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A CROSS-SECTIONAL STUDY ON NUTRITIONAL PROFILE AND FOOD BEHAVIOUR OF AUTISTIC CHILDREN

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ABSTRACT

The health and nutritional profile of autistic children are greatly influenced by their abnormal food behaviours which is further compounded with mal-digestion and malabsorption. The present work was aimed to elicit the nutritional status and food behaviour, and to explore the influence of atypical behaviours and dietary restrictions on the nutritional status of autistic children identified as per DSM IV criteria. Sixty autistic children both boys and girls in the age group of 5-16 years were assessed. The study revealed that 70% children were shorter and 65% of them were lighter than the NCHS standards. The majority of children had normal haemoglobin level and the immunoglobulin (Ig) G and IgA levels were more or less normal but IgE levels were markedly elevated in all the children. Food selectivity, appetite and picky eating were the predominant factors that altered their food habits. Classical food behaviour of these children impaired their nutritional status and wellbeing.

Keywords: Autistic children, BMI, food behaviours, haemoglobin, immunoglobin, nutritional profile

INTRODUCTION

Autism spectrum disorder (ASD) is a complex neurodevelopmental condition that occurs early in childhood and is characterised by impairments in social communication, restricted interests and repetitive behaviours (APA, 2013). It is estimated that the prevalence of autism globally is 1 in 132 (Baxter, 2015) and a study conducted in India found the prevalence rates to be 1% in 2-6-year old and 1.4% in 6-9-year old children (Arora, 2018). The children with autism have impaired nutritional and health status. There is a growing consensus that poor nutritional status during childhood has long-lasting scarring consequences in adulthood, both in terms of health and mortality, and in terms of other measures of human capital (Glewwe and Miguel, 2007). Well-nourished children have high alertness and better stamina to participate in therapies, educational activities and social interactions thereby are less susceptible to diseases and possess improved coping skills. When behaviour involves eating disorders, it may lead to the situations of clinical or subclinical malnutrition. It is unclear whether autistic children suffer from the hidden symptoms of malnutrition or not. Many children with ASD have immune system abnormality and suffer from infections (Shaw, 2002).

Dietary factors play a vital role in maintaining the immune defense, because malnutrition is the most common cause of secondary immunodeficiency all over the world, which impairs cell-mediated immunity that is altered at an early stage in the development of undernutrition (Bourke, 2016). The behavioural characteristics of autistic children are also manifested in their food habits

making them vulnerable to the nutritional deficiencies and undernutrition (da Silva and Gomes, 2024). Food behaviours and food habits play a crucial role in the health and well-being of children. The present study was aimed to examine some crucial factors like nutritional status and food behaviour in autism and to explore the impact of atypical behaviour and dietary restrictions on the nutritional status of autistic children.

MATERIALS AND METHODS

Selection and grouping of autistic children

The present study was conducted in the year 2021 at the Dolphin and Seagul Special School and Center, Tiruchirappalli, Tamil Nadu (India). Sixty children, identified to be autistic by DSM IV criteria of APA (Segal, 2000), both boys and girls in the age group of 5-16 years were selected for this study. The children taking medications for other ailments such as seizures or hyperactivity were excluded from the study. The children comparable in terms of the therapies received and schooling were chosen as subjects for the present study. Formal consent was obtained from the school authorities as well as from the individual's parents. The prior approval was obtained from the Human Ethical Committee of the University (vide HEC.2010.15) for the conduct of this study.

Assessment of nutritional status

Comprehensive nutritional assessment involved the evaluation by anthropometric, clinical, biochemical and dietary methods (Srilakshmi, 2006). The anthropometric measurements were used as proxies for assessing the eventual extent and severity of malnutrition. The most commonly used measurements were: body weight and height based on the age and sex of each individual. The height of all the subjects were measured using a fibre glass measuring tape. Since height is affected only by long-term nutritional deprivation, it was considered as an index of chronic or long duration malnutrition (Rao *et al*., 2010). From the recorded weight and height of individual child the body mass index (BMI) was worked out as ratio of weight (kg) to height (m). The BMI-age-percentiles were calculated using the growth chart developed by the Center for Disease Control and Prevention (*https://www.cdc.gov/growthcharts/clinical_charts.htm*). The clinical examination was done for all the individuals using the World Health Organisation (WHO) clinical assessment proforma (Jelliffe, 1966). Changes in hair, eyes, mouth and teeth were recorded with the help of a physician.

Biochemical methods for nutritional assessment were used to recognize acute malnutrition, confirm the clinical diagnosis of a deficiency disease and detect the subclinical micronutrient deficiencies (Truswell and Mann, 2007). Since autism is an immune deficiency disorder as per theory, the immune status of children was assessed by determining the immuno-globulin (Ig) G, A and E through immuno-turbidimetry method (Otsuji, 1982). Further, iron deficiency is found to be associated with certain behaviour patterns in autistic children, therefore haemoglobin was tested through cyanmethaemoglobin method (Dacie and Lewis, 1991) and the grading of anaemia was done as per the WHO guidelines (WHO, 1989).

A weighment survey was conducted by food weighment method (Srilakshmi, 2006) using the weighment form for three days among the families of all the 60 selected autistic children. From the individual consumption, raw equivalents were calculated and nutrient intake computed using the food composition table (Gopalan *et al*., 2007). A comparison of food and nutrient intake of the selected children with recommended dietary allowance (RDA) was also done.

Assessment of food behaviour of autistic children

Children with autism have feeding difficulties and unusual eating patterns. Many of these youngsters have extremely limited food repertoire, which is likely related to sensory regulatory difficulties, desire for sameness, or other issues (Williams, 2000). An interview schedule was

developed to study the eating habits and feeding problems of autistic children. The parents were oriented about different food behaviours exhibited by the autistic children and were guided by the investigator to fill in the details appropriately pertaining to their child.

Statistical design and data analysis

Data were analysed by GraphPad Prism 9.3.1. The mean, ranges, and standard deviation of the height, weight and IgG, IgA and IgE levels were compared using the ANOVA test. Haemoglobin level group-wise comparison and food intake was performed using independent t-test and correlation for nutrient intake. The level of significance was set at $p < 0.05$.

RESULTS AND DISCUSSION

Anthropometric measurements

The height in relation with age is a preferred measure of determining the long-term nutritional status since weight is liable to change within a short time. Autistic boys aged 5-6, 12-13 and 13-14 yr were shorter than the NCHS standards (Table 1). Stuntedness among children is usually due to long term malnutrition which could be due to their classical behaviour pattern affecting their activities and consumption of food. Boys between 6-11 yr were found at par with their NCHS counterparts. Autistic girls of all ages, except the 9-10 yr group, were shorter than the NCHS standards depicting their poor nutritional status due to inadequate nutritional intake which has been compounded by their erratic food habits and food behaviours commonly presented by the autistic children.

Table 1: The mean height (cm) and weight (kg) increments of autistic children

Age group (yrs)	Boys			Girls			Boys		Girls	
	N	NCHS standard height	Mean height*	N	NCHS standard height	Mean height	NCHS standard weight	Mean weight*	NCHS standard weight	Mean weight
5 - 6	15	109.9	104.3 ± 2.4	2	108.4	95 ± 3.3	18.7	14.9 ± 3.8	17.7	11.0 ± 3.2
6 - 7	2	116.1	119.5 ± 2.1	2	114.6	113 ± 1.3	20.7	18.0 ± 3.2	19.5	28.5 ± 3.5
7 - 8	11	121.7	122.6 ± 2.9	1	120.6	110 ± 2.8	22.9	22.5 ± 2.8	21.8	16.0 ± 2.9
9 - 10	6	132.3	131.0 ± 1.8	1	132.2	137 ± 2.9	28.1	24.7 ± 2.9	28.5	45.0 ± 2.9
10 - 11	4	137.5	139.5 ± 2.9	1	138.3	126 ± 2.5	31.4	27.0 ± 2.6	32.5	18.0 ± 2.6
12 - 13	3	149.7	144.7 ± 3.1	nil	nil	nil	39.8	33.0 ± 2.9	nil	nil
13 - 14	6	156.0	153.5 ± 1.9	1	157.1	122 ± 3.1	45.0	45.8 ± 2.8	46.1	28.0 ± 5.8
16 - 15	nil	nil	Nil	5	162.4	150 ± 3.2	nil	nil	55.9	57.6 ± 3.8

*Significant at 5% level

The entire group of autistic boys were lighter in comparison to the NCHS standards (Table 1). The autistic features in many children were coupled with hyperactivity and bizarre eating habits, which are major concern. Autistic girls aged 6-7, 9-10, and 16 -17 yr were heavier than their NCHS counterparts, whereas autistic girls belonging to the other age groups weighed lesser than the standard. Clinical observations suggest that autistic children may be at increased risk for overweight due to fewer opportunities to engage in structured physical activity, social isolation, increased sedentary behaviour and unusual dietary pattern (Curtin, 2005). The weight deficiency in autistic girls is an indicator of their food selectivity and poor attention they receive at home. The height and weight of autistic boys was significantly greater at $p < 0.05$ when compared with autistic girls.

The BMI percentile calculated for autistic children revealed that about 36.7% boys and 6.7% girls were underweight (Table 2). BMI of males was significantly lower than females when compared with age matched reference population. Underweight in these children was mainly attributed to their altered food behaviours, with low food intake. Some of the autistic children were

Table 2: BMI percentiles of the autistic children

Status	Male	Female
	N	N
Underweight (5th centile)	22 (36.7%)	4 (6.7%)
Normal (5th-85th centiles)	22 (36.7%)	4 (6.7%)
At-risk-for-overweight (85th-95th centiles)	1 (1.6%)	1 (1.6%)
Overweight (> 95th centile)	2 (3.3%)	4 (6.7%_

The values in brackets represent percentage

found to be hyperactive which is caused by under-weightness.

There were 36.7% boys and 6.7% girls with optimal weight, 1.6% each of boys and girls studied were at risk for overweight. The study group consisted of a large number of over-weight children. More number of girls (6.7%) than boys (3.3%) were over-weight, since they were constrained to their home owing to menarche and had very less play or physical activities.

Biochemical parameters

The haemoglobin status of autistic children revealed the overall mean haemoglobin levels of 11.8 g dL^{-1} in children of 5-11 yr age as against the WHO standard of 11.5 g dL^{-1} (Table 3) which is a good indicator of their nutritional status. In 25% children who were in the age group of 12-16 yr the mean haemoglobin level was 12.2 g dL^{-1} which is at par with WHO standard. Cook *et al*. (2002) stated than iron deficiency, with or without anaemia, can impair cognition and is associated with mood changes and poor concentration in children. Mean haemoglobin levels of autistic children was significantly higher ($p < 0.05$) when compared with the standard haemoglobin levels.

Table 3: Mean blood haemoglobin levels of the autistic children (g dL^{-1})

Age group (years)	N	Standard haemoglobin level (WHO)	Mean haemoglobin level*
5 - 11	45 (75%)	11.5	11.8 ± 0.65
12 - 16	15 (25%)	12.0	12.2 ± 0.58

*Significant at 5% level; N = Number of autistic children in the group;
The values in brackets represent percentage

IgG, IgA and IgE levels was recorded for all the autistic children (Table 4). IgG antibodies may be involved in causing food allergies. The mean IgG levels of autistic boys ranged from 1029-1324 mg dL^{-1} which was within the normal range of 700-1600 mg dL^{-1}. In spite of their poor nutritional status and atypical food behaviours, the children maintained normal IgG level. The mean IgG levels of autistic girls ranged from 780-1491 mg dL^{-1}, though they were within the normal range, the children of 7 and 13 yr age had the IgG values in lower normal range.

Table 4: Mean blood IgG, IgA and IgE levels (mg dL^{-1}) of autistic children

Age		Boys		Girls	Boys	Girls	Boys	Girls
(yr)	N	IgG*	N	IgG	IgA*	IgA	IgE*	IgE
5	15	1029.1 ± 0.65	2	1294.5 ± 2.10	149.1 ± 0.98	128.9 ± 1.54	942.9 ± 1.32	793.7 ± 1.36
6	2	1218.5 ± 1.20	2	1491.5 ± 2.14	142.0 ± 1.56	190.8 ± 1.69	312.0 ± 1.23	420.7 ± 1.73
7	11	1128.8 ± 1.54	1	780.0 ± 1.98	131.5 ± 1.35	14.0 ± 1.58	583.7 ± 1.54	27.3 ± 0.32
9	6	1207.7 ± 1.26	1	1444.0 ± 1.84	121.2 ± 1.65	246.0 ± 2.10	1092.5 ± 1.27	804.6 ± 2.50
10	4	1125.2 ± 1.56	1	1140.0 ± 1.64	198.2 ± 1.39	172.0 ± 1.24	384.2 ± 2.10	105.0 ± 1.29
12	3	1324.3 ± 1.24	nil	Nil	169.7 ± 1.87	nil	118.7 ± 1.78	nil
13	6	1088.0 ± 1.02	1	903.0 ± 2.12	170.7 ± 1.39	123.0 ± 1.57	426.3 ± 1.64	435.0 ± 1.31
16	nil	nil	5	1230.6 ± 2.16	nil	173.8 ± 1.52	nil	375.9 ± 1.24

*Significant at 5% level

IgA is involved in protecting the nasal and intestinal lining from microbial infections. The IgA levels recorded in autistic boys ranged from 121 to 198 mg dL^{-1}. The values were within the normal range (72-400 mg dL^{-1}), however it was observed that all the autistic boys recorded IgA values in lower normal range. The mean immunoglobulin levels of autistic girls were as low as 14 mg dL^{-1} in

7 yr old and 246 mg dL^{-1} in 9 yr old girls. These children with immunoglobulins in borderline would be more susceptible to infections if their system is challenged by a strong antigen.

The mean IgE levels registered for autistic boys of 5-9 yr age group was very high, ranging from 312 to 1092 mg dL^{-1}, and it was 27 to 804 mg dL^{-1} in autistic girls as against the normal range of 0-52 mg dL^{-1}. IgE antibody is mostly involved in allergies of all kinds. Elevated IgE in blood is associated with a history of excessive allergies. The mean IgE levels of autistic boys in 10-16 yr age group was 118 to 426 mg dL^{-1} and in autistic girls 105-435 mg dL^{-1}. Abnormal immunoglobulins such as increased IgE may reflect the dis-regulation of immune system in persons with autism (Trajkovski *et al*., 2008). The mean IgG, IgA and IgE levels of autistic boys was greater than girls and was significant at $p < 0.05$.

Clinical findings

There were no specific clinical signs observed in autistic children. However, xerosis of skin was present in two children; flaky paint dermatosis, local skeletal deformity and beading of ribs which are the signs of vitamin A and vitamin D deficiency were found in one child each, respectively.

Food and nutrient intake of autistic children

The mean food intake of autistic children was compared with the recommended dietary allowances (RDA) suggested by Indian Council of Medical Research (ICMR) in terms of childhood group (5 -9 yr) and adolescent group (10-16 yr)[Table 5]. The cereals and millets are the main source of energy, and study revealed that cereal and pulse intake were less in both the groups as compared to the recommended RDA, explaining the cause of underweight in autistic children. The vegetable intake such as green leafy vegetable, roots and tubers and other vegetables was only 50% of the RDA. Since many of these children exhibited chewing difficulties there was a high degree of dislike towards vegetable preparations and the fruit intake was < 50%. All children consumed milk with added commercial health mixes or in the form of tea and coffee. It was found that the fat and sugar intake was more than RDA which may be attributed to the consumption of junk foods and sweets. Autistic children consumed deficit quantities of all the foods and excess of concentrated source of energy but the mean food intake was significantly higher ($p<0.05$) in 10-16 yr group.

Table 5: Food intake per day of autistic children

Foods	5-6 years		7-9 years	
	Mean intake	RDA (ICMR)	Mean intake*	RDA (ICMR)
Cereals and millets	212.1	240	301.1	330
Pulses	44.1	52.5	47.0	60
Green leafy vegetables	35.2	75	42.3	100
Roots and tubers	51.9	100	64.3	100
Other vegetables	42.1	75	52.9	100
Fruits	44.4	100	51.2	100
Milk and milk products	276.2	500	352	500
Fats and oils	28.0	25	26.9	25
Sugar and jiggery	37.9	30	40.9	30

*Significant at 5% level

Nutrient intake of autistic children

The mean nutrient intake of autistic children as compared to the RDA is shown in Table 6. Energy and protein intake was marginally less, and fat intake more in both the groups of children, due to the consumption of junk foods and confectionaries. Calcium and iron intake was less in both the groups due to the lower intake of dairy products and green leafy vegetables. β-carotene intake was < 50% of the intake recommended by ICMR which may mainly be attributed to the low quantities of green leafy vegetables and vegetable intake.

All the three B-vitamins, i.e. thiamine, riboflavin and niacin, were less than the safe daily intake. Vitamin C intake was only about 50% of the recommended intake by ICMR which reflects their poor intake of fruits and vegetables. Deficiencies of vital nutrients in the diet of autistic children compromise their immune system and make them more vulnerable to the infections and

Table 6: Mean nutrient intake per day of autistic children

Nutrient intake day^{-1}	5-6 years		7-9 years	
	Mean intake	RDA ICMR	Mean intake*	RDA ICMR
Energy (kcal)	1383.6	1520	2006.3	2320
Protein (g)	18.0	24.8	26.2	46.6
Fat (g)	28.1	27.5	37.8	38.8
Calcium (mg)	384.7	600	426.5	800
Iron (mg)	10.2	14.5	12.9	26.8
β–carotene (µg)	1715.5	4000	2078.9	4800
Thiamine (mg)	0.6	0.75	0.86	1.2
Riboflavin (mg)	0.6	0.9	0.97	1.2
Niacin (mg)	8.2	12	11.5	14.5
Vitamin C (mg)	24.6	40	26.7	40

*Significant at 5% level

deficiency disorders. Autistic children consumed deficit quantities of most vital nutrients and excess of energy and fat, the mean nutrient intake was significantly higher ($p < 0.05$) in 10-16 yr age group.

Food behaviours of the autistic children

The dietary habits of autistic children revealed that they had certain food beliefs, food allergies and mal-digestion of specific foods. The allergic responses to food were studied among the test samples, and 7 parents reported that their children exhibited allergic response to foods which were mostly due to physiological changes. None of the parent was aware of the behavioural changes due to the intake of specific foods. Majority of parents (90%) did not believe that food affected the behaviour of their children. A few parents (10%) cited that food definitely affected the behaviour of their child and certain foods such as sweets and confectionary made them more hyperactive and lead to increased abnormal behaviours. About 7% parents opined that their children had a certain degree of addiction to milk and milk products aggravated due their abnormal behaviours.

Food selectivity is a characteristic phenomenon in autistic children. A good appetite in children is an indicator of good health. In this study appetite of 60% children was good for the foods they liked alone and in 40% children it was good for most of the foods (Table 7). Intense food selectivity compounded this aspect making them vulnerable to the malnutrition. However, none of the children's appetite was found bad.

Table 7: Food selectivity of autistic children

Parameters	Details	No. (%)
Appetite	Good for the foodsliked	36 (60.0)
	Good for most of the foods	24 (40.0)
Picky eating	Present	50 (83.3)
	Absent	10 (16.7)
Factors affecting food selection	Taste	46 (76.7)
	Texture	6 (10.0)
	Temperature	10 (16.7)
	Smell	26 (43.3)
	Appearance	22 (36.7)

Picky eating was found in 83.3% children, with various factors affecting their food choices. The greatest nutritional risk came not from refusing certain foods but from the diets with a limited variety or repertoire of foods. Autistic children had certain food addictions, many of them were sensitive to the taste of food, 76.7% children had strong inclination to the taste of food. The smell of food was other factor that led to the acceptance or rejection of food. The smell of foods that are not familiar and comfortable may affect the ability of a child to eat (Wheeler, 2004). About 44% children were in the habit of smelling the food before eating. Some children ate only homemade foods prepared in a particular style, while most children relished foods bought from restaurants and hotels. The appearance of food was also a matter of concern for 36.7% children who ate the food only when it was presented in a particular form. Similarly, 16.7% children ate the food only when they were warm and at room temperature and they avoided the foods that were at extremes of temperature. Around 10% children were particular about the texture of food, while some children avoided foods that were sticky and gelatinous while a few avoided hard and crispy items.

Specific food behaviours of autistic children are presented in Table 8. The food behaviours of autistic children were unique and much different from a normal child. One of the characteristic features of autistic children was to insist on rituals, such as eating in the same plate or same place. This habit existed in all the children studied. Lowe (2010) stated that autistic children tend to refuse refuse more foods and are more likely to restrict their diets to a smaller variety of foods than other children. Most children were in the habit of swallowing the food without proper mastication, 61.7% children refrained from chewing the food and swallowed both hard and soft foods, though they were repeatedly insisted to chew the foods. Feeding the autistic children was laborious in 23.3% as they exhibited the habit of packing the food in their mouth, held the food in mouth for a prolonged period without chewing and it took 30-60 min to feed the child a single meal. About 30% children were in the habit of spitting away the food. The foods that were commonly spitted out included the vegetables and hard foods. It was found that 41.7% children threw away the food during self-feeding process or toppled the foods when they were fed by their mothers or care givers. This attitude persistently existed in the children though their mothers adopted certain changes in cooking methods and made their children eat under the supervision of teacher or care taker.

Table 8: Food behaviours of autistic children

Food behavior	N	Percentage
Insisting on rituals	29	48.3
Trouble chewing food	37	61.7
Holding food in mouth	14	23.3
Spitting food	18	30.0
Throwing food	25	41.7
Pica	21	35.0
Mouthing objects	19	31.7
Smelling food	26	43.3
Eating in certain places	27	45.0
Not trying new foods	31	51.7
Specific food preparations	23	38.3

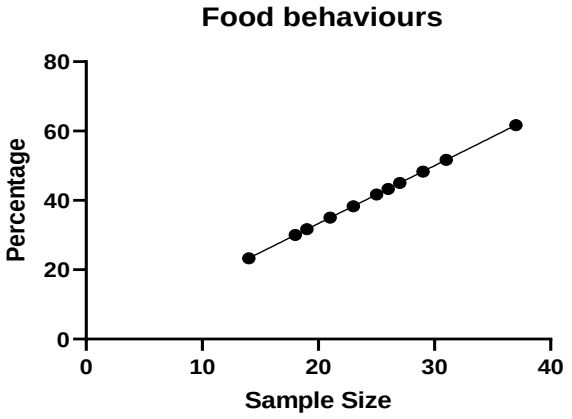

Fig. 1: Food behaviours of autistic children

Pica is common in people with developmental disabilities, including autism and mental retardation. About 35% autistic children exhibited this behaviour. Some children ate chalk, crayons, rubber or sometimes even inedible things and filth, because they were not able to discriminate edible foods from non-edible items. Mouthing the objects such as toys, coins, keys, pencils etc., was present in 31.7% children. Certain sensory characteristics were strong in autistic children. About 43.3% children smelt the food each time before eating. The acceptance or rejection of foods was mainly based on the flavour of food. Repetition and insisting on rituals were the characteristics of autistic children. They ate comfortably only in certain places, outside the home especially in public places like hotels and restaurants. This behaviour was observed in 45% children.

New things were always resisted by autistic children and this applied to the food as well. About 51.7% children were unwilling to try new foods and 38.3% children were accustomed to the taste and flavour of foods prepared in specific ways as they refused to eat the food, when it was prepared differently. For instance, some children would eat the food only if it was prepared by their mother, some had a liking to fried foods.

Conclusion: The anthropometric measurements such as height and weight in most autistic children were lower than the NCHS standards. The BMI percentile revealed maximum number of underweight children. The blood haemoglobin study revealed that 40% autistic children had mild

anaemia. The IgA and IgG levels were normal in most of the children IgE was abnormally elevated in all the children indicating an alteration in their immune system probably owing to food intolerances. Food and nutrient intakes were unsatisfactory. These children showed high degree of food selectivity and classic food behaviours which impacted their nutritional status. Nutrition education emphasizing the intake of balanced diet, dietary modification and establishing consistent change in food habits coupled with improved physical activities is crucial for promoting the nutritional status, health and well-being of autistic children.

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