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ABSTRACT

Introduction: There is increasing interest in relation to the involvement of diet in the etiology and treatment of Autistic Spectrum Disorder (ASD). A general concern observed is children with ASD may be at nutritional risk due to their behaviours around food and eating [4,11,26,27]. Minimal research has examined the effect of exclusion diets on nutritional intake [3]. The degree of dietary restrictions required when following an elimination diet has raised concerns that nutritional adequacy may be compromised in those children with ASD who are already vulnerable because of food fussiness, feeding difficulties, limited diets and out of the ordinary eating habits that go beyond the usual "picky eating" behaviour, seen in most children at specific developmental stages [4, 9]. Diet modification of a child with ASD is generally undertaken without the guidance of a qualified health professional. Improvident dietary changes may adversely compromise nutritional adequacy of a child already with difficult eating behaviours [3].

Methods: The nutritional intake of 73 ASD children who attended the allergy clinic at RPAH was analysed and compared to that of 41 Non ASD children. A series of validated questionnaires was used to assess nutritional adequacy of the study participants which included The Four-Day Diary were the child's dietary intake was analysed and nutritional adequacy assessed via the Percentage Recommended Daily Intake (RDI) given for macro-and micro-nutrients. The Food Frequency Questionnaire (FFQ) was used in this study to detect any differences in reported nutrient intakes which may have been apparent between the two dietary intake methodologies. The General Behaviour and Health Checklist for Children was used to establish whether caregivers had received information about various dietary modifications implemented.

Results: The results of our study revealed that the RDI recommendations for both cohorts were adequately met. There was no significant difference between the means of the nutrient intake of the two cohorts for the 4-Day Food Diary when assessed with a T-test. The different diets of the ASD cohort were compared, with only the intake of riboflavin found to be significantly different. A Post Hoc test revealed that it occurred between the Regular and Gluten/Casein Free Diet (GF/CF). The Dietary Guidelines for Children and Adolescences in Australia's (DGCCA) daily intake was not met for the Cereal food group; however, overall intake based on the food groups was similarly spread across the two cohorts. It was found that dietary advice was commonly undertaken without guidance of a qualified health professional.

Discussion: Children with ASD may be considered nutritionally "at risk" on an elimination diet, dietary investigations highlighted that the nutrient intake of children with ASD was analogous to that of Non ASD children and they adequately met recommendations for all the nutrients.

AIM

The aim of this investigation is to document the role of dietary behaviour on the health of children with ASD and determine whether the imposition of dietary restrictions/eliminations effect good nutrition, in the management of ASD children. In addition to determining the major sources of dietary advice sort by primary caregivers.

INTRODUCTION

Autism is a complex life-long developmental disability that affects the individual's understanding and interpretation of the world around them [3,7,28,29]. Often, autism is referred to as a triad of impairments as social communication; social interaction and imaginative understanding are affected [1,2,3]. Additional signs are obsessive repetitive behaviour, hyperactivity, self-injury and often selective eating [2,30].

An association between behavioural disorders and dietary intake was made as early as the mid sixties and has been associated with improvements in behaviour [2,8]. There is an ever- increasing interest in possible dietary involvement in the etiology and treatment of Autistic Spectrum Disorder (ASD). Research has focused on the physiological and behavioural effects of dietary change, but has not examined the effect of exclusion diets on nutritional intake [3].

Children with ASD have a range of behaviours that have an effect on the way that these children interact with foods. It is commonly observed those children with ASD show repetitive patterns of activity or behaviour and an obsessive desire to cling to routines and order [10,11]. Autistic children often present with food fussiness, feeding difficulties, limited diets, and out of the ordinary eating habits that go beyond the usual "picky eating" behaviour, seen in most children at specific developmental stages [4,9]. A general concern observed is children with ASD may be at nutritional risk due to their behaviours around food and eating [4,11,26,27]. It is currently not understood why food restrictions are so frequent in autism. Research in this area has postulated diet restrictions are simply a variant of other restricted activities seen in autism whilst others have connected the child's aversion to certain foods with sensory sensitivities in areas such as food smell and food texture [4,3].

The Royal Prince Alfred Hospital (RPAH) Allergy Unit has developed a special interest in the investigation of food problems, and has adapted their elimination diet and challenge program to examine children with behaviour problems, including those with ASD. The Simplified Elimination Diet (Refer to appendix 6) used at the RPAH was developed in the early 1980's. Although originally based on the elimination diets of Rowe [17], Shelley [18,] Feingold [19] and Warin and Smith [20], the diet at RPAH is further restricted as a result of extensive examination of salicylate content in common foods [7,6]. From the outset it was recognised that nutritional adequacy must be monitored in patients undergoing dietary investigation, and care has been taken to address this at a clinical level and nutrient intake has been systematically documented in such patients [46].

Elimination diets in conjunction with double blind placebo controlled food challenges are considered to be the "gold standard" in the diagnosis and treatment of food allergy and food intolerance. However, the strictness and degree of dietary restriction required when following elimination diets has raised concerns that nutritional adequacy may be compromised. Criticisms such as these have been particularly evident in children with ASD who already have unusual or disordered eating behaviours, and as a consequence may be more vulnerable when placed on a highly restrictive elimination diet [22] or gluten and casein free diet (GF/CF).

There has been a recent upsurge of public and media interest in the dietary intervention of a GF/CF diet where it has been suggested that an opioid peptide excess caused by the incomplete breakdown of gluten and casein is seen in children of ASD and therefore is currently being used in the treatment and management of ASD. Though this type of restrictive diet is considered an alternative treatment and often classed in the same category as naturopathy [23,24]. Concern about dietary adequacy is also evident in those children who follow this type of restrictive diet where entire food groups are excluded.

Nutritional studies investigating food diary records of children with autism have identified low intakes of calcium and riboflavin [12] vitamin A, C, fat [10], Vitamin D and iron [11]. Other studies conducted into the nutritional affect of long term adherence to an restrictive diet (without milk, wheat or egg) showed an inadequate energy intake and failure to thrive [15,16]. It has been clearly documented that ASD youngsters have an extremely limited food repertoire [4,11], Concerns are raised that the extent of dietary limitations necessary when following a restricted diet, compromise variety, and hence nutrient intake and may put these individuals with ASD at a greater risk of nutritional insufficiency [14.]

Modification or restriction of the diet of a child with ASD is generally undertaken without the guidance of a qualified health professional. Most parents rely on non professional help from secondary sources of information, such as books, magazines, the internet, TV programs, family/friends or alternative practitioners such as naturopaths [3,13]. Additionally, improvident dietary changes may adversely compromise the nutritional adequacy of a child who already has a difficult eating behaviour [3,13]. This tendency of relying on peripheral sources of information rather than that of a health professional may result from a lack of reliable information and general knowledge about the disorder.

To date research has been largely anecdotal with relatively little detailed information known about the impact of dietary behaviours and how restrictive diets affect the nutritional status of ASD children as compared to children of the same age and sex without ASD.

Preliminary research conducted in 2003 has suggested that it is the behaviour of the child rather than the imposition of a restrictive/elimination diet that affects the child's dietary preferences and in turn influences their nutritional status [3]. The aim of this investigation is to document the role of dietary behaviour on the health of children with ASD and determine whether the imposition of dietary restrictions/eliminations effect good nutrition, in the management of ASD children.

METHODS

Previous Research

The study is a continuation of work formerly started in 2003. An extensive questionnaire booklet with nine detailed questionnaires was previously developed to gather data on the study participants. The FFQ was modified from that used in 2003 to include information on the salicylate, glutamate, amine, preservative and artificial colour content of foods.

Ethics Approval

Ethics Approval was sought and granted by the Ethics Review Committee of the Central Sydney Area Health Service (RPAH Zone) (refer to appendix 1).

Participant Recruitment

Subjects were recruited randomly for inclusion in the research study from two subpopulations, selection as follows:

1. ASD Cohort – children aged 3-10 years recruited on a volunteer basis, diagnosed with ASD, existing or previously seen at the RPAH Allergy Clinic; and a group from the Illawarra School for Autistic Children, diagnosed with ASD.

2. CONTROL Cohort – children aged 3-10 years without ASD, either known to study investigators or attending Childcare Centres or Kindergartens in the Central Sydney Area Health Service region or siblings of ASD subjects. This formed an age-matched control group considered to be a "well" control group, in that the participants had not been diagnosed with ASD nor any food intolerance or allergy.

Inclusion Criteria

Inclusion criteria for both cohorts included caregivers of children aged between 3 to 10 years, male and female. Children were selected between the ages 3-10 years given that ASD is generally diagnosed at 3 years of age [25] and caregivers are likely to still have a good indication of what their child is consuming. Inclusion criteria of the ASD cohort included primary caregivers of children with ASD, diagnosed as per DSM IV criteria-American Psychiatric Association [1].

Exclusion Criteria

Exclusion criteria for both cohorts included primary caregivers of children with any other metabolic disorders other than coeliac disease or asthma; it also included the primary caregivers that have had contact with their child less than 4 days per week. Self-administered questionnaires were filled out on behalf of the child, to ensure adequate knowledge of the child's eating behaviour and eating patterns. It was important that the caregiver had regular contact with the child. A controlled variable includes any unknown mental issues that will be quantified by the mental health assessment questionnaires.

Subject Consent and Confidentiality

Subject's caregivers were initially contacted by telephone. After an initial interest was expressed the caregivers were provided with an expression of interest form along with an information sheet detailing the aims and procedures of the study, the questionnaire booklet, 4-day food diary with a requested return date and a reply paid envelope for return back to the Allergy Unit. Completion of the expression of interest forms indicated the participants consent and allowed participants to register for further involvement in the study (refer to appendix 2 and 3). Questionnaire booklets, the 4-day diet diary and the expression of interest forms were distributed already coded with a study identification number and cohort number. Upon booklet returns only the identification number and the child's initials were used as identification. Questionnaires returned to the Allergy Unit by the 15th October 2004 were included in the study results.

Study Participants

To date, 73 ASD children and 43 Control children have been studied for their nutritional adequacy using the Food Frequency Questionnaire (FFQ).

Table 1: Statistics on the sex, age, height and weight of the FFQ study population

FFQ	ASD n = 73	CONTROL n = 41
SEX		
Female	10	13
Male	63	28
AGE (Years)		
Mean ± STDEV	6.75 ± 3.54	6.39 ± 0.71
Median	6	6
Range	3 – 12	3 – 12
HEIGHT (CM)		
Mean ± STDEV	120.62 ± 19.80	118.51 ± 14.14
Median	120	120
Range	93 – 160	100 – 146
WEIGHT (KG)		
Mean ± STDEV	24.78 ± 4.10	23.54 ± 4.24
Median	22.5	22
Range	14 – 50	15 – 36

Table 1: Shows statistics for the sex, age, height and weight of the FFQ study participants

Of the 114 study participants that took part in the FFQ only 73 thus far returned their questionnaires for analysis of dietary sufficiently using the 4- Day Food Diary. The study group comprised of 54 ASD children and 19 Control children.

Table 2: Statistics on the sex, age, height and weight for the Food Diary Participants

4-Day Food Diary	ASD n = 54	CONTROL n = 19
SEX		
Female	7	6
Male	47	13
AGE (Years)		
Mean STDEV	6.80 ± 1.41	7.26 ± 1.41
Median	6	8
Range	3 – 16	3 – 12
HEIGHT (CM)		
Mean STDEV	121.71 ± 9.19	125.95 ± 13.44
Median	119	128
Range	93 – 170	100 – 146
WEIGHT (KG)		
Mean ± STDEV	25.81 ± 1.77	26.32 ± 2.12
Median	24.5	25
Range	14 – 53	16 – 36

Table 2: Demonstrates sex, age, weight and height of the 4-Day Food Diary participants

Study Design: Questionnaire Booklets

Two Questionnaires and the 4-Day food diary were implemented to assess the speculated dangers and impositions dietary restrictions have on the nutritional status of children with ASD compared with those without ASD as well as assessing any dietary changes and food reactions experienced by the child either now or in the past.

The Four Day Food Diary

The 4-day food diary (refer to appendix 5) is considered a validated method of assessing a child's dietary intake and dietary habits. The 4-day food diary provide Australian RDI values for 25 macro- and micro-nutrients, this method is deemed suitable for determining whether nutritional adequacy is met. This was performed during the child's usual diet over 4 consecutive days including one weekend. The importance of quantifying foods was emphasized and each caretaker was given careful verbal and written instructions on how to record intake, brand names, recipes and cooking methods in the food diary. Mixed food items not included in the database were added separately according to individually recorded recipes, nutrient panels and nutrient information obtained from manufactures. If the quantity of food consumed was omitted, average serve sizes were substituted. Dietary supplements were not incorporated into the analysis. Examples were supplied for the caretakers, and a contact telephone number was provided if further assistance was required.

The Food Frequency Questionnaire (FFQ)

The FFQ (refer to the appendix 4) is based on the CSIRO FFQ and was modified to make it applicable to the study. Caretakers were asked to describe the food intake of the child by rating how often they had consumed over 200 food and beverage items. The caregivers were asked to place an answer for each food on the list as either "Never Tried", "Didn't Like" or "Rarely" consumed over either of the time frames of a month, week or day. The usual serving sizes were indicated, which were assisted by a usual serving size for a child as indicated in the Dietary Guidelines for Children and Adolescents in Australia (DGCAA). The questionnaires also included qualitative and quantitative questions relating to food preparation methods and dietary habits which were used to modify the assessment of nutrient intake. The FFQ improves confidence in results for nutrient intake, and serve as a useful comparison with 4-day food diaries as instruments for measuring accurate nutrient intake. While not validated for children less than 10 years of age, the questionnaires were used in this study nevertheless to detect any

differences in reported nutrient intakes which may have been apparent between the two dietary intake methodologies.

General Behaviour and Health Checklist for Children-Section 2 (GBHCC-60)

The GBHCC-60 (refer to appendix 4) was developed by the RPAH Allergy Unit and was used to explore any food reactions experienced by the participants, as well as dietary changes and previous nutritional advice. The GBHCC-60 questionnaire determined where the caregivers of the children received their information about the various dietary modifications implemented and whether professional guidance or nutrition support had been utilized at some point in time.

Data Analysis

Identified coded data were entered into Microsoft Excel 2002 (Microsoft Corp., USA). Once entered into the study database, the data was checked to ensure accuracy. The descriptive statistics (Mean, Median, Standard Deviations and Range) were calculated for age, height and weight using the Microsoft Excel Program 2002. When recording participant responses to questionnaires only definite answers were included. Blank answers were treated as a null response, and were therefore not included in data analysis.

The Four Day Food Diary

The 4- Day Food intake diaries were analysed by using the SERVE nutritional software program. The SERVE program utilises NUTTAB, the Australian nutrient composition database (Department of community services and health. Composition of Foods Australia. Canberra: Australia Government Publishing Service, 1992), which also contains data from the British McCance and Widdowson's food tables. For each participant the Macro-and Micro- nutrients where expressed as percentage RDI's (Example in appendix 7).

ASD and Control Cohort:

Statistical analysis was performed using Statistical Package for the Social Sciences (SPSS) Version 12.0. Significant difference in factor scores was determined by Independent Sample T-test at a 95% confidence interval for the two cohorts for each of the nutrients being examined (refer to appendix 11).

ASD Various Diets:

The ASD cohort was divided into the three diet groups that the children with ASD where implementing (Regular Diet, GF/CF Diet and the Elimination Diet), this was complied using Microsoft excel 2002. Data on the specific diets was further analysed to determine the variance within the three groups, for the various nutrients, using One Way ANOVA and Post Hoc Bonferroni analysis with SPSS Version 12.0 (as above) with significance determined at a 0.05 critical level (refer to appendix 12).

The Food Frequency Questionnaire (FFQ)

The scores from the FFQ were obtained by establishing an average serves per day intake for each food listed on the FFQ by calculating the "Rarely Eaten" as eaten once over the three month period, and multiplying the weekly number by four and the daily number 30, then dividing the total monthly frequency by 30. The serving sizes recorded where as indicated in the Dietary Guidelines for Children and Adolescence in Australia (DGCAA). Foods that were not answered by the caregivers were presumed to be "Never Tried". The results collected from the FFQ were entered into Microsoft Excel 2002 and sorted into two age groups (4-7 and 8-11 years for the ASD and Control groups) so that the results could be compared to that of the recommended daily serves for the five food groups as per the DGCAA. The average serves consumed for the two age groups were compared with that of the recommended daily serves of the DGCAA so that nutritional adequacy could be determined. This methodology was then compared with the results of the 4- Day food diary.

The General Behaviour and Health Checklist for Children-Section 2 (GBHCC-60)

Data from the questions 70 and 71 of the GBHCC-60 questionnaire was compiled into Microsoft Excess 2002 to determine if parents had sort dietary advice. Responses were collated into two key groups Health Professional and Non Health Professional.

RESULTS

The Four Day Food Diary

Nutritional Adequacy

Participants were asked to record the type and amount of food and beverage items they had consumed over four consecutive days, in order to obtain an estimate of their average nutrient intakes. Nutritional adequacy of the diets was then assessed by comparison with Recommended Dietary Intake (RDI) values calculated for sex, weight and age.

ASD and Control Cohort:

Table 3: Percent RDI (mean) and Independent Samples T-test for each individual nutrient for the ASD and Control Cohort.

ASD VS CONTROL			
NUTRIENTS	% RDI		P-VALUE
	ASD GROUP n = 54	CONTROL GROUP n = 19	INDEPENDENT SAMPLES T-TEST
CARBOHYDRATE	143.7	118.8	0.201
ENERGY	128.8	110.2	0.173
FAT *	116.3	104.3	0.386
PROTEIN	288.5	266.6	0.452
CALCIUM *	105.0	116.0	0.471
IRON *	169.4	140.8	0.290
SODIUM	485.7	489.7	0.947
ZINC	129.7	122.3	0.594
NIACIN	250.8	251.4	0.985
RIBOFLAVIN *	153.2	202.8	0.128
RETINOL *	170.0	150.1	0.248
THIAMIN	218.2	214.9	0.919
VITAMIN C *	312.3	231.4	0.204
FOLATES TOTAL	185.4	180.4	0.448

Table 3: The above table illustrates the group mean (%RDI) for the selection of nutrients for the two cohorts. The array of group means in Table 3 for both the ASD and Control cohort ranged from 105.0 (Calcium) to 485.7 (Sodium) for the ASD cohort and 104.3 (Fat) to 489.7 (Sodium) for the Control cohort. No significant difference was found between the two sample means when an Independent Samples T-test was carried out on the nutrient intakes for the two cohorts with the critical levels ranging from 0.128 for the nutrient Riboflavin to 0.985 for the nutrient Niacin.

* Nutrients of concern for children with ASD.

Figure 1: Clustered Box plots summaries of Calcium, Sodium and Fat for the ASD and Control Cohorts

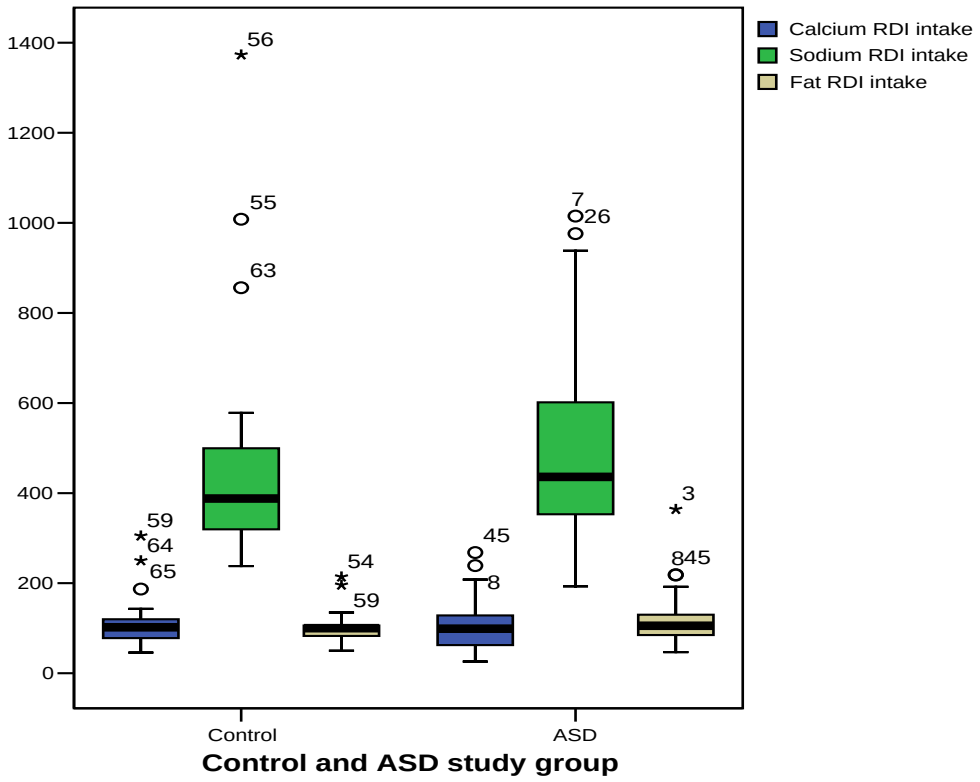

Figure 1: The above box plot illustrates the median, quartiles and outlier values for the nutrients. The variation in the intake of the nutrients calcium, sodium and fat as a percentage of RDI for both the control and ASD cohort are seen above, all three nutrients for both cohorts are highly variable with each having a number of outliers. The nutrient sodium for both cohorts is far above the 100% RDI level. The plot also shows that the control cohort has an outlier that is over three times the median value and the ASD cohort has an outlier that is more than two times the median value.

Figure 2: Clustered Box plots summaries of Iron, Vitamin A, C and Riboflavin for the two cohorts

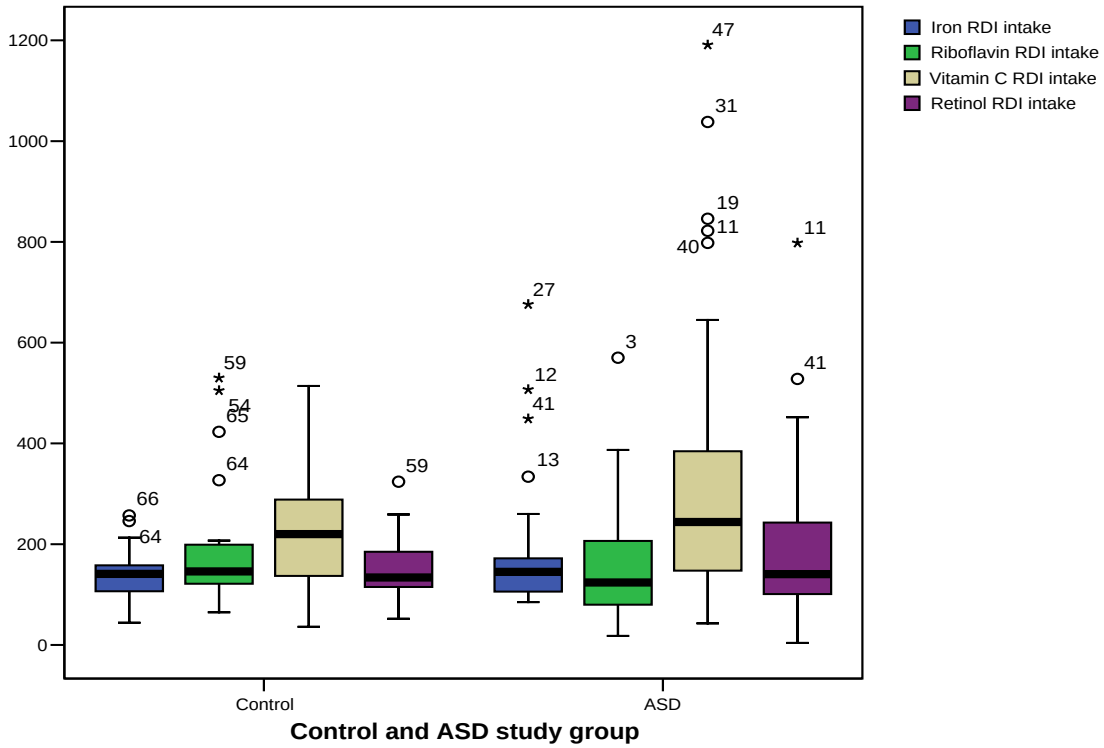

Figure 2: The above box plot illustrates the variation in the intake of the nutrients iron, riboflavin, vitamin C and retinol as a percentage of RDI for both the control and ASD cohorts. The large number of outliers in the plot shows that the nutrient intakes are highly variable amongst both cohorts. A large number of outliers are found in the nutrient intake of vitamin C and iron for the ASD cohort and riboflavin for the control cohort.

ASD Various Diets:

Table 4: Percent RDI (mean), Anova and Post Hoc Test results for each individual nutrient for the Various Diets within the ASD Cohort.

ASD VARIOUS DIETS							
	% RDI			p-VALUE	POST HOCS TESTS		
NUTRIENTS	REGULAR DIET n = 26	CASEIN ± GLUTEN FREE DIET n = 16	ELIMINATION DIET n = 12	ONEWAY ANOVA	Regular Diet VS CF/GF Diet	CF/GF Diet VS Elimination Diet	Elimination Diet VS Regular Diet
RIBOFLAVIN	199.0	99.8	134.7	0.009*	0.009*	1.000	0.245
CARBOHYDRATE	128.0	171.1	169.4	0.208			
ENERGY	126.5	137.1	136.4	0.592			
FAT	128.6	105.6	98.9	0.194			
PROTEIN	307.8	270.2	283.5	0.566			
CALCIUM	120.8	86.3	102.9	0.082			
IRON	176.0	174.3	192.0	0.930			
SODIUM	499.8	442.8	443.7	0.572			
ZINC	133.1	134.8	136.3	0.987			
NIACIN	282.2	217.8	236.7	0.271			
RETINOL	181.1	162.9	124.9	0.348			
THIAMIN	255.6	181.3	202.0	0.140			
VITAMIN C	359.0	238.2	267.7	0.282			
FOLATES TOTAL	185.2	201.7	219.5	0.801			

Table 4: The above table illustrates the group mean (%RDI) for all the nutrients for the various diets within the ASD cohort. No significant difference exists among the means of the three different diet groups at the 0.05 critical level when a One-Way Anova test was carried out on all of the nutrient intakes except for the nutrient Riboflavin. Riboflavin failed the test with a critical value of 0.009. A Post Hoc Bonferroni test was conducted on the Riboflavin and it was found that a difference in means exist between the Regular and GF/CF diet where the critical value was 0.009.

FFQ dietary intakes compared with the recommended serves of the DGCAA.

The Dietary Guidelines for Children and Adolescents in Australia are the recommended guide to food, nutrition and health. The number of food serves a child should eat from the five food groups each day for optimal nutrition depends on their age group. Adequate nutrition for growth needs to come from a wide variety of nutritious foods – cereals, vegetables, fruits, lean meats and dairy foods.

Table 5: Comparison of the recommended daily serves for the Main Food Groups as per the DGCAA for the ASD and Control cohort.

RECOMMENDED INTAKE *	ASD VS CONTROL									
FOOD GROUPS	SERVES PER DAY 4 – 7 YRS	ASD GROUP n=44		CONTROL n= 25		SERVES PER DAY 8 - 11 YRS	ASD GROUP n=29		CONTROL n= 13	
GLUTEN CEREALS	5-7	3.0	4.3	4.3	4.8	6-9	3.9	5.3	5.2	5.8
GLUTEN-FREE CEREALS		1.3		0.5			1.4		0.6	
VEGETABLES	2		2.9		4.0	3		2.9		4.0
FRUITS	1		3.2		3.1	1		3.5		2.9
DAIRY	2	4.9	6.0	3.9	4.1	2	7.6	8.6	4.7	5.0
SOY		1.1		0.2			1.0		0.3	
MEAT	0.5	3.6	3.8	1.7	2.9	1	1.8	2.0	2.2	2.4
MEAT ALTERNATIVE		0.2		0.2			0.2		0.2	
EXTRAS-FATS	1-2	7.3	7.4	5.8	6.1	1-2	6.3	6.4	7.3	7.3
EXTRAS-SUGARS		0.1		0.3			0.1		0.0	

Table 5: From the table above it can be seen that there was no considerable difference between the ASD and Control cohort for either the 4-7 and 8-11 age groups for the average daily servings of the following food groups: Cereals (including Gluten-Free), Vegetables, Fruit, Dairy (Including alternatives) and Meats (Including alternatives). It can be seen above that both the ASD and Control cohorts consumed in excess of the daily recommended serves as per stated in the DGCAA, except Cereals (both Gluten and Gluten free) where both age groups of the two cohorts just failed to meet those serves recommended by the DGCAA. The 4-7 yrs ASD cohort consumed an average of 4.3 and

the Controls consumed 4.8 serves of cereal-based foods per day while the 8-11 yrs ASD cohort consumed an average 5.3 and the Control cohort consumed 5.8 serves. As demonstrated above this is marginally below that of the recommended serves of Cereals where the DGCAA recommends between 5-7 and 6-9 servings of cereal-based foods for 4-7 and 8-11 year olds respectively.

* From the Dietary Guidelines for Children and Adolescence in a Australia (DGCAA)

History and Sources of Dietary Modifications

Primary caregivers were asked if they had modified their child's diet for improvements in behavioural problems or learning difficulties and where they had seeked their sources of dietary information from in the GBHCC-60 questionnaire.

Table 6: History of Dietary Modifications: Percentage of participants in both cohorts that have seeked dietary advice at some point in time.

DIET ADVICE	DIET ADVICE - ASD GROUP (%) n = 73	DIET ADVICE - CONTROL GROUP (%) n = 38
PROFESSIONAL ADVICE	**9.6**	**7.9**
NON PROFESSIONAL ADVICE	**54.8**	**84.2**
BOTH PROFESSIONAL AND NON PROFESSIONAL ADVICE	**35.6**	**7.9**

Table 6: The table above demonstrates where the two study cohorts have sort dietary advice. The majority of primary caregivers for both ASD and Control had not received professional dietary advice before implementing dietary changes with 54.8% and 84.2% respectively. It can also be seen that only 9.6% of the ASD and 7.9% of the Control cohort participants had solely relied on professional dietary advice and 35.6% of the ASD and 7.9% of the Control had both sort professional and non professional dietary advice at some point in time.

Sources of Recommendation Changes in Dietary Modification

Respondents were asked the exact sources of Professional and Non Professional Advice that they had undertaken. As shown in Table 7 dietary advice about modifications to diets were sourced from a wide range of areas with multiple consultations common among the subjects.

Table 7: Mayor Sources of Recommendation for Dietary Modifications in both cohorts.

Professional Advice	Non Professional Advice
G.P Doctor Paediatrician Health Professionals RPA Dietitian	Naturopath Parent Groups Books/ Journal Article Television Program Radio Program Internet Communication Newspaper Article Friend/Relative Advice

Table 7: The above table reveals the different sources of Professional and Non Professional advice employed by the two cohorts.

DISCUSSION

An elimination diet involves the extensive restriction of a variety of foods which contain natural and artificial chemicals that may provoke symptoms in sensitive individuals, and is often implemented to examine and improve behaviour problems seen in children with ASD. Clinical studies have shown that preservatives in healthy foods consumed daily may cause irritability, restlessness, inattention, and sleep disturbance in some children [40]. Moreover, children subjected to a standard elimination diet such as the Royal Prince Alfred Hospital diet showed an improvement in behaviour [40]. However, the nutritional complications of elimination diets are poorly defined [39]. It has been suggested that elimination diets may have negative effects on growth and food intake of children [35,36].

Some studies have reported that children with autism exhibit more general feeding problems including food refusal, requiring specific presentations of foods and specific utensils, eating only low texture foods, and eating a more narrow variety of foods than children without autism [35,36]. These out of ordinary eating habits combined with the implementation of the elimination diet has been suggested to be harmful to these already vulnerable individuals putting them at a greater risk of nutritional insufficiency.

The hypothesis that children with ASD on elimination/restrictive diets are at a greater nutritional risk than regular children with no ASD was not supported [35,36]. In fact, the current study showed that nutritional adequacy of the diet of children with ASD was not compromised when further restricted when following an elimination diet [9,37,22] . This study also compared the nutritional intake of children with autism with the diets of regular children with no ASD.

Four Day Food Intake Diary

ASD and Control Cohort:

Study results from the analysis of nutrient intake reported by primary caregivers for four consecutive days in the 4-Day Food Intake Diary showed that children with ASD are nutritionally adequate. Study results, illustrated in Table 3 (Page 13) found that both the ASD and Control cohorts as whole groups consumed enough foods containing sufficient amounts of all the macro-and micro- nutrients to obtain nutritional adequacy, when assessed and compared to that of the percentage RDI's for the specific sex,

age and weight. However, there were cases in both cohorts where the intake of calcium, riboflavin, vitamin A, C, fat, vitamin D and iron were low as illustrated in Figures 1 and 2. Further to that, Independent Samples T-tests were conducted between the two cohorts to compare means of nutrient intake and no significant differences were found between those children with or without autism, as seen in Table 3, where results were greater than the critical value (P=0.05). This emphasizes that the nutritional status between children with and without ASD is similar, thus suggesting the "picky eating" behaviour in children with ASD is no different to that seen in most children at specific developmental stages.

While it was seen from the results of this study that both cohorts as a whole were adequately nourished and consumed in excess of the recommended RDI's for the nutrients including those seen to be of particular concern for children with ASD as stated in published literature [10,11,12] , there was high variance between the range of nutrient intakes as seen in Figures 1 and 2, illustrated by the large number of outliers. Of particular concern is the soaring level of sodium consumed by some study participants as illustrated in Figure 1, where many children in both cohorts consumed at least four times greater than the recommendations of the RDI's and some more than eight times, without even adding salt to their food. The high levels of sodium seen in the diets are largely to blame of the relatively low RDI set for salt combined with the high consumption of processed and packaged foods in particular potato crisps, breads, cheese, and tomato sauce which were often most liked food for the cohorts [54].

ASD Various Diets

To determine whether the imposition of the elimination diet was harmful and restricted nutritional competence in sensitive individuals, the nutrient intake of the various diets implemented by the ASD cohort was analysed. The most significant nutritional change which occurred when following a restrictive diet was a decrease in the mean intake of Riboflavin, with a critical value of 0.009. The difference existed between ASD children following a regular diet with those implementing a Gluten and Casein Free diet. This decrease is likely to occur because foods rich in Riboflavin such as milk and dairy products were eliminated from a gluten/casein free diet in addition to the exclusion of breads and cereals that are often fortified with riboflavin and significantly contribute to the overall intake of this B vitamin. This significant difference however does not impact on the nutritional adequacy for the majority of children with ASD on the diet, with the average mean intake above that of the RDI for

riboflavin. However, a concern is, as seen in Figure 2, there are a small number of cases which have a very low intake of riboflavin.

The RDI values are set at the level of intake of essential nutrients considered to be adequate and to meet the known nutritional needs of most healthy persons [41]. As exemplified in Table 4 (Page 14) nutrient intakes for the children with ASD on various diets were in excess of 85% of the RDI, by convention an inadequate dietary intake was considered to be less than 85% of the RDI for sex, weight and age. A worrying result is the mean intakes of calcium for those ASD children on a gluten/casein free diet (86.3%) were just above that of the RDI daily intake. This was because of the restricted dairy and bread consumption while following this type of diet. Milk and dairy foods are by far the richest sources of calcium [42] and is an explanation for the reduced intake of calcium. However, it should be noted that although lower in calcium, bread also makes a significant contribution to overall intakes of calcium because it is such a regular component of diets. Children following a gluten/casein free diet largely got their sources of calcium from fortified soy milk and products, enriched rice milk; juice enriched with calcium, almonds and dried fruits in addition those children not on gluten free diets got a significant amount of calcium from bread and bread products. As seen in Figure 2 some of the ASD cohort's intake of calcium was very low, however it should be noted that supplements were not included in the analysis of the nutrient intakes of these children and supplements were commonly used.

Since 4-Day Food Intake Diaries may not adequately assess the intake of certain nutrients (e.g. vitamin A, whose intake varies from day to day), a Food Frequency Questionnaire was also employed and compared to that of the DGCAA so that differences in the estimated nutrient intakes obtained using the two measurement methods could be identified.

Food Frequency Questionnaire

The dietary variety of children with ASD was not significantly different to that of the control cohort. Both cohorts were seen to have a similar proportion of the Major Food Groups in their diets, and both of the cohorts met the new requirements set by the DGCAA for all Food Groups with the exception of cereals.

The anecdotal reporting of limited food intake from the focus group studies [43,44] and the diagnosis criteria of repetitive and often restricted patterns of behaviour with food, including difficulties with change was not demonstrated by the results of the FFQ. This study put forward a new [45] aspect to the study of the nutritional adequacy of children with ASD as compared to the control cohort, as to date there has been no published studies on dietary intake which have actually tested their ASD cohort against a control of a Non-ASD sample. From the results of the study (page 15) the DGCAA daily intake was not met for the cereal food group; however, an overall intake based on the food groups was similarly spread across the two cohorts.

From the results Page 15 there were no considerable differences among those with or without ASD for the number of serving eaten across the food groups. However, the most notable difference was between the intake of dairy foods (including soy and soy products) where the control cohort consumed 2-3 serves less dairy than that of the ASD cohort. While both cohorts consumed dairy in excess of those recommended by the DGCAA the mean number of serves for the 4-7 year old and 8-11 year old ASD cohort was 6.0 and 8.6 correspondingly, while it was 4.1 and 5.0 respectively for the control cohort. Repetitive food behaviours and a desire to cling to routine and similarities as well as a particular likeness for white coloured foods [45] are possible reasons for the greater consumption of dairy in the ASD cohort compared to that of the control cohort.

Surprisingly, both the ASD and Control cohorts consumed in excess of the recommendations for the fruit and vegetable food groups. From the results page 15 it can be seen that while children with ASD may have a diet limited in variety it was still possible to reach the daily intake for the food groups.

Of concern was the findings that both cohorts consumed 6-7 serves of the extra food group (fat and sugar) with the majority of the serve coming from fat rather than sugars suggesting the high level of processed foods in the diet, particularly French fries and potato crisps that were favored by both cohorts [54]. These findings are in keeping with research that showed that children's food choices are largely determined by food preferences and children like to eat high-fat, high-sugar foods [55].

Children with ASD failed to meet the mean number of serves of cereals as recommended by the DGCAA as illustrated in Table 5 while the control cohort were borderline of the requirements for the age groups. The average serves per day consumed by the ASD cohort was 4.3 for the 4-7 year olds and

5.3 for the 8-11 year olds where it is recommended that the 4-7 year olds consume 5-7 serves, and the 8-11 years consume 6-9 serves. This low cereal intake could be for a number of reasons. Firstly, the DGCAA has recently been revised and changes have been made to the cereal requirements for all age groups. I.e. the cereal intake has been doubled. It is possible that these recommended daily intake serves are set too high to be reached on a daily basis. 5-7 serves of the cereal group for the 4-7 age group is equivalent to 10-14 slices of bread and 6-9 serves of the cereal group for the 8-11 year olds is equivalent to a staggering 12-18 slices of bread. It is suggested that the DGCAA be reviewed as it is difficult to consume such a large serve of cereals in one day. Secondly some of the children within the ASD cohort are following Gluten-Free diets and therefore as a consequence the majority of popular cereals e.g. wheat, rye and oats are eliminated from the diet reducing the average mean of cereals for the entire group as a whole and increasing the consumption of the other food groups such a meats.

The children with ASD daily consumption of meat and meat alternatives was found to be greater than that of the control cohort as seen in Table 5. The larger meat consumption of the ASD cohort as a whole could be explained by the reduced daily intake of cereals by the children on a gluten-free diet with the ASD cohort. From the results on average, the study cohorts meet the age-appropriate DGCAA recommendations for the core food groups.

The evidence presented in this study show that nutrition is not comprised when following an elimination diet. A possible reason for this finding was that the caregivers of children with ASD are more likely to adhere to sound dietary principles. Often feeding times are a struggle for caregivers as stressed in the focus group *"All of a sudden he stopped eating certain things and now he's very restrictive in his food choices. He won't eat anything green, orange or yellow. He will only eat potatoes. He can't have anything with sauce on it. If you dish up the dinner and little bit of gravy has gone on a piece of meat or something, the whole plate is no good. We have to start again"* [44]. Although children with ASD may be eating from a restricted diet lacking in variety, the child would accept enough of a range of foods to be nutritional sufficient, as seen in the 4-Day Food Intake Diary results in Table 1 and 2 and in the FFQ results in Table 5.

When interpreting these results it should be noted that the association of dietary change and nutritional intake status may be subject to bias [48,49,52]. Many studies [50,51,53] have compared the validity of various nutrient intake methodologies and while it was not the aim of this study to assess which of these were

more accurate and reliable; two different nutrient intake assessment methods were implemented in this study to improve the confidence in results.

The FFQ was implemented as a tool of comparison with 4-day food diaries as instruments for measuring accurate nutrient intake. While not validated for children less than 10 years of age, the questionnaires were used in this study nevertheless to detect any differences in reported nutrient intakes which may have been apparent between the two dietary intake methodologies. Results for nutrient intake indicated that the two dietary assessment methods compared very favourably. The overall similarity in results obtained using the two methods substantiates the accuracy of the nutrient intakes estimated using either method.

Additionally it has been suggested that the use of parental reporting of foods eaten by children may created less accurate results than methods of actual presentation of foods [9]. This may be due to caregivers limiting exposure, presenting foods to the child that they will readily accept, or inaccurately reporting of what the child eats. However, as noted in Ahern *et al.* (2001) artificial eating environments may also create problems with feeding for children with autism due to the various difficulties in accepting differences in their environments. Consequently, the use of multiple parental report measures of nutrient intake, including the FFQ, affords more confidence in the results of this study and may provide a more normalized view of children with autism's typical eating patterns.

A study has shown that if the selective feeding issues of children with autism are not addressed, these children are at higher risk for nutritionally related medical problems, such as rickets [38], rather than the imposition of an elimination diet for the management of these behavioural problems as previously thought. While the long-term effects of feeding problems are not clear, it is certainly possible they could lead to nutritional deficits and significant medical issues [37].

Although significantly more research should be conducted to determine the feeding problems associated with autism and how these impact on dietary intake, this study provides one of the most comprehensive preliminary investigations into the differences between the nutritional status of children with and without ASD. The results of this study indicate that the imposition of the elimination diet for the management of behavioural problems does not adversely impact on nutritional status of children with ASD. The results of this study concur and are supported by research conducted in 1996 and 1997

by Soutar [46] and Chiu [47] respectively found that both adults [46,47] and children [47] undergoing dietary intervention maintained nutritional adequacy on the simplified elimination diet (SED), where it was concluded that nutritional adequacy is not necessarily linked to the level of dietary restriction.

General Behaviour and Health Checklist for Children

This study also looked at what sources the parents used for dietary advice. It was found from Tables 6 and 7 in the results section of this report that the majority of primary caregivers for both the ASD and Control cohort have not received professional dietary advice before implementing dietary changes with 54.8% and 84.2% respectively. As the children with ASD have adequate nutrition, these results are a positive finding because it was previously thought that unless professional guidance or nutritional support was provided major changes to the diet may have further complicated their dysfunctional feeding behaviours and marked selectivity often presented in people with autism [55, 56]. The majorities of the caregivers are implementing dietary changes without any guidance of a health professional and from the results obtained via the 4-Day Food Intake Diary and the FFQ, nutritional adequacy is obtainable. The caregivers are well informed and capable of implementing dietary changes without adversely compromising nutritional adequacy of a child who already has a difficult eating behaviour.

CONCLUSION

Children with ASD have been considered nutritionally "at risk" on an elimination diet, however, the current study showed that the nutrient intake of children with ASD was equivalent to that of control children and both cohorts adequately met requirements for all nutrients. It has also concluded that the majority of primary caregivers had not received professional dietary advice before implementing dietary changes. Results for nutrient intake indicated that the two dietary assessment methods compared very favourably. Overall similarity in results obtained using the two methods confirm the accuracy of estimated nutrient intakes using the 4-Day Food Intake Diary.

FUTURE RESERARCH

Although the data provides preliminary evidence to show that children with ASD on elimination/restricted diets are not at a greater nutritional risk than regular children without ASD, this study has some main areas that require further research.

Firstly, the small sample size, with only 19 subjects in the control cohort, compared to the 54 in the ASD cohort it is difficult to make firm conclusions. There was also a small sample size of ASD children following the various diets and to provide stronger conclusions a larger number on each diet should be used in future studies. Further subjects need to be recruited to further valid findings. It would also be ideal to focus on children at the lower end of the nutrient intake levels as seen in Figures 1 and 2 and look at the value that nutrient supplements play in the diets children in particular children with ASD.

In addition future research needs to focus on the effect of diet in ASD, or there response to challenge to determine the main dietary triggers for children with ASD.

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APPENDIX 1: Ethics Approval

APPENDIX 2: Expression of Interest

APPENDIX 3: Information for Participants

APPENDIX 4: Questionnaires used in study

APPENDIX 5: Four Day Food Intake Diary

APPENDIX 6: The Simplified Elimination Diet

APPENDIX 7: Example of SERVE analysis % RDI

APPENDIX 8: Percentage of RDI for the various study groups

APPENDIX 9: Figures 1-7: The comparison of nutrient intakes as percentage RDI between the studies different group of participants

APPENDIX 10: Tables of results for the entire study groups for the various nutrients

APPENDIX 11: Statistical Analysis for the ASD and Control cohort

Appendix 12: Statistical analysis for the ASD cohorts various diets

Appendix 13: FFQ Raw Data for the various diets