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THE ROLE OF DIETARY FATTY ACIDS IN CHILDREN'S BEHAVIOUR AND LEARNING

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ABSTRACT

A growing awareness and understanding of the profiles of local children in County Durham, UK, experiencing learning and behavioural difficulties throughout the education system, has resulted in a number of school based nutritional intervention studies being undertaken. Evidence suggests that some children and young adults with developmental difficulties have a deficiency of particular omega 3 and omega 6 polyunsaturated fatty acids and supplementation with these nutrients can have an impact on their behaviour, concentration and performance on standardised assessments. The first randomised placebo controlled trial to be carried out on children in Durham with developmental coordination disorder has demonstrated significant effects of fatty acid supplementation on behaviour, reading and spelling performance. We are conducting further scientific studies within Durham and neighbouring Authorities in the North of England to be published at a future time. We have also carried out a number of open label treatment studies within schools to help us understand better the role that nutritional intervention can play across a broader range of age groups and abilities. The results suggest positive outcomes for a substantial proportion of children who are more able to engage with the educational opportunities presented to them. This is an important finding to be shared with educationalists, health professionals and importantly the parents.

Key words: Omega-3, omega-6, ADHD, Dyslexia, Dyspraxia, Autism.

INTRODUCTION

By the end of the 1980s there was increasing awareness amongst educationalists in County Durham of the difficulties experienced in the classroom by children with Attention Deficit Hyperactivity Disorder (ADHD), Dyslexia, Dyspraxia and Autistic Spectrum Disorders. These difficulties were not only evident in

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school aged children but also young adults, many of whom had been newly diagnosed as having symptoms of a neurodevelopmental disorder.

It was probable that some juveniles, who had not had their difficulties recognised, presented with behavioural problems, which resulted in exclusion from mainstream educational provision. Therefore in 1996 I screened 69 inmates aged between 15 and 17 years at Deerbolt Young Offenders Institution in Durham and discovered that more than 50% had specific learning difficulties, with the majority having additional problems with attention and impulse control (Portwood, I999a). Some had accessed support and were given additional resources in school, but many reported that this had made little difference to their attainments.

By the late 1990s, attention was beginning to focus on the importance of nutrition on children's behaviour and learning. By then, I had completed individual assessments on more than 600 children aged between 4 and 16 years, all with specific difficulties in reading, co ordination, movement, relating to peers or displaying symptoms of inattention and hyperactivity. Most concerning was that for nearly 20% of these pupils, the usual strategies for intervention—targeted reading practice, structured co ordination activities and behavioural management—had produced only minimal improvement (Portwood, 1999b). The examination of the developmental histories of this group suggested that a high proportion had eczema, asthma and lactose intolerance as babies indicating that, perhaps, dietary deficiencies could offer some potential explanation for their failure to respond.

At the same time I was aware of concerns amongst nursery staff who were reporting, year after year, an increase in the incidence of attentional problems and hyperactivity in the three year olds attending their settings.

I presented an overview of the evidence relating to nutrition and children's behaviour and learning to the primary school head teachers in Durham in 2001, it was agreed that children's nutrition was fundamental to learning. The head teachers were determined to use this information to support pupils in their schools and this was the beginning of the extensive research that has been undertaken in a range of settings in the county and is presented in this paper. The first: a randomised placebo-controlled trial with primary aged children (5–12 years). The second: an open label study with adolescents (12–15 years). The third: an open-label study with pre-schoolers (18 months–3 years).

Setting the scene an overview of studies examining the effect of fatty acid supplementation on learning and behavioural conditions

The evidence so far has demonstrated that some children with learning and behavioural difficulties, particularly associated with ADHD, have biochemical deficiencies of omega-3 and 6 long-chain fatty acids (Stevens *et al*., 1995, Mitchell *et al*., 1987) which are most likely to be metabolic in origin. In line with this are clinical observation studies that have shown an association between fatty acid deficiency signs and the extent of difficulties associated with a particular condition (Taylor *et al*., 2000, Richardson *et al*., 2000). Several supplementation trials combining the omega-3 fatty acids eicosapentaenoic acid (EPA) and docosahexaenoic acid (DHA) and more often than not the omega-6 fatty acid gamma linolenic acid (GLA) have demonstrated that dietary input can alter these deficiencies in children and adults with ADHD (Stevens *et al*., 2003, Young *et al*., 2005). Trials have provided evidence that supplementation with this combination of fatty acids can have a significant impact on attention, concentration and learning performance in children with Dyslexia, Dyspraxia and ADHD (Stevens *et al*., 2003, Richardson and Puri, 2002, Richardson and Montgomery, 2005). Other trials, where docosahexaenoic acid (DHA) has been provided alone, have shown no improvements (Hirayama *et al*., 2004, Voight *et al*., 2001). It has therefore been suggested that EPA must be present and may play a greater role than DHA in the treatment of these conditions. Indeed Stevens *et al*. (2003) found a significant correlation between the increase in proportion of EPA in red blood cells and the reduction in disruptive behaviour (Stevens *et al*., 2003).

Randomised placebo controlled trial

The findings of a double blind trial of over 120 schoolchildren in County Durham with developmental coordination disorder has been published elsewhere, in which six capsules of omega-3 and -6 fatty acid supplementation (eye q^{TM}) (or placebo) were administered each day for a total of 6 months. In addition to motor coordination problems these children aged between 6 and 12 years displayed increased hyperactivity and inattention compared to population norms, performance on reading and spelling assessments were on average 1 year behind the children's chronological age. This is consistent with populations of DCD children who frequently display the cognitive and behavioural characteristics associated with other conditions such as attention deficit hyperactivity disorder (ADHD) and dyslexia (Dewey *et al*., 2000, Rasmussen and Gillberg, 2000, Ramus *et al*., 2003, Portwood, 2005).

Following fatty acid supplementation significant reductions were shown in ADHD symptomatology, as measured by the long form of the Conners' teacher rating scale (CTRS:L-R). Based on ratings of the Conners' ADHD Index scale, the effect size of the active group after 6 months of supplementation was 0.70. This compares with medication trials using methylphenidate (0.78). We observed that the reductions in hyperactivity enabled the children to concentrate better within the classroom and access the learning opportunities presented to them. This was demonstrated in the active supplementation group who made on average 9.5 months gain in reading age during the first 3 month period and a 6.6 month gain in spelling age. The placebo group experienced similar progress in the cross over period of the trial.

In the classroom the pupils were no longer reminded constantly to stay on task. This resulted in more effective teaching, benefiting the whole group, not just the children involved in the trial. Staff reported that the pupils' work output increased, not only in quantity, but also in quality. There were marked improvements in the handwriting of many of the pupils.

Figure 1a is an example of 10-year-old Sam's handwriting before supplementation. Figure 1b shows the improvement 6 months later.

It was also significant that the children felt better about themselves. With rising self-esteem the children were more likely to involve themselves in tasks they found difficult. This enabled them to acquire new skills more readily and improve their rate of learning.

The trial, which we completed in July 2002, strongly indicated to us that this particular dietary intervention could impact greatly on children's behaviour and learning. However we were aware that our sample was selected specifically for childhood developmental coordination disorder and results could not necessarily be generalized across the school population. Since then therefore part of my work in Durham has been to study different groups of children who may be under achieving in the classroom due to

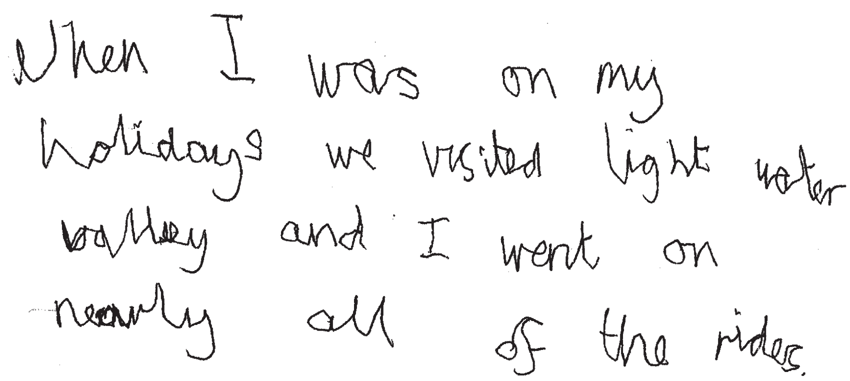

Figure 1a

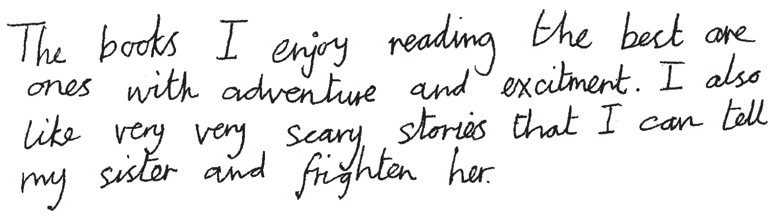

Figure 1b

neurodevelopmental conditions, behavioural difficulties or low socio economic areas and assess whether or not they too could benefit from fatty acid supplementation. The support of Durham and neighbouring Local Education Authorities has facilitated the completion of two further randomised placebo controlled trials: (1) an investigation of the effects of fatty acid intervention on children with autism; (2) supplementation of mainstream schoolchildren with no learning difficulties but poor concentration within the classroom.

Both trials have been running concurrently and finished in October 2005—results of which will be available early next year. In addition a number of open label studies have been conducted since our first supplementation trial, the outcomes of two I report here.

METHOD

Open label study—adolescents

Permanent exclusions from maintained primary, secondary and special schools in England have risen from 8,320 in 1999/2000 to 9,880 in 2003/2004—an increase of 19%. Of all permanent exclusions in 2003/2004, 84% were in secondary schools, and 68% of all permanent exclusions during this period were of pupils aged between 12 and 14 years (Statistics from UK Government's Department for Education and Skills). In addition, at Key Stage 3 (ages 12–14), boys are reported to have higher truancy rates and are more likely to be excluded and outperformed by girls in all of the National Tests (Statistics from UK Government's Department for Education and Skills).

Staff at Greenfield Community Arts College (pupils aged 11–16) in Newton Aycliffe, County Durham, had identified a group of potentially vulnerable students aged between 12 and 15, who had persistent difficulties with behaviour and were at risk of exclusion. From these, pupils were recruited for an open-label treatment study of fatty acid supplementation if they exhibited problems with concentration, behaviour and in some cases, aggression, across a range of lesson periods.

In total, 20 children (18 males and 2 females) were selected. Clinical assessment demonstrated symptoms of fatty acid deficiency (Stevens *et al*., 1995) and higher than average incidences of eczema, asthma, dry flaky skin and lactose intolerance in early childhood. Teachers completed the Conners' Teacher Rating Scales—Long Form (CTRS-R:L) before and 3 months after supplementation to provide an indication of behavioural problems according to ADHD criteria outlined in DSM-IV-TR (American Psychiatric Association). To ensure good inter-test reliability, the same teacher completed the assessment at baseline and 3-month follow-up.

RESULTS

17 children completed the trial, 2 left the school and so could not be seen for follow-up, and 1 child withdrew himself from the trial (data on the latter child has been included in this analysis). At baseline Conners' teacher ratings revealed scores of moderate severe ADHD (> 60) on 12 of the 13 scales (see Table 1 for means), with the exception of the Perfectionism scale which reflected 'mild' ADHD symptomatology (< 60). At baseline 94% (17/18) of children had moderate severe ratings on the DSM-IV Global Total Scale. This was also the case for teacher ratings on the DSM IV Inattention scale, and 89% of children (16/18) were rated as moderate-severe on the scale for DSM-IV Hyperactive-Impulsive (see Figure 2a).

After 3 months of fatty acid supplementation ratings on 12 of the 13 scales (except Anxious-Shy) had reduced significantly, according to the Wilcoxon signed ranks test (see Table 1). Mean reductions in the t-scores of the DSM-IV global scales (DSM Inattention, DSM Hyperactive Impulsive and DSM Global Total) were –12.3 (p < 0.0006), –17.0 (p < 0.004) and –15.4 (p < 0.0005) respectively. In terms of clinical outcome, there was a substantial drop in the number of pupils who were rated as 'severe' on the DSM-IV ADHD scales (see Figure 2b). At baseline, 15/18 children (83%)

TABLE 1

Teacher behaviour ratings at baseline and after 3 months' supplementation

	Baseline (n = 18)		3 months (n = 18)		Wilcoxon signed test	
	Mean	SD	Mean	SD	Z-value	*P*-value
Sub-scales						
Oppositional	75.3	14.4	60.5	11.5	–3.52	0.0004
Cognitive Problems	71.0	9.1	59.4	8.9	–3.68	0.0002
Hyperactivity	80.0	11.8	64.7	11.8	–3.64	0.0003
Anxious-Shy	64.5	11.87	59.2	12.0	–1.48	*ns*
Perfectionism	57.9	13.4	50.7	9.7	–2.21	0.03
Social Problems	64.4	11.5	54.8	9.4	–3.26	0.001
Global scales						
Connors' Index	79.6	10.5	64.7	8.1	–3.60	0.0003
Restless-Impulsive	79.4	10.5	65.2	9.5	–3.63	0.0003
Emotional Lability	77.7	10.6	64.1	11.2	–3.63	0.0003
Connors' Global	8.13	10.5	65.6	10.2	–3.73	0.0002
DSM Inattention	74.4	8.7	62.1	7.8	–3.44	0.0006
DSM Hyp-Imp	80.1	12.6	63.1	11.1	–3.53	0.0004
DSM Global	79.3	10.8	63.9	9.2	–3.50	0.0005

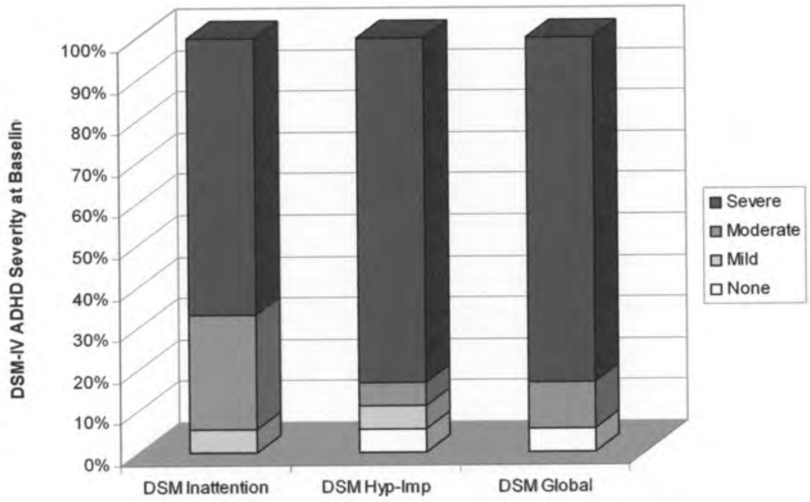

Figure 2a. Severity of DSM-IV ADHD ratings at baseline

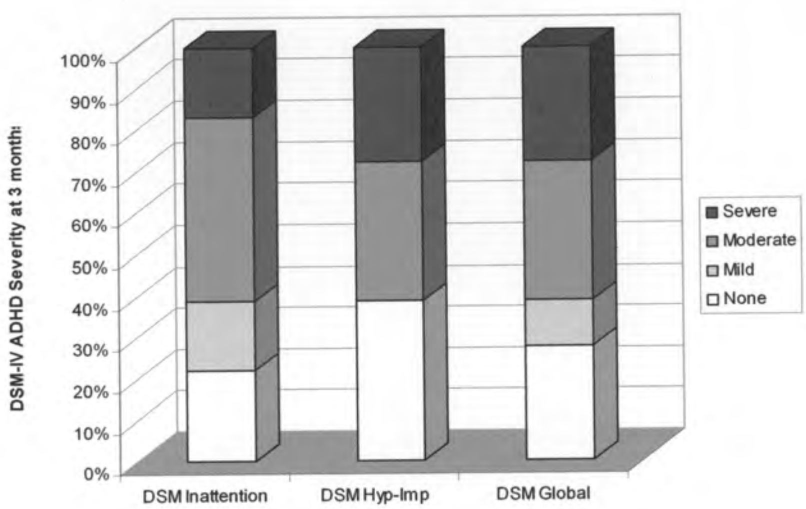

Figure 2b. Severity of DSM-IV ADHD ratings following supplementation

were rated as severe on DSM-IV Global scale, compared to only 5/18 at 3 months (28%). On the DSM-IV Inattention scale, 12/18 (67%) had severe ratings at baseline, compared to 3/18 (17%) at 3 months. Ratings on DSM -IV Hyperactive-Impulsive were severe for 15/18 (83%) pupils at baseline, and only 5/18 (28%) at 3 months.

According to teacher reports following the trial, seven of the 17 pupils (41%) to have completed a course of supplementation had significantly calmed down, were more focused in the classroom and this had resulted in positive improvements in school work. Reported behavioural incidents reduced dramatically, and importantly, of the six pupils who showed the most positive response, four made a commitment to progress to further education upon leaving school.

Open label study pre schoolers

The Sure Start initiative is a government programme within the UK that aims to "achieve better outcomes for children, parents and communities". As part of this, Sure Start Peterlee in County Durham has introduced fatty acid supplementation to a number of pre-school children aged 18 months to 3 years who have been selected within this socio-economically deprived area.

65 children from this programme were assessed at baseline and again after 5 months of fatty acid supplementation. The supplement was delivered in an emulsified form once per day to optimize compliance and this enabled 47 (72%) to complete the treatment period. 15 children (23%) withdrew early from the trial and a further 3 (5%) have missing data. Assessments included parent ratings of children's behaviour and concentration measured on a five point scale of 'very good' through to 'very poor'—as well as developmental profiles, which included assessment of expressive and receptive language. This developmental assessment had been previously standardised using 400 children in the county—this we believed to be a good representative sample which was taken primarily from maintained nurseries across Durham. Participation in such provision is much higher in the North of England than the South where more children are enrolled with private and voluntary providers (Statistics from UK Governments Department for Education and Skills). This enabled comparisons to be made against local rather than national norms.

Behaviour and concentration—Of the 47 parents whose children completed supplementation 22 (47%) rated their children's behaviour as either 'poor' or 'very poor', 27 (36%) were 'moderate', and 8 (17%) rated them as 'good' or 'very good'. On rating their children's ability to concentrate, 29 parents (65%) chose 'poor' or 'very poor', 13 (29%) selected 'moderate', and only 3 parents (7%) said their children were 'good' or 'very good' at concentrating (see Figures 3 and 4).

Following 3 months of supplementation parental ratings of behaviour increased to 32 (67%) saying their child was 'good' or 'very good', so that only 2 (4%) parents still considered their child's behaviour to be 'poor' or 'very poor'. Consistent with this improvement in behaviour were improved

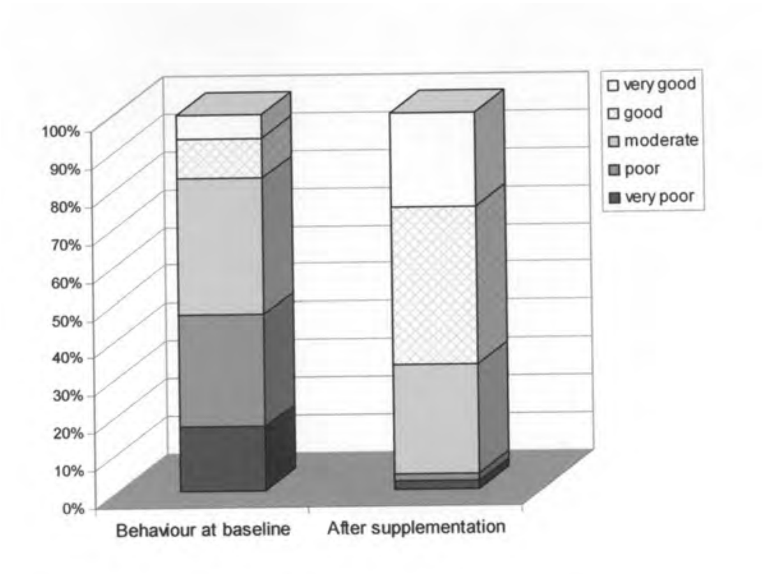

Figure 3. Parental behaviour ratings before and after supplementation

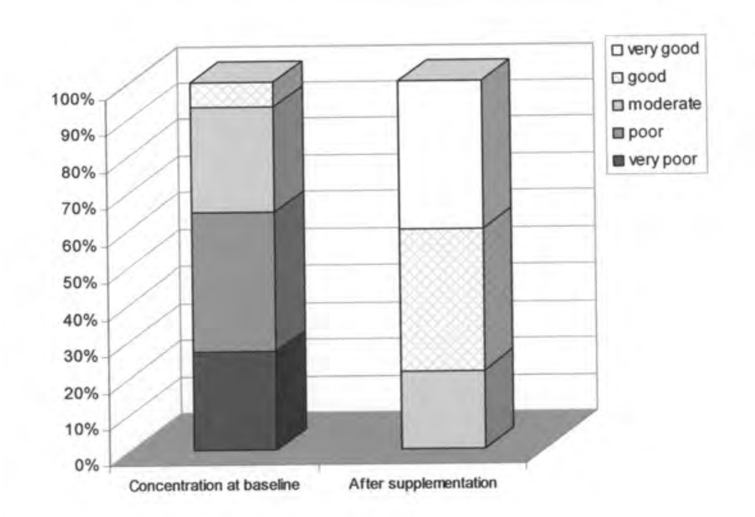

Figure 4. Parental concentration ratings before and after supplementation

ratings of concentration: 37 of the parents (78%) said their children were 'good' or 'very good' following supplementation, compared to 65% who rated their children as 'poor' or 'very poor' at concentrating, none gave this rating after 3 months.

Language development—All children taking part in the Sure Start scheme have developmental assessments completed at regular time intervals—18, 24, 30 and 36 months. This enabled us to compare children who were taking the fatty acid supplement with those who were not, by matching the former group by age and date of assessment, with a control group of children. Both groups had the same opportunities to access support from the Sure Start programme which included: training for parents, nursery/playgroup experiences and specialist language support.

We compared 47 children (mean age: 25.1 months) who completed supplementation with 47 controls (mean age: 25.7 months) on the language tests of this assessment battery—measuring both expressive and receptive language ability in preschool children—to see if any group differences emerged.

At baseline there were no significant differences between the treatment and control groups on expressive language (18.1 ± 4.9 versus 19.4 ± 4.3 months) and receptive language (19.5 ± 4.3 versus 20.5 ± 4.0 months). After the five month period, the supplemented group made 8.8 months' improvement in expressive language ability and 7.1 months' improvement in receptive language—above expected developmental gains. In contrast, the control group made an average gain in expressive language of 5.1 months, and 4.1 months in receptive language. The Mann Whitney U Test demonstrated that the improvements in the supplemented group were significantly greater in both expressive language ($p < 0.00001$) and receptive language ($p < 0.0001$) than those seen in the control group of children.

We decided that by calculating the difference between chronological age and language achievement (expressed in months) at the start of the scheme, that we would have a better understanding of the language abilities of these two groups of children, and therefore be more sensitive to how much we might have expected them to progress in 5 months. Figures 5 and 6 demonstrate that in both groups children's language progress was substantially behind than expected for their chronological age and statistical analysis showed that there was no between group difference in this respect. After 5 months the group taking supplements showed a reduced lag in language ability—nearly catching up with chronological age—whilst the control group stayed consistently behind their chronological age. The difference between the two groups at 5 months, in terms of language lag, was highly significant ($p < 0.0005$; $p < 0.005$ respectively).

We observed that the impact of the supplement in reducing excitability and improved concentration in the children—as measured by their parents—was a fundamental shift towards more qualitative time spent at home, where parents were more able to engage their youngsters in activities such as role

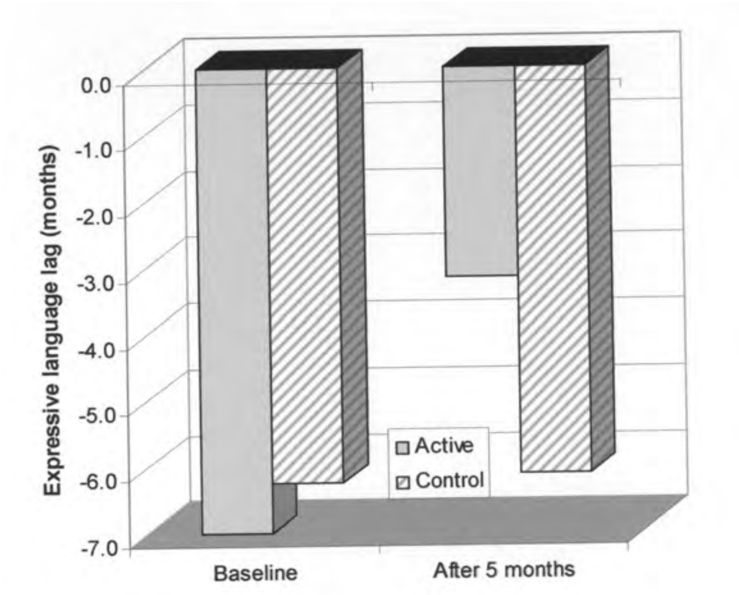

Figure 5. How far children's expressive language ability falls behind, according to chronological age, at baseline and 5 months of active supplementation, and in controls

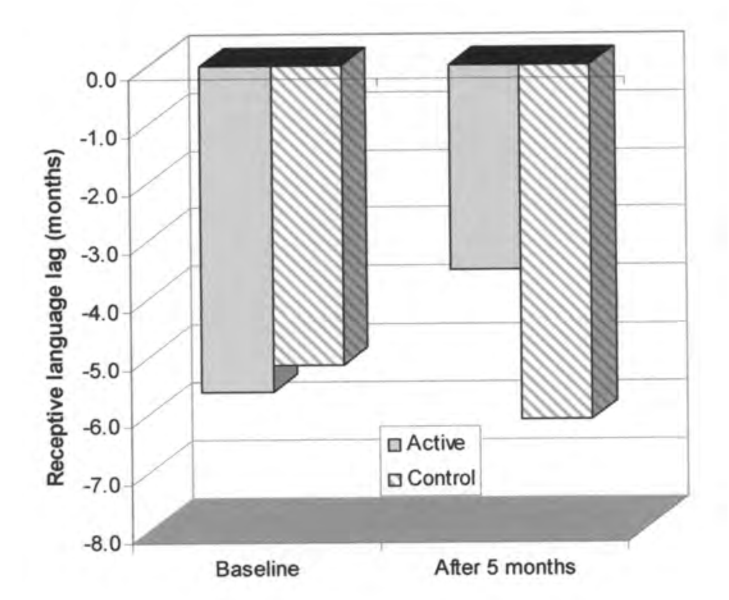

Figure 6. How far children's receptive language ability falls behind, according to chronological age, at baseline and 5 months of active supplementation, and in controls

play, form boards and most importantly sitting with them to read books. I believe that it is the improvement in the child parent bond, in these crucial early years, which has facilitated the remarkable changes we have seen in the development of the children's language skills. Parents had attended training on developing language skills and they received regular support from family workers. Parents reported that the improvements in their children's concentration enabled them to utilise their newly learnt skills. The 8 months' improvement in expressive language in the five month period of the study reflects a considerable leap, particularly as these children were between 18 months and 2.5 years at the time of assessment. Although the 5 month gain in the control group was significantly less than the active supplement group, this was still impressive considering that the children were well behind their chronological age at baseline. This suggests that the support from Sure Start workers has also been positive.

DISCUSSION

Our ongoing research programme in Durham is helping to raise awareness of the effects that poor diet has on children's concentration and subsequent behaviour and learning. Where we are seeing children from disadvantaged areas there is greater likelihood that poor diet will have a more profound effect on their behaviour and learning. Indeed the evidence suggests that in the Peterlee cohort of preschool children, unlike the other studies we have completed, almost two thirds of the children involved are responding very positively.

It is very difficult to level the playing field for disadvantaged children if one of the reasons for their inability to access the opportunities presented to them is because they just cannot concentrate. Our research to date has shown that nutritional intervention, particularly the use of specific omega-3 and -6 fatty acids, can help to significantly overcome this hurdle. Once the children involved in the studies were able to focus their attention they subsequently derived far greater benefit from the developmental programmes offered through parents and advised by the project workers. It is especially important to examine preventative approaches which are able to support children before they have had a chance to fail.

The results from Peterlee are so strong that I would encourage other Sure Start Managers and indeed parents of young children to consider the effects of diet. When parents observe the changes in their children following supplementation they may be persuaded that a healthy diet is essential to well-being and encourage them to examine the nutritional value of the food their children are eating.

Whilst the Greenfield study was a non controlled open-label trial the fact that improvements were seen in teenage children with ADIID who had repeatedly displayed conduct problems in the classroom makes it unlikely that participation in this local small-scale trial was enough in itself to produce such outstanding result. It is therefore more likely that the effects of fatty acid supplementation were attributable for the substantial improvements seen. These pupils had accessed numerous behaviour and anger management programmes in the past which had not produced any real effect on improving concentration or bringing about behavioural change.

School staff noticed changes in many of the students within the first month of the study. The students at Greenfield were able to talk about changes within themselves at the end of the study. They said they were more focused, could remember instructions and found class work less exhausting. Two pupils complained about difficulties sleeping prior to being involved in the study. They said they `couldn't switch off. They attributed improved sleeping to improved mood and behaviour during the day. One pupil has just received an award for his outstanding progress in school during the last academic year.

CONCLUSION

There is increasing evidence to suggest that some children and young adults have a deficiency of omega-3 and -6 long chain fatty acids. This can have a marked impact not only on their concentration and behaviour but also educational attainments and self-esteem. Whilst it is important that further investigation of dietary interventions are undertaken, it is essential that the importance of nutrition for children's general wellbeing is presented in a forum which is accessible to parents. Professionals in Health and Education are seeking information but ultimately it is parents who will have the greatest effect on the outcomes of their children.

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"I declare that neither 1, nor the employees of Durham Education Authority have any conflict of interest"

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