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Association between Autism Spectrum Disorder and Iron Deficiency in Children Diagnosed Autism Spectrum Disorder in the Northern West Bank

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Abstract
Iron has an important role in cognitive, behavioral, and motor development. A high prevalence of iron deficiency (ID) has been reported in people with autism. Children with autism are at risk for ID and this condition may increase the severity of psychomotor and behavioral problems, some of which already inherently exist in these children. **Aim of the study:** The aim of this study is to investigate the association between autism and iron deficiency in autistic children in the Northern West Bank and to identify food selectivity and compare indices of food selectivity among children with autism, children with mental disorders and typically developing children (normal children).**Background**: Autism is a developmental disorder characterized by qualitative abnormalities of social interaction, impairments in communication, and unusual forms of repetitive behavior . Research shows that a high prevalence of iron deficiency has been reported in children with autism spectrum disorders. Inadequate dietary iron intake was considered as a cause of iron deficiency, and low iron intake was thought to be associated with food selectivity which is commonly seen in children with autistic disorders. **Method:** 90 children with an age range of 3 to 13 years participated in a case control study distributed into study group and two control groups. Thirty children diagnosed with autism according to DSMIV and ICD-10 criteria served as a study group, 30 children with mental disorders other than autism served as a control group, and 30 typically developing children taken from the public functioned as a second control group. The three groups were matched for age, gender and geographical area. Serum ferritin, hemoglobin, hematocrit, mean corpuscular volume, and red cell distribution width values were measured and analyzed with food habit survey and demographic data. **Results:** ID was detected in 20% (N = 6/30) of autistic children based on Serum ferritin level (SF< 10µ/l), compared with 0% for the two control groups (p= 0.0001). Anemia was defined as hemoglobin <110g/l for children under the age of 6 years and hemoglobin <120g/l for children between 6 and 13 years of age .When analysis done for HGB to these six children (children who have low serum ferritin); it was found that 66.6% (4/6) of the children two were pre-school male children (HGB is less than 110g/1), and the other two were one male and one female of school children (HGB is less than 120g/l) have iron deficiency anemia, and the iron deficiency anemia was 13.3% (4\30) for all autistic group. The results indicated that these differences were for males. It was found also that the frequency of low iron intake in these children was associated with feeding difficulties and food selectivity; there was a significant difference between children in the autistic group who chose foods with a red color as a favorite 23% (7/30) compared to the other two control groups: 0%, respectively (p= 0.0001). The results demonstrated also a significant difference in the frequency of snacks per day (≥ 4) in autistic children 40% (12/30) compared to both mental disorder 16.7 % (n = 5/30) (p = 0.006) and typically developing children 6.7% (n = 2/30) groups (p = 0.001).**Conclusions:** Results of this study indicated that there is an association between autism, iron deficiency and anemia. Low levels of serum ferritin in autistic children might be a sign of iron deficiency and an early precursor of iron deficiency anemia. These findings suggest that food selectivity is more common in children with autism than in typically developing children. These findings suggest that ferritin levels should be measured in children with autism as a part of routine investigation.
Keywords: Child, Autism, Mental disorder, typically developing children, Iron deficiency, Iron deficiency anemia, Ferritin.

1. Introduction

The number of children known to have autism has increased dramatically since the 1980's (Newschaffer, 2007). The reviews of epidemiology in estimating the global prevalence is that one to two cases of autism exist per 2,000 people, and about six per 1,000 people have Autistic Spectrum Disorders (ASD) (Newschaffer, 2007). ASD averages a 4.3:1 male to female ratio (Newschaffer, 2007). In Palestine there is no epidemiological data

collected for autism at a national level.

The diagnostic criteria for autism are identified in ICD-10 (World Health Organization, 1993) and in DSM-IV (American Psychiatric Association, 1994). Autism is accompanied by mental retardation in three out of four patients. The underlying etiology of autism it is not known clearly however, it is suggested that autism most likely results from the interaction of multiple genetic and environmental factors (Steyaert & De la Marche, 2008).

Autism is a neurodevelopment disorder characterized by qualitative impairments in social interaction, and verbal and non-verbal communication, along with restricted, stereotyped interests and behaviors (APA, 1994). Autism is a severe, life-long developmental disorder that compromises functioning across multiple domains including social behavior, language, sensory function, and ritualistic/repetitive behaviors and interests. While the etiology of autism is complex and not fully understood, strong evidence from twin and family studies suggests a large genetic contribution (Freitag, 2007; Gupta & State, 2007).

Iron deficiency (ID) is the most common and persevering nutritional disorder and continues to be an important public health problem worldwide (WHO, 2007). Specifically in children in the first years of life, hemoglobin (HGB) levels below 11 g/dL have been related to negative cognitive, social, and emotional effects that may lead to irreversible behavioral squeals, even after appropriate treatment (Carter, 2010; Lozoff, 2007).

There is considerable evidence about the important role of iron in cognitive, behavioral, and motor development (Beard 2001). It is a component of many enzymes involved in neurotransmitter synthesis, and in iron deficiency (ID), due to decreased activity of associated enzymes, monoamine neurotransmitter systems may be affected (McCann and Ames 2007). A decrease in brain iron concentration is accompanied by changes in serotonergic and dopaminergic systems, in cortical fiber conduction, and myelogenesis (Erikson et al. 2001).

Viteri (1998) stated that the tragedy of ID is that unless it is severe and prolonged enough to cause anemia, it is silent, not being evident by clinical signs, and therefore ID must be prevented before anemia is detected. This is especially important in children with ASD who already suffer from severe communication, behavioral and intellectual impairment.

Serum ferritin (SF) is the most widely used marker of iron stores in body tissues, including the brain. Low levels are a sign of ID and an early precursor of iron deficiency anemia. It declines before serum iron when iron stores are depleted and exhibits less variability than serum iron (Hallberg 2002). Researches show that a high prevalence of ID has also been reported in children with ASD (Bilgiç 2010; Dosman 2006; Latif 2002). Inadequate dietary iron intake was considered as a cause of ID, and low iron intake was thought to be associated with food selectivity which is commonly seen in children with autistic disorders (Cermak 2010; Herndon 2009; Johnson 2008; Xia 2010).

However, it was shown that SF concentration return to a normal level with iron supplementation (Dosman et al. 2007) and this finding supports the notion that ID is associated with low iron intake in children with ASDs. The high frequency of low iron intake in these children is thought to be associated with feeding difficulties and food selectivity (Cornish 1998).

Feeding difficulties and food selectivity are major concerns in the majority of children on the spectrum, in which the child rejection of variety causes problems. There may be selectivity regarding the shape, color, smell and consistency of the food and the way it is presented to the child. Disruptive mealtime behavior and the consumption of large amounts of milk may cause further nutritional difficulties (Baron-Cohen and Bolton 1993).

Many parents report gastrointestinal symptoms in their ASD children; however, gastrointestinal symptoms of these children received little attention. D`Eufemia et al. (1996) reported increased intestinal permeability in nine of 21 (43%) patients with autistic disorder. The report of Wakefield et al. (1998) represents the first effort to evaluate the gastrointestinal tract in children with autism. In a case report, it was described three children with ASD and chronic diarrhea that had an increased pancreatico-biliary secretory response after secretin injection, suggesting that gastrointestinal dysfunction might be associated with ASD (Horvath 1998).

Significance/Relevance of the problem: The iron has important role in cognition, behavior, mood, concentration and communication. It is not clear whether the person with autism has an iron deficiency due to disease itself or anything related to behavior, environment, parenting and growth issue. Because of autism may not be the only mental illness which has iron deficiency, so it's important to do research on other psychiatric disorders group. Autism is not the first priority in the community mental health in Palestine. The author wishes to emphasize the neglected disorder (Autism), where we have many problems in diagnosis and treatment. Considering the absence of sufficient research on the relationship between autism and the lack of iron, this study aims to relate autism and iron deficiency, as the first study in Palestine. The author wishes this study to be the first step for other researcher in the future.

Aim of the study: The aim of this study is to investigate the association between autism and iron deficiency in autistic children in the northern West Bank and to identify food selectivity and compare indices of food selectivity among children with autism, children with mental disorders and typically developing children (normal

children).

2. Method and Procedure: Research design: Three groups were considered in a case-control study: a study group, and two control groups. Study group: Thirty ASD children participated from three geographical areas. Contact with children were performed by several rehabilitation centers. The control group (1), 30 children were selected by another mental disorders, but not ASD from the same centers. The control group (2), 30 typically developing children were chosen from the general population of the same geographical and cultural property of the other groups. Setting: The study was conducted in the North West Bank, and three cities were included (Jenin, Nablus, Tulkarm).

2.1 Study Sample

Purposive sampling of the study, the researcher took 50% of ASD children. The total number of diagnosed children for autism is about 60 and 30 of them were recruited in the study group by performing a simple random. The three groups were matched for gender, and age.

2.2 Study period

The study sample collected between September 2012 and finished at December 2012.

2.3 Inclusion criteria:

For study grou: Children who are diagnosed with ASD by (DSM-V) and ICD (11) by a psychiatrist, and Children who do not take supplements of iron or vitamins. For control group (1): Children who are diagnosed with mental disorders, but not ASD, and children who do not take supplements of iron or vitamins. For control group (2): Children who are free from any disease and they do not take any type of medications or supplements of iron or vitamins.

2.4 Exclusion criteria

For study group: Children with chronic neurological disorders or physical illness than ASD. Since ferritin is a marker of inflammation, children with infection or other inflammatory conditions were excluded from the study, children who received iron supplements during the last 3 months and / or who were on any dietary restrictions and children who are inpatients in rehabilitation centers. For control group (1): Children diagnosed with ASD, or having Autistic features, children who are inpatients in rehabilitation centers, children who have any type of infections, or acute illness and children who received iron supplements during the last 3 months and / or who were on any dietary restrictions. For control group (2): Children who have any dietary restrictions, children who take any type of medications or have any illness

2.5 Tool of the study

None of the available assessment forms were sufficient for the purposes of this study, for this purpose the authors developed a questionnaire includes specific food habits survey in Arabic language. The questionnaire was translated to the English language. After developing a thorough understanding of the research, the next step was to generate statements/questions for the questionnaire. In this step, content from literature/theoretical framework is transformed into statements/questions. In addition, a link among the objectives of the study and their translation into content was established. Scales are devices used to quantify a subject's response on a particular variable. As a result, a draft questionnaire is ready for establishing validity. Validity is the amount of systematic or built-in error in measurement (Norland 1990). Validity is established using a panel of experts and a field test. The Arabic version was handed to the participants. The questionnaire was given to nine people: two doctors, three nurses, three researchers, and one statistician, who were asked to judge whether or not the questions were appropriate and reasonable. After some changes the questionnaire was considered valid. The next step was to conduct a field test using subjects not included in the sample. Make changes, as appropriate, based on both a field test and expert opinion. Reliability was established using a pilot test by collecting data from 20 subjects not included in the sample. Data collected from pilot test was analyzed using SPSS (Statistical Package for Social Sciences). Reliability of the survey was investigated with a test—retest. The test—retest correlation coefficient was 0.82. The questionnaire was described as appropriate and gave a correct picture of their experience by 100% of the participants..

Description of questionnaire: The questionnaire was divided into three sets, first set for background information, the second set for parent information and the third set of nine questions for patient information (food habits survey). The questions were open-ended questions. There is one close ended question about gastric dysfunction. The closed-ended question had options and the participant has to choose among these options the most appropriate answer. Thereafter the patients were asked to report other things that were not mentioned before. Parents were interviewed about their child's dietary habits. Parents also completed a demographic questionnaire and were instructed by the author to complete a food habit survey. The completed questionnaire

record was returned to the researchers.

2.6 Laboratory measurements

Ferritin, hemoglobin, hematocrit, Mean corpuscular volume (MCV), and Red Cell Distribution Width (RDW) values were measured. Serum ferritin level is taken as an indicator of ID, because ID is the only cause of low ferritin concentration. Serum ferritin level reliably shows iron levels in body tissues including brain and is also an early precursor of ID (Worwood 1997). There is no consensus in the literature about the cutoff value for low serum ferritin in children (Cortese 2009). The author used ferritin cutoff of <10 ng/mL for preschoolers and <12 ng/mL for school-aged children to estimate iron deficiency since this was a widely used criterion in previous studies (Dosman 2006; Latif 2002).

The following cutoffs were used based on our hospital laboratory values: HGB Hemoglobin <110g/l (De Maeyer et al. 1989), hematocrit, <35%; mean corpuscular volume (MCV), <80 fL; and red cell distribution width (RDW), >14.5%. Ferritin, hemoglobin, hematocrit, MCV, and RDW values were measured in fasting blood in the morning at the university laboratory using standard measurement assays. All subjects with iron deficiency were informed. Anemia was defined as hemoglobin <110g/l for children under the age of 6 years and hemoglobin <120g/l for children 6 to 13 years of age (De Maeyer et al. 1989).

2.7 *Procedure*

Compliance with Ethical Standards was conducting. The study has been performed in accordance with the ethical standards as laid down in the 1964 Declaration of Helsinki and its later amendments. Ethical approval was obtained from the Institutional Review Board (IRB) of University, and a permission was obtained to conduct the study from rehabilitation centers. Participation was voluntary and the participants were able to withdraw from the study at any time without any negative consequences. The study purposes were explained to all parents. The parents who agreed to participate in the study have read the participant`s letter, and informed consent was obtained from all individual participants included in the study. All participants gave their informed consent in writing prior to inclusion in the study. The demographic data was taken and the blood samples were withdrawn. Safety and security during the procedure (drawing of blood samples) was taken, and the procedure of blood taking was done by professionals. The amount of blood taken from each of the child is two ml. Volume of two ml is enough, 1 ml in Edita tube and 1 ml in the plane tube. Blood tubes were sent immediately to University laboratory after putting them in ice to keep them valid. The control group (1) mental disorder but not ASD was chosen from the same rehabilitation center or other centers with a matching to the same criteria for age and number of male and female as much as possible. The process of participation was the same for the study group . For the control group (2) typically developing children, was selected from general population as the closest geographic area, and matching was performed as much as possible to the study group. The process of participation was same for the study and control group (1) group. laboratory results were sent back to rehabilitation centers and families. A food habit survey was used to record the diet of children.

2.8 Ethical considerations

Ethical approval was obtained from the Institutional Review Board (IRB) of An-Najah National University. A letter from the university to obtain permission to conduct the study in the rehabilitation centers was obtained. The process and purpose of the study was described in detail to the child and their care givers and care givers who agreed to participate in the study were asked to sign an informed consent. Participation was voluntary and they were able to withdraw from the study at any time without any negative consequences. The information kept confidential. Safety and security during the procedure (drawing of blood samples) was taken. Care was taken into account in order to ease the pain and anycomplication of needle sticks. The procedure of blood taking was done by professionals.

2.9 Data analysis

Data were analyzed using SPSS 20.0 software (SPSS, Inc., Chicago, IL, USA). Demographic data and Clinical measurement were shown as means, frequency, and SD or percentages. Descriptive analyses of hematological values were conducted. A chi-square test is used to investigate if there is a relationship between two categorical variables. In SPSS, the chi square option is used on the statistics subcommand of the crosstabs command to obtain the test statistic and its associated p-value. A one-way analysis of variance (ANOVA) is used when a categorical independent variable (with two or more categories) and a normally distributed interval dependent variable and to test for differences in the means of the dependent variable broken down by the levels of the independent variable. An independent samples t-test is used when to compare the means of a normally distributed interval dependent variable for two independent groups. A probability level of $p<.05$ was used to indicate statistical significance.

3. Results

3.1Demographic characteristics of the study sample:

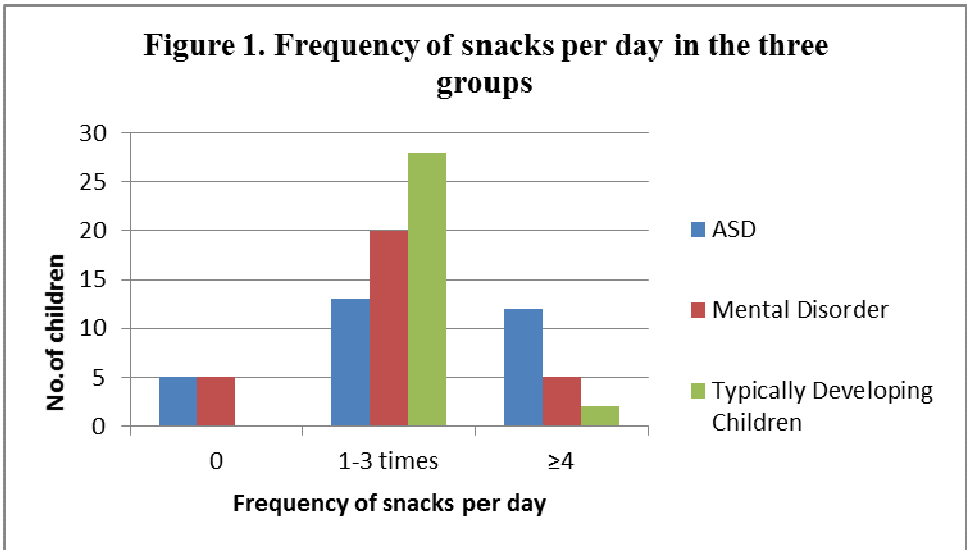
The number of study sample meeting the inclusion criteria were 90. 33.3% (30/90) are children diagnosed ASD, 33.3% (30/90) are mental disorders children, and 33.3% (30/90) are typically developing children. All patients completed the study protocol. The response rate was 100%. The three groups were similar with respect to demographic characteristics. The results showed by using Crosstab/Chi-Square test that there was no significant difference between the groups in term of age, sex, method of delivery, maternal age at delivery, length of pregnancy **(Table 1).**

Table (1): Demographic characteristics: Age, gender, method of delivery, maternal age at delivery, length of pregnancy are distributed by the groups n (%)

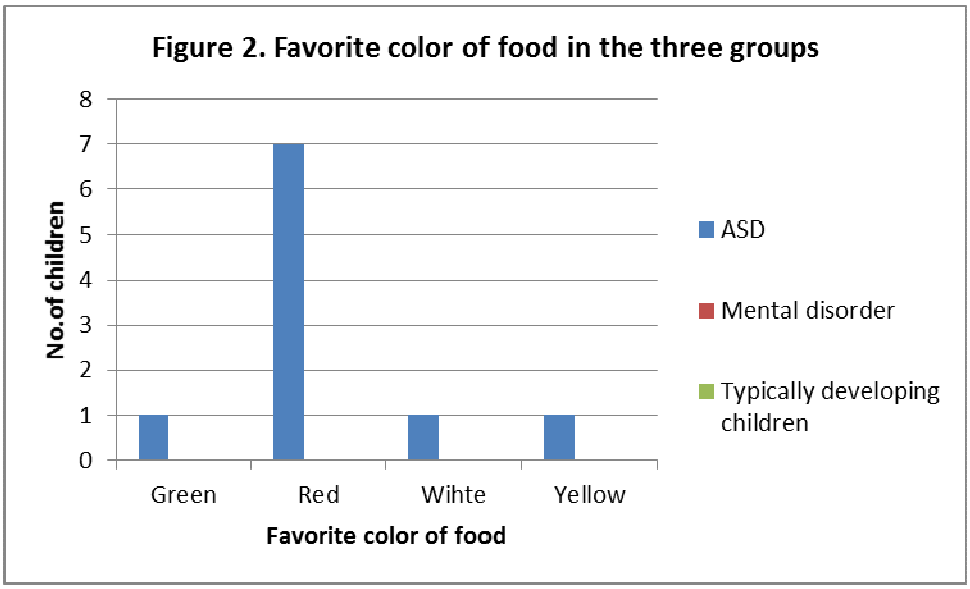
Category	Variable	ASD n=30	Mental disorder n=30	Typically developing n=30	Sig*
Gender n (%)	Female	8 (26.7%)	13 (43.3%)	8 (26.7%)	0.280
	Male	22 (73.3%)	17 (56.7%)	22 (73.3%)	
Age n (%)	School age ≥6	18 (60%)	19 (63.3%)	19 (63.3%)	
	Pre- school age < 6	12 (40%)	11 (36.7%)	11 (36.7%)	0.954
Method of delivery n (%)	Normal	22 (73.3%)	21 (70%)	24 (80%)	0.664
	Cesarean	8 (26.7%)	9 (30%)	6 (20%)	
Mothers Age on delivery n (%)	< 19 years	1 (3.3%)	1 (3.3%)	0 (0%)	
	20-29 years	16 (53.3%)	16 (53.3%)	18 (60%)	0.557
	30-39 years	10 (33.3%)	12 (40%)	12 (40%)	
	40- 49 years	3 (10%)	1 (3.3%)	0 (0%)	
Length of pregnancy n (%)	Full term	27 (90%)	27 (90%)	28 (93.3%)	
	Premature	3 (10%)	3 (10%)	2 (6.7%)	0.872

The results showed also that no significant (p=0.441) differences among the ASD, mental disorder and typically developed children groups for the frequencies of meals per day.

The results demonstrated a significant difference in the frequency of snacks per day (≥ 4) in ASD children (n = 12/30) compared with both mental disorder (n = 5/30) (p = 0.006) and typically developing children (n = 2/30) groups (p = 0.001) **Fig 1.**



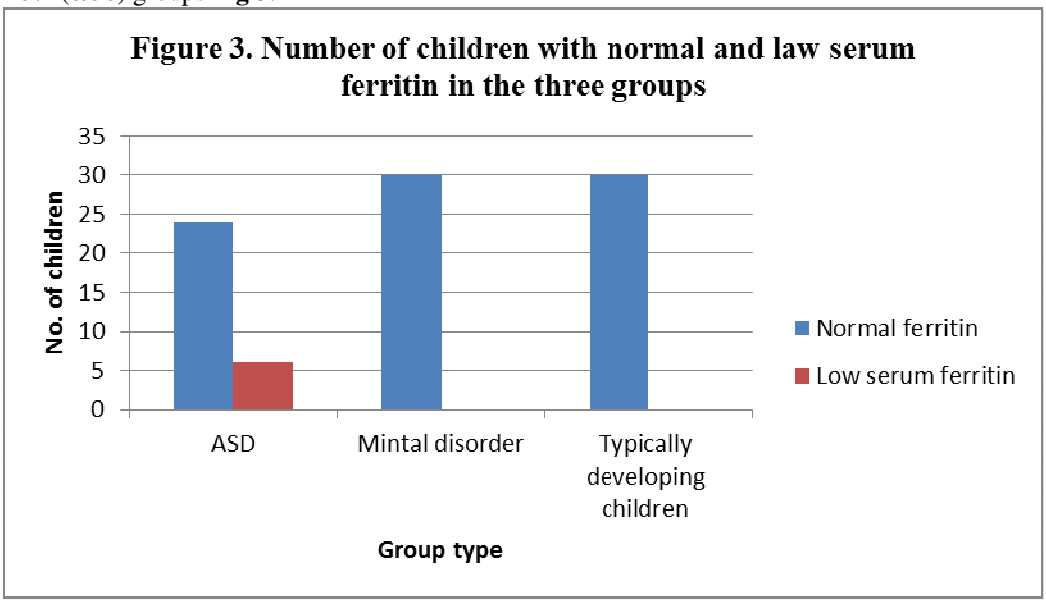
Consistent relationship was found between dietary iron intake and ferritin. Low ferritin was more prevalent among the ASD children who ate food preferences according to red color compared to the prevalence among the entire sample of children. Related to the issue of the favorite color of food, there was a significant difference between children in the ASD group who chose food with red color as favorite 23% (7/30) compared to the other two control groups 0%, respectively (p= 0.0001) **Fig 2.**



Regarding to gastric dysfunction "Unusual annoying symptoms" there are no significant differences between groups (p=0.386).

3.2 Clinical measurement

The study group was divided into two groups as group 1, cases <6 years old (n=12), and group 2, cases ≥6 years old (n=18). The proportion of children amongst ASD group with serum ferritin less than the cutoff value of "10 ng/mL " for pre-school age and "12 ng/mL " for school-age children are significantly lower by 20% (6/30) (p = 0.002), by using Crosstab/chi-square test, compared with a mental disorders 0% (0/30) and typically developing children 0% (0/30) groups **Fig 3.**



Anemia was defined as hemoglobin <110g/l for children under the age of 6 years and hemoglobin <120g/l for children 6 to 13 years of age (De Maeyer et al 1989). Serum ferritin levels below 12µg were taken as evidence of iron deficiency. It was found that 20% (6/30) of patients in the autistic group have low ferritin. When we analyzed the other laboratory measurements for them, we found that 66.6% (4/6) of children (two males are pre-school children (HGB is less than 110g/l), and the other two, one male and one female are school children (HGB is less than 120g/l) have iron deficiency anemia. The result was indicated for who have anemia that these differences are for the males 75% (3/4) (Table 2).

Table (2): Laboratory tests for school & pre-school children who have low serum ferritin and their classification to iron deficiency and iron deficiency anemia based on measurements of Hemoglobin (HGB), hematocrit (HCT), mean corpuscular volume (MCV), red cell distribution width (RDW) & ferritin

No	Age	sex	HGB (g/dL)	HCT (%)	MCV (fL)	RDW (%)	Ferritin (ng/mL)	Classification
1	School	male	110	39.0	75.3	19.0	7.2	anemia
2	Pre-school	male	100	29.3	63.6	17.8	2.1	anemia
3	Pre-school	male	109	33.3	74.3	15.2	8.6	anemia
4	Pre-school	female	123	36.2	71.9	15.1	9.5	Iron deficiency
5	School	female	114	34.7	76.8	15.0	7.4	anemia
6	Pre-school	male	118	34.9	73.0	16.9	5.6	Iron deficiency

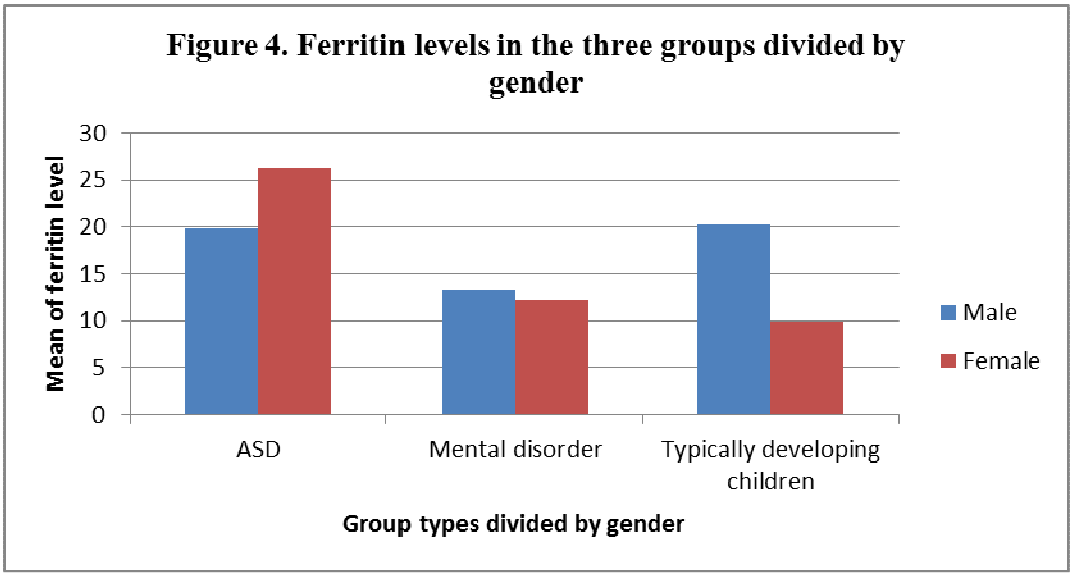
The result demonstrated that HGB level differed between the three groups [F (4.371), p=0.016]. Further analysis indicated that the HGB in autism group is lower compared to the typically developing children group ($P < 0.05$). The result indicated also that HCT level differed between the three groups [F (4.330), p=0.016]. Further analysis showed that the HCT in autism group is lower compared to typically developing children group ($P < 0.05$). The result indicated that MCV level differed between the three groups [F (3.051), p=0.052]. Further analysis indicated that the MCV in autism group is lower compared to typically developing children group ($P = 0.052$) (Table 3).

Table (3): One Way ANOVA test for the association between the means of clinical measures of Hemoglobin (HGB), hematocrit (HCT), mean corpuscular volume (MCV), red cell distribution width (RDW), and Ferritin in the three groups.

Measures	ASD n=30	Means: Mental disorder n=30	Means: Typically developing n=30	**(F)**	**Sig.***
HGB(g/dL)	11.543	11.960	12.250	4.371	0.016*
HCT(%)	34.320	36.453	35.707	4.330	0.016*
MCV(fL)	76.597	80.243	78.213	3.051	0.052
RDW(%)	14.373	14.630	13.850	2.302	0.106
Ferritin(ng/mL)	29.630	29.513	35.880	1.167	0.316

* The mean difference is significant at the 0.05 level.

When analyzing the ferritin level related to the gender; it was shown that males have lower rate of ferritin level than females rate in ASD group but it wasn't significant (p=0.697), but the males in typically developing children have higher rate of ferritin level than females rate and it was significant (p=0.017) (figure 4).



4. Discussion

In the current study, it has demonstrated that 20% of children with ASD had law serum ferritin, 13.3% had iron deficiency anemia. These findings confirmed that iron deficiency and anemia are common in ASD, in parallel

with previous researches (Bilgiç et al. 2010; Dosman et al. 2007; Latif et al. 2002).

Previous studies were investigating the iron status in children with ASD, there was a study held in Turkey by Herguner et al. (2012) was in agreement with the results of the current research. It was found that 24.1% of ASD children had low serum ferritin. While in other study the low serum ferritin results were "two times and half" higher than this study results. A study held in UK, performed the relationship between ASD and iron deficiency. It was shown a high prevalence of low serum ferritin among ASD children (52%) Latif et al. (2002). In Another study from Canada, Dosman et al. (2006) reported that ferritin level was low in 8.3% of 1–2-year-old children, in14.2% of 3–5-year-olds and in 20% of 6–10-years-old.

Another study from Turkey demonstrated that iron deficiency was detected in 32.3% of children with autism spectrum based on low serum ferritin level (Bilgic et al. 2010) which is in agreement of this study. The results of the current study on iron deficiency anemia was 13.3% is consistent with the results of Latif et al. (2002) who reported that 11.5% of the autistic children were shown to have iron deficiency anemia.

In the current study the hemoglobin (HGB) and hematocrit (HCT) were significantly lower in ASD group than the other two groups. Low HGB and HCT levels are considering as the biggest risk that ASD children might face in fact that is the condition of anemia (Herguner et al. 2012).

In the current study the age was divided in two categories: pre-school age (from 3 to less than 6 years old), and school age (from 6 to 13 years old); the difference in incidence of iron deficiency between the categories was considerable: the pre-school aged children have low serum ferritin 33.3% than school aged children 11%. Similar results were obtained by Herguner et al. (2012) who reported that low serum ferritin was more prevalent in preschool-aged than school-aged children (32.4% vs. 20.3%).

In the ASD group in the current study, four children were anemic (13.3%) three were male and one was a female. Analyzing the results of gender differences within the affected children in the study group, there was an association between gender and iron deficiency anemia. This result indicates that these differences for males, this results are in contrast with the study of Latif et al. (2002) who showed that six children were anemic (11.5%), five were male and one was female.

Children with ASD frequently have narrow food preferences, according to shape, texture, or color (Cornish 1998) as it is the case in this study which was showed that selectivity of food confined in color of food (33.3%) from the ASD group; especially red color 23% (7/30), However Cermak (2010); Herndon (2009); Johnson (2008) and Xia (2010) reported that inadequate dietary iron intake was considered as a cause of iron deficiency, and low iron intake was thought to be associated with food selectivity which is commonly seen in children with ASD.

This study reported that ASD children had high frequency of snacks per day, one of the explanation may be related to behavioral therapy which has been noticed to be adopted in rehabilitation centers. The therapy would be based in these cases that given, as most positive reinforcement to the child, candies were given to the child when he/she performs an achievement to encourage him/her, and these several snacks based on candies per day would make the child replete when he takes his meal.

In this study regarding the gastric dysfunction that manifest by unusual annoying symptoms as diarrhea, constipation, vomiting, gazes or abdominal distention, there were no significant differences between ASD group and other two control groups, in contrast to Horvath (1999) who reported that "twenty-two" of "twenty-five" autistic children (88%) had symptoms such as nighttime awakening with irritability, signs of abdominal discomfort. This study also is not congruent with a study of Wakefield et al. (1998) that described intestinal dysfunction in children with autistic spectrum disorder and D'Eufemia et al. (1996) that reported increased intestinal permeability in nine of 21 (43%) patients with ASD. The report of Wakefield et al. (1998) represented the first effort to evaluate the gastrointestinal tract in children with ASD.

5. Conclusion

Results of this study indicated that there is an association between ASD, iron deficiency and iron deficiency anemia. Low levels of serum ferritin in ASD children might be a sign of iron deficiency and an early precursor of iron deficiency anemia. These findings suggest that food selectivity is more common in children with ASD than in typically developed children. These findings suggest that ferritin levels should be measured in children with ASD as a part of routine investigation.

6. Recommendations

The authors recommend that all children diagnosed with ASD should have a full blood count and that their serum ferritin should be measured as part of their routine investigation, especially if they are selective with food and their diet has low iron content

Iron supplementation should be recommended to all children with low serum ferritin in order to avoid developing iron deficiency anemia in future. Involvement of an experienced pediatric dietitian in children with ASD is an important part of their management to enhance adequate dietary iron intake.

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