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THE EFFECT OF SUPPLEMENTATION OF OMEGA-3, ZINC AND MAGNESIUM RICH SNACK IN REDUCING THE NEUROBEHAVIORAL SYMPTOMS IN CHILDREN WITH ATTENTION DEFICIT HYPERACTIVITY DISORDER (ADHD)- A PILOT STUDY

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Background:

ADHD is a neurobehavioral disorder characterized by inattentiveness, impulsivity and hyperactivity. The causes for ADHD are multifactorial and requiring a multifaceted treatment approach. Dietary modification and some nutrients play a major role in the management of ADHD and should be considered as part of the treatment protocol. **Objectives:** To formulate and standardize a nutritious cookie with emphasis on omega-3, zinc and magnesium rich food sources and to evaluate the outcome (reducing the symptoms of hyperactivity, inattentiveness and impulsivity) of supplementation. **Materials and methods: The Purposive random sampling technique** was conducted on 16 children in the age group of 4-8 years (boys) diagnosed with ADHD. They were segregated as study and control group (eight children in each group). The study group was supplemented cookies rich with omega-3, zinc and magnesium rich food sources over a period of 8 weeks + 4 days. Behavior was assessed at the baseline and at the end of the supplementation period using Child behavior checklist (CBCL). **Results:** Following 8 weeks+ 4 days of supplementation, the study group children showed a significant reduction in symptoms such as inattention, hyperactivity and impulsivity ($p<0.001$). Though there was a reduction in the total and ADHD scores in the control group but still, it was not statistically significant.**Conclusion:** The results conclude that omega-3, zinc and magnesium enriched snack has a beneficial effect in reducing ADHD symptoms instudy group children and long term consumption of foods rich in these nutrients can bring about a greater change in their behavior and can improve the quality of life.

Key Words: *Attention - Hyperactivity, Scoring, micronutrients, Supplementation,* Outcome

INTRODUCTION

Attention deficit hyperactivity disorder (ADHD) is characterized by poor achievement in school, poor memory, lack of self-control with above-normal or normal intelligence and impulsive hyperactive behavior. It is mostly recognized at the age of six to seven years when they are taken to school and learning becomes difficult. **(Chriss et al 2007).** According to National Institute of Health Consensus Development

Conference Statement, there were approximately 5% of children affected with ADHD in 1998.

There are several screening diagnostic tools for ADHD.**Eiraldi RB et al in 2000 and J Biederman et al in 2005 found that CBCL attention problems subscales have better utility and are more useful for ruling out ADHD and related co-morbid disorders. Kidd 2000,**states that although psychostimulant medications can be effective in the management of ADHD, a combination of behavioral therapies and psychostimulants can be the best option for most children. Apart from the above, dietary interventions also play a role in the control of ADHD.

Elimination technique was first introduced with the Feingold theory which implicated preservatives, artificial colorings and cross-reacting natural salicylates as the cause of various illnesses including ADHD **(Pelsser et al, 2009)**. Other than elimination approach, there is the inclusion approach of dietary intervention of ADHD. Among the supplements that are often added to foods and drinks to help manage ADHD, Omega-3, zinc and magnesium have the greatest benefits to reducing neurobehavioral symptoms on children suffering from ADHD **(Huss et al, 2010)**. Study done by Boris et al reveal that a diet rich in fish oils helps alleviate symptoms of Attention Deficiency Hyperactivity Disorder **(Boris, 1994).**

There is increasing evidence that many children with behavioral problems are sensitive to one or more food components that can negatively impact their behavior **(Schnoll R et al, 2003 & Cruz et al, 2006)**hence dietary modifications play a major role in the management of ADHD and should be considered as part of the treatment protocol.

AIM OF STUDY

To evaluate the outcome of combined effect of Omega-3, Zinc and Magnesium rich cookies in improving the neurobehavioral symptoms in ADHD children.

METHODOLOGY

Study was carried out at Vidhya Sudha, Sri Ramachandra University, Porur, Chennai after obtaining written consent from parents. The overall duration of this study was 3 months (from January 2014) and supplementation was carried out for a period of 8 weeks+4 days.

STUDY DESIGN& SAMPLING TECHNIQUE:

This was a randomized-control pilot study aimed at evaluating the efficacy of a snack rich with omega-3, zinc and magnesium in reducing the symptoms such as hyperactivity, inattentiveness and impulsivity in children with ADHD.A total of 16 boys in the age group of 4-8 years were recruited and purposive random sampling was done. They were segregated into study group and control group (8 children in each group) and all 16 children completed the follow up.

INCLUSION CRITERIA

Boys in the age group of 4-8 years with hyperactivity symptoms and who were not on any medications especially for ADHD.

EXCLUSION CRITERIA

- Children without hyperactivity symptoms
- Children with conditions such as cerebral palsy, down's syndrome, mental retardation, dyslexia, global developmental delay and microcephaly

ETHICS APPROVAL

- The study was approved by the Institutional Ethics committee of Sri Ramachandra University on 06/11/2013. REF NO: CSP/13/OCT/31/188

STANDARDIZATION OF THE RECIPE:

The recipe used for the preparation of the cookie was standardized till the final product with acceptable quality was achieved.

Ingredients were selected based on their nutritional properties. The developed cookie was then subjected to organoleptic evaluation for its appearance, colour, flavor, texture and taste by a group of panelists and the scores were interpreted. The finalized cookie was sent for further nutrient analysis to an outside laboratory.

S.NO	NUTRIENTS	UNCOOKED VALUES (/100g)	COOKED VALUES (/100g)
1.	Energy (kcal)	910	465
2.	Protein (g)	11.49	15.19
3.	Fat (g)	62.98	25.31
4.	Carbohydrate (g)	54.63	29.18
5.	Zinc (mg)	6.37	13.66
6.	Magnesium (mg)	102.28	8.44
7.	Omega-3 fatty acids (g)	2.2	1.78
SHELF LIFE	No microbial contamination observed for 4 days		

TOOLS USED FOR DATA COLLECTION

1.ASSESSMENT OF ANTHROPOMETRY: Standing height, weight and mid arm circumference were recorded at the baseline and at the end of the study period.

2.NUTRITION COUNSELING: In the present study, nutrition counseling was given in group to the mothers of the subjects which included

- Introduction to nutrition
- Balanced diet and proper meal timings
- Food guide pyramid
- Foods to be included and avoided in ADHD and
- Importance of fluids

3.THREE DAYS FOOD RECORD: Diet history was taken using the 3 days food record (two weekdays and one weekend day) and the percentage met and percentage deficit was calculated for the selected nutrients.

4.ASSESSMENT OF BEHAVIOUR: Assessment of the behavioral symptoms was evaluated using the child behaviour checklist (CBCL).

STATISTICAL ANALYSIS

Statistical analysis were performed using SPSS version 17 and two tailed tests set at $p < 0.05$ level of significance. Independent sample t-test was used to evaluate the differences between variables.

RESULTS

NUTRIENT CONTENT OF THE DEVELOPED PRODUCT

Omega-3, zinc and magnesium rich cookie was developed using nutritious ingredients like Ragi, Bajra, Roasted Bengal gram flour, Flaxseeds and Palm sugar. The developed cookie was subjected to organoleptic evaluation in comparison with the other 2 samples of different combination. The results showed that out of 3 samples presented, sample C scored highest in terms of appearance, colour, flavour, texture and taste.

ACCEPTANCE AND TOLERANCE WITH REGARD TO SUPPLEMENTATION

Tolerance to the supplementation was good and no side effects noticed in the supplemental group. The cookie developed was greatly accepted by children and there was no wastage.

COMPARISON OF ADHD CBCL SCORES BETWEEN THE STUDY GROUP AND CONTROL GROUP

From the above table it is clear that the supplemental group had a beneficial effect on the neurobehavioural symptoms which had reflected in the ADHD scores ($p<0.001^{**}$)

GROUP SCORES (ADHD)	MEAN ± STD.DEV (Initial)	MEAN ± STD.DEV (Final)	MEAN ± STD.DEV (Initial + Final)	P-VALUE
STUDY	25.875 ±7.41	16.125 ±6.57	9.750 ± 1.250	0.000**
CONTROL	15.875 ±5.22	17.75 ±5.28	1.8975 ± 3.044	0.125^{NS}

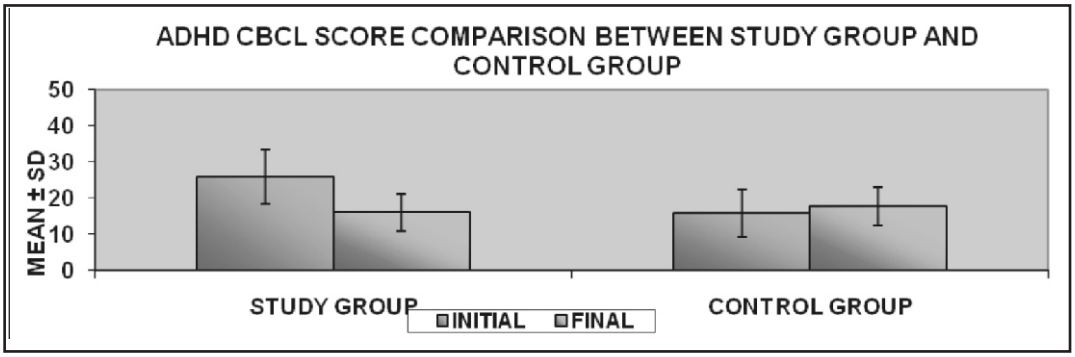


Fig: 2

COMPARISON OF INITIAL AND THE FINAL NUTRIENT INTAKE OF THE STUDY GROUP

NUTRIENT (N=8)	MEAN ± STDEV (Initial)	MEAN ± STDEV (from supplement)	MEAN ± STDEV (Final)	p-VALUE
ENERGY (kcal)	630.775 ± 112.819	463.750±3.53	1094.525 ± 116.349	0.000**
PROTEIN (g)	12.35 ± 4.92	15.22 ± 0.10	27.57 ± 5.02	0.000**
FAT (g)	6.77 ± 3.34	25.34 ± 0.10	32.11 ± 3.44	0.000**
ZINC (mg)	1.57 ± 0.78	13.68 ± 0.07	15.25 ± 0.85	0.000**
MAGNESIUM (mg)	1.05 ± 0.28	8.45 ± 0.03	9.5 ± 0.31	0.000**
OMEGA-3 (g)	0.065 ± 0.04	0.955 ± 0.04	1.02 ± 0.08	0.000**

which was assessed using the CBCL. Control group ($p = 0`.125^{NS}$) didn't show a positive outcome.

This table shows that there is a significant improvement in their intake after supplementation in the study group.Therewas no difference between the initial and the final nutrient intake in the control group children.

DISCUSSIONS

"According to the international classification systems (ICD 10 OR DSM IV), the maximum age of onset of symptoms of ADHD is seen before the age of seven" [Döpfner, 2008]. This reference supports the present study wherein 50% were in the age group of 5 years. It also says that the nutritional deficiency is attributed to the inadequate food intake.

The present study reveals that omega-3, zinc and magnesium enriched snack has a positive effect in reducing symptoms such as hyperactivity, impulsivity and inattention in children with ADHD. Our findings correlate with the previous studieswhich indicates that a combination of omega-3 and omega-6 fatty acids as well as magnesium and zinc consumption on attentional, behavioral, and emotional problems of children and adolescents has a beneficial effect. Also the nutrient analysis of the cookie showed that it had a higher protein & calorie content. The intake of this cookie would meet the daily requirements for the selected micronutrients like zinc, magnesium and omega-3 fatty acids. Tolerance to the supplementation was good and no side effects noticed in the supplemental group.Zinc has an imperative role in regulating neuronal apoptosis and neurogenesis. Lack of zinc in the diet and the brain causes apoptotic neural death through the mitochondrial pathway and caspase activation (**Katz et al, 2008)**. This leads to abnormal regulation of survival signals **(Silfverdal et al 2008).** Zinc deficiency has been associated with deficits in attention, learning, memory, and neuropsychological behavior **[Bhatnagar S 2001].**Magnesium supplements play an imperative role in sulfation and methylation and are thus important for the pathways of detoxification that is critical for children with Attention Deficiency Hyperactivity Disorder. **(Silfverdal et al 2008).**Magnesium, as a cofactor for enzyme production, is involved in neurotransmitter synthesis and some studies have found magnesium deficiencies associated with ADHD**(Starobrat-Hermelin et al, 2007)**Studies also show that a high-protein, low-sugar, no-additive diet combined with ADHD-friendly supplements like fish oil and zinc can drastically improve ADHD symptoms in children with no side effects. **[Sinnet al. 2007].**

Using CBCL, children's behavioral symptoms was evaluated. In the Inattention category, symptoms such as distraction, eye contact and concentration was improved in all the study group children after the supplementation period. Similarly in the hyperactivity category, though there wasn't much improvement in the entire symptoms still, behavior such as demanding attention, mood changes were reduced.

Independent t-test showed a significant difference in the weight for age, total scores, ADHD scores and nutrient intake ($p < 0.000$) of the study group. Though there was a reduction in the total and ADHD scores in the control group but still, it was not statistically significant.With the help of supplementation, the study group children were able to meet one third of the RDA for all the selected nutrients except for magnesium. This is probably because the magnesium found in foods is of low levels and the bioavailability from plant origin is also less.

MERITS OF THE STUDY

★ The cookie supplemented was laboratorically tested for shelf life and safety
★ There were no drop outs during the study
★ Significant reduction was observed with respect to the ADHD symptoms in study group children
★ Weight gain was noticed in the study group children
★ In addition to the usual dietary intake, provision of three cookies per day was helpful in meeting the children's daily requirements for macro and micronutrients.

LIMITATIONS OF THE STUDY

★ Smaller sample size due to it being a pilot study
★ Biochemical parameters were not assessed since the objective of the study was to evaluate the effect of supplementation with respect to the reduction in the CBCL scores.

CONCLUSION

Long term consumption of multiple micronutrients such as zinc, magnesium, and iron as well as macronutrient rich foods can reduce ADHD symptoms in children. The newly developed "N-rich cookie" is free from additives and adulterants and is rich with protein, fat, zinc and omega-3 fatty acids in higher content.

Thus when compared to the commercially available cookies, the newly developed N-rich cookies is nutritionally safe especially for children with special needs.

FUTURE RECOMMENDATIONS:

★ The cookie developed may be studied with regard to its effect on improving the weight gain in undernourished children and children who have problem with attention deficit.
★ The flavour of the cookie may be enhanced by adding natural flavouring substances such as mint powder, orange powder or ajwan.
★ Rare and nutritious ingredients like lotus stem, wheat germ and horse gram which are low cost can also be used to enhance the micronutrient content of the product.
★ Few researches suggest that a high protein and iron rich diet also plays an important role in ADHD. Therefore, the future scientists must look into the effect of multiple micronutrient supplementations through naturally available food sources.

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