## Introduction

According to the Diagnostic and Statistical Manual of Mental Disorders (*DSM-IV-TR*, ***APA, 2000***), Attention Deficit Hyperactivity Disorder (ADHD) “is a persistent pattern of inattention and/or hyperactivity-impulsivity that is more frequent and severe than is typically observed in individuals at a comparable level of development.” There are three subtypes of ADHD that are used to diagnose individuals based on the predominant symptom pattern that has existed for at least the past 6 months (***APA, 2000***). Although most individuals have symptoms of both inattention and hyperactivity-impulsivity, there are some individuals have symptoms of both inattention and hyperactivity-impulsivity, there are some individuals in whom one or the other pattern is predominant.

The number of children diagnosed with ADHD has grown markedly since being recognised as a specific disorder in the 1970s. The prevalence rate of ADHD within

Western cultures is approximately 5%, and remains the most common psychiatric illness among young children, with an estimated 50% of these children retaining ADHD symptoms for the rest of their lives. (***Sarris et al., 2011***). In an article reviews epidemiological studies on ADHD in all the Arab countries conducted from 1966 through 2009. It was concluded that ADHD rates in Arab populations were similar to those in other cultures (***Farah et al., 2009***).

There are no available data on the prevalence of ADHD in Egypt (to the best of our knowledge) except for in Alexandria; a study was conducted among 1,350 primary school children in grades 3 through 5; the results revealed that the prevalence of ADHD symptoms was 7.48% (11.67% for boys and 3.58% for girls). (***Attia, et al. 2000***). In A study conducted in Dammam city, Saudi Arabia, and sample size of 1287 students aged 6-13 years, it was found that the overall prevalence of combined ADHD was 16.4%, with a prevalence of 12.4% for hyperactivity-impulsivity and 16.3% for inattention disorders respectively (***Al Hamed et al., 2008***).

ADHD is a major behavioral problem that has attracted much attention and has been associated with the presence of certain elements in the diet. One hypothesis is that food intolerance, food additives, sugar intake, a low micronutrient intake, and polyunsaturated fatty acid (PUFA) deficiency predispose children to ADHD and related behavioral symptoms, such as hyperactivity, delinquency, and aggressive behaviors (***Bellisle, 2004; Benton, 2007; McCann et al., 2007; Benton, 2008; Sinn, 2008; Sinn et al., 2008; Benton, 2010***). Effective and safe treatments are therefore of great importance. While stimulants and atomoxetine are efficacious in many children, these medications can have side effects such as insomnia, decreased appetite, irritability and impaired growth (***Doggett, 2004***).

The long-chain polyunsaturated fatty acids (PUFAs) fall into two main families: omega-3 and omega-6. The omega-3 PUFAs are derived from fish and some plants, whereas the omega-6 PUFAs are derived mainly from vegetable oil. The principal precursors of the omega-3 and omega-6 PUFAs cannot be endogenously synthesized from carbohydrates (***Mazza et al., 2007***). Thus, the source of α-Linolenic acid (ALA) with 18 carbons, 3 double bonds, the first located at the third carbon from the last (ω) (18:3:ω3), and Linoleic acid (LA-18:2ω6), is entirely nutritional. ALA is converted in the body to Eicosapentaenoic acid (EPA-20:5:ω3), and Docosahexaenoic acid (DHA-22:6:ω3) comprising the omega-3 group. Similarly, LA is converted to Arachidonic acid (AA-20:4:ω6), representing the omega-6 group. The conversion of the precursors to omega 3/6 acids is performed by an enzymatic system of elongation and desaturation which is responsible for the steady state ratio of ω3/ω6, vital for normal membrane fluidity. The specific concentrations of omega-3 and omega-6 PUFAs in blood or cell membranes reflect dietary intakes (***Gadoth, 2008***).

PUFA comprises 15–30% of the brain dry weight (***Hallahan and Garland, 2005***), and are considered essential for normal brain development. AA and DHA are the main fatty acids in the cell membrane phospholipids especially in the grey matter comprising 6% of its dry weight while LA, ALA and EPA are present in very low concentration in nerve tissue. Both ω-3 and ω-6 are essential for growth and function of the developing and mature brain.

Lower levels of long-chain polyunsaturated fatty acids, particularly omega-3 fatty acids, in blood have repeatedly been associated with a variety of behavioral disorders including ADHD. The exact nature of this relationship is not yet clear. A number of the physical and behavioural symptoms of essential fatty acid deficiency mimic some of the symptoms described in typical ADHD patients; therefore it is conceivable, that either dietary deficiency of omega-3 fatty acids, or altered metabolic handling of these fatty acids, could contribute to the abnormalities observed in those affected by ADHD. Several studies have examined fatty acid status in patients with ADHD, but only recently have researchers begun to examine efficacy of high dose supplementation on ADHD behaviours (***Antalis et al., 2006; McNamara and Carlson, 2006; Germano et al., 2007; Sorgi et al., 2007***).

Zinc is an important cofactor for metabolism relevant to neurotransmitters, prostaglandins, and melatonin, and indirectly affects dopamine metabolism. It is necessary for 100 different metalloenzymes and metal–enzyme complexes (***Toren et al. 1996***), many of them in the central nervous system. It contributes to structure and function of brain (***Black 1998***). Specific to ADHD, the dopamine transporter has a zinc binding site that blocks transport (***Lepping and Huber 2010***). Both animal data

(***Halas and Sandstead 1975; Sandstead et al. 1977; Golub et al. 1996***) and human findings suggest involvement of zinc deficiency in hyperactivity. Human zinc deficiency syndrome includes concentration impairment and jitters (***Aggett and Harries 1979***).

***Bilici et al. (2004)*** reported a trial of zinc supplementation alone as treatment for ADHD; participants received zinc sulfate 150 mg/day (containing about 40 mg elemental zinc) for 12 weeks, a rather high dose. After 12 weeks' treatment, the 46-item clinician-rated ADHD Scale showed that the supplemented group improved by 25.4±9.7 compared with the placebo group, which improved by only 12.7±5.4 ($P$= 0.002).

# Methods and Materials

This study included 70 children classified into three groups

Children groups :

- Group 1 : 30 children ( 24 M – 6 F ) suffered from Attention Dificit Hyperactivity Disorder ( control )
- Group 2 : 20 children ( 14 M – 6 F ) suffered from Attention Deficit Hyperactivity Disorder and take PUFAS only
- Group 3 : 20 children ( 15 M – 5 F ) suffered from Attention Deficit Hyperactivity Disorder and take PUFAS + Zinc

They were selected from the attendants at the outpatient department, Children with Special Needs, Abou El-Rich pediatric hospital in Cairo

## Inclusion criteria :

1- Good physical health

2- Agreement not to make any changes in treatment for ADHD ( medical, nutritional, dietary or behavioral ) during the three months of the study

All three groups of children were subjected to following :

1- Personal date include :

name, sex, date of birth, address, number of brothers and sisters, arrangement in the family, classes

**2-3d Diet records :**

parents of the children will complete 3-d diet records this record will be aspects of eating behavior, food choices, quanities of food

**3- Fatty acid analysis :**

Fasting blood samples were drawn at baseline and after 3 month of treatment. Following blood collection,Analysis of the EFA composition of plasma will be analyzed by a fast gas chromatographic method as previously described (Masood et al., 2005).

**4-Conners test :**

The revised Conners' Parent Rating Scale long version (CPRS-R:L) will be administered during visit #1 of the study for all subjects and completed by the attending parent or guardian. Assessment of common problems was based on the child's behaviour in the preceding month and they will be asked to circle the best answer for each item. All parent- rating scores were converted to T-scores through the use of the CPRS:L sheet for score profiling. The scale will be used to assess not only ADHD, but also problems with conduct, cognition, family relationships, emotional issues, anger management, and/or anxiety.

**5-Discharge of 3-d diet :**

Include all quanties of food that children took in all 3 days

### 6-Dietary analysis by using Food analysis tables:

Include contents of food

## Result & Discussion

Table (1) & figure (1) , Showed that there are non significant change in Free Fatty Acids % ( F.F.A % ) in control group during all over period of the test ( 12 weeks)

Table(1) Showed that the different% of (.F.A%) in control group .

| Groups | ( F.F.A%) |
|---|---|
| | |

| control | Mean ± SD |
|---|---|
| Before | 0.483 a ± 0.13 |
| After | 0.712 a ± 0.49 |
| Sig. | .163 |

$P<0.05$ $p<0.01$

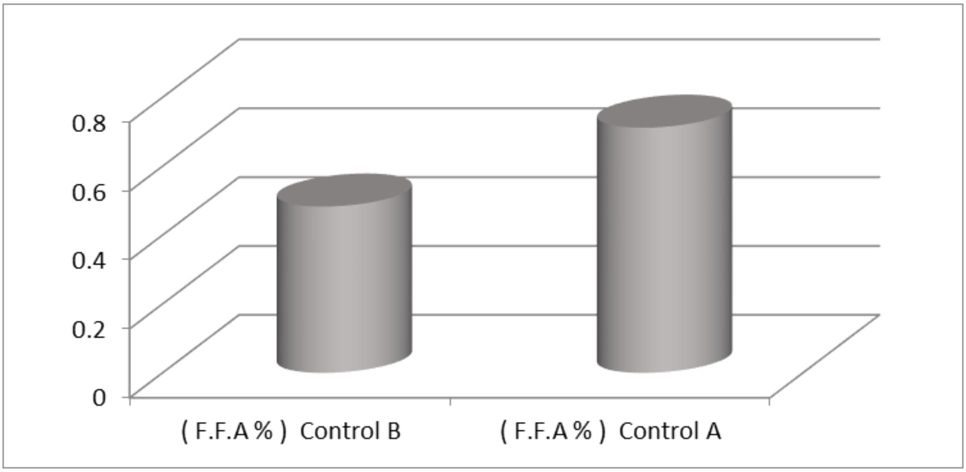


figure (1) Showed that the different% of ( F.F.A%) in control group

Table (2) & figure (2) , Showed that there are significant change in ( F.F.A% ) by ($p < 0.014$ ) in group supplemented with omega 3 .

There is an improvement in ( F.F.A % ) was observed in children supplemented with omega 3 when compared (F.F.A % ) before with ( F.F.A % ) after .

These results in agreement with those observed by ( **Burgess JR et al , 2000** ) who suggested that children with ADHD have an abnormal PUFA profile and agreement with ( **Colter AL et al , 2008** ) who reported that low levels of longchain in the plasma and red cells of children with ADHD compared with controls and although agreement with ( **Elizabeth Hawkey and Joel Nigg 2014** ) found that lower over all blood levels of omega 3 in children with ADHD .

Table (2) : Showed the different % of ( F.F.A %) before and after in group supplemented with omega 3 .

| Groups | ( F.F.A%) |
|---|---|
| Omega3 | Mean ± SD |
| Before | 0.534 b ± 0.17 |
| After | 0.671 a ± 0.19 |
| Sig. | .014 |

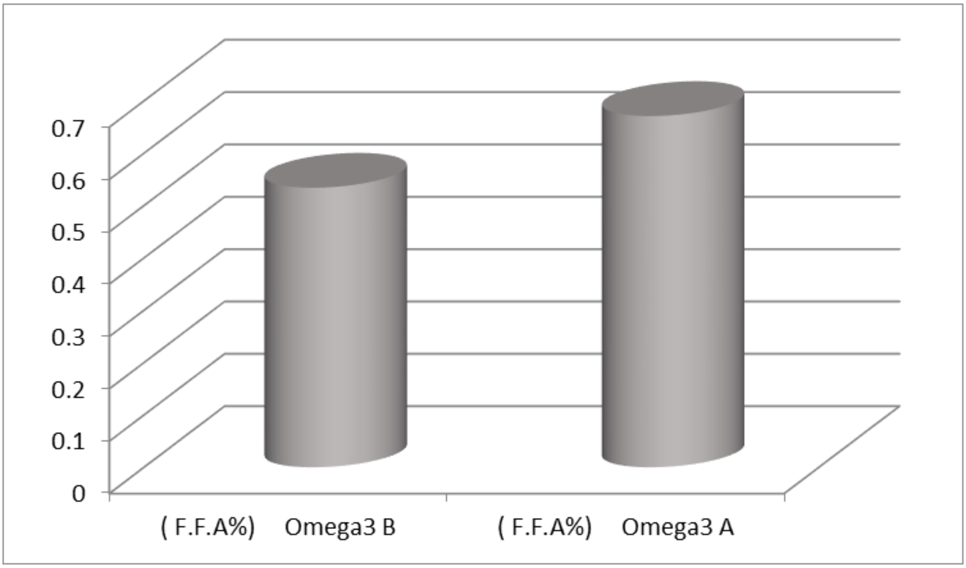


Figure (2) : Showed the different % of ( F.F.A % ) before and after in group supplemented with omega 3.

Table (3) & figure (3), Showed that there are non significant change in ( F.F.A % ) in group supplemented with omega3 and zinc during all over period of the test ( 12 weeks ) .

Table (3) : Showed the different% of ( F.F.A %) before and after in group supplemented with omega 3 and zinc.

| Groups | ( F.F.A%) |
|---|---|
| Omega3+Zinc | Mean ± SD |
| Before | 0.499 a ± 0.14 |
| After | 0.685 a ± 0.42 |
| Sig. | .227 |

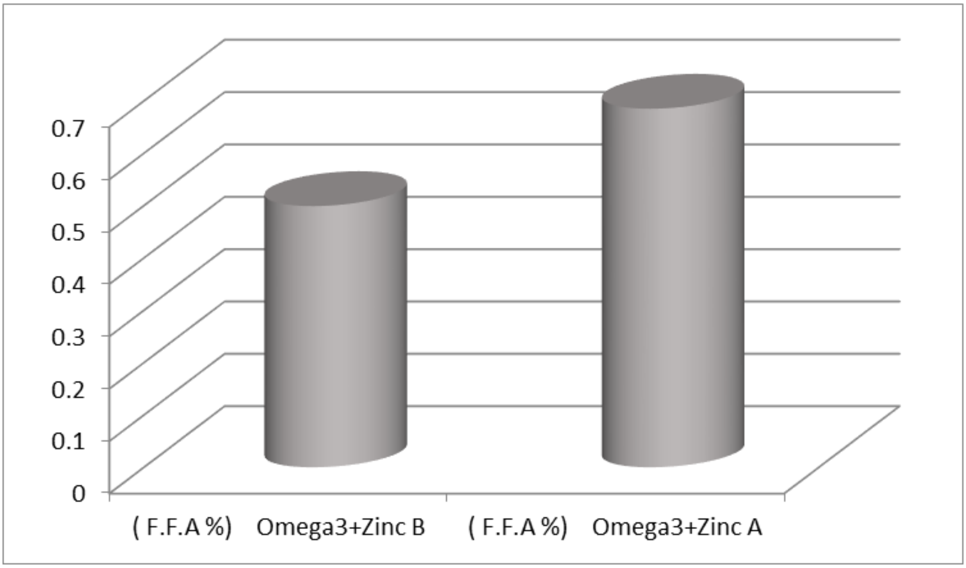


Figure (3) : Showed the different% of (F.F.A %) before and after in group supplemented with omega 3 and zinc.

Table (4) & figure (4) , Showed that there are significant change in zinc % by ( p<.015 ) there is an improvement in zinc % was observed in children supplemented with zinc when compared zinc % before with zinc % after .

These results in agreement with those observed by **Bilici et al.** (2004) who reported a trial of zinc supplementation alone as treatment for ADHD; for 12 weeks, a rather high dose. After 12 weeks' treatment, the 46-item clinician-rated ADHD Scale showed that the supplemented group improved by 25.4±9.7 compared with the placebo group, which improved by only 12.7±5.4 (*P*= 0.002) and agreement with ( **Arnold LE et al , 2005** ) who Published reports of the role of zinc in ADHD show low zinc levels in serum

Table ( 4) : showed the different % of zinc % before and after in group supplemented with omega 3 and zinc.

| Groups | Zinc% |
|---|---|
| Omega3+Zinc | Mean ± SD |
| Before | 42.3 b ± 6.06 |
| After | 46.9 a ± 8.48 |

| | |
|---|---|
| Sig. | 0.015 |

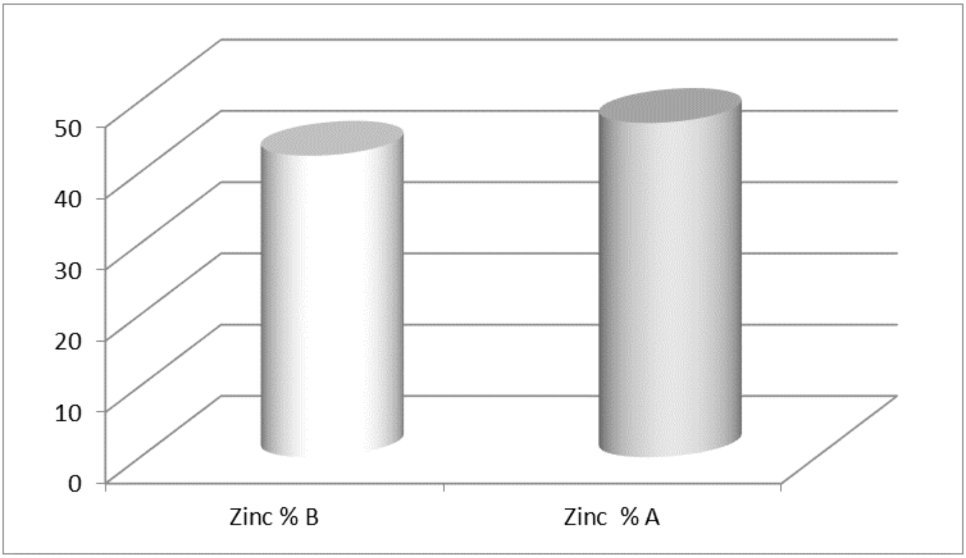

Figure (4) : showed the different % of zinc % before and after in group supplemented with omega 3 and zinc.

Table (5) & figure (5) , Showed that there are significant change ( $p < 0.05$) in the conners test between control group and the treated groups. There is an improvement in conners test was observed in children supplements with omega 3 when compared with the control .

These results in agreement with those observed by ( **Sinn and Bryan 2007** ) Significant medium to strong positive treatment effects were found on parent ratings of core ADHD symptoms, inattention, hyperactivity/impulsivity, on the Conners Parent Rating Scale (CPRS) in both PUFA treatment groups compared with the placebo group these results were replicated in the placebo group, and the treatment groups continued to show significant improvements on CPRS core symptoms

The percent of improvement by omega 3 was ( 20 % ) while the percent of improvement by omega3 + zinc was (19 % ).

Table ( 5) : Showed the different in conners test in three groups of children before and after supplement .

| Groups | Conners |
|---|---|
| | Mean ± SD |
| Control | 84.70 a ± 8.04 |
| Omega 3 | 67.40c ± 11.10 |
| Omega 3 + zinc | 68.10b ± 16.67 |
| F | 6.177 |
| Sig. | .006 |

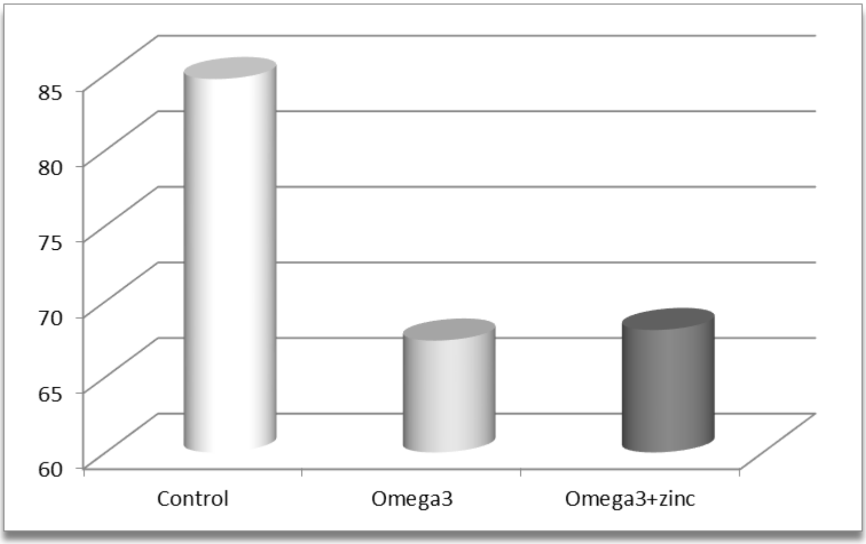


Figure (5) : Showed the different in conners test in three groups of children before and after supplement.

Table ( 6 ) & figure ( 6 ), Showed that there are significant change in the conners test between control group and group which supplemented with omega3 The percent of improvement by omega 3 was ( 20 % ).

Table ( 6 ) : Showed the different in conners test between control group and the group supplemented with omega 3 .

| Groups | Conners |
|---|---|
| | Mean ± SD |
| Control | 84.70 a ± 8.04 |
| Omega 3 | 67.40 b ± 11.10 |

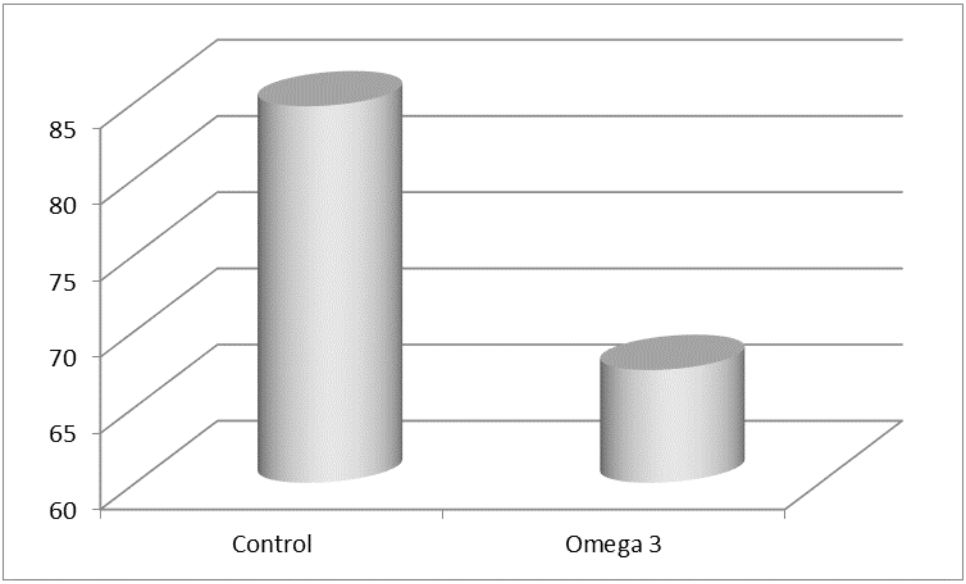


Figure ( 6 ) : Showed the different in conners test between control group and the group supplemented with omega 3 .

Table ( 7 ) & figure ( 7) , Showed that there are significant change in the conners test by (p< .011 ) between control group and group which supplemented with omega3+zinc.

The percent of improvement by omega 3 was ( 19 % ).

Table ( 7 ) : Showed the different in conners test between control group and the group supplemented with omega 3+zinc .

| Groups | Conners |
|---|---|
| | Mean ± SD |
| Control | 84.70 a± 8.04 |
| Omega3 + Zinc | 68.10 b ± 16.67 |
| Sig. | .011 |

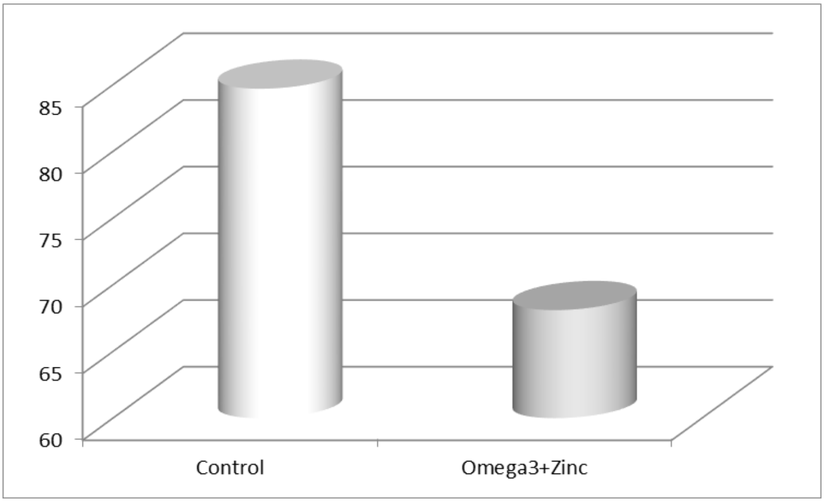


Figure ( 7 ) : Showed the different in conners test between control group and the group supplemented with omega 3+zinc

Table ( 8 ) & figure ( 8 ) , Showed that there are non significant change in conners test in control group during all over period of the test ( 12 weeks ) .

Table (8 ) : Showed the different in conners test in before and after in control group .

| Groups | Conners |
|---|---|

| Control | Mean ± SD |
|---|---|
| Before | 72.1 a ± 7.85 |
| After | 68.9 b ± 9.72 |
| Sig. | .333 |

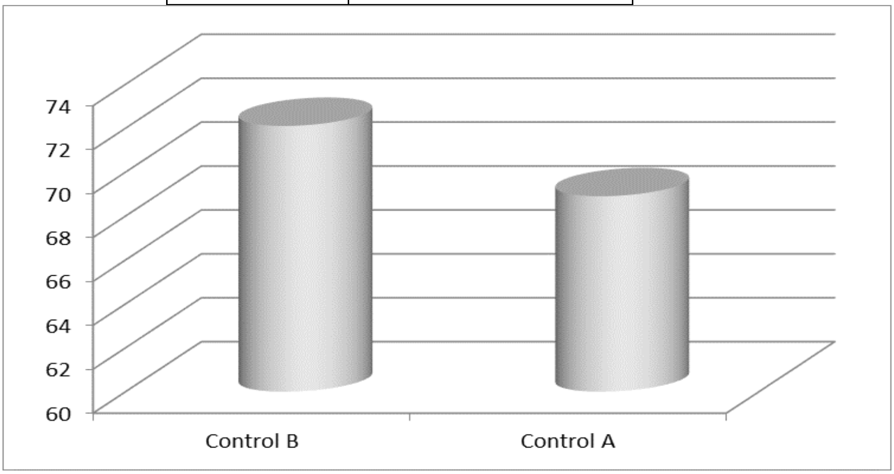


Figure ( 8) : Showed the different in conners test in before and after in control group .

Table ( 9) & figure ( 9) , showed that there are significant change in conners test by ($p< .001$ ) in group supplemented with omega 3.

There is an improvement in conners test was observed in children supplemented with omega 3 when compared with result of conners test before taking omega3. The percent of improvement by omega 3 was about ( 12 % )

Table ( 9 ) : Showed the different in conners test in before and after in group supplements with omega 3 .

| Groups | Conners |
|---|---|
| Omega 3 | Mean ± SD |
| Before | 77.3 a ± 11.63 |
| After | 67.4 b ± 11.10 |
| Sig. | .001 |

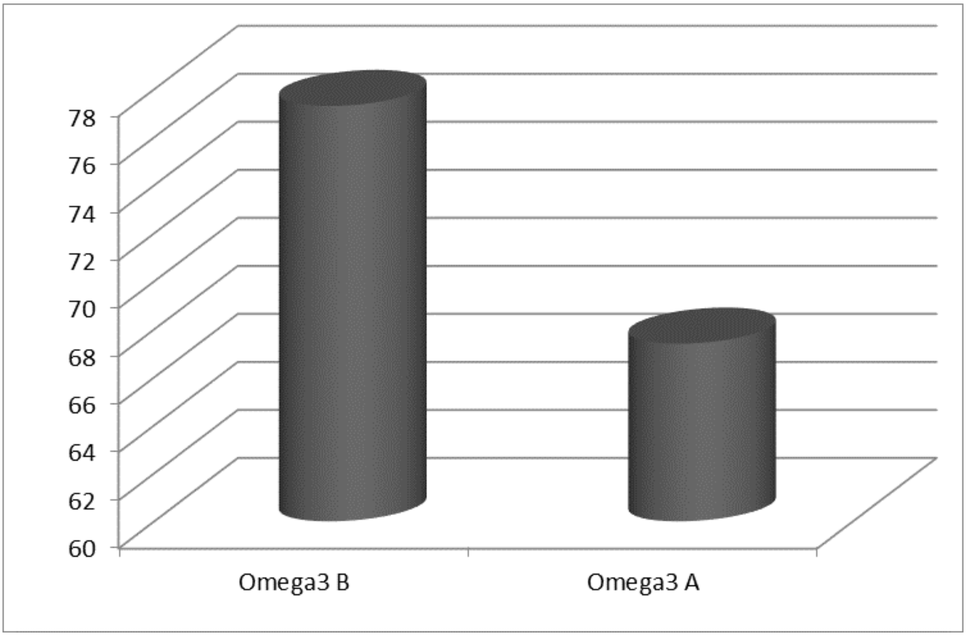


Figure ( 9) : Showed the different in conners test in before and after in group supplements with omega 3

Table (10) & figure ( 10 ) , showed that there are significant change in conners test by ( p<.017 ) in group supplemented with omega 3+zinc.There is an improvement in conners test was observed in children supplements with omega 3+zinc when compared with result of conners test before taking the supplement .The percent of improvement by omega 3 was ( 15 %).

Table ( 10 ) : Showed the different in conners test in before and after in group supplements with omega 3+zinc.

| Groups | Conners |
|---|---|
| Omega3+Zinc | Mean ± SD |
| Before | 80.8 a ± 13.30 |
| After | 68.1 b ± 16.67 |
| Sig. | .017 |

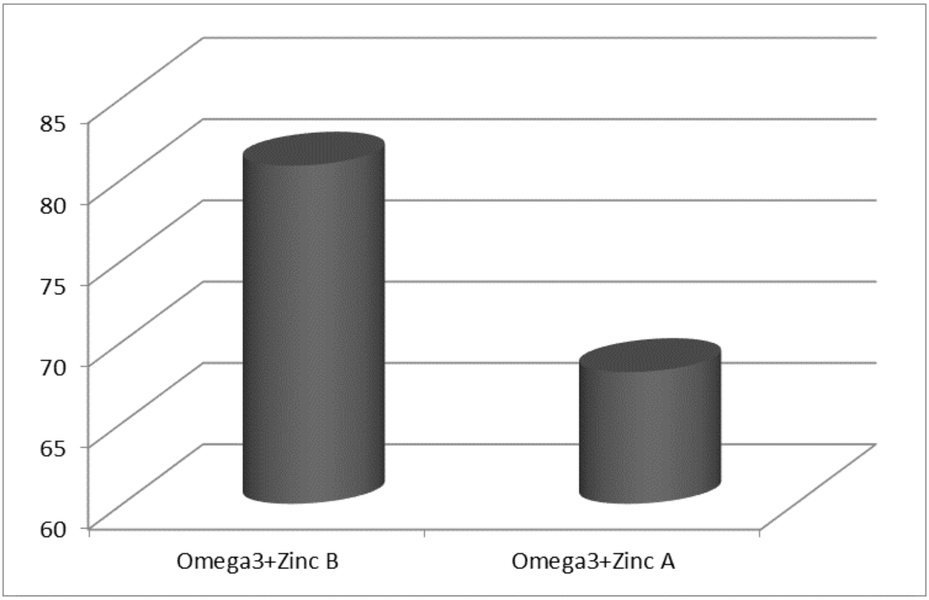


Figure ( 10 ) : Showed the different in conners test in before and after in group supplements with omega 3+zinc.

## Recommendation

1- Nutrition Education is an important role for all ages also for children with ADHD.
2- Children with ADHD should avoid food containing natural salicylates such as almonds,apricots,grapes.

3- Also should avoid all foods containing artificial colors,flavors,sweeteners.

4- Children with ADHD should increase intake of natural sources of vitamin B complex such as breads, yeast, egg, milk, whole grains, cheese, beans, dark green leafy vegetables, rice, liver to improve behavior and attention.

5- Children should increase intake of natural sources of omega-3 fatty acids such as fish, tuna, salmon, nuts, butter.

6- Children should increase intake of natural sources of zinc such as nuts, spinach, beans, mushrooms, beef, wheat germ.

7- Children with ADHD should increase fresh vegetables and fruits.

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