nutritional inadequacies to be more likely to present mealtime behavioral issues—though this severe food selectivity was not associated to compromised growth or obesity. Similarly, Castro et al. (2016) underscored the relationship between increased overweight and obesity and greater food-related behavioral problems in children with ASD, and a relationship has also been reported between a higher BMI and greater nutritional deficiencies due to selective preferences for processed foods, sweets, and soft drinks (Shmaya, Eilat-Adar, Leitner, Reif, & Gabis, 2015). Our findings in the form of altered

body composition, inadequate intake, food selectivity, and altered mealtime behavior thus underscore the importance of monitoring children with ASD who have food problems, in order to identify possible nutritional imbalances and introduce dietetic measures to improve their health, autonomy and quality of life.

The present study has some limitations that should be considered. We did not measure the degree of ASD, although the children with ASD who participated in the study were enrolled in specialized centers and had been previously officially diagnosed. Another limitation is the use of questionnaires, which, although validated, depend on the parent participation and subjective opinion for completion. Thus, mealtime behavioral problems were not obtained through direct observation, which could have avoided bias. Last, the lack of standardized values for nutritional recommendations between countries and the variations in nutritional recommendations for different age groups make it very difficult to compare nutritional intake findings between different studies conducted on children with ASD—hence the diversity of the results observed in the literature as reported in a meta-analysis carried out by Esteban-Figuerola et al. (2019). As a strength, the assessment of nutritional status by combining body composition with food intake and frequency of food consumption, as well as mealtime behavior, and statistical analysis for multiple comparisons, would demonstrate new findings revealing a possible overestimation of nutritional differences between children with ASD and the controls. Future studies therefore should include similar analyses in order to avoid false positives in relation to the nutritional status of children with ASD compared to their healthy counterparts.

5 | CONCLUSIONS

The present study found children with ASD to be more likely to have unsatisfactory BMI values at either the underweight or obese extremes of the range, a greater degree of inadequate intake, high food selectivity as indicated by their consumption frequency, and more disruptive mealtime behavior than neurotypical children. We suggest monitoring nutritional inadequacies and implementing nutritional strategies to expand the variety of foods children with ASD consume. The link between more disruptive eating behaviors and greater nutritional inadequacy might encourage parents and therapists in their endeavors to improve such behaviors even before body composition becomes affected.

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CONFLICT OF INTEREST

The authors declare that they have no conflicts of interest.

AUTHOR CONTRIBUTIONS

Jorge Molina-López and Beatriz-Leiva García carried out the collection, analysis, and interpretation of data, and drafted the manuscript. Jorge M. López, Beatriz-Leiva García, Elena Planells, and Paloma Planells recruited the patients and collected nutritional data. Elena Planells, and Paloma Planells designed the study. Jorge M. López, Beatriz-Leiva García, Elena Planells helped in the analysis and interpretation of the data. Jorge M. López, Beatriz-Leiva García helped to draft the manuscript. All authors read and approved the final manuscript.

DATA AVAILABILITY STATEMENT

The data that support the findings of this study are available on request from the corresponding author. The data are not publicly available due to privacy or ethical restrictions.

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REFERENCES

Adams, J. B., Johansen, L. J., Powell, L. D., Quig, D., & Rubin, R. A. (2011). Gastrointestinal flora and gastrointestinal status in children with autism – Comparisons to typical children and correlation with autism severity. *BMC Gastroenterology*, *11*(1), 22. https://doi.org/10.1186/1471-230X-11-22

American Psychiatric Association. (2013). Diagnostic and statistical manual of mental disorders: DSM-5.

Aranceta Bartrina, J., Arija Val, V., Maíz Aldalur, E., Martínez de la Victoria Muñoz, E., Ortega Anta, R. M., Pérez-Rodrigo, C., … Serra Majem, L. (2016). Dietary guidelines for the Spanish population (SENC, December 2016); the new graphic icon of healthy nutrition. *Nutrición Hospitalaria*, *33*(Suppl. 8), 1–48. https://doi.org/10.20960/nh.827

Ashley, K., Steinfeld, M. B., Young, G. S., & Ozonoff, S. (2020). Onset, trajectory, and pattern of feeding difficulties in toddlers later diagnosed with autism. *Journal of Developmental and Behavioral Pediatrics: JDBP*, *41*(3), 165–171. https://doi.org/10.1097/DBP.0000000000000757

Bandini, L. G., Anderson, S. E., Curtin, C., Cermak, S., Evans, E. W., Scampini, R., … Must, A. (2010). Food selectivity in children with autism spectrum disorders and typically developing children. *The Journal of Pediatrics*, *157*(2), 259–264. https://doi.org/10.1016/j.jpeds.2010.02.013

Bandini, L. G., Curtin, C., Phillips, S., Anderson, S. E., Maslin, M., & Must, A. (2017). Changes in food selectivity in children with autism spectrum disorder. *Journal of Autism and Developmental Disorders*, *47*(2), 439–446. https://doi.org/10.1007/s10803-016-2963-6

Barrett-Connor, E. (1991). Nutrition epidemiology: How do we know what they ate? *The American Journal of Clinical Nutrition*, *54*(1), 182S–187S. https://doi.org/10.1093/ajcn/54.1.182S

Burrows, T. L., Martin, R. J., & Collins, C. E. (2010). A systematic review of the validity of dietary assessment methods in children when compared with the method of doubly labeled water. *Journal of the American Dietetic Association*, *110*(10), 1501–1510. https://doi.org/10.1016/j.jada.2010.07.008

Castro, K., Faccioli, L. S., Baronio, D., Gottfried, C., Perry, I. S., & Riesgo, R. (2016). Feeding behavior and dietary intake of male children and adolescents with autism spectrum disorder: A case-control study. *International Journal of Developmental Neuroscience*, *53*, 68–74. https://doi.org/10.1016/j.ijdevneu.2016.07.003

Castro, K., Slongo Faccioli, L., Baronio, D., Gottfried, C., Schweigert Perry, I., & Riesgo, R. (2017). Body composition of patients with autism spectrum disorder through bioelectrical impedance. *Nutrición Hospitalaria*, *34*(4), 875–879. https://doi.org/10.20960/nh.210

Cermak, S. A., Curtin, C., & Bandini, L. G. (2010). Food selectivity and sensory sensitivity in children with autism spectrum disorders. *Journal of the American Dietetic Association*, *110*(2), 238–246. https://doi.org/10.1016/j.jada.2009.10.032

Chan, R. S. M., & Woo, J. (2010). Prevention of overweight and obesity: How effective is the current public health approach. *International Journal of Environmental Research and Public Health*, *7*(3), 765–783. https://doi.org/10.3390/ijerph7030765

Chistol, L. T., Bandini, L. G., Must, A., Phillips, S., Cermak, S. A., & Curtin, C. (2018). Sensory sensitivity and food selectivity in children with autism spectrum disorder. *Journal of Autism and Developmental Disorders*, *48*(2), 583–591. https://doi.org/10.1007/s10803-017-3340-9

Criado, K. K., Sharp, W. G., McCracken, C. E., De Vinck-Baroody, O., Dong, L., Aman, M. G., … Scahill, L. (2018). Overweight and obese status in children with autism spectrum disorder and disruptive behavior. *Autism*, *22*(4), 450–459. https://doi.org/10.1177/1362361316683888

Cuervo, M., Corbalán, M., Baladía, E., Cabrerizo, L., Formiguera, X., Iglesias, C., … Alfredo Martínez, J. (2009). Comparison of dietary reference intakes (DRI) between different countries of the European Union, the United States and the World Health Organization. *Nutrición Hospitalaria*, *24*(4), 384–414.

Curtin, C., Hubbard, K., Anderson, S. E., Mick, E., Must, A., & Bandini, L. G. (2015). Food selectivity, mealtime behavior problems, spousal stress, and family food choices in children with and without autism spectrum disorder. *Journal of Autism and Developmental Disorders*, *45*(10), 3308–3315. https://doi.org/10.1007/s10803-015-2490-x

Dovey, T. M., Kumari, V., Blissett, J., & Mealtime Hostage Parent Science Gang. (2019). Eating behaviour, behavioural problems and sensory profiles of children with avoidant/restrictive food intake disorder (ARFID), autistic spectrum disorders or picky eating: Same or different? *European Psychiatry: The Journal of the Association of European Psychiatrists*, *61*, 56–62. https://doi.org/10.1016/j.eurpsy.2019.06.008

Eddy, K. T., & Thomas, J. J. (2019). Introduction to a special issue on child and adolescent feeding and eating disorders and avoidant/restrictive food intake disorder. *International Journal of Eating Disorders*, *52*(4), 327–330. https://doi.org/10.1002/eat.23052

Esteban-Figuerola, P., Canals, J., Fernández-Cao, J. C., & Arija Val, V. (2019). Differences in food consumption and nutritional intake between children with autism spectrum disorders and typically developing children: A meta-analysis. *Autism*, *23*(5), 1079–1095. https://doi.org/10.1177/1362361318794179

Esteban-Figuerola, P., Morales-Hidalgo, P., Arija-Val, V., & Canals-Sans, J. (2021). Are there anthropometric and body composition differences between children with autism spectrum disorder and children with typical development? Analysis by age and spectrum severity in a school population. *Autism*, *25*(5), 1307–1320. https://doi.org/10.1177/1362361320987724

Fritz, C. O., Morris, P. E., & Richler, J. J. (2012). Effect size estimates: Current use, calculations, and interpretation. *Journal of Experimental Psychology. General*, *141*(1), 2–18. https://doi.org/10.1037/a0024338

Graf-Myles, J., Farmer, C., Thurm, A., Royster, C., Kahn, P., Soskey, L., … Swedo, S. (2013). Dietary adequacy of children with autism compared with controls and the impact of restricted diet. *Journal of Developmental and Behavioral Pediatrics: JDBP*, *34*(7), 449–459. https://doi.org/10.1097/DBP.0b013e3182a00d17

Hendy, H. M., Seiverling, L., Lukens, C. T., & Williams, K. E. (2013). Brief assessment of mealtime behavior in children: Psychometrics and association with child characteristics and parent responses. *Children's Health Care*, *42*(1), 1–14. https://doi.org/10.1080/02739615.2013.753799

Herndon, A. C., DiGuiseppi, C., Johnson, S. L., Leiferman, J., & Reynolds, A. (2009). Does nutritional intake differ between children with autism spectrum disorders and children with typical development? *Journal of Autism and Developmental Disorders*, *39*(2), 212–222. https://doi.org/10.1007/s10803-008-0606-2

Hubbard, K. L., Anderson, S. E., Curtin, C., Must, A., & Bandini, L. G. (2014). A comparison of food refusal related to characteristics of food in children with autism spectrum disorder and typically developing children. *Journal of the Academy of Nutrition and Dietetics*, *114*(12), 1981–1987. https://doi.org/10.1016/j.jand.2014.04.017

Hyman, S. L., & Johnson, J. K. (2012). Autism and pediatric practice: Toward a medical home. *Journal of Autism and Developmental Disorders*, *42*(6), 1156–1164. https://doi.org/10.1007/s10803-012-1474-3

Hyman, S. L., Stewart, P. A., Schmidt, B., Cain, U., Lemcke, N., Foley, J. T., … Ng, P. K. (2012). Nutrient intake from food in children with autism. *Pediatrics*, *130*(Suppl. 2), S145–S153. https://doi.org/10.1542/peds.2012-0900L

Jensky-Squires, N. E., Dieli-Conwright, C. M., Rossuello, A., Erceg, D. N., McCauley, S., & Schroeder, E. T. (2008). Validity and reliability of body composition analysers in children and adults. *The British Journal of Nutrition*, *100*(4), 859–865. https://doi.org/10.1017/S0007114508925460

Johnson, C. R., Turner, K., Stewart, P. A., Schmidt, B., Shui, A., Macklin, E., … Hyman, S. L. (2014). Relationships between feeding problems, behavioral characteristics and nutritional quality in children with ASD. *Journal of Autism and Developmental Disorders*, *44*(9), 2175–2184. https://doi.org/10.1007/s10803-014-2095-9

Kamal Nor, N., Ghozali, A. H., & Ismail, J. (2019). Prevalence of overweight and obesity among children and adolescents with autism spectrum disorder and associated risk factors. *Frontiers in Pediatrics*, *7*, 38. https://doi.org/10.3389/fped.2019.00038

Kral, T. V. E., Souders, M. C., Tompkins, V. H., Remiker, A. M., Eriksen, W. T., & Pinto-Martin, J. A. (2015). Child eating behaviors and caregiver feeding practices in children with autism Spectrum disorders. *Public Health Nursing*, *32*, 488–497. https://doi.org/10.1111/phn.12146

Kraemer, H. C., & Kupfer, D. J. (2006). Size of Treatment Effects and Their Importance to Clinical Research and Practice. *Biological Psychiatry*, *59*(11), 990–996. https://doi.org/10.1016/j.biopsych.2005.09.014

Leader, G., Tuohy, E., Chen, J. L., Mannion, A., & Gilroy, S. P. (2020). Feeding problems, gastrointestinal symptoms, challenging behavior and sensory issues in children and adolescents with autism spectrum disorder. *Journal of Autism and Developmental Disorders*, *50*(4), 1401–1410. https://doi.org/10.1007/s10803-019-04357-7

Leiva-García, B., Planells, E., Planells Del Pozo, P., & Molina-López, J. (2019). Association between feeding problems and oral health status in children with autism spectrum disorder. *Journal of Autism and Developmental Disorders*, *49*(12), 4997–5008. https://doi.org/10.1007/s10803-019-04211-w

Lenhard, W., & Lenhard, A. (2017, October 1). Computation of effect sizes. https://doi.org/10.13140/RG.2.2.17823.92329

Malhi, P., Venkatesh, L., Bharti, B., & Singhi, P. (2017). Feeding problems and nutrient intake in children with and without autism: A comparative study. *The Indian Journal of Pediatrics*, *84*(4), 283–288. https://doi.org/10.1007/s12098-016-2285-x

Marí-Bauset, S., Llopis-González, A., Zazpe, I., Marí-Sanchis, A., & Morales Suárez-Varela, M. (2017). Comparison of nutritional status between children with autism spectrum disorder and typically developing children in the Mediterranean region (Valencia, Spain). *Autism*, *21*(3), 310–322. https://doi.org/10.1177/1362361316636976

Marí-Bauset, S., Llopis-González, A., Zazpe-García, I., Marí-Sanchis, A., & Morales-Suárez-Varela, M. (2015). Nutritional status of children with

autism spectrum disorders (ASDs): A case-control study. *Journal of Autism and Developmental Disorders*, *45*(1), 203–212. https://doi.org/10.1007/s10803-014-2205-8

Mataix, J. (2011). *Food composition tables* (1, 5th ed.). Granada: University of Granada.

McCarthy, H. D., Cole, T. J., Fry, T., Jebb, S. A., & Prentice, A. M. (2006). Body fat reference curves for children. *International Journal of Obesity*, *30*(4), 598–602. https://doi.org/10.1038/sj.ijo.0803232

Murphy, J., Zlomke, K., VanOrmer, J., & Swingle, H. (2020). Impact of disruptive behavior in childhood feeding difficulties. *Journal of Clinical Psychology in Medical Settings*, *27*(2), 406–415. https://doi.org/10.1007/s10880-019-09646-y

Nagy, P., Kovacs, E., Moreno, L. A., Veidebaum, T., Tornaritis, M., Kourides, Y., … IDEFICS consortium. (2014). Percentile reference values for anthropometric body composition indices in European children from the IDEFICS study. *International Journal of Obesity*, *38*(S2), S15–S25. https://doi.org/10.1038/ijo.2014.131

Neumeyer, A. M., Sokoloff, N. C., McDonnell, E. I., Macklin, E. A., McDougle, C. J., Holmes, T. M., … Misra, M. (2018). Nutrition and bone density in boys with autism spectrum disorder. *Journal of the Academy of Nutrition and Dietetics*, *118*(5), 865–877. https://doi.org/10.1016/j.jand.2017.11.006

Peverill, S., Smith, I. M., Duku, E., Szatmari, P., Mirenda, P., Vaillancourt, T., … Ungar, W. J. (2019). Developmental trajectories of feeding problems in children with autism spectrum disorder. *Journal of Pediatric Psychology*, *44*(8), 988–998. https://doi.org/10.1093/jpepsy/jsz033

Schreck, K. A., Williams, K., & Smith, A. F. (2004). A comparison of eating behaviors between children with and without autism. *Journal of Autism and Developmental Disorders*, *34*(4), 433–438. https://doi.org/10.1023/b:jadd.0000037419.78531.86

Serra-Majem, L., Ribas-Barba, L., Pérez-Rodrigo, C., & Bartrina, J. A. (2006). Nutrient adequacy in Spanish children and adolescents. *The British Journal of Nutrition*, *96*(Suppl. 1), S49–S57. https://doi.org/10.1079/bjn20061701

Sharp, W. G., Berry, R. C., Burrell, L., Scahill, L., & McElhanon, B. O. (2020). Scurvy as a sequela of avoidant-restrictive food intake disorder in autism: A systematic review. *Journal of Developmental & Behavioral Pediatrics*, *41*(5), 397–405. https://doi.org/10.1097/DBP.0000000000000782

Sharp, W. G., Berry, R. C., McCracken, C., Nuhu, N. N., Marvel, E., Saulnier, C. A., … Jaquess, D. L. (2013). Feeding problems and nutrient intake in children with autism spectrum disorders: A meta-analysis and comprehensive review of the literature. *Journal of Autism and Developmental Disorders*, *43*(9), 2159–2173. https://doi.org/10.1007/s10803-013-1771-5

Sharp, W. G., Postorino, V., McCracken, C. E., Berry, R. C., Criado, K. K., Burrell, T. L., & Scahill, L. (2018). Dietary intake, nutrient status, and growth parameters in children with autism spectrum disorder and severe food selectivity: An electronic medical record review. *Journal of the Academy of Nutrition and Dietetics*, *118*(10), 1943–1950. https://doi.org/10.1016/j.jand.2018.05.005

Shmaya, Y., Eilat-Adar, S., Leitner, Y., Reif, S., & Gabis, L. (2015). Nutritional deficiencies and overweight prevalence among children with autism spectrum disorder. *Research in Developmental Disabilities*, *38*, 1–6. https://doi.org/10.1016/j.ridd.2014.11.020

Striegel-Moore, R. H., Rosselli, F., Perrin, N., DeBar, L., Wilson, G. T., May, A., & Kraemer, H. C. (2009). Gender difference in the prevalence of eating disorder symptoms. *International Journal of Eating Disorders*, *42*(5), 471–474. https://doi.org/10.1002/eat.20625

Thullen, M., & Bonsall, A. (2017). Co-parenting quality, parenting stress, and feeding challenges in families with a child diagnosed with autism spectrum disorder. *Journal of Autism and Developmental Disorders*, *47*(3), 878–886. https://doi.org/10.1007/s10803-016-2988-x

Wentz E.Björk A., & Dahlgren J. (2019). Is there an overlap between eating disorders and neurodevelopmental disorders in children with obesity? *Nutrients*, *11*(10), 2496. https://doi.org/10.3390/nu11102496

Zimmer, M. H., Hart, L. C., Manning-Courtney, P., Murray, D. S., Bing, N. M., & Summer, S. (2012). Food variety as a predictor of nutritional status among children with autism. *Journal of Autism and Developmental Disorders*, *42*(4), 549–556. https://doi.org/10.1007/s10803-011-1268-z

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