# A STUDY OF THE RELATIONSHIP BETWEEN FOOD INTOLERANCE AND BEHAVIOUR IN CHILDREN

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# ABSTRACT

**Introduction :** For many years, a wide range of behaviours have been attributed to adverse food reactions, particularly in children. The hypothesis suggests that behavioural problems are aggravated by certain foods and chemicals in food intolerant children, and that removal of these substances from the child's diet will provide an improvement in the child's behaviour. Since the 1970's, many studies have evaluated the diet-behaviour hypothesis, though confusion and controversy exists due to conflicting and contradictory results. More recent, clinically controlled studies have demonstrated positive behavioural food effects through diets eliminating salicylates, amines, food colours, preservatives and additives. **Aims :** To investigate the relationship between food intolerance and behaviour in a cohort of children presenting to the RPAH Allergy Unit by : 1) Documenting the occurrence of food intolerance and behaviour problems; 2) Determining the extent and nature of dietary compliance on leaving the Allergy Unit; and 3) Examining the effects of dietary intervention on behaviour and associated symptoms. **Methods :** Data was collected from medical and dietetic notes on 423 children who presented to the RPAH Allergy Unit between 1995 and 1998 for behavioural problems. Parents were sent a Questionnaire to obtain additional information about the child's symptoms and dietary modifications. They were also sent a Conners' Parent Rating Scale (CPRS) to compare their present behaviour with that recorded on the CPRS which they completed on presentation. **Results :** Seventy-seven percent of children started the elimination diet (SED) as prescribed by the RPAH Allergy Unit, with 91% reporting improvement in symptoms. Eighty-one percent continued on 'modified diets', regardless of whether they started or completed the elimination diet or challenges. The most common chemicals reacted to were amines, salicylates, colours, glutamates and preservatives respectively, and hence were the most restricted. Thirty-eight percent reported significant improvements in behaviour, and 50% rated children's symptoms overall as much better or completely well. Statistically significant improvements in conduct, learning, impulsivity and hyperactivity were demonstrated by the CPRS comparisons. **Discussion :** Results confirm a diet-behaviour connection in children who participated in the study, though a low response-rate (31%) and possible response-bias preclude generalisability.

# 1. INTRODUCTION

## 1.1 Overview

"Food sensitivity" is the unpleasant and reproducible response which certain individuals exhibit after eating a specific food or food component. These "adverse food reactions" have long been recognised to cause a wide variety of symptoms, syndromes and diseases (Ferguson, 1992), and appear to be an increasingly common occurrence in the population. Of all the possible reactions, behavioural ones are the most controversial and the most difficult to document objectively. This relationship is the subject of ongoing scientific research, widespread media attention, and increasing public interest and awareness.

For many years, a wide range of behaviours have been attributed to adverse food reactions, particularly in children. The basic hypothesis involves the proposition that, in susceptible (food sensitive) individuals, certain active food substances can give rise to adverse effects on behaviour or aggravate pre-existing behavioural problems. Thus, if a relationship between food substances and disruptive behaviour is demonstrated, then removal of the offending substances should provide an amelioration of behavioural problems.

The most common of these problems involve hyperactivity, impulsiveness and inattention, such as are those evidenced in Attention Deficit Hyperactivity Disorder (ADHD). To date, the field continues to be plagued by marked differences of opinion as to the cause, definition, evaluation and treatment of ADHD. Reported prevalence rates of ADHD in children of primary-school age across various studies range from 3-

10%, making it one of the most common psychiatric disorders of childhood (Barkley, 1990). Many more children have similar problems with hyperactivity and attention, but are never formally diagnosed with ADHD (Paltin, 1993). Whether clinically diagnosed ADHD or not, what differentiates these children is that the degree of these behavioural characteristics are *developmentally inappropriate* for their age and sex (Barkley, 1990). Since the 1970's a plethora of clinical research has evaluated the diet-behaviour hypothesis. The conclusions of these studies, however, have rarely correlated. Confusion and controversy continues to exist in this field because of conflicting and contradictory results (Esteban, 1992). It is precisely because of this lack of agreement in the scientific community, together with the high prevalence of ADHD and the complexity of its aetiology, that more research must be conducted to further evaluate the role of diet in the management of this disorder.

## 1.2 Terms and Definitions

Adverse reactions to food can be due to several mechanisms, and correct differentiation of the type of reaction in each individual is essential for appropriate diagnosis and dietetic management (Clarke, McQueen, Samild & Swain, 1996). While many people use the word "allergy" to refer to any type of adverse reaction, it's use should be confined to reactions which have an immunological basis. Other food reactions not mediated by the immune system are termed "food intolerance" (Rowe and Briggs, 1995), and it is this type of reaction that is believed to play a part in the behaviour of food sensitive children.

### 1.2.1 Food Allergy

Food allergies, also known as atopic reactions, are immunological reactions mediated by the production of IgE (Immunoglobulin-E) antibodies to particular food proteins. They commonly occur after ingestion of foods such as egg, cow's milk, fish, soy, wheat, peanuts and other nuts (Schwartz, 1992). In highly sensitive children, acute, reproducible symptoms often occur within an hour or less of contact or ingestion, including itching and swelling around the mouth, nausea, vomiting, diarrhoea, hives, and abdominal cramps; in some cases anaphylaxis may occur.

Diagnosis is made by careful clinical history, detection of specific IgEs by the Skin Prick Test (SPT) or RAST blood tests, and dietary modification with supervised food challenges. Management of food allergy involves complete avoidance of the relevant food proteins (Clarke et al., 1996).

### 1.2.2 Food Intolerance

Adverse food reactions with a nonimmunologic pathogenesis are mediated through pharmacologic, metabolic, toxic or psychological mechanisms, and are termed "food intolerances". Pharmacological food intolerance is seen amongst predominantly non-atopic people of all ages. Symptoms may involve the skin (e.g. urticaria, mouth ulcers, eczema), gastrointestinal tract (e.g. nausea, abdominal discomfort, diarrhoea), upper respiratory tract (e.g. rhinitis, asthma, sinusitis), or the central nervous system (e.g. headache, lethargy, myalgia, and behavioural disturbances) (Loblay and Swain, 1986; Clarke et al., 1996). These reactions can be provoked by natural compounds such as salicylates, amines, and glutamates, and some artificially added substances (preservatives, colours, flavours, and added MSG). Chemically, there is little

difference between ‘natural’ and ‘artificial’ ingredients, and both may cause adverse reactions if sufficiently large amounts are consumed (Clarke et al., 1996).

These chemicals are common to many foods, and their effects are dose-related and frequently cumulative. A person becomes symptomatic when they reach their triggering threshold for the substance, with often delayed onset occurring anywhere from 30 minutes to 48 hours (Swain, 1988). As such, many do not recognise the relationship between foods and symptoms, or are unaware of the cumulative effects of apparently tolerated foods. In addition, most are sensitive to several chemicals and adverse reactions are most likely to occur when these are eaten in combination (Loblay et al., 1986).

Investigation of pharmacological food intolerance is therefore not a simple task, concomitant with the fact that there is no currently available skin or blood test that can identify the offending chemicals. To date, the only reliable method of confirming diagnosis is to perform systematic dietary elimination followed by double-blind placebo-controlled challenge testing (Schwartz, 1992). The method developed and employed at the RPAH Allergy Unit involves four stages (Loblay and Swain, 1992) :

1. The first step is to determine whether symptoms are diet-related. This is done by prescribing the elimination diet (Appendix 1), which is designed to avoid all the known chemicals that might be involved. This diet is maintained over a minimum period of two weeks; if symptoms have not remitted after six weeks, food intolerance is unlikely to exist.

2. If the patient is symptom free for five consecutive days, double-blind challenges with purified chemicals (and placebos) are administered in order to identify the range of food components to which they are sensitive.
3. An individualised diet is prescribed depending on the results of the challenges.
4. Gradual and systematic liberalisation is encouraged by trialling small amounts of suspect foods in order to raise the dose threshold for reactions and re-establish tolerance of as many foods as possible.

### 1.2.3 Attention Deficit Hyperactivity Disorder (ADHD)

The cluster of problems involving inattention, hyperactivity, and impulsiveness, has been referred to by a multitude of descriptive terms over the years, including *hyperkinetic syndrome, hyperactive disorder, minimal brain dysfunction, Strauss syndrome, and attention-deficit disorder with or without hyperactivity.* It is currently referred to in the Diagnostic and Statistic Manual of Mental Disorders (DSM-IV, 1994) as a*ttention deficit hyperactivity disorder (ADHD).* This disorder is distinct from other disorders of childhood because it is the difference in intensity, persistence and clustering of symptoms rather than the presence or absence of symptoms that confirms diagnosis (Goldstein and Goldstein, 1990).

As previously noted, three factors in particular seem to characterise children with ADHD: lower impulse control, difficulty with attention, and excessive activity and movement. Impulsive behaviour is sudden and unexpected, and it happens without much planning or forethought for consequences. It is seen in behaviours such as yelling out in class, butting into others' conversations or games, or riding a bike onto the street. The inattentive child quickly loses the focus of their attention. They may be

easily distracted, forgetful in daily activities, dreamy; they may have difficulty in organising or finishing tasks, and are often inattentive to verbal instructions. The child with ADHD does not have the ability to regulate their hyperactive behaviour to fit home and school demands. They fidget with their hands and feet or squirm in their seat when they are expected to sit still, or jump from the table when they need to stay in their seat; they take much longer than other kids to calm down after a high-energy activity; and the fluctuations of their hyperactivity are not very predictable. Although all children display these behaviours some of the time, in children with ADHD, their frequency and intensity interferes with interpersonal and educational adjustment.

In addition to these three core behavioural symptoms, there is a cluster of other associated behaviours which vary in their presentation. These may include irritability, aggression, anxiety, frustration, and mood swings. Many studies have also shown co-morbidity of ADHD with learning and speech disabilities (20-50% of ADHD children), oppositional defiant disorder (up to 65%), and conduct disorder (estimated to be found in 45-50%) (Barkley, 1990; NHMRC, 1997).

ADHD problems typically cause significant and pervasive impairment in a child's day-to-day interaction with all areas of their environment, and result in an inability to meet situational demands in an age-appropriate fashion. The uneven, unpredictable behaviour of children with ADHD creates difficulty with home, school and community situations, including peer interaction, academic achievement and general adjustment. Consequent negative feedback, negative reinforcement and an inability to meet the reasonable demands of family, friends and teachers, appear to have a significant impact on a child's emerging personality and cognitive skills.

ADHD involves many variables which combine to push a child towards and over the threshold of the disorder. The multiplicity of aetiology, heterogenity of symptoms, changes over time, and range of possible treatments, make management of ADHD complex and confusing. General consensus stresses successful management through a multimodal approach, in which a variety of medical and nonmedical interventions may be utilised (NHMRC, 1997). Approaches may typically combine medication, educational, behavioural and /or developmental therapies, and dietary intervention.

### 1.2.4 Conners' Parent Rating Scale (CPRS)

There is no single assessment tool that can conclusively establish a diagnosis of ADHD in a child who displays core symptoms. Barkley (1990) notes that the three most important components in a comprehensive evaluation are the clinical interview, medical examination, and the completion and scoring of behaviour rating scales. With regard to the latter component, a variety of rating scales have been developed over the years to test for the presence of behavioural conditions, among them ADHD.

The most widely used are those developed by C. Keith Conners, initially used to measure response to medication in ADHD children. The original 93-item Parent Questionnaire was revised and shortened to 48 items. Factor analysis of the scale yields factors in the areas of conduct problems, learning problems, psychosomatic symptoms, impulsivity, anxiety and hyperactivity. The 48 items are scored on a four-point scale with the following ratings : not at all (score =0); just a little (score =1); pretty much (score =2); and very much (score =3). Based upon a comparison of the child's score with the age-by-sex normative data, the practitioner can make a statistically relevant comparison of the child's behaviour to a normative sample (Goldstein and Goldstein, 1990).

Parent ratings have been shown to be reliable indicators of child behaviours, and the CPRS has been shown to have sufficient reliability and validity for practical application, (Conners, 1997). However, the CPRS is not meant to be the sole criterion for assessment and diagnosis of ADHD. Rather, it is used extensively for selecting and identifying children with behavioural problems for study, for providing measures of children's behaviour, and for monitoring and evaluating the effects of treatment (Barkley, 1990).

## 1.3 Historical Background to the Food-Behaviour Hypothesis

Behavioural food reactions in children were first described in the medical literature by Shannon (1922) who pointed out that 'allergic' children were "restless, irritable, peevish, out-of-sorts, high strung, and difficult to manage". In 1973, the notion of a relationship between diet and children's behaviour was brought to the forefront by Dr. Ben Feingold. At a meeting of the American Medical Association, he presented a preliminary report which proposed an association between hyperactivity and the ingestion of naturally occurring salicylates, artificial food colours and additives. Furthermore, he claimed that up to 50% of hyperactive children became well or improved markedly on a diet free of these substances (Feingold, 1975a).

Barkley (1990) notes that this hypothesis occurred at the same time that Americans were expressing a great interest in natural foods, health consciousness, and life expectancy extensions via "environmental manipulations". The idea thus captured the public imagination, and following the publication of his book (Feingold, 1975b) so

widespread became this view that more than 100 parent self-help organisations sprang up in the USA, UK and Australia, advocating the "Feingold Diet" (Swain, 1988).

Originally the Feingold Diet (or Kaiser-Permanente diet) excluded salicylates only. Intolerance to aspirin - a salicylate - is well recognised in its association with allergic diseases, including food allergy (Loblay and Swain, 1986). It was then discovered that salicylate-sensitive patients also reacted with similar symptoms to benzoic acid and food colouring agents such as tartrazine. This cross-reactivity was used to add artificial colours and flavours to the list of excluded foods, which soon included other food additives such as preservatives.

## 1.4 Early Studies

In the late 1970's, several clinical trials were designed to test Feingold's hypothesis. Three **uncontrolled, open** trials placed subjects on an elimination diet that excluded active food substances, and improvements in symptoms were compared to baseline symptoms when the subjects were on the normal diets (Cook & Woodhill, 1976; Salzman, 1976; Brenner, 1977). These studies reported improvement in baseline hyperactive and disruptive behaviours when children were placed on elimination diets. However, their findings have been criticised as equivocal due to logistic and methodological limitations - an absence of diet monitoring, unclear sample descriptions, lack of control group or diet crossovers or the employment of a "blind" procedure, inadequate consideration of placebo effects, and failure to use standardised validated rating scales.

In general, other more 'reliable', controlled "diet replacement" trials conducted in this period yielded much less impressive results. Conners, Goyette, Southwick, Lees and

Andrulonis (1976) used an experimental diet which excluded artificial colours, flavours and naturally occurring salicylates. A double-blind crossover design was used with a group of hyperactive children, with mixed results. The older primary school children showed no behavioural food effects. A statistically significant reduction in behaviour problems when on the experimental diet was reported only by the teachers (and not the parents) of the younger children.

Harley, Ray, Tomasi et al. (1978) conducted another 'diet replacement' trial, in which naturally occurring and added salicylates, synthetic dyes, and artificial flavours were eliminated. While they did find significant parent behavioural ratings indicative of food effects in preschool children, again they found no significant effects for the older primary school children, concluding that "the overall results do not provide convincing support for the experimental (Feingold) diet".

Several double-blind placebo-controlled food challenge (DBPCFC) studies (the "gold-standard" of techniques to ascertain whether adverse reactions occur) of that period did show positive behavioural food effects in single-case studies. However, subsequent attempts to replicate their findings with larger groups of subjects failed to confirm preliminary results (Harley, Matthew and Eichman, 1978; Levy and Hobbes, 1978; Goyette, Conners and Petti, 1978; Mattes and Gittleman, 1978).

The issue became strongly politicised, with advocates calling for the removal of food additives from school cafeteria foods. Because of the major implications of Feingold's assertions and recommendations for the public and the food industry, the Nutrition Foundation in the USA established a National Advisory Committee on Hyperkinesis and Food Additives (1980), charged with the task reviewing and evaluating evidence on the subject. Some studies did in fact identify a small number of children in whom

challenges appeared to provoke a consistent adverse reaction compared to placebo (Harley et al., 1978; Williams, Cram, Tausig and Webster, 1978; Weiss et al., 1980; Swanson and Kinsbourne, 1980). However, the committee concluded that most studies provided "sufficient evidence to refute the claim that artificial colourings, artificial flavourings and salicylates produce hyperactivity".

Breakey (1997) notes that the still often quoted position that 'the relationship between diet and behaviour has not been proven' is based on the above-mentioned research of the 1970s. While the weight of scientific evidence seemed to have refuted Feingold's hypothesis, it did not resolve the question completely as some children were seen to react. It is necessary to review important research from the 1980s and 1990s to obtain a clearer view of the diet-behaviour picture.

## 1.5 More Recent Studies

After a lull of scientific interest following the conclusions of several governmental bodies, the controversy was rekindled by a carefully controlled study by Egger, Carter, Graham, Gumley and Soothill (1985). They were the first researchers to use a markedly more restrictive diet than previous authors, and openly challenged the responders with a broad range of artificial colours, preservatives, and foods. One major criticism of previous replacement studies and challenge studies is that most targeted only one substance or class of substances (e.g. artificial colours), often failing to take account that most behavioural disturbances are sensitive to more than one class and that the effects can be cumulative (Loblay and Swain, 1986). Swain (1988) notes that unless a broad elimination diet is conducted in order to reduce the "background noise" of symptoms, as well as to lower the dose threshold for challenge reactions,

erroneous results may occur. In Egger et al. (1985), sixty two of 76 selected children (79%) with hyperactivity improved objectively when on the highly restricted and individualised "oligoantigenic" diet. The authors conducted a cross-over placebo-controlled double-blind test after identifying suspected foods, and showed a clear association between deterioration in behaviour and exposure to the suspect food, but not placebo. Forty-five different foods and additives were implicated overall.

Kaplan, McNicol, Conte and Moghadam (1989) used a dietary replacement design in which all food was provided for families. The two previous dietary replacement studies (Conners et al., 1976; Harley et al., 1978) have been criticised because of treatment order effects, in which an elimination diet seems to have a more powerful effect when it follows the placebo control diet, thus confounding results. They were also criticised because behavioural effects had been observed primarily in parent and teacher reports rather than in laboratory testing, which suggested that the parents were not actually blind to the interventions (Wender, 1986). Kaplan et al. (1989) resolved the problem of order effects, and ruled out parental bias as a source of treatment effect. Again, as with Egger et al. (1985), the dietary intervention was broad, eliminating not only artificial colours and flavours, but also preservatives, MSG, chocolate, and caffeine. In addition, several substances were avoided in selected children when parents indicated that the foods might be a problem, and an attempt was made to reduce exposure to common environmental inhalants in the home. Their results showed a 50% improvement in behaviour in 42% of the children as a result of the diet.

In the 1990s, this trend toward a positive relationship between diet and behaviour has continued to be confirmed by a number of studies. Carter, Urbanowicz, Hemsley et al. (1993) conducted a study using a similar design to that of Egger et al. (1985), but with improved methodology and more clearly defined outcome measures. Of 78 eight children who completed their 'few food' diet, parents of 59 (76%) felt there had been a worthwhile improvement in behaviour, two children (3%) became worse, and 17 (22%) did not respond. Twenty-three of the children whose behaviour had improved were then entered into the double blind phase of the trial. Subsequent behavioural ratings by parents showed a statictically significant effect of the suspected foods. Results confirmed that diet can contribute to behaviour disorders in children and that this effect can be shown in a double-blind, placebo controlled trial.

Since then, three other DBPCFC studies (Boris and Mandel, 1994; Rowe and Rowe, 1994; Sutinen, 1995) have demonstrated a substantial and significant difference of behaviour between children's original diet and the elimination diet. These studies have added further and considerable weight to the proposition that behavioural food reactions can be produced by certain food substances in food sensitive children.

## 1.6 Summary

It is important to realise that the conceptualisation of this issue has changed greatly since the 1970s. Early research appeared to have disproved Feingold's claims that a small amount of any one suspect chemical would produce significant change in all sensitive children. By the 1980s there was greater recognition of the complexity of the issues – individual differences both in the variation of suspect chemicals or foods not tolerated, as well as in the pattern of symptoms changed by diet. In addition, recognition of the fact that if one is to explore beyond anecdotal evidence, the methodological difficulties involved in assessing the association between behaviour and diet are considerable.

Consequently, researchers changed and improved aspects of their methodology. Sample selection was adjusted; problems of order effect were resolved; a broader range of suspect foods and chemicals was excluded from elimination diets; challenge and wash-out periods were extended; more controlled designs were utilised. In doing so, the more recent research of the 1980s and 1990s has provided clearer, more statistically reliable results, establishing that there is a diet-behaviour connection, and that significant changes in behaviour can be attained with dietary intervention.

# 2. AIMS

The purpose of this current research project was to investigate the relationship between food intolerance and behaviour in a cohort of children presenting to the RPAH Allergy Unit. Specific aims were :

1. To document the occurrence of food intolerance and behavioural problems by analysing medical records and dietetic notes.
2. To determine the extent and nature of dietary compliance upon leaving the Allergy Unit by means of a Food Allergy and Intolerance Questionnaire.
3. To examine the effect of dietary intervention on behaviour and associated symptoms, through a Questionnaire and the Conners' Parent Rating Scale.

# 3. METHODS

## Ethical Approval

Ethical approval was obtained from the Ethics Review Committee of the Central Sydney Area Health Service (RPAH Zone). An ethics application was also submitted to the University of Wollongong.

## Recruitment

### Subjects

A cohort of 423 children (3-12 years of age), both male and female, who had been seen by Dr. Velencia Soutter (Paediatrician) at the RPAH Allergy Unit, presenting with behavioural problems, were included in the study. The subjects were selected from a total cohort of 1200 children seen at the clinic between 1995 and 1998 with a variety of symptoms. Figure 1 illustrates the methodology in a flow diagram.

## Procedure

### Data Collection

Preliminary information was gathered from medical records and dietetic files of children seen by Dr. Soutter between 1995 and 1997 and entered into an Access database (Microsoft Office 97). Patients were divided into two groups :

1. Children with behavioural and gastrointestinal (GIT) symptoms (Initial data recorded by Ugur Murat for use in a parallel study on food intolerance and GIT symptoms)
2. Children with behavioural symptoms in the absence of recorded GIT symptoms.

RECRUITMENT OF SUBJECTS

Children who presented at RPAH allergy unit with behavioural symptoms and food allergy/intolerance

between 1995 and 1998

Through records of RPAH allergy unit

PACKAGES SENT

Containing:

- Letter of invitation to participate
- Conners' Parent Rating Scale
- Food allergy/intolerance questionnaire
- Food frequency questionnaire (only for the recruited 20 patients)
- Reminder letter (sent after 4 weeks of initial package to non-responders)

DATA COLLECTION

Questionnaires returned via mail by participants

DATA ANALYSIS

Figure 1: Diagram of Study Methodology

## The Survey

All parents and carers of children with behavioural symptoms (with and without GIT symptoms) were sent a package containing :

1. Information/invitation to participate letter outlining the aims and procedures of the study (Appendix 2)
2. Generic Follow-up Food Allergy and Intolerance Questionnaire (Appendix 3)
3. Conners' Parent Rating Scale (CPRS) (Appendix 4)
4. A reply-paid envelope

Four weeks after the initial mailing, a reminder letter was sent to parents who did not respond to the initial invitation for participation (Appendix 5).

## Data Analysis

Data from the Follow-up Questionnaire and CPRS were recorded in the Access database.

All descriptive statistics (mean, range, and standard deviations) were calculated using Microsoft Excel.

A Students' t-test (paired samples) was used to test for differences between initial and final CPRS behaviour scores.

P values less than 5% were reported as evidence of statistical significance.

# 4. RESULTS

## Subjects

### Age of Presentation to the Allergy Clinic

The total survey sample consisted of 423 children who presented to the Allergy Unit with behavioural symptoms. The mean age was 6.76 years (SD 2.61) and the range was 2.18 – 15.76 years. Table 1 shows the number of boys and girls in each age division.

**Table 1 :** *Age of presentation to the Allergy Unit for children with behavioural symptoms*

| Age in Years | Male (N=303) | Female (N=120) | Total (N=423) |
|---|---|---|---|
| < 3 | 7 | 6 | 13 |
| 3-7 | 205 | 74 | 279 |
| 8-12 | 81 | 38 | 119 |
| > 12 | 10 | 2 | 12 |

### Gender

- In the total survey sample of 423 children with behavioural symptoms, there were significantly more males 72% (N=303) than females 28% (N=120) ($p<0.05$, $p=5.7x10^{-19}$).
- In the "behaviour only" subset of 273 children, there were significantly more males 76% (N=207) than females 24% (N=66) ($p<0.05$, $p=1.46x10^{-17}$).
- In the "behaviour + GIT" subset of 150 children, there were significantly more males 64% (N=96) than females 36% (N=54) ($p<0.05$, $p=6.05x10^{-4}$).

**Gender and Age of Respondents Compared to Total Survey Sample**

There is a high correlation in age and sex distribution between the survey respondents and the total survey sample. A summary of the results is presented in Table 2.

**Table 2 :** *Gender and Age of Total Survey Sample and Respondents*

| **Sex and Age** | **Total Survey Sample (N=423)** | **Survey Respondents (N=133)** |
|---|---|---|
| Gender | | |
| Male (%) | 72 | 66 |
| Female (%) | 28 | 34 |
| Mean age (years) | 6.76 (SD 2.61) | 6.44 (SD 2.52) |
| Age range (years) | 2.18-15.76 | 2.18-12.62 |

**Behavioural and Associated Symptoms at Presentation**

All the children in the total survey sample (N=423) had their symptoms recorded in the medical notes on presentation to the clinic. The main behavioural symptom recorded was hyperactivity (50%). The most common symptoms associated with behaviour were found to be irritable bowel (20%), asthma (17%) and eczema (17%). A summary of behavioural and associated symptoms is presented in Table 4.

**Table 4 :** *Presenting Symptoms in the Total Survey Sample and Subgroups*

| Symptoms | Total Survey Sample (N=423) | % of Total Survey Sample | % of Behaviour Only Subgroup (N=273) | % of Behaviour + GIT Subgroup (N=150) |
|---|---|---|---|---|
| **Behaviour** | | | | |
| Hyperactive/restless | 213 | 50 | 47 | 57 |
| ADHD (Diagnosed) | 119 | 28 | 38 | 9 |
| Concentration | 83 | 20 | 26 | 8 |
| Learning Difficulties | 83 | 20 | 27 | 6 |
| Irritable | 77 | 18 | 24 | 7 |
| Mood Swings | 71 | 17 | 22 | 7 |
| Aggressive | 60 | 14 | 19 | 5 |
| Anxious | 38 | 9 | 8 | 11 |
| Violent | 7 | 2 | 3 | - |
| **CNS** | | | | |
| Headaches | 46 | 11 | 8 | 17 |
| Leg Pains | 30 | 7 | 7 | 7 |
| **Other** | | | | |
| Sleep Disturbance | 20 | 5 | 7 | 1 |
| **Gastrointestinal** | | | | |
| Irritable bowel | 83 | 20 | - | 55 |
| Abdominal pains/cramps | 51 | 12 | 5 | 25 |
| Diarrhoea/loose stools | 38 | 9 | 2 | 21 |
| **Respiratory** | | | | |
| Asthma | 72 | 17 | 18 | 15 |
| Blocked/Runny nose | 81 | 20 | 25 | 9 |
| Sinus irritation | 31 | 7 | 3 | 15 |
| **Skin** | | | | |
| Eczema | 73 | 17 | 18 | 16 |
| Mouth Ulcers | 17 | 4 | 2 | 7 |

Total number of symptoms reported by survey respondents was calculated from Question 14 of the Food Allergy and Intolerance Questionnaire. Table 5 shows the percent of total survey respondents (and the two subgroups) who reported a mild, moderate or severe symptom. If one compares this table with Table 4, it can be seen that the survey respondents report a greater number of associated symptoms than the total survey sample.

**Table 5 :** *Reported Symptoms of Total Survey Respondents and Subgroups*

| **Symptom/ Problem** | **Total Survey Respondents (N=133)** | **% of Total Survey Respondents** | **% of "Behaviour Only" (N=89)** | **% of "Behaviour + GIT" (N=44)** |
|---|---|---|---|---|
| Behaviour[1] | 108 | 82 | 85 | 73 |
| Learning[2] | 70 | 53 | 58 | 41 |
| Sleep[3] | 62 | 47 | 46 | 48 |
| Nose[4] | 60 | 45 | 43 | 50 |
| Abdominal[5] | 54 | 41 | 26 | 68 |
| Headache | 39 | 29 | 26 | 36 |
| Ear Infection | 38 | 29 | 28 | 30 |
| Leg Pains | 38 | 29 | 22 | 41 |
| Diarrhoea | 36 | 27 | 18 | 45 |
| Eczema | 35 | 26 | 26 | 34 |

**CPRSs at Presentation**

At presentation, parents were required to fill in the CPRS. Three-hundred-and-fifty-three completed an initial CPRS, of which 111 responded to the survey. A comparison of behaviour ratings between the two groups is represented in Table 3, showing significant similarities in mean behaviour scores on presentation.

**Table 3 :** *Behaviour Ratings of Respondents Compared to Total Survey Sample*

| | **Mean T Scores at Presentation** | |
|---|---|---|
| **Behaviour** | **Total Survey Sample (N=353)** | **Survey Respondents (N=111)** |
| Conduct | 70.52 | 72.49 |
| Learning Difficulties | 77.41 | 74.84 |
| Psychosomatic | 66.18 | 65.68 |
| Impulsive-Hyperactive | 69.33 | 69.43 |
| Anxiety | 58.71 | 57.59 |
| Hyperactive | 76.87 | 75.93 |

## Food Allergy and Intolerance Questionnaire

Parents of one-hundred-and-thirty-three patients completed the Food Allergy and Intolerance Questionnaire (a response rate of 31.0%).

### The Simplified Elimination Diet (SED)

Seventy-seven percent (n=102) started the elimination diet (Q1). Of these, 91% (n=93) reported noticing an improvement in their child's symptoms (Q3). When asked how long it was before they noticed any improvement (Q4), the mean was 15.3 days (SD 12.66 days), and range was between 1 and 60 days.

**Table 5 :** *Time Taken to Notice Improvement on the elimination diet*

| Days | % of Respondents (N=85) |
|---|---|
| 1-7 | 42 |
| 8-14 | 23 |
| 15-21 | 15 |
| 22-28 | 7 |
| > 28 | 13 |

When asked how long it took for their child's symptoms to settle on the elimination diet, the mean time was 27.12 days (SD 25.37); median 21 days; range 2-180 days. Results are summarised in Table 6.

**Table 6 :** *Time Taken for Symptoms to Settle on the elimination diet*

| Days | % of Respondents (N=65) | Days | % of Respondents (N=65) |
|---|---|---|---|
| 1-7 | 15 | 29-35 | 11 |
| 8-14 | 25 | 35-42 | 8 |
| 15-21 | 12 | > 42 | 12 |
| 22-28 | 17 | | |

### Challenges

Respondents who started their child on the elimination diet and noticed an improvement (n=93) were asked if they completed any challenges (Q7). Eighty percent (n=75) did so. Of these, 53% were food challenges, 20% were capsule challenges, and 26% were both food and capsule challenges. Only 38% finished all the challenges (n=29).

The specific symptoms elicited by these challenges could not be accurately ascertained due to problems in the design of the Questionnaire. However, a tally of all those who reported mild, moderate, or severe reactions to particular chemicals/foods shows that amines, salicylates and colours were the most reactive substances. Results are summarised in Table 7.

**Table 7 :** *Reactions to Chemicals/Foods after Challenges*

| | **Reactions to Challenges (n=75)** |
|---|---|
| **Amines** | 68% |
| **Salicylates** | 60% |
| **Colours** | 52% |
| **Glutamates** | 39% |
| **Preservatives** | 32% |
| **Antioxidants** | 27% |
| **Propionates** | 23% |
| **Milk** | 21% |
| **Nitrates** | 17% |
| **Wheat** | 12% |

**Severity of Symptoms**

All parents were asked (Q14) to rate their child's symptoms as none, mild, moderate or severe, *before* coming to the clinic, and *now*. One-hundred-and-thirty-three questionnaire respondents answered this question. The results are summarised in Tables 8.

**Table 8 :** *Severity of Symptoms for all respondents (N=133)*

| | % Severe | | % Moderate | | % Mild | | % None | |
|---|---|---|---|---|---|---|---|---|
| **Symptom** | **Before** | **Now** | **Before** | **Now** | **Before** | **Now** | **Before** | **Now** |
| **Behaviour**[1] (n=108) | 65 | 9 | 30 | 27 | 5 | 47 | - | 17 |
| **Learning**[2] (n=70) | 44 | 13 | 21 | 16 | 35 | 51 | - | 20 |
| **Sleep**[3] (n=62) | 38 | 8 | 38 | 23 | 21 | 36 | 3 | 33 |
| **Nose**[4] (n=60) | 40 | 12 | 40 | 30 | 20 | 25 | - | 33 |
| **Abdominal**[5] (n=54) | 31 | 2 | 49 | 25 | 18 | 37 | 2 | 36 |
| **Headache** (n=39) | 20 | 8 | 41 | 13 | 38 | 51 | 1 | 28 |
| **Ear Infection** (n=38) | 37 | 6 | 34 | 18 | 26 | 18 | 3 | 58 |
| **Leg Pains** (n=38) | 28 | - | 28 | 22 | 44 | 40 | - | 38 |
| **Diarrhoea** (n=36) | 42 | 8 | 42 | 11 | 16 | 36 | - | 44 |
| **Eczema** (n=35) | 37 | 5 | 34 | 20 | 26 | 49 | 3 | 26 |

[1]Behaviour Problems; [2]Learning Difficulties; [3]Sleep Disturbances;
[4]Blocked/Runny; [5]Pain/cramp/colic.

One-hundred-and-seventeen (88%) respondents reported significant improvement in one or more symptom. “Significant improvement” was designated as a change in severity of symptom from “severe” to “mild/none” or from “moderate” to “none”. Significant change in behaviour was reported by most, followed by abdominal pain and sleep disturbance. Results are summarised in Table 9.

**Table 9 :** *Reported Significantly Improved Symptoms*

| **Symptom** | **Number Reporting Significant Improvement (N=117)** | **% Reporting Significant Improvement** |
|---|---|---|
| Behaviour Problems | 45 | 38 |
| Abdominal Pain/cramp | 22 | 19 |
| Sleep Disturbance | 21 | 18 |
| Learning Difficulties | 19 | 16 |
| Blocked/RunnyNose | 17 | 15 |
| Diarrhoea/Loose Stools | 16 | 14 |
| Ear Infection | 16 | 14 |
| Headache | 12 | 10 |
| Eczema | 8 | 7 |
| Leg Pains | 7 | 6 |

[1]Behaviour Problems; [2]Learning Difficulties; [3]Sleep Disturbances; [4]Blocked/Runny; [5]Pain/cramp/colic.

**Modified Diets**

Parents were asked if they currently had their child on a modified diet (Q15). One-hundred-and-eight (81%) children had continued on a modified diet. Of these, 88 were those who had started the elimination diet, and 20 were those who did not start the elimination diet. In other words, 65% of those children who did not start the elimination diet, still had modified diets; and 86% of those who started the elimination diet, continued a modified diet.

They were also asked to indicate how much the child's intake was restricted for specific foods and chemicals. Of the 108 who continued dietary modifications, the most commonly restricted chemical was additives (92%), followed by MSG (86%), salicylates (78%), amines (77%). Dairy products were restricted by 45%, and wheat by 19%. The results are summarised on Table 10.

**Table 10 :** *Degree of Restriction in Modified Diets (N=108)*

| **Food/ Chemical** | **% Not Restricted** | **% Somewhat Restricted** | **% Quite Restricted** | **% Highly Restricted** |
|---|---|---|---|---|
| Salicylates | 8 | 33 | 26 | 20 |
| Amines | 6 | 27 | 28 | 22 |
| Additives | 1 | 19 | 27 | 46 |
| MSG | 6 | 12.5 | 18 | 56 |
| Milk/Dairy | 30 | 16 | 10 | 19 |
| Wheat | 44 | 9 | 4 | 5 |

NB : Restrictions of multiple chemicals/foods were reported.

**Medication**

Sixty-eight children continued to require medication to control their symptoms. The main medications used were for ADHD and atopic problems such as asthma, rhinitis and eczema. The results are summarised in Table 11.

**Table 11 :** *The continuing need for medication*

| **Medication** | **% of Survey Respondents (N=133)** |
|---|---|
| Ritalin/dexamphetamine | 20.3 |
| Nasal sprays | 15.8 |
| Asthma drugs | 12.8 |
| Antihistamine | 11.3 |
| Steroid creams | 7.5 |
| Catapres | 3.8 |
| Tofranil | 3.0 |
| Efalex | 3.0 |

**Overall Improvement in Symptoms**

Parents were asked to compare their child now *overall*, with when they first brought them to the clinic (Q17). The responses are presented in Table 12.

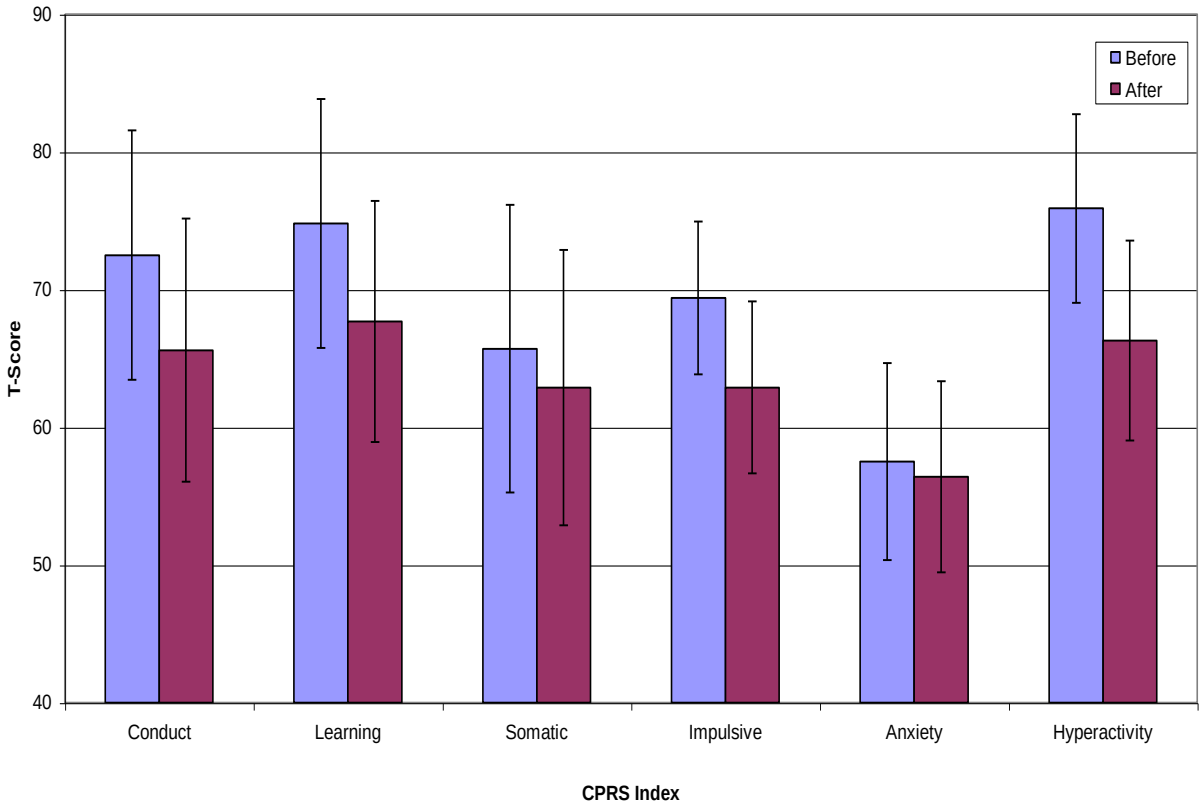
**Table 12 :** *Overall Improvement in Symptoms*

| **Rating** | **Behaviour Only** **% of Respondents (N=85)** | **Behaviour + GIT** **% of Respondents (N=39)** | **Total** **% of Respondents (N=124)** |
|---|---|---|---|
| Completely well | 5 | 3 | 5 |
| Much better | 46 | 56 | 49 |
| A little better | 36 | 26 | 33 |
| The same | 11 | 15 | 12 |
| Worse | 2 | - | 2 |

## Conners' Parent Rating Scale (CPRS) for Behaviour

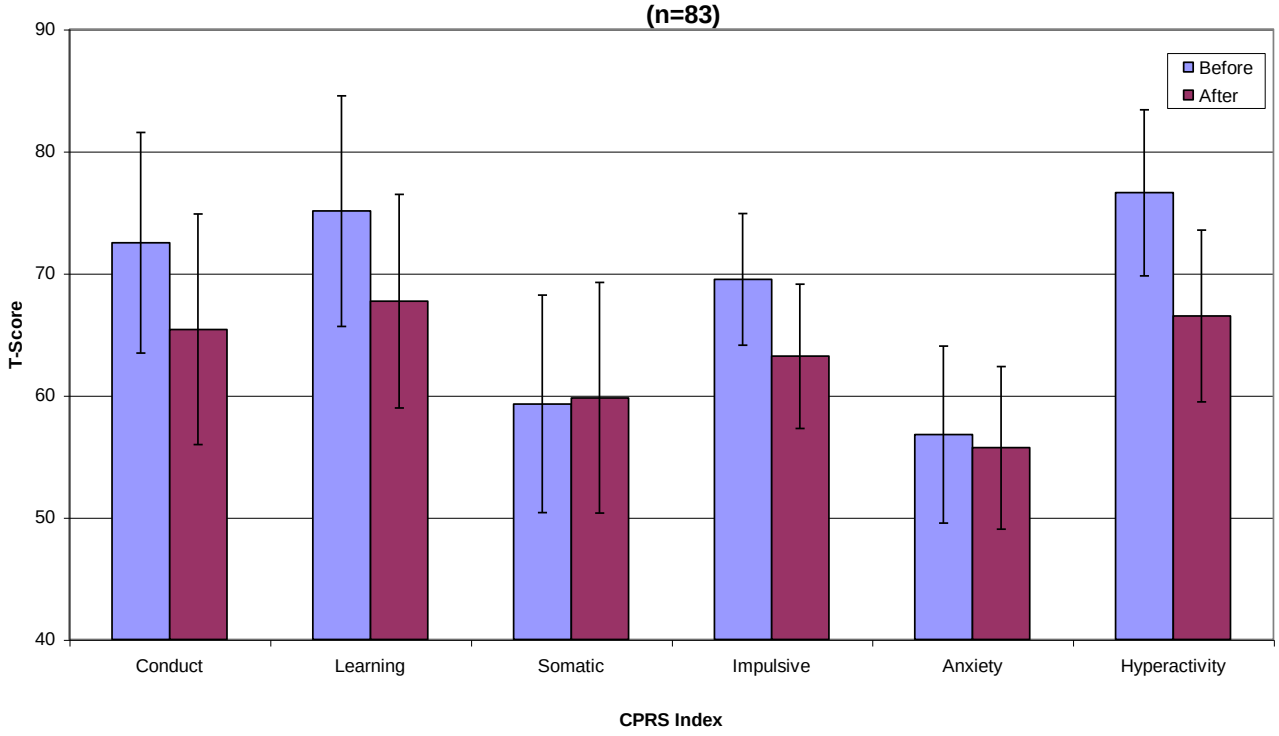
Changes in behaviour were assessed using a paired t-Test comparing returned CPRSs to those completed at initial presentation. Of the 133 respondents, 111 matched before-and- now scales were obtained and compared. Figure 2 shows the results of the total survey respondents. Statistically significant improvements were seen in *conduct* ($p<0.001$, $p=0.00001$, $df=110$), *learning* ($p<0.001$, $p=0.00002$, $df=110$), *impulsive* ($p<0.001$, $p=1.9\times10^{-7}$, $df=110$), and *hyperactive* ($p<0.001$, $p=1.4\times10^{-9}$) index's. No statistically significant improvement was seen in *somatic* ($p<0.05$, $p=0.09$, $df=110$) or *anxiety* ($p<0.05$, $p=0.14$, $df=110$).

**Figure 1: Comparison of CPRS T-Scores for Total Survey Respondants (N=111)**



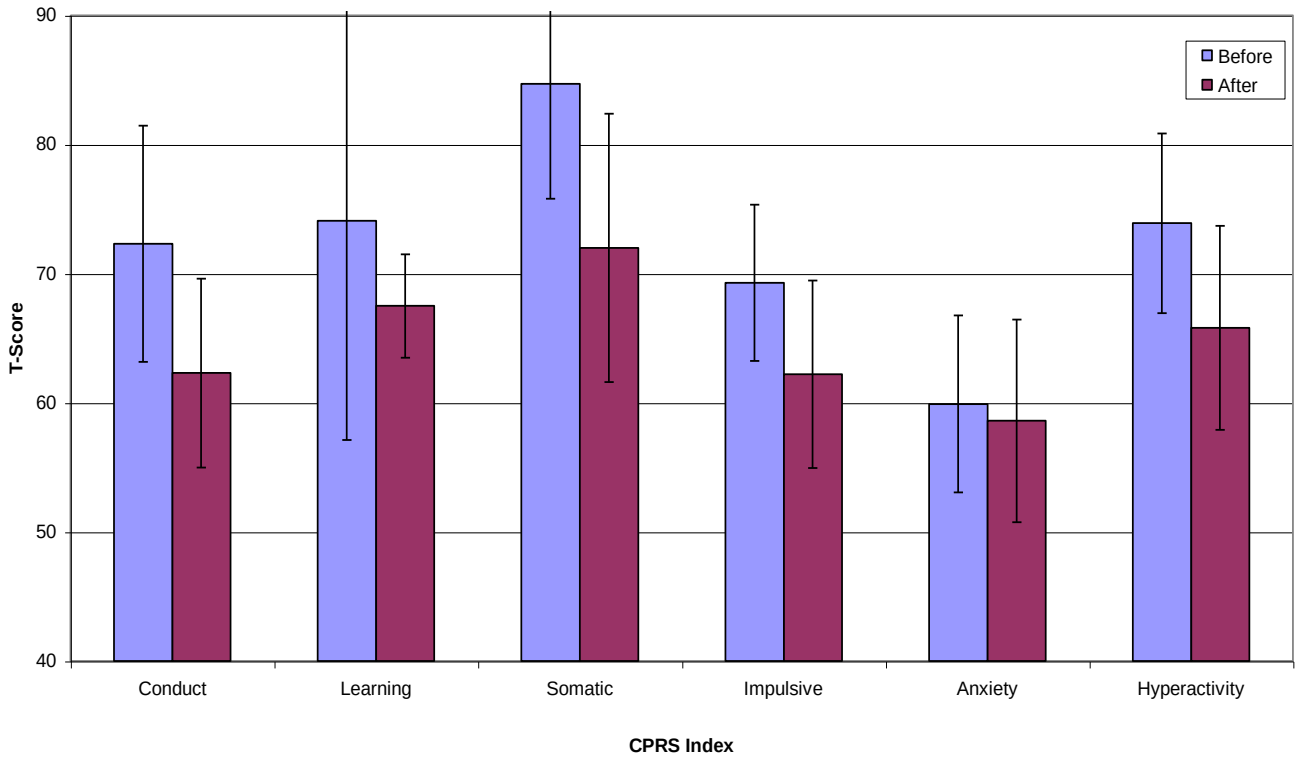
Eighty-three matched CPRSs were obtained for the "Behaviour Only" group. Statistically significant improvements between 'before' and 'now' on T-scores were obtained for : *conduct* ($p<0.001$, $p=0.0001$, $df=82$); *learning* ($p<0.001$, $p=0.0002$, $df=82$); *impulsive* ($p<0.001$, $p=0.00002$, $df=82$); and *hyperactivity* ($p<0.001$, $p=1.1\times10^{-7}$) index's. No statistically significant change was found in *somatic* ($p<0.05$, $p=0.4$, $df=82$) or *anxiety* ($p<0.05$, $p=0.2$, $df=82$) Index's. Results are summarised in Figure 3 below.

**Figure 1: Comparison of CPRS T-Scores for "Behaviour Only" Subgroup (n=83)**



Twenty-eight matched CPRSs were obtained for the "Behaviour + GIT" group. Statistically significant improvements between 'before' and 'now' on T-scores were obtained for : *conduct* ($p<0.01$, $p=0.003$, $df=27$); *learning* ($p<0.05$, $p=0.02$, $df=27$); *somatic* ($p<0.01$, $p=0.003$, $df=27$); *impulsive* ($p<0.01$, $p=0.002$, $df=27$); and *hyperactivity* ($p<0.01$, $p=0.002$, $df=27$) index's. No statistically significant change was found in *anxiety* ($p<0.05$, $p=0.32$, $df=27$) Index. Results are summarised on Figure 4.

**Figure 1: Comparison of CPRS T-Scores for "Behaviour + GIT" Subgroup (n=28)**



The responses of those who reported a behaviour symptom in question 14 (see Table 7) were categorised as "significantly improved" or "no significant improvement". These were then cross-referenced with their change (before vs. after) in CPRS hyperactivity (HA) T-score (this index is often used as a "global" assessment of behaviour) to determine if their "reported" behaviour change was reflected by a similar change in CPRS behaviour. Fourteen of those who reported a significant change in behaviour had no significant improvement in their CPRS HA T-score. Twenty-six of those who reported no significant improvement in behaviour, had significantly improved CPRS HA T-scores. The results are summarised in Table 13.

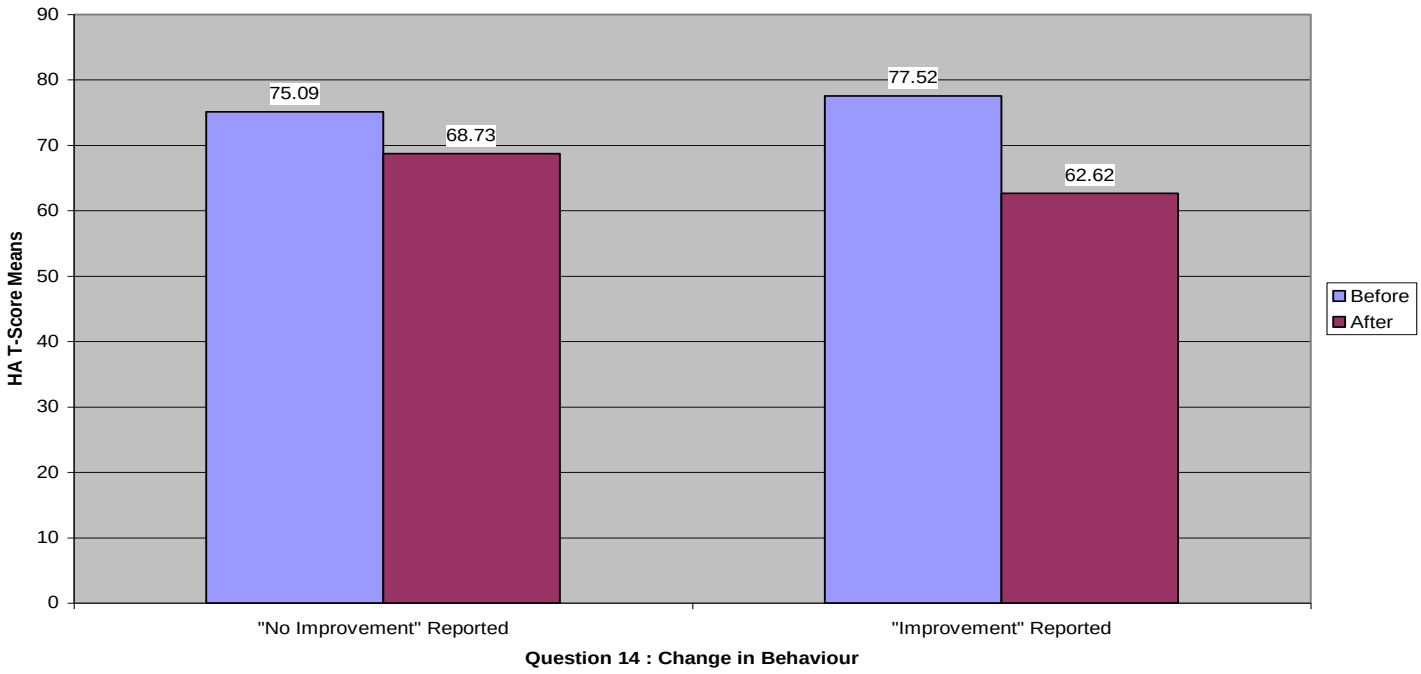
**Table 13 :** *Reported Behaviour Change vs. Change in Hyperactivity Index of CPRS*

| | **Significantly Improved CPRS HA T-Score[1]** | **No Significant Improvement in CPRS HA T-Score[2]** | |
|---|---|---|---|
| **Significantly Improved Behaviour[3]** | 25 | 14 | 39 |
| **No Sig. Improvement in Behaviour** | 22 | 31 | 53 |
| | 47 | 45 | 92 |

[1] = change in CPRS Behaviour Index of greater than 1 standard deviation
[2]= change in CPRS Behaviour Index of less than 1 standard deviation
[3]= Question 14 : "severe" to "mild/none"; "moderate" to "none"
[4]= Question 14 : "severe" to "moderate"; "moderate" to "mild"; "mild" to "none"

Mean before and after hyperactivity index T-scores were calculated in a paired t-test to determine if these apparently discordant reports of behaviour change were significant. In the group reporting a significant improvement in behaviour, there was indeed a statistically significant improvement in HA scores ($p<0.001$, $p=0.000006$, $df=38$). However, in the group reporting no significant improvement in behaviour, there was in fact a statistically significant improvement in HA scores ($p<0.001$, $p=0.0008$, $df=52$). Results are summarised in Figure 5.

**Figure 4 : Reported Change vs. Change in CPRS**



A similar cross-reference and comparison was performed with Question 17, to determine if parents' "overall" improvement rating was reflected in their CPRS HA T-scores for before and now. Twenty-two who rated their child as significantly better, actually had no significant improvement in their HA T-scores. Nineteen who reported no significant improvement, had significant improvements in HA T-scores. The results are summarised in Table 14.

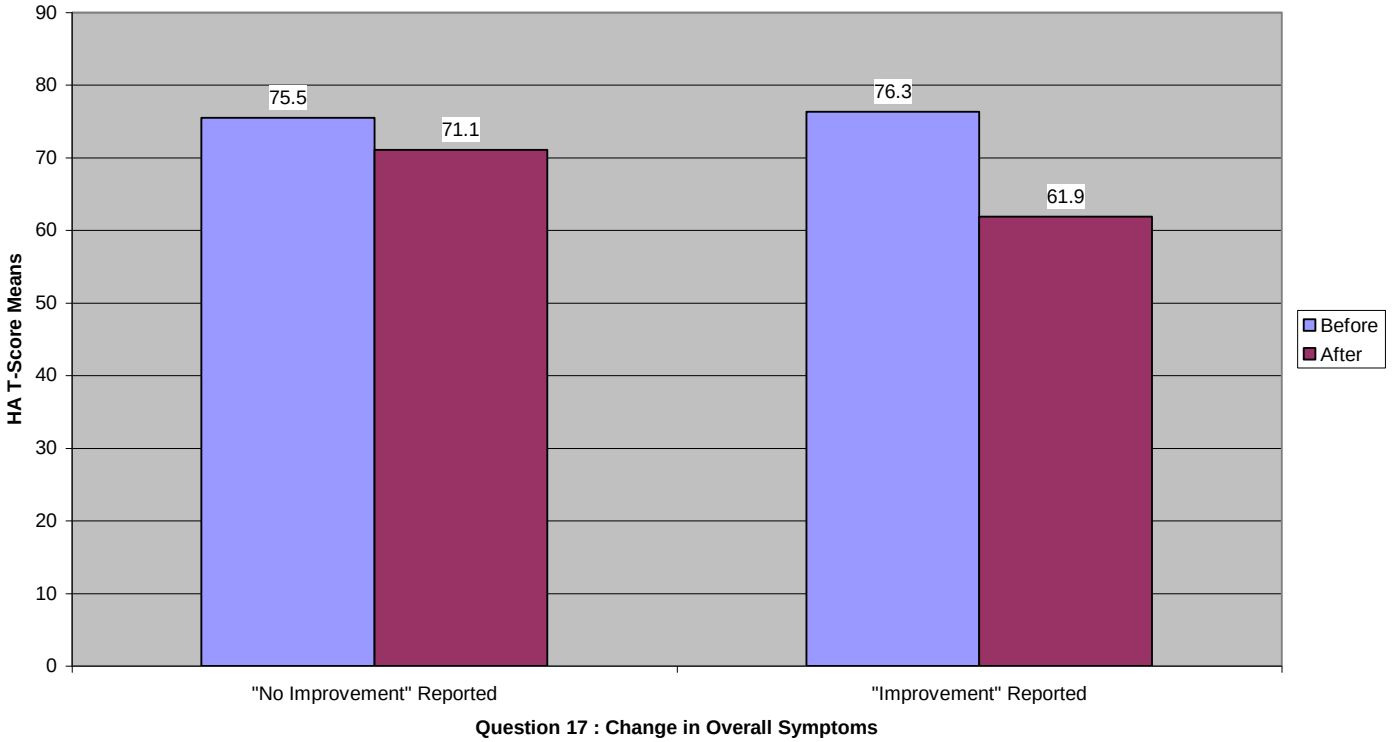
**Table 14 :** *Overall Reported Improvement vs. vs. Change in Hyperactivity Index of CPRS*

| | **Significantly Improved CPRS HA T-Score[1]** | **No Significant Improvement in CPRS HA T-Score[2]** | |
|---|---|---|---|
| **Significantly Improved Overall[3]** | 36 | 22 | 58 |
| **No Sig. Improvement Overall[4]** | 19 | 32 | 51 |
| | 55 | 54 | 109 |

[1] = change in CPRS Behaviour Index of greater than 1 standard deviation
[2]= change in CPRS Behaviour Index of less than 1 standard deviation
[3]= Question 17 : "much better" or "completely well"
[4]= Question 17 : "same", "a little better", or "worse"

To determine if these apparently discordant reports of behaviour change were significant, mean before and after hyperactivity index T-scores were calculated in a paired t-test. In the group reporting a significant improvement overall, there was also a statistically significant improvement in HA scores ($p<0.05$, $p=4.8x10\text{-}10$, $df=57$). Again, in the group reporting no significant improvement overall however, there was actually a statistically significant improvement in HA scores ($p<0.05$, $p=0.03$, $df=50$). Results are summarised in Figure 6.

**Figure 5 : Overall Change vs. CPRS Change**



**Specific Improvements on the CPRS**

Changes on each of the 48 items of the matched-CPRSs were also assessed. A "significant improvement" was designated as a change in rating from "very much" to "just a little" or "not at all", or from "pretty much" to "not at all". Table 15 illustrates the problem behaviours that indicated the most significant improvements, though improvements were seen to lesser degrees on all items.

**Table 15 :** *Behaviours of Respondents with Significant Improvements*

| **Symptom/Problem** | **% of Total Respondents (N=106)** | **% of Behaviour Only Subgroup (n=80)** | **% of Behaviour + GIT Subgroup (n=26)** |
|---|---|---|---|
| Restless in a squirmy sense (i.e. can't sit still) | 18 | 19 | 13* |
| Restless, always on the go | 19 | 23 | 8* |
| Easily frustrated in efforts | 18 | 23 | 4* |
| Mood changes quickly and drastically | 23 | 27 | 9* |
| Stomach aches | 8* | 5* | 23 |
| Worries more than others | 8* | 6* | 23 |

*Not a significant proportion of respondents

# 5. DISCUSSION

This study reports on a group of children who presented to the RPAH Allergy Unit for investigation of the role of food intolerance in their behavioural symptoms. This was a retrospective, observational study, based on :

1. Clinical data recorded by a paediatrician and/or dietitian;
2. Parent-reported questionnaire information; and
3. Child behavioural ratings as indicated by parents.

The low response rate of 31% may be due to :

1. Use of a mail-out questionnaire as the choice for data collection which :
   - Does not account for changes of address
   - Does not allow for one-on-one contact with possible participants
2. Families with young children who were too busy to reply.
3. Belief of parents that their child did not fit the criteria for a study on behaviour
4. Parents who may have been less likely to respond if :
   - The diet did not lead to a clinical improvement
   - They were unhappy with the quality of service provided
   - They were disinterested in dietary modification as a means of controlling symptoms

The first three possible reasons for the low-response rate are unlikely to affect the generalisability of the results. In addition, the gender and age of the respondents highly correlates with those of the total survey sample; and behaviour ratings at presentation, as indicated by mean T-scores for the CPRS, were significantly similar. However, response bias that may have occurred and the small sample size, precludes

generalisation of the results either locally to the total survey sample or globally to children with ADHD. Nonetheless, the results of this study do provide valuable information on a cohort of children who have presented to the RPAH Allergy Unit.

**Gender and Age**

In this study there were significantly more males than females. This is consistent with the high preponderance of boys with ADHD – usually reported as being 4-9 times as common than in girls, depending on the setting - found by most authors (NHMRC, 1997). Hinshaw (1994) suggests that boys seem to display greater levels of aggressive and anti-social behaviours, while diagnosed girls tend to display higher rates of cognitive impairment. The results of this study cannot confirm this paradigm, though the more disruptive behaviour of boys may be an explanation for disproportionate rates of referral, and a possible under-reporting of females with symptoms characteristic of ADHD.

The majority of children presenting to the clinic were between the ages 3 and 7. Harley et al. (1978) were the first to suggest that younger children are more vulnerable to nutrition-behaviour interactions, and Kaplan et al. (1989) conducted their study only on preschool-aged boys as a consequence. Other studies have also found notable differences in the clinical features of children aged 2 to 6 years, compared to those aged 7 to 14 years (Rowe and Rowe, 1994). The symptoms and behaviours of the younger children in the survey sample were not compared with those of the older children (8-12 years), though an analysis and investigation of the efficacy of dietary modification at different ages may be warranted.

**Behaviour at Presentation**

According to Conners (1997), a T-score of 45-55 is average; 56-60 is slightly atypical and should raise some concern; 61-65 is mildly atypical and a possible significant problem; 66-70 is moderately atypical and indicates a significant problem; and 70+ is markedly atypical and a significant problem. In both the total survey sample and the survey respondents, mean T-scores indicated significant problems well above the average for conduct, learning difficulties, somatic symptoms, impulsivity and hyperactivity. Only anxiety scores were less significant and slightly above average. This highlights the severity of behaviours exhibited by children who present to the Allergy Unit.

**Behavioural and Associated Symptoms at Presentation**

Symptoms at presentation were those recorded by the paediatrician as clinically observed, and/or as reported by the parents. Though it was difficult to ascertain exact numbers, it should be noted that while all children had some form of behavioural symptom recorded, this was not always the reason for referral, nor was it always the primary reason for presenting to the clinic. Personal communication with the paediatrician (Dr. Soutter) suggests that some parents may feel reluctant to admitting that their child has "behavioural problems"; others bring their children into the clinic with somatic disturbances that are so troubling that they mask clear behavioural symptoms. Hyperactivity was the most common symptom recorded by the paediatrician, though it should be noted that the term "hyperactive" has become a global term for a range of behavioural disturbances.

It was expected that the "Behaviour Only" group had little or no gastrointestinal symptoms, since this was the defining factor for sorting the two subgroups. It is

interesting that in the GIT group, while hyperactivity was common, only a small percentage of this group recorded other behavioural symptoms. It is probable though that as this group was documented by another researcher who was more interested in the gastrointestinal symptoms, they may have been less stringent than the present author in detailing the behavioural symptoms.

**The Elimination Diet**

Seventy-seven percent of children started the elimination diet with 91% reporting improvement of symptoms. While most saw improvements within the first two weeks, it took an average of about 4 weeks for symptoms to settle. These time frames are consistent with the recommendations of the RPAH Allergy Unit to maintain the elimination diet for a minimum of 2 weeks, and up to 6 weeks.

**Challenges**

While over 90% of those who started the elimination diet reported improvements, not all of those tried challenges, and only 38% of those actually finished all the challenges. It is likely that many parents recognised suspect foods or chemicals early on in the elimination diet, and rather than continue with the regimen, simply eliminated those substances from their child's diet. Rather than attribute this to complacency, this is testament to the implicit and often extreme difficulty of dietary management that many parents involved in this study, and others commentators (Carter et al., 1993), have alluded to. Indeed, dietitians at the RPAH Allergy Unit maintain phone, fax and e-mail contact with patients on the elimination diet, acting as much "counsellors of motivation and encouragement", as dietetic advisors.

It is unfortunate that due to limitations in the design of the generic Food Allergy and Intolerance Questionnaire, specific symptoms evoked by those who did complete challenges are not available. Such information may have been available in dietetic notes, though time constraints did not allow for this to be analysed. Nevertheless, a tally of all those who reported a reaction (regardless of severity) to challenges, was recorded. The most common chemicals reacted to respectively were amines (68%), salicylates (60%) and colours (52%), followed by glutamates (39%), and preservatives (32%). Very similar percentages were documented by Swain (1988) as those most responsible for causing behavioural changes (with the exception of amines, to which only one-third reacted).

**Modified Diets**

Despite the 'drop-out' rate for starting the elimination diet (23%) and the low number of respondents who finished all challenges, 81% of respondents still had their child on a "modified diet". Eighty-two percent of those who started the elimination diet, continued to modify their child's diet, highlighting long-term compliance of aspects of the elimination diet. An almost equally large proportion of those who did not start the elimination diet, still continued to modify their child's diet, more likely than not based on advice given to them by the RPAH Allergy Unit.

Of those who continued dietary modifications, the most commonly restricted substances were additives, followed closely by MSG, salicylates, amines, and then to a lesser degree, dairy products and wheat. For patients who come to the clinic, subsequent dietary restriction and modification reflects three aspects :

1) Avoidance/restriction of substances observed or suspected (through challenges) to cause a reaction.
2) Avoidance/restriction of substances as explained by the dietitian and RPAH Allergy Unit resources that may cause a reaction (particularly salicylates and amines).
3) Avoidance/restriction of substances that are most easily identifiable, avoidable, and/or which the general public readily accepts as causing a reaction in some people (e.g. additives and MSG).

**Symptoms Reported**

Of particular interest are the percent of children's symptoms as reported by their parents (see Table 5). Firstly, it is interesting to note that only 82% (and not 100%) reported behaviour problems. While it may seem that the remaining 18% don't consider their child to have a behaviour problem, it is more likely that these children had learning difficulties - given the co-morbidity of learning difficulties with ADHD. These subjects were thus recruited as having "behaviour problems". Secondly, and more importantly, is the percent of children reporting associated somatic symptoms.

While only 5% of the total survey sample were recorded as having sleep disturbances, 47% of survey respondents reported this symptom; while only 20% of the total survey sample were recorded as having a blocked or runny nose, 45% of survey respondents reported this symptom. Survey respondents reported a far greater occurrence of each somatic symptom than was recorded for the total survey sample. This suggests several possibilities regarding the survey respondents : 1) They underreported these symptoms when they presented to the clinic, perhaps because their main reason for coming was the amelioration of behaviour problems; 2) They simply and by chance

had more somatic problems than the total survey sample; or 3) Response bias - they were more likely to respond to the survey if behaviour changes were accompanied by improvements in somatic symptoms.

**Medication**

The results of this study reflected the need for additional medications to control behaviour, rhinitis, asthma and eczema. With regard to medications for the control of behaviour, twenty percent of respondents were using Ritalin or Dexamphetamine, and an additional 10% were using Catapres, Tofranil and Efalex. Most controlled studies have excluded the use of medications/psychostimulants to determine a diet-behaviour connection. While medication is the most effective short-term treatment for the disruptive behaviours of ADHD (NHMRC, 1997), it is the general consensus that a variety of approaches is a more effective mode of management than any individual form of management alone. Equally then, dietary modification is intended to work synergistically with medications, should they be required.

**Improvements in Symptoms**

Parents were asked to report their child's symptoms *before* they came to the clinic and *now*, as severe, moderate, mild or none. Without exception, the number of children experiencing severe symptoms dropped dramatically, and the number reporting no symptoms increased greatly. While improvements were reported in all symptoms, 88% of respondents reported *significant* improvements in one or more symptom. Of these, **significant improvements in behaviour problems (38%)** predominated. In addition, **over 50% of survey respondents rated their child's symptoms *overall* as much better or completely well**. A third reported that overall symptoms were just a

little better, while 12% had no change in symptoms, and 2% were worse. These results closely resemble parental reports of improvement in behaviour due to diet by some authors (Kaplan et al., 1989; Swain, 1988), though less than others (Boris and Mandel, 1994; Carter et al., 1993).

Significant improvements, though in lesser proportions than those seen in behaviour, were also reported in abdominal pain/cramp, sleep disturbance, blocked/runny nose, diarrhoea, ear infection, eczema and leg pains respectively. Whether alleviation of these symptoms caused behavioural improvements is a matter of contention. Determination of this aspect would require comparing behavioural change in a sample population with other physical symptoms to a sample population with no physical symptoms. Carter et al. (1993) attempted to achieve this (though not completely successful) and found no difference between the groups with regards to behavioural improvement, as did Kaplan et al. (1989).

Behavioural improvements were also attained from the Conners Parent Rating Scale (CPRS), and these serve as perhaps the best barometer for highlighting significant treatment effects. Initial ratings completed at presentation served as baseline indicators of behaviour problems prior to dietary intervention, and change was evaluated by comparing these scores to those derived from ratings received in response to the current survey.

For both the total survey respondents and the "behaviour only" subgroup, **statistically significant improvements were noted in conduct, learning, impulsivity, and hyperactivity**. While improvements were noticed with the somatic and anxiety

index's, they were not statistically significant. The most significant improvements in these groups were found to be in problems of restlessness, frustration and particularly mood changes. These latter two are consistent with the findings of Carter et al. (1993), in which parents commented that their children had become more manageable and more amenable to reasoning rather than less active or better able to concentrate.

The main difference in the "behaviour + GIT" subgroup, were the additionally statistically significant improvements in the somatic index. In this group, the most significant improvements were seen in problems of stomach aches and worrying. This highlights the fact that behavioural improvements are significant regardless of gastrointestinal problems.

Interestingly, it was observed that of those who reported significant improvements in symptoms overall and in behaviour, the CPRS scores of some did not reflect these improvements. While these anomalies were not found to be statistically significant, they do suggest further investigation. Likewise, there was a proportion of respondents who reported no significant improvements overall or in behaviour, yet whose CPRS scores showed significant improvements. These discordant reports of behaviour change were however, statistically significant, suggesting a potential bias in parental ratings.

Parents have generally been found to be reliable observers and raters of their children's behaviours (Rowe and Rowe, 1994). However, Barkley (1990) notes that the characteristics and mental status of the adult will affect their opinion. In addition, some parents will tend to exaggerate minor symptoms, while others may be reluctant to admit their child has problems because they fear this reflects badly on their parenting abilities. Behavioural improvements may seem secondary to the parents in comparison to improvements in physical symptoms, thus causing an under-reporting of behavioural improvements.

# 6. CONCLUSION

Identifying food intolerance with the use of the elimination diet and challenges, and modifying the diet as a consequence, has proven in this study to be beneficial in the improvement of behaviour problems and associated symptoms. However, this is a difficult and exacting regimen. Many parents continue to modify their child's diet, regardless of starting or completing the elimination diet or challenges. As the same substances – amines, salicylates, colours, preservatives and additives - are implicated, avoidance of these substances to varying degrees by children who participated in this study resulted in improved behaviour compared to when they first presented to the RPAH Allergy Unit.

Owing to the marked improvements in behaviour exhibited by respondents of this study, it is tempting to extrapolate these findings to the total survey sample, though caution is warranted given the low-response-rate and possible response-bias. Even more presumptuous though would be to generalise the findings of this study to the greater ADHD 'public'. History has taught us that only the most carefully controlled studies can provide conclusive answers to the diet-behaviour hypothesis. Recent studies employing double-blind, placebo-controlled food challenge designs, the 'gold standard' of scientific research, have demonstrated that behavioural improvements can be achieved through diet in a proportion of children with behaviour problems like those exhibited in ADHD. I[1]t appears that these are the children who present to the RPAH Allergy Unit.

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