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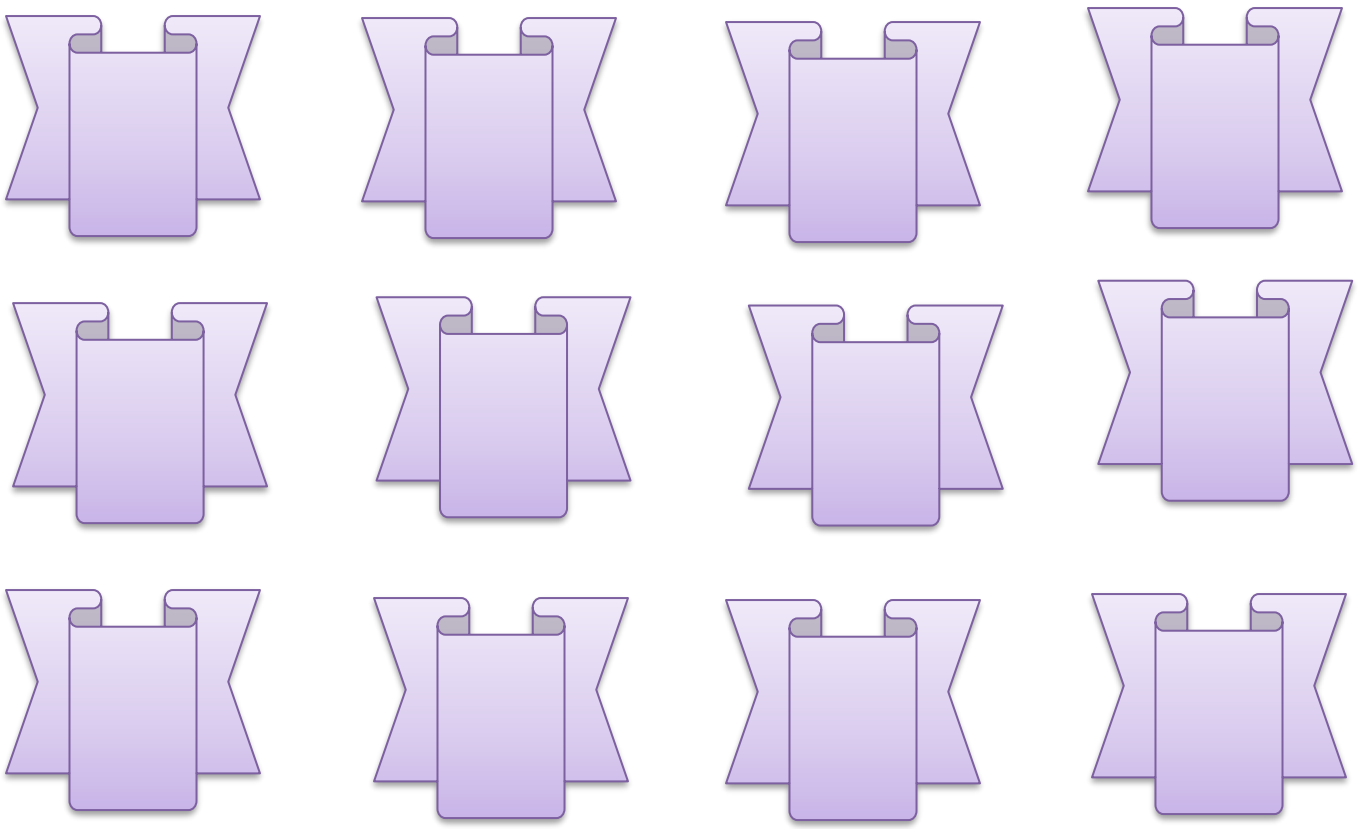

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Original Article

Assessment of Serum Carnitine level in Children with Iron Deficiency Anemia

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ABSTRACT

Background: Carnitine is acquired through the consumption of animal-derived foods, in addition to being endogenously synthesized within the body. It assumes a significant function in the energy metabolism of numerous tissues. Iron serves as a crucial co-factor in the process of carnitine synthesis. Nevertheless, the significance of iron deficiency in relation to its role as a potential cause of secondary carnitine deficiency remains inadequately established. It has been noted that individuals' carnitine levels differ based on factors such as their gender, food, and body type. The amount of carnitine in one's diet is inversely proportional to their plasma carnitine levels.

The Aim of the work: To assess the serum concentrations of carnitine in pediatric patients diagnosed with iron-deficiency anemia, in comparison to a control group of healthy children.

Patients and Methods: This cross-sectional study included 48 children who attended the pediatric clinic of Bab El-Sharia University Hospital, the duration of this study was 6 months in the period from February 2022 to August 2022. Serum creatinine was collected from every patient at the time of the study.

Results: Our results showed that There was a significant difference between the two studied groups regarding dairy products, RBCs count, measurements of Hb, measurements of MCV, measurements of MCH, measurements of MCHC, measurements of serum iron, measurements of serum ferritin and serum carnitine level. A positive correlation between levels of serum carnitine and Hb levels.

Conclusion: It could be suggested that the observed low serum carnitine levels in these children may potentially be attributed to iron deficiency.

Keywords: Serum Carnitine level; Iron Deficiency Anemia; Children.

INTRODUCTION

Iron deficiency anemia [IDA] is a commonly observed hematological disorder among children, with a prevalence of 20.1% in industrialized nations for children aged 0 to 4 years, and 5.9% for those aged 5 to 14 years. The figures of 39 and 48.1% pertain to developing nations [1]. According to a study conducted in Egypt with a clinical approach, it was found that 43% of the individuals within the age range of 6 to 24 months exhibited iron deficiency anemia [IDA] [2]. Iron deficiency resulting from insufficient consumption of bioavailable iron in the diet is the primary underlying factor contributing to the development of anemia [3].

Hemoglobin and cytochrome production, as well as other elements of energy metabolism, depend heavily on iron. In addition, it plays a role in the production of carnitine as a co-factor. Carnitine can be generated in the body and consumed through foods obtained from animals. It's crucial to the energy metabolism of many different tissues. The production of carnitine requires the presence of iron as a co-factor. The role of iron insufficiency in secondary carnitine deficit, however, is not well established [4].

So, this study aims to assess the serum concentrations of carnitine in pediatric patients diagnosed with iron-deficiency anemia, in comparison to a control group of healthy children.

PATIENTS AND METHODS

This study is a cross-sectional study that included 48 children who attended the pediatric clinic at Bab El-Sharia university hospital from February 2022 to August 2022. Patients were divided into 2 groups, group 1 which included 24 children with iron deficiency anemia, and group 2 which included 24 children as a control group. Our study followed the Helsinki Declaration principles. Ethical approval was obtained from the faculty of medicine [Al-Azhar University]. We included our patients according to the following criteria:

The inclusion criteria are 1] Age from 1-15 years. **2]** Both genders. **3]** Patients with Iron deficiency anemia.

The exclusion criteria: 1] Other types rather than Iron deficiency anemia. 2] Patients with chronic kidney disease, chronic liver disease, or sepsis.

Data collection: A detailed history was taken including age, gender, and history of dietary habits which included protein source food intake, fruits and vegetables intake among the study population. A complete physical examination was done at the time of recruitment. The following investigations were done for every patient, CBC, Serum ferritin [SF], and serum creatinine. Serum carnitine level was done by human total carnitine Elisa kit as the following: 1] All reagents, samples, and standards were prepared. 2] Sample and ELISA reagent added into each well, incubated for 1 hour at 37 37 °C. 3] The plate was washed 5 times. 4] Substrate solutions A and B were added and incubated for 10 minutes at 37 °C. 5] Stop solution added and color developed. 6] The OD value read within 10 minutes.

Statistical Analysis: The data were collected, tabulated, and subjected to statistical analysis using SPSS 26.0 for Windows [SPSS Inc., Chicago, IL, USA]. The qualitative data were presented in numerical and percentage forms. Minimum and maximum values, as well as the mean, median, and standard deviation, were used to characterize the numerical data. P-value ≤ 0.05 indicates significance. The Chi-square test was utilized to evaluate the statistical significance between qualitative variables. An Independent T-test was used was utilized to evaluate statistical significance between quantitative parametric data.

RESULTS

The demographic characteristics were described in Table 1 in which the two groups were comparable regarding sex and age. Table [2] showed no significant difference between the two studied groups regarding weight and height. The difference between the 2 groups in terms of regarding dairy product intake was significant statistically [P = 0.001]. Also, we found no difference between the 2 groups regarding protein-source food [Table 3].

Table [4] Showed measurements of complete blood count among the study population. RBCs count in the IDA group ranged from 2.63 to 4.92 with mean ± SD = 3.64 ± 0.55 while in the control group, the RBCs count ranged from 3.8 to 5.3 with mean ± SD = 4.55 ± 0.35 with highly statistically significant difference [p= <.001] between the two groups. Hb in the IDA group ranged from 6.4 to 10.2 with mean ± SD = 8.75 ± 0.92 while in the control group, the Hb

ranged from 10.2 to 14.2 with mean ± SD = 11.58 ± 1.04 with a statistically significant difference [p= <.001] between the two groups. There was a statistically significant difference [p= 0.001] between the two groups regarding red blood cell indices [MCV, MCH, and MCHC].

In the present study, serum iron in the IDA group ranged from 14 to 132 with mean ± SD = 37.18 ± 27.88, while in the control group, the serum iron ranged from 16 to 167.8 with mean ± SD = 64.78 ± 46.98 with statistically significant difference [p= 0.018] between the two groups. Serum ferritin in the IDA group ranged from 12.5 to 143 with mean ± SD = 42.53 ± 27.63 while in the control group, the serum ferritin ranged from 19.1 to 176.5 with mean ± SD = 71.25 ± 52.18 with statistically significant difference [p= 0.023] between the two groups [Table 5].

Serum carnitine level among the study population. Serum carnitine in the IDA group ranged from 17.5 to 193.4 with mean ± SD = 37.29 ± 35.43 while in the Control group, the serum carnitine ranged from 20 to 388.8 with mean ± SD = 85.28 ± 80.27 with a statistically significant difference [p= 0.012] between the two groups.

A positive correlation between serum carnitine level and Hb level was found [r= 0.059, P value = 0.6] [Figure 1].

Table [1]: Demographic characteristics among the study population

	Variables	IDA Group [n = 24]	Control group [n = 24]	P value
Sex, n [%]	**Male**	12 [50%]	9 [38%]	**0.383**
	Female	12 [50%]	15 [63%]	
Age [years]	**Mean ± SD.**	5.42 ± 2.17	4.75 ± 2.38	**0.316**
	Median [IQR]	5.25 [3.75 - 7.25]	4.5 [3 - 6]	
	Range [Min-Max]	7 [2 - 9]	8 [2 - 10]	

Table [2]: Measurements of weight and height among the study population

		IDA Group [n = 24]	Control group [n = 24]	P value
Weight [kg]	**Mean ± SD.**	17.95 ± 4.49	18.23 ± 5.16	**0.845**
	Median [IQR]	17.35 [15.05 - 21.83]	17.55 [14.5 - 19.75]	
	Range [Min-Max]	16.3 [10.5 - 26.8]	18.3 [11.5 - 29.8]	
Height [cm]	**Mean ± SD.**	102.25 ± 11.07	99.77 ± 12.22	**0.465**
	Median [IQR]	101.1 [90.8 - 110.65]	98.25 [89.75 - 108.2]	
	Range [Min-Max]	37 [85 - 122]	39.7 [85 - 124.7]	

Table [3]: Dairy product intake, and Protein source food intake among the study population

		IDA Group [n = 24]	Control group [n = 24]	P value
Dairy products intake	**Positive intake**	6 [25%]	18 [75%]	**0.001**
	Negative intake	18 [75%]	6 [25%]	
Protein source food intake	**Positive intake**	13 [54%]	11 [46%]	**0.564**
	Negative intake	11 [46%]	13 [54%]	

Table [4]: Complete Blood count among the study population

		IDA Group [n = 24]	Control group [n = 24]	P Value
RBCs count	**Mean ± SD.**	3.64 ± 0.55	4.55 ± 0.35	**<0.001**
	Median [IQR]	3.8 [3.42 - 3.9]	4.52 [4.5 - 4.7]	
	Range [Min-Max]	2.29 [2.63 - 4.92]	1.5 [3.8 - 5.3]	
Hemoglobin	**Mean ± SD.**	8.75 ± 0.92	11.58 ± 1.04	**<0.001**
	Median [IQR]	8.9 [8.3 - 9.43]	11.5 [10.75 - 12.05]	
	Range [Min-Max]	3.8 [6.4 - 10.2]	4 [10.2 - 14.2]	
MCV	**Mean ± SD.**	67.02 ± 9.05	76.04 ± 8.08	**<0.001**
	Median [IQR]	63.25 [61.28 - 67.43]	78 [72.6 - 80.12]	
	Range [Min-Max]	32 [58.2 - 90.2]	37.4 [59.7 - 97.1]	
MCH	**Mean ± SD.**	23.43 ± 3.96	27.1 ± 2.66	**<0.001**
	Median [IQR]	22.55 [20.85 - 26.88]	27.25 [25.18 - 28.78]	
	Range [Min-Max]	12.6 [18 - 30.6]	9.5 [23 - 32.5]	
MCHC	**Mean ± SD.**	27.72 ± 4.36	31.25 ± 2.43	**<0.001**
	Median [IQR]	28.35 [23.6 - 31.35]	31.75 [29.48 - 32.42]	
	Range [Min-Max]	13.8 [21.2 - 35]	8.2 [26.8 - 35]	

Table [5]: Serum iron, ferritin, and creatinine levels among the study population

	IDA Group [n = 24]	Control group [n = 24]	P
Serum Iron			
Mean ± SD.	37.18 ± 27.88	64.78 ± 46.98	0.018
Median [IQR]	23.75 [19.15 - 46.1]	40.8 [31.35 - 87]	
Range [Min-Max]	118 [14 - 132]	151.8 [16 - 167.8]	
Serum Ferritin			
Mean ± SD.	42.53 ± 27.63	71.25 ± 52.18	0.023
Median [IQR]	36.05 [24.5 - 53.97]	52.4 [27.45 - 100.5]	
Range [Min-Max]	130.5 [12.5 - 143]	157.4 [19.1 - 176.5]	
Serum Carnitine level			
Mean ± SD.	37.29 ± 35.43	85.28 ± 80.27	0.012
Median [IQR]	30.8 [21.3 - 34.83]	59.85 [40.35 - 90.35]	
Range [Min-Max]	175.9 [17.5 - 193.4]	368.8 [20 - 388.8]	

t: Independent T-test

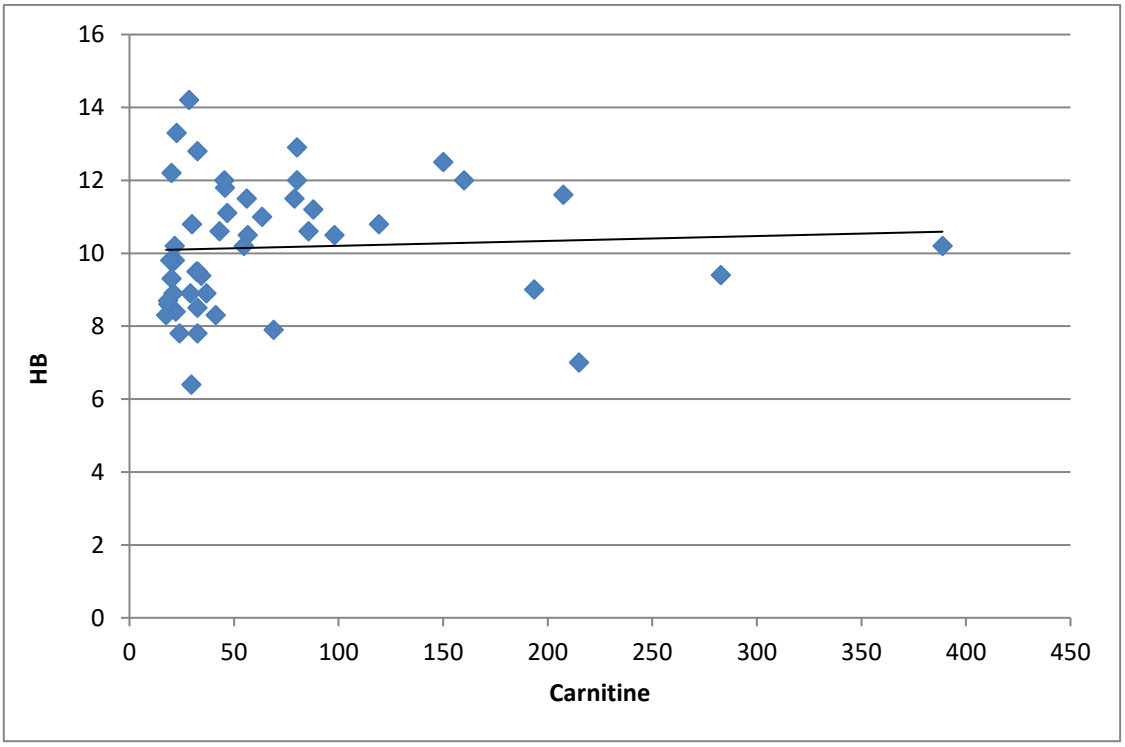

Figure [1]: Scatter plot graph showing a positive correlation between serum carnitine level and Hb level

DISCUSSION

Iron deficiency [ID] is a prevalent health issue on a global scale, characterized by a plasma ferritin level below 12 µg/L, without accounting for potential confounding factors such as infection or inflammation. The influence of ID extends to the psychomotor development and cognitive capacities of children [5].

Carnitine serves various physiological roles within the human body, one of which involves facilitating the translocation of fatty acids across the inner mitochondrial membrane to enable their subsequent oxidation via beta-oxidation. It is derived not only from animal-derived foods but also synthesized de novo. Iron is a necessary component for the biosynthesis of carnitine, along with essential amino acids and vitamins. Carnitine deficiency can manifest as a familial disorder, albeit rare, or as a consequence of diverse conditions such as total parenteral nutrition [TPN], malnutrition, metabolic disease, nephropathies, valproate treatment, hemodialysis, malabsorption, and prematurity [6].

There is a scarcity of research studies examining the correlation between carnitine levels and iron-deficiency anemia in children [7].

In our study, regarding gender distribution of the study population, there was no significant difference between the two studied groups, which was supported by the study of **Mohamed *et al.*** [8].

There was a statistically significant difference [p= 0.001] between the groups in this study in relation to dairy product consumption. Protein intake was compared between the two groups, and there was no significant difference [p= 0.564]. which is consistent with those of **Mohamed *et al.*** [8]. However, previous studies conducted by **Al-Ghwass *et al.*** [9] and **Chandrasekhar *et al.*** [10] have demonstrated that insufficient vitamin C consumption, diets rich in iron absorption inhibitors, and infrequent consumption of meat are associated with the development of iron deficiency anemia [IDA].

The rapid growth and development experienced during childhood and adolescence necessitate increased intake of micro and macronutrients. Consequently, teenage females, particularly those who undergo menstruation, face an elevated susceptibility to developing iron deficiency anemia [IDA] [11].

In the study in our hands, the RBCs count in the IDA group ranged from 2.63 to 4.92 with mean ± SD = 3.64 ± 0.55 while in the control group, the RBCs count ranged from 3.8 to 5.3 with mean ± SD = 4.55 ± 0.35 with highly statistically significant difference [p= <.001] between the two groups.

Hemoglobin in the IDA group ranged from 6.4 to 10.2 with mean ± SD = 8.75 ± 0.92 while in the control group, the Hb ranged from 10.2 to 14.2 with mean ± SD = 11.58 ± 1.04 with a highly statistically significant difference [p= <.001] between the two groups.

Mean corpuscular volume in the IDA group ranged from 58.2 to 90.2 with mean ± SD = 67.02 ± 9.05 while in the control group, the MCV ranged from 59.7 to 97.1 with mean ± SD = 76.04 ± 8.08 with a statistically significant difference [p= 0.001] between the two groups.

Mean corpuscular hemoglobin in the IDA group ranged from 18 to 30.6 with mean ± SD = 23.43 ± 3.96 while in the control group, the MCH ranged from 23 to 32.5 with mean ± SD = 27.1 ± 2.66 with a statistically significant difference [p= 0.001] between the two groups.

Mean corpuscular hemoglobin concentration in the IDA group ranged from 21.2 to 35 with mean ± SD = 27.72 ± 4.36 while in the control group, the MCHC ranged from 26.8 to 35 with mean ± SD = 31.25 ± 2.43 with a statistically significant difference [p= 0.001] between the two groups. Our results were in agreement with the study of **Moraleda *et al.*** [12], and **Purwanto *et al.*** [13].

The present study showed that serum iron in the IDA group ranged from 14 to 132 with mean ± SD = 37.18 ± 27.88 while in the control group, the serum iron ranged from 16 to 167.8 with mean ± SD = 64.78 ± 46.98 with statistically significant difference [p= 0.018] between the two groups.

Regarding serum ferritin in the IDA group ranged from 12.5 to 143 with mean ± SD = 42.53 ± 27.63 while in the control group, the Serum ferritin ranged from 19.1 to 176.5 with mean ± SD = 71.25 ± 52.18 with statistically significant difference [p= 0.023] between the two groups.

In accordance with our results, the study of **Das *et al.*** [14] as they provided evidence indicating that levels of serum iron and ferritin were notably reduced in patients diagnosed with iron deficiency anemia [IDA] in comparison to the control group. Also, our results were in line with a study by **Vaghela and Mandot [15]**.

Our results showed that carnitine in the IDA group ranged from 17.5 to 193.4 with mean ± SD = 37.29 ± 35.43 while in the control group, the carnitine ranged from 20 to 388.8 with mean ± SD = 85.28 ± 80.27 with a statistically significant difference [p= 0.012] between the two groups.

Our results demonstrated a positive correlation between serum carnitine level and Hb level by Pearson's correlation coefficient [r = 0.059], which is in line with **Citak *et al.*** [4], and **Tanzer *et al.*** [16].

The biosynthesis of carnitine necessitates the presence of iron, and experimental studies have demonstrated that iron deficiency leads to a reduction in liver carnitine levels in animals. Moreover, additional evidence also corroborates the notion that certain observations in cases of severe iron deficiency anemia could be associated with reduced levels of carnitine in

bodily tissues, leading to diminished exercise capacity and muscle stamina.

Conclusion: A positive correlation between serum carnitine level and Hb level was proved. Iron deficiency anemia is associated with significant carnitine deficiency.

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