

RESULTS

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This study included 80 patients presenting with convulsive disorders, carefully selected from the Neurology Outpatient Clinic, New Children's Hospital, Cairo University, in the period 1997-1998. Also, the study included twenty subjects as controls.

According to sex and age, patients were classified into 53 males (66%) with a mean age at presentation of 5.3 +/- 3.4 years (*range: 0.6-13*) and 27 females (34%) with a mean age at presentation of 4.7 +/- 3.5 years (*range: 0.6-13*) (Table: 9 , Figure: 3 & 4).

Controls were classified into 9 males (45%) with a mean age at presentation of 4.42 +/- 3.85 years (*range: 1-12*) and 11 females (55%) with a mean age at presentation of 4.45 +/- 2.53 years (*range: 1-10*) (Table: 9 , Figure: 3 & 4).

According to therapy, 25 patients (31%) were on antiepileptics at time of presentation. And, 55 patients (69%) presented without medications (**Table: 9**).

Patients were classified into two categories: clinical and aetiological classification (**Table: 10 , Figure: 5**)

1. **Clinical classification:** which include generalized 46 (57.5%), focal 18 (22.5%), and febrile 16 (20%).
2. **Aetiological classification:** which include febrile and afebrile patients. Afebrile patients are subdivided into idiopathic 50 (62%), symptomatic 14 (18%). However, febrile patients 16 (20%) were not classified because the small number of subgroups which would not allowed proper statistical analysis.

In the following lines, statistical analysis for patients and controls concerning the followings will be described:

- Glutamate dehydrogenase in leukocytes (*GD*)
- Isocitrate dehydrogenase in leukocytes (*ID*)
- Glutamate oxaloacetate transaminase in leukocytes (*GOTL*)
- Glutamate oxaloacetate transaminase in red blood cells (*GOTR*)

- Copper in hair
- Zinc in hair
- Manganese in hair
- Magnesium in hair

All the results of the study were documented in two **master tables**, one for the patients and the other for the controls, including the age, sex, medication, classification of epilepsy and the values of enzymes and trace elements (**Table: 11 & 12**).

As regard the mean and standard deviation of the enzymes & trace elements studied, the following table showed the results of T-test for all patients and controls (**Table: 13 , Figure: 6 & 7**). Zinc concentrations in the hair from convulsive patients were significantly higher than those in controls ($p < 0.01$). On the other hand, CuZn, MgZn and MnZn concentrations in the hair from convulsive patients were significantly decreased compared with those from controls ($p < 0.05$) (**Table: 13**).

As regard the sex, the following table showed the results of T-test for male & female patients (**Table: 14 , Figure: 10 & 11**). Mn concentrations in the hair from convulsive male patients were significantly lower than those in female patients ($p < 0.05$).

As regard therapy, the following tables showed the results of T-test for treated patients & controls (**Table: 15**), untreated patients & controls (**Table: 16**), and treated & untreated patients (**Table: 17 , Figure: 8 & 9**).

MnZn concentrations in the hair from treated patients were significantly lower than those in controls ($p = 0.01$) (**Table: 15**). Zinc concentrations in the hair from untreated patients were significantly higher than those in controls ($p < 0.05$) (**Table: 16**). CuZn, MgZn and MnZn concentrations in the hair from untreated patients were significantly lower than those in controls ($p < 0.05$) (**Table: 16**).

Mg concentrations in the hair from treated patients were significantly lower than those in untreated ($p < 0.05$) (**Table: 17**).

As regard clinical classification, the following table showed the results of T-test for focal, febrile and generalized, patients & controls respectively (**Table: 18, 19 & 20**). Zn concentrations in the hair from focal convulsive patients were significantly increased compared with those from controls ($p < 0.01$) (**Table: 18**). However, Mn, CuZn and MnZn concentrations in the hair from focal convulsive patients were significantly decreased compared with those from controls ($p < 0.05$) (**Table: 18**).

Mn and MnZn concentrations in the hair from febrile convulsive patients were significantly decreased compared with those from controls ($p < 0.05$) (Table: 19). Also, CuZn, MgZn and MnZn concentrations in the hair from generalized convulsive patients were significantly decreased compared with those from controls ($p < 0.05$) (Table: 20).

As regard aetiological classification, the following table showed the results of T-test for idiopathic, symptomatic and febrile patients & controls respectively (Table: 21, 22 & 19). Mn, CuZn, MgZn and MnZn concentrations in the hair from idiopathic convulsive patients were significantly lower than those in controls ($p < 0.05$) (Table: 21).

CuZn concentrations in the hair from symptomatic convulsive patients were significantly lower than those in controls ($p < 0.05$) (Table: 22). Also, Mn and MnZn concentrations in the hair from febrile convulsive patients were significantly lower than those in controls ($p < 0.05$) (Table: 19).

Finally, there is a correlation between the data of enzymes and trace elements of controls and patients (*treated & untreated*) respectively (Table: 23, 24 & 25). Appreciable results as guided by the significant and highly significant values were recorded.

There is significant correlation between glutamate dehydrogenase concentration in leukocytes and manganese concentration in hair of controls. Also, there is significant correlation between the following trace elements concentration in hair of controls: Cu and MgCu, Zn and MgZn, Mn and MgMn, Mg and MgCu, CuZn and MnZn. Whereas, there is highly significant correlation between the following trace elements concentration in hair of controls: Zn and CuZn, Zn and MnZn, CuZn and MgZn (**Table: 23**).

There is significant correlation between the following trace elements concentration in hair of treated patients: Cu and CuZn, Zn and CuZn, Zn and MgCu, Mn and MgMn, CuZn and MnZn, MgZn and MnZn. Whereas, there is highly significant correlation between the following trace elements concentration in hair of treated patients: Mg and MgCu, CuZn and MgZn. Also, There is highly significant correlation between isocitrate dehydrogenase and glutamate oxaloacetate transaminase concentration in leukocytes (**Table: 24**).

There is significant correlation between the following trace elements concentration in hair of untreated patients: Cu and MgCu, Mn and MgMn, MgZn and MnZn, MgZn and MgMn. Also, there is significant correlation between isocitrate dehydrogenase and both glutamate oxaloacetate transaminase and glutamate dehydrogenase concentration in leukocytes.

Also, there is significant correlation between isocitrate dehydrogenase in leukocytes and MgMn concentration in hair of untreated patients (**Table: 25**).

There is highly significant correlation between the following trace elements concentration in hair of untreated patients: Zn and CuZn, Zn and MgZn, Zn and MnZn, Mg and MgZn, Mg and MgMn, Mg and MgCu, Mn and MnZn, CuZn and MgZn. Also, there is highly significant correlation between glutamate dehydrogenase in leukocytes and MgMn concentration in hair of untreated patients (**Table: 25**).

Figure(3): Mean age of patients and controls.

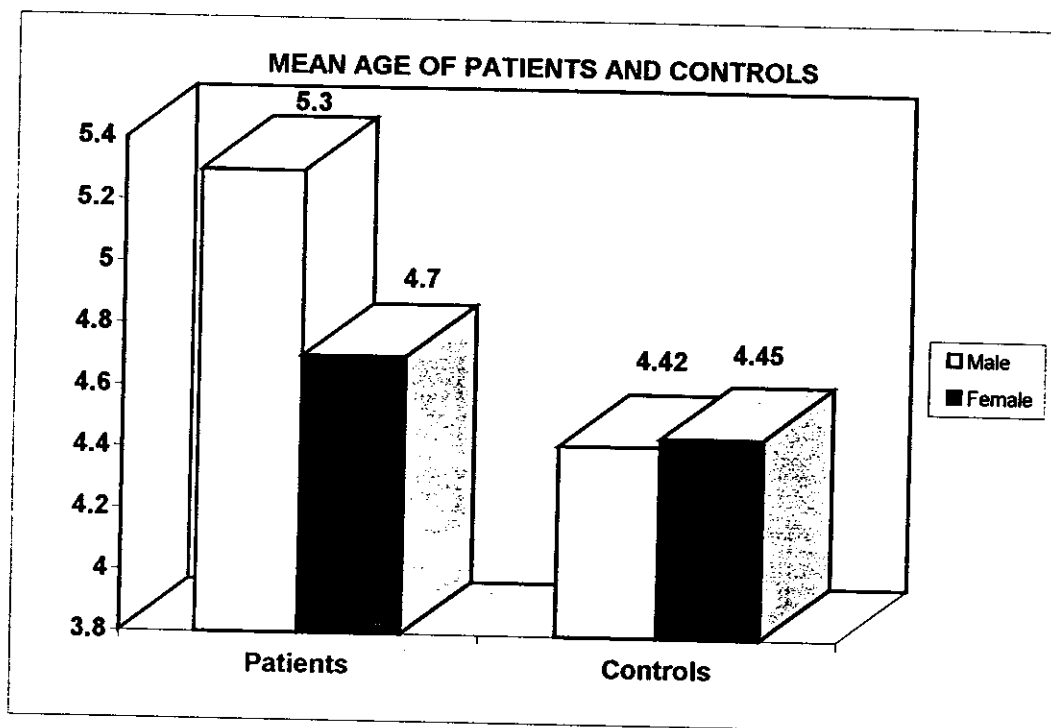


Figure (4): Sex distribution of patients and controls.

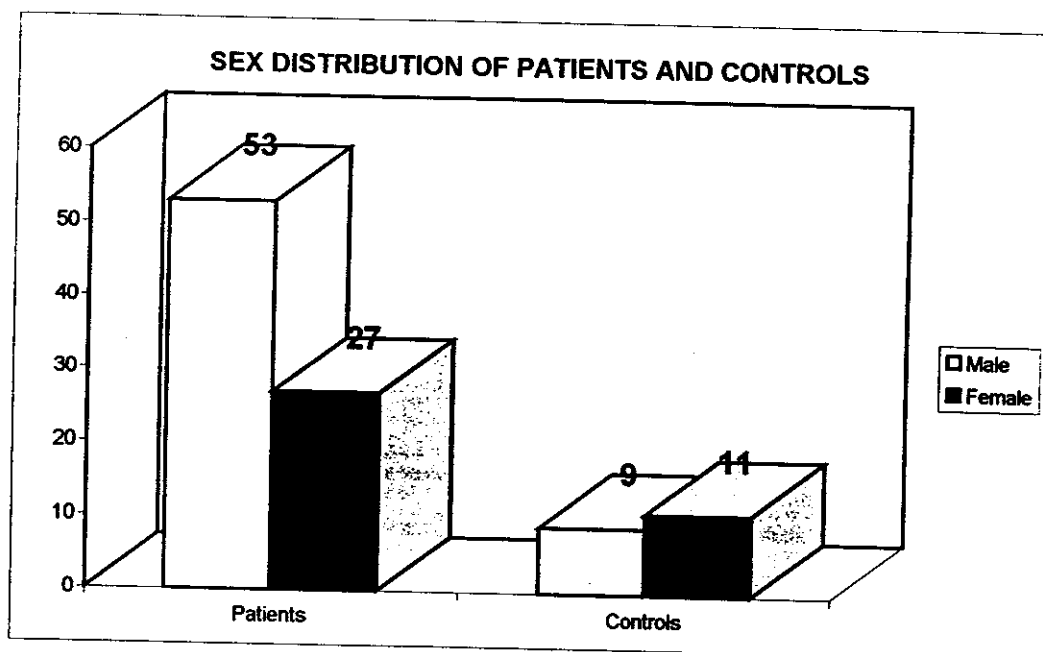


Figure (5): Classification of patients

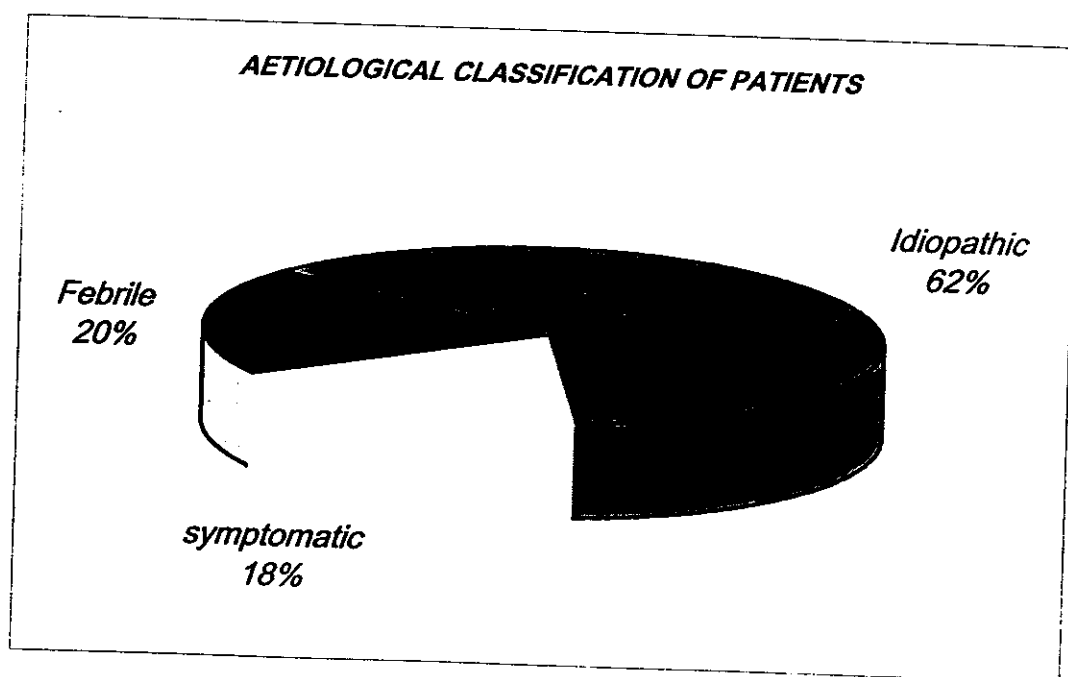
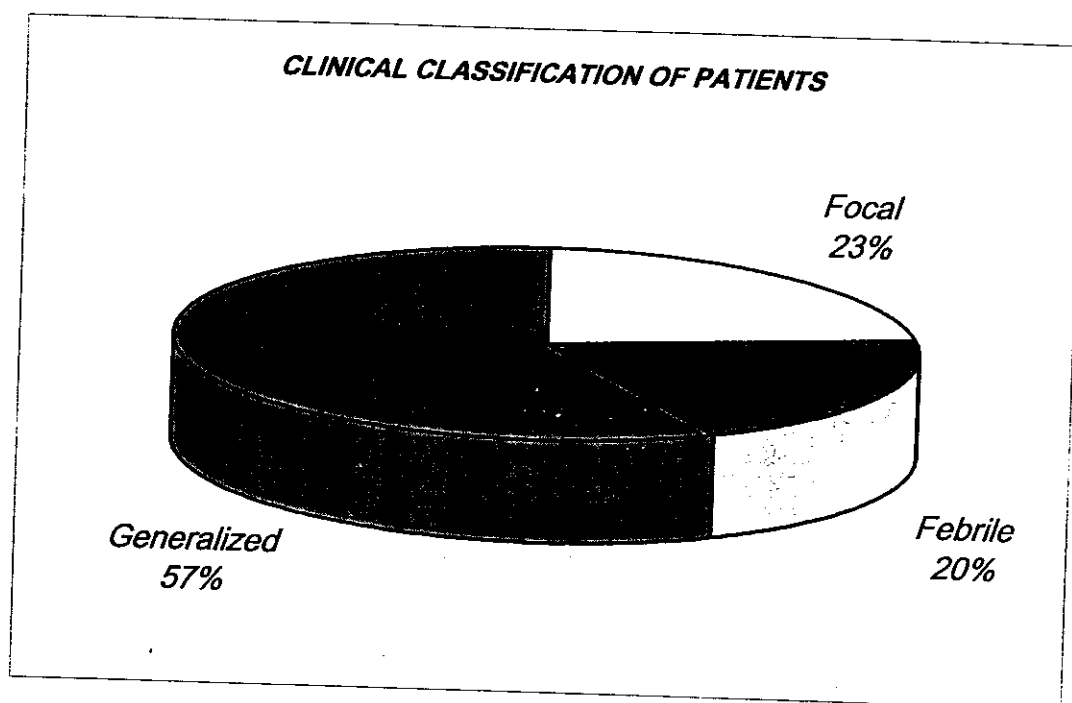


Figure (6): Mean of enzymes of patients and controls.

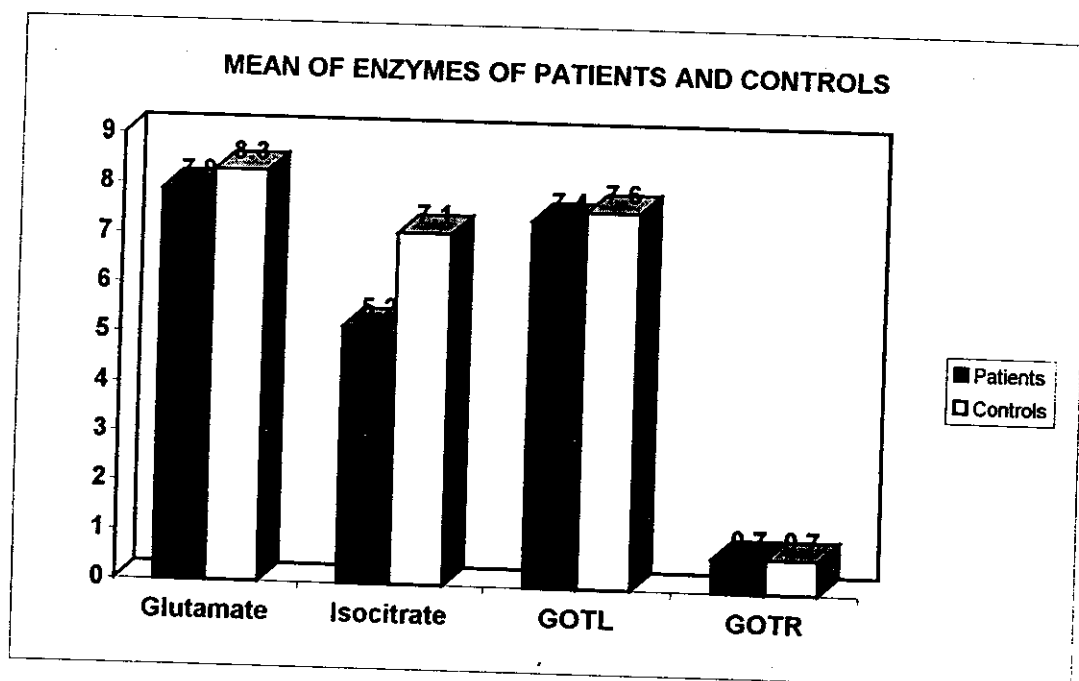


Figure (7): Mean of trace elements of patients and controls

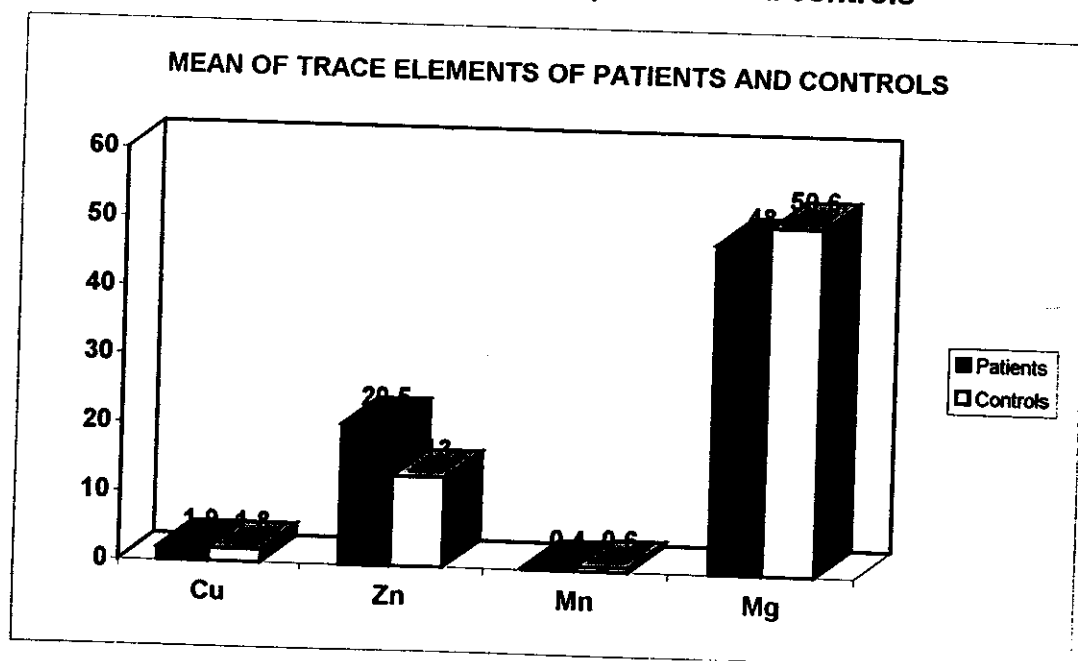


Figure (8): Mean of enzymes of treated and untreated patients.

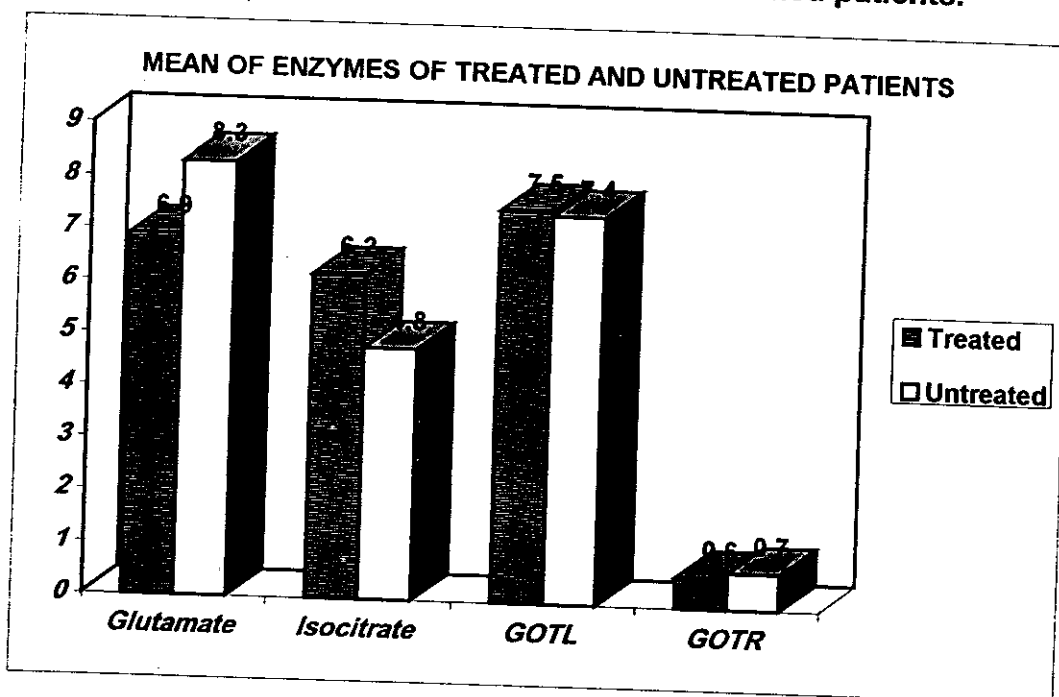


Figure (9): Mean of trace elements of treated and untreated patients.

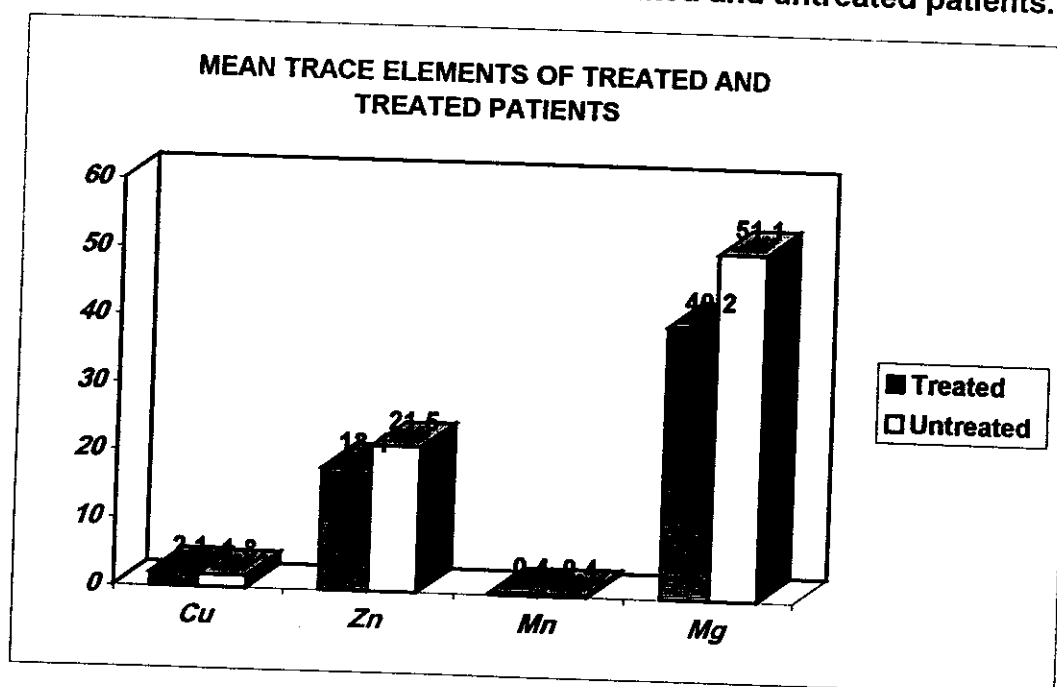


Figure (10): Mean of enzymes of male and female patients.

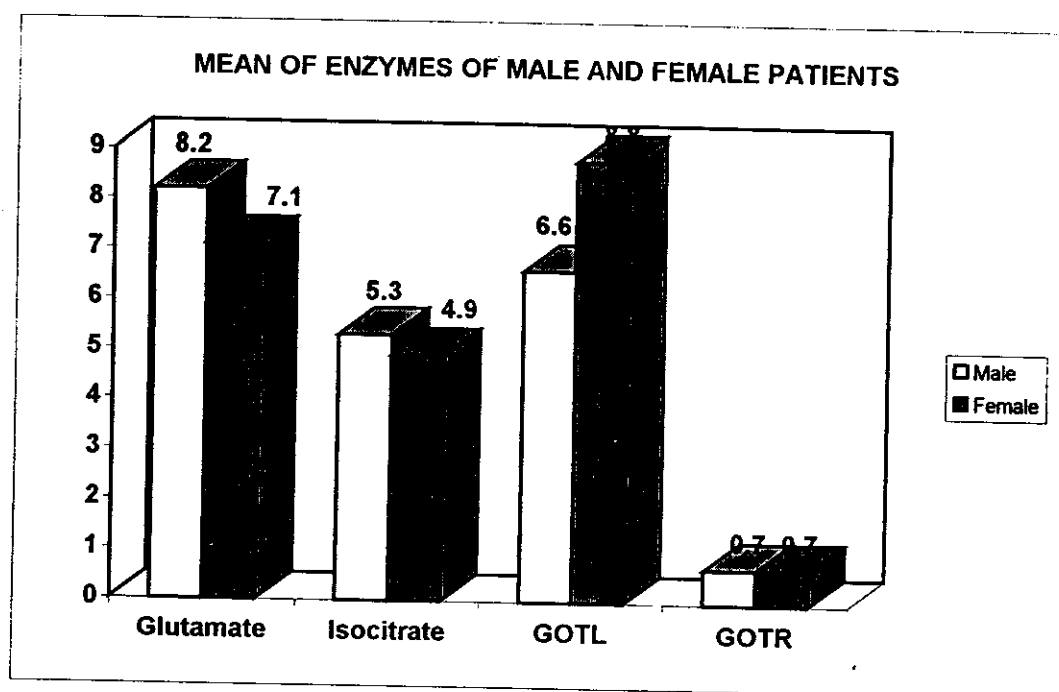


Figure (11): Mean of trace elements of male and female patients.

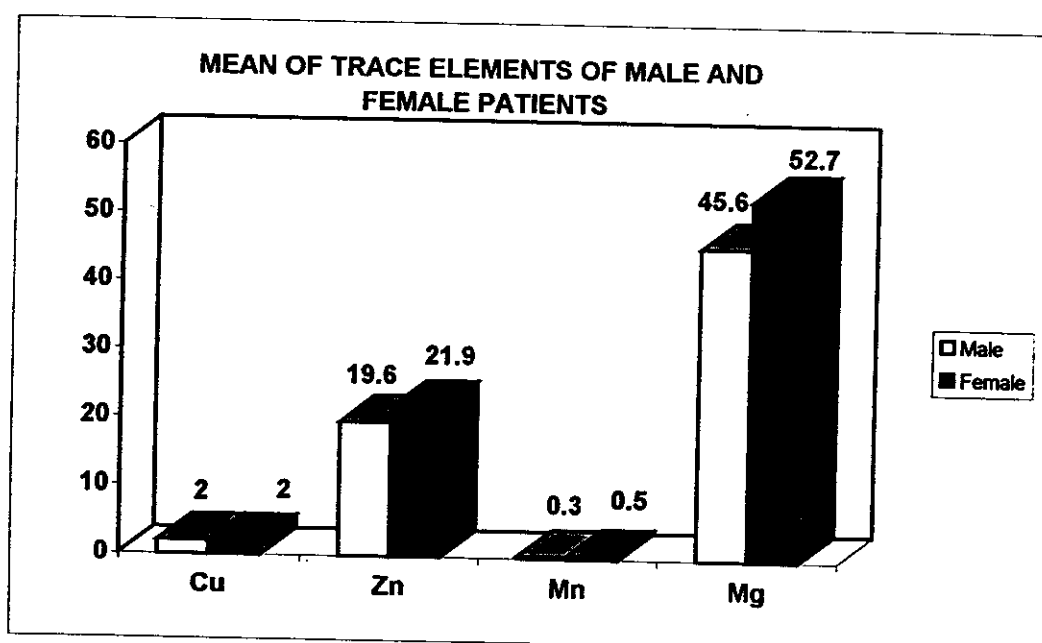


Table (9): Mean age and standard deviation of patients & controls and treated & untreated patients.

Patient	N	%	Mean age (y)	S.D.	Range
Male	53	66	5.3	3.4	0.6-13
Female	27	34	4.7	3.5	0.6-13
Control					
Male	9	45	4.42	3.85	1-12
Female	11	55	4.45	2.53	1-10
Treated	25	31	5	3.3	0.6-13
Untreated	55	69	5.4	3.5	0.7-13

Table (10):Classification Of Patients:

	Clinical Classification			Aetiological Classification	
	N	%		N	%
Focal	18	22.5	Idiopathic	50	62
Febrile	16	20	symptomatic	14	18
Generalized	46	57.5	Febrile	16	20

Table (11): Master table of patients.

N	Sex	Age	Type	Class	Med	GD	ID	GOTL	GOTR	Mg	Cu	Zn	Mn
1	F	5.5	foc	1	2	0.25	0.31	0.24	0.11	20.3	1.34	39	0.43
2	M	13	feb	3	2	0.9	0.5	0.9	0.73	26	2.29	28.5	0.23
3	M	13	foc	1	2	0.29	1.5	0.32	0.18	38.2	3.62	25.7	0.4
4	M	7	feb	3	2	0.42	0.5	0.4	0.13	37.2	2.4	7.6	0.19
5	M	3	gen	1	1	12.2	6	2.3	0.23	16.1	1.8	9	0.13
6	M	4	gen	2	1	1.7	1.4	0.58	0.21	47.7	2	22.8	0.2
7	M	3.5	gen	1	2	1.7	4.3	0.83	0.14	75.6	3	23.4	0.68
8	F	11	gen	1	1	2.5	6.2	9.6	0.19	21.7	1.5	12.5	0.41
9	M	1.2	gen	2	2	6.7	4.1	3.2	3	31.5	2.5	29.8	0.36
10	F	1	gen	1	2	10.2	8.5	8.23	0.35	53.9	2.6	0	0.68
11	F	8	gen	2	2	12	7.4	17.1	0.05	61.6	2	8.1	0.51
12	F	0.9	foc	1	2	9.4	2.9	14	0.41	71.3	2.6	8.7	0.35
13	M	1.8	feb	3	2	17.6	6.4	16.7	3.19	34.9	2.4	19.4	0.42
14	M	13	gen	1	2	8.8	0.9	7.09	0.08	35	1.5	7.6	0.49
15	M	4.2	foc	1	2	12.3	7.6	5.9	1.28	51.9	1.6	21.7	0.23
16	M	0.6	foc	1	1	6.5	12.1	4.7	0.08		2	15.4	0.25
17	F	6.5	gen	1	1	4.3	2.6	10.5	0.43	36.9	2.3	4.6	0.25
18	F	1.2	feb	3	1	5.5	4.6	8.9	0.75	54.3	3.3	0	0.41
19	F	2.2	gen	1	2	6.6	9.9	5.5	0.71	93.5	3.6	48.5	0.44
20	M	6	gen	1	1	12.1	2.9	4.6	1.02	26.3	1.8	15.3	0.77
21	M	0.8	gen	1	1	25.1	7.7	6.1	0.48	33.6	2	6.9	0.35
22	M	6	gen	1	1	1.2	1.4	11.6	0.2	18.9	1.7	0	0.23
23	M	8.2	foc	2	1	5.1	3.1	12.4	0.67	40.4	1.4	0	0.49
24	M	5	gen	1	1	1.2	3	1.22	2.38			0	0.52
25	M	3	gen	1	2	4.4	3.7	2.8	1.88	91	1.4	0	0.45
26	M	6.2	gen	1	2	1.8	2.3	1.8	0.26	37	2.2	0	0.33
27	F	2	gen	1	2	0.6	1.5	1.17	1.02	37.2	1.2	21.8	0.33
28	F	3.5	foc	1	1	2.4	3	29.1	1.45	40.9	3	0	0.3
29	M	2.5	feb	3	2	1.3	13.3	1.29	0.09	63.8	2	0	0.24
30	F	0.6	gen	2	1	1.8	2.3	1.83	0.27	86.6	1.2	48.9	0.32
31	M	1.5	gen	1	1	14.7	18.4	25	0.16	55.2	1.4	51.5	0.88
32	F	2.5	feb	3	2	3.6	9	17.4	0.37	37.3	0.9	11.2	0.34
33	M	4	foc	1	2	4.5	11.2	2.18	0.1	69.8	1.6	20.3	0.49
34	M	10	gen	2	1	10.4	8.6	3.35	0.1	69.5	4.4	14.3	0.64
35	M	7	gen	2	1	1.6	9.6	1.53	0.34	49.4	1	10.4	0.59
36	M	4	feb	3	2	4.4	8.1	3.18	0.08	23.7	1.5	20.9	0.16
37	F	4	gen	2	2	19.8	12	14.4	0.66	20.8	3.4	38.2	0.3
38	M	1.5	gen	1	2	4	2.5	19.8	0.25	67.6	1.5	0	0.34
39	M	1.5	gen	1	2	28	8.5	6.7	0.23	65.2	1.5	18.6	0.34
40	M	6	feb	3	2	91.2	13.7	10.9	0.85	87.2	1.2	14.2	0.22

F: Female

M: Male

Med 1: Treated

Med 2: Untreated

Class 1: Idiopathic

Class 2: symptomatic

Class 3: Febrile

Foc: Focal

Feb: Febrile

Gen: Generalized

GD: Glutamate Dehydrogenase

ID: Isocitrate Dehydrogenase

GOTL: Glutamate Oxaloacetate Transaminase in Leukocytes

GOTR: Glutamate Oxaloacetate Transaminase in Red cells

Cu: Copper

Zn: Zinc

Mg: Magnesium

Mn: Manganese

mU/min/mg protein: Unit of enzyme in leukocytes

mU/min/mg Hb: : Unit of enzyme in red blood cells

Table (11) continued: Master table of patients.

N	Sex	Age	Type	Class	Med	GD	ID	GOTL	GOTR	Mg	Cu	Zn	Mn
41	M	5	feb	3	2	5.7	10.6	27.7	0.09	28.6	0.9	51.1	0.2
42	M	9	foc	1	2	4	10	9.6	2.49	22.3	3.9	43	0.27
43	F	4	foc	2	2	5.8	1.7	14	0.63	86	1.6	27	0.65
44	F	5	gen	1	1	3.5	2.2	8.43	2.55	58	1.8	0	1.72
45	F	4.5	gen	1	2	4	3.3	6.34	0.87	57.3	4.5	0	0.49
46	M	4.2	gen	2	2	2.8	2.3	0.9	2.3	29.1	1.3	11.8	0.77
47	F	9	gen	1	2	1.26	3.6	2.77	0.09	90.5	0.8	13.3	2.08
48	M	13	gen	1	2	2.6	4.8	0.63	0.12	68.2	2.3	8.1	0.59
49	M	5.5	foc	1	2	3.8	4.7	0.92	0.14	1.82	0.9	45.3	0.2
50	F	6.5	foc	1	1	7.5	9.2	0.89	0.21			0	0.69
51	M	6	feb	3	2	5.4	2.2	17.5	0.6	55.4	1.5	0	0.48
52	M	1.5	gen	1	2	18.8	1.1	13.5	0.47	30.5	2.2	11.2	0.49
53	M	1.5	feb	3	2	6	2.4	9.7	0.98	38.4	2.3	0	0.51
54	F	6	gen	1	2	37.1	4.6	9	1.34	96.5	0.8	18.1	0.27
55	M	13	gen	1	2	3.3	0.7	5.45	1.7	33.8	1.1	17.9	0.21
56	M	3	gen	1	2	5.4	2.25	8.73	0.19	69	1.2	0	0.23
57	F	8	gen	1	2	5.4	2	7.93	1.13	15.1	1.3	18.3	0.11
58	F	0.7	gen	2	2	6.6	2.3	9	1.1	39.1	1.3	0	0.43
59	F	12	foc	1	2	3.7	4.6	1.8	0.47	55.3	1.8	39.9	0.31
60	F	13	gen	2	1	15	9.2	3.63	1.17	50	1.5	12	0.15
61	M	2.5	gen	1	1	6.5	6.4	3.11	0.74	30.6	1.9	19.1	0.42
62	M	4	gen	2	2	0.74	0.9	3.59	0.55	43.8	1.3	0	0.14
63	M	4	feb	3	2	6	3.6	14.6	0.29	13.3	1	2.8	0.18
64	F	9	gen	2	2	9.1	2.7	10.9	0.06	42.8	1.7	9.3	2.02
65	F	6	gen	1	1	8.3	15.6	20.3	0.54	49.8	1.9	19.7	0.3
66	M	12	foc	1	2	8.5	6.3	8.15	0.36	65.5	1.7	36	0.18
67	M	4.5	gen	1	1	5.1	6.4	6.23	0.23	22.3	2	19.5	0.14
68	F	2.5	gen	1	2	4.1	1.7	5.37	1.4	66.9	2.1	18.1	0.53
69	M	3	foc	1	2	5.4	2.2	8.8	1.09	25.9	1.1	12	0.27
70	M	2	feb	3	1	12	7.3	5.82	0.39	38	2.7	7.9	0.64
71	M	9	foc	1	2	5.8	4.9	6.64	0.5	49	2.3	28.7	0.55
72	M	4	feb	3	2	6.6	2	7.93	0.15	92.1	1	0	0.38
73	M	9	gen	1	2	3.9	1.6	1.27	0.71	51.5	9.5	9.7	0.68
74	M	5.5	feb	3	2	5.5	4.6	4.5	0.73	31	1.4	0	0.35
75	F	2.6	gen	1	1	1.9	0.6	0.91	0.75	27	2	0	0.33
76	M	8	gen	1	1	4.5	5.6	7.27	1.35	12.5	4.1	0	0.67
77	M	3.5	foc	1	2	5	6.1	9.7	0.65	110	0.7	8.3	0.35
78	M	4	feb	3	2	5.1	6.4	2.49	0.9	70.1	0.1	23.1	0.45
79	M	6.2	foc	1	2	13.4	11.1	10.7	1.57	38	1.7	3.7	0.19
80	M	6	gen	1	2	4.5	4.2	0.54	0.98	65.8	1.6	19.9	0.53

F: Female M: Male
 Med 1: Treated Med 2: Untreated
 Class 1: Idiopathic Class 2: symptomatic Class 3: Febrile
 Foc: Focal Feb: Febrile Gen: Generalized
 GD: Glutamate Dehydrogenase ID: Isocitrate Dehydrogenase
 GOTL: Glutamate Oxaloacetate Transaminase in Leukocytes
 GOTR: Glutamate Oxaloacetate Transaminase in Red cells
 Cu: Copper Zn: Zinc Mg: Magnesium Mn: Manganese
 mU/min/mg protein: Unit of enzyme in leukocytes
 mU/min/mg Hb: : Unit of enzyme in red blood cells

Table (12): Master table of controls.

N	Sex	Age	GD	ID	GOTL	GOTR	Mg	Cu	Zn	Mn
1	M	1.5	4	5	5.95	0.77	110.5	1.73	0	0.24
2	F	2	2	5	1.94	2.65	51.83	1.99	22.61	0.36
3	F	4.5	1.5	5.8	3.06	0.95	51.21	3.16	11.34	0.65
4	F	1.7	1.4	1.8	6.98	1.06	77.22	2.48	2.85	0.41
5	F	10	7	21.5	10.27	1.63	84.85	0.76	16.94	0.34
6	F	4.7	10.2	24.7	9.8	1.65	27.47	2.06	12.45	1.1
7	M	12	17.4	14.5	25.34	1.27	57.34	1.93	24.94	0.34
8	F	5	6.1	3.7	14.79	0.87	25.93	2.42	1.95	0.36
9	F	7	3.4	4.1	16.47	0.12	39.71	1.68	6.28	0.37
10	M	9	7.2	4.4	8.73	0.14	30.47	1.61	28.2	0.67
11	M	2	8.4	3.4	4.09	0.5	62.08	2.8	16.27	0.99
12	F	4	46.7	8.7	2.26	0.13	38.82	2.76	7.54	2.11
13	M	6	5.2	1.06	8.47	0.05	33.53	1.41	1.99	0.52
14	F	4	3.1	1.9	0.75	0.02	62.08	2.12	10.71	1.18
15	M	3.5	2.7	1.6	1.32	0.08	53.25	1.18	15.5	0.35
16	F	5	6.1	1.7	7.4	0.11	52.8	44.09	0	2.84
17	M	3.5	1.6	1.9	1.54	0.53	18.97	12.31	42.72	0.15
18	F	1	18.2	11.2	6.54	0.22	33.56	1.71	16.56	0.16
19	M	1	3.1	7.9	3.06	0.34	36.84	0.42	0	0.29
20	M	13	3	1.8	7.33	0.29	34.97	0.98	0	0.46

F: Female M: Male
 GD: Glutamate Dehydrogenase ID: Isocitrate Dehydrogenase
 GOTL: Glutamate Oxaloacetate Transaminase in Leukocytes
 GOTR: Glutamate Oxaloacetate Transaminase in Red cells
 Cu: Copper Zn: Zinc Mg: Magnesium Mn: Manganese
 mU/min/mg protein: Unit of enzyme in leukocytes
 mU/min/mg Hb: : Unit of enzyme in red blood cells

Table (13): T-Test of all patients & controls.

	All Patients		Control		Significance	
	N	Mean	N	Mean	P	
Glutamate	79	7.9 +/- 11.4	18	8.3 +/- 10.7	0.8	N.S.
Isocitrate	79	5.2 +/- 3.9	18	7.1 +/- 6.8	0.1	N.S.
GOTL	79	7.4 +/- 6.4	18	7.6 +/- 6.2	0.9	N.S.
GOTR	79	0.7 +/- 0.7	18	0.7 +/- 0.7	0.9	N.S.
Cu	77	1.9 +/- 0.8	18	1.8 +/- 0.7	0.6	N.S.
Zn	57	20.5 +/- 12.9	15	13 +/- 8.1	0.009	S.
Mn	79	0.4 +/- 0.3	18	0.6 +/- 0.4	0.1	N.S.
Mg	76	48 +/- 23.6	18	50.6 +/- 23.2	0.6	N.S.
CuZn	57	0.1 +/- 0.1	15	0.3 +/- 0.3	0.001	S.
MgZn	56	3.3 +/- 2.6	15	6.8 +/- 7	0.004	S.
MnZn	57	0.03 +/- 0.03	15	0.09 +/- 0.08	0.026	S.
MgMn	76	138.6 +/- 87	18	131 +/- 115.9	0.7	N.S.
MgCu	76	35.9 +/- 59.6	18	32.6 +/- 23.5	0.8	N.S.

Table (14): T-Test of male & female patients.

	MALE		FEMALE		Significance	
	N	Mean	N	Mean	P	
Glutamate	53	8.2 +/- 12.9	27	7.1 +/- 7.4	0.6	N.S.
Isocitrate	53	5.3 +/- 3.9	27	4.9 +/- 3.8	0.6	N.S.
GOTL	53	6.6 +/- 6.2	27	8.8 +/- 6.8	0.1	N.S.
GOTR	53	0.7 +/- 0.7	27	0.7 +/- 0.5	0.8	N.S.
Cu	52	2 +/- 1.3	26	2 +/- 0.9	0.9	N.S.
Zn	39	19.6 +/- 12.3	19	21.9 +/- 14.1	0.5	N.S.
Mn	53	0.3 +/- 0.1	27	0.5 +/- 0.5	0.03	S.
Mg	51	45.6 +/- 23.1	26	52.7 +/- 23.8	0.2	N.S.
CuZn	39	0.1 +/- 0.1	19	0.1 +/- 0.1	0.4	N.S.
MgZn	38	3.2 +/- 2.7	19	3.5 +/- 2.5	0.7	N.S.
MnZn	39	0.02 +/- 0.02	19	0.03 +/- 0.05	0.3	N.S.
MgMn	51	139.2 +/- 88.5	26	135.1 +/- 85	0.8	N.S.
MgCu	51	37.1 +/- 70.5	26	32.3 +/- 27.3	0.7	N.S.

N: Number

S: Significant

N.S.: Non Significant

GD: Glutamate Dehydrogenase ID: Isocitrate Dehydrogenase

GOTL: Glutamate Oxaloacetate Transaminase in Leukocytes

GOTR: Glutamate Oxaloacetate Transaminase in Red cells

Cu: Copper Zn: Zinc Mg: Magnesium Mn: Manganese

Table (15): T-Test of treated patients and controls.

	Treated		Control		Significance	
	N	Mean	N	Mean	P	
Glutamate	25	6.9 +/- 5.7	18	8.3 +/- 10.7	0.5	N.S.
Isocitrate	25	6.2 +/- 4.4	18	7.1 +/- 6.8	0.6	N.S.
GOTL	25	7.5 +/- 7.4	18	7.6 +/- 6.2	0.9	N.S.
GOTR	25	0.6 +/- 0.6	18	0.7 +/- 0.7	0.8	N.S.
Cu	23	2.1 +/- 0.8	18	1.8 +/- 0.7	0.2	N.S.
Zn	16	18.1 +/- 13.5	15	13 +/- 8.1	0.2	N.S.
Mn	25	0.4 +/- 0.3	18	0.6 +/- 0.4	0.2	N.S.
Mg	22	40.2 +/- 18.3	18	50.6 +/- 23.2	0.1	N.S.
CuZn	16	0.17 +/- 0.13	15	0.3 +/- 0.3	0.1	N.S.
MgZn	15	3.1 +/- 1.9	15	6.8 +/- 7	0.06	N.S.
MnZn	16	0.03 +/- 0.02	15	0.09 +/- 0.08	0.01	S.
MgMn	22	117.1 +/- 79.2	18	131 +/- 115.9	0.6	N.S.
MgCu	22	21.7 +/- 15.3	18	32.6 +/- 23.5	0.08	N.S.

Table (16): T-Test of untreated patients and controls.

	Untreated		Control		Significance	
	N	Mean	N	Mean	P	
Glutamate	54	8.3 +/- 13.3	18	8.3 +/- 10.7	0.9	N.S.
Isocitrate	54	4.8 +/- 3.6	18	7.1 +/- 6.8	0.07	N.S.
GOTL	54	7.4 +/- 6	18	7.6 +/- 6.2	0.9	N.S.
GOTR	54	0.7 +/- 0.7	18	0.7 +/- 0.7	0.8	N.S.
Cu	54	1.8 +/- 0.8	18	1.8 +/- 0.7	0.9	N.S.
Zn	41	21.5 +/- 12.7	15	13 +/- 8.1	0.02	S.
Mn	54	0.4 +/- 0.3	18	0.6 +/- 0.4	0.1	N.S.
Mg	54	51.1 +/- 24.9	18	50.6 +/- 23.2	0.9	N.S.
CuZn	41	0.1 +/- 0.1	15	0.3 +/- 0.3	0.002	S.
MgZn	41	3.4 +/- 2.8	15	6.8 +/- 7	0.01	S.
MnZn	41	0.03 +/- 0.04	15	0.09 +/- 0.08	0.002	S.
MgMn	54	147.4 +/- 89.3	18	131 +/- 115.9	0.5	N.S.
MgCu	54	41.6 +/- 69.4	18	32.6 +/- 23.5	0.5	N.S.

Table (17): T-Test of treated and untreated patients.

	Treated		Untreated		Significance	
	N	Mean	N	Mean	P	
Glutamate	25	6.9 +/- 5.7	54	8.3 +/- 13.3	0.5	N.S.
Isocitrate	25	6.2 +/- 4.4	54	4.8 +/- 3.6	0.1	N.S.
GOTL	25	7.5 +/- 7.4	54	7.4 +/- 6	0.9	N.S.
GOTR	25	0.6 +/- 0.6	54	0.7 +/- 0.7	0.7	N.S.
Cu	23	2.1 +/- 0.8	54	1.8 +/- 0.8	0.1	N.S.
Zn	16	18.1 +/- 13.5	41	21.5 +/- 12.7	0.3	N.S.
Mn	25	0.4 +/- 0.3	54	0.4 +/- 0.3	0.6	N.S.
Mg	22	40.2 +/- 18.3	54	51.1 +/- 24.9	0.04	S.
CuZn	16	0.17 +/- 0.13	41	0.1 +/- 0.1	0.1	N.S.
MgZn	15	3.1 +/- 1.9	41	3.4 +/- 2.8	0.7	N.S.
MnZn	16	0.03 +/- 0.02	41	0.03 +/- 0.04	0.8	N.S.
MgMn	22	117.1 +/- 79.2	54	147.4 +/- 89.3	0.1	N.S.
MgCu	22	21.7 +/- 15.3	54	41.6 +/- 69.4	0.03	S.

Table (18): T-Test of focal epileptic patients and controls.

	Focal		Control		Significance	
	N	Mean	N	Mean	P	
Glutamate	18	5.75 +/- 3.5	18	8.3 +/- 10.7	0.3	N.S.
Isocitrate	18	5.6 +/- 3.7	18	7.1 +/- 6.8	0.4	N.S.
GOTL	18	7.7 +/- 7.1	18	7.6 +/- 6.2	0.9	N.S.
GOTR	18	0.68 +/- 0.6	18	0.7 +/- 0.7	0.9	N.S.
Cu	17	1.9 +/- 0.8	18	1.8 +/- 0.7	0.6	N.S.
Zn	15	25 +/- 13.5	15	13 +/- 8.1	0.007	S.
Mn	18	0.36 +/- 0.15	18	0.6 +/- 0.4	0.04	S.
Mg	16	49.1 +/- 27.1	18	50.6 +/- 23.2	0.8	N.S.
CuZn	15	0.11 +/- 0.12	15	0.3 +/- 0.3	0.04	S.
MgZn	14	3.5 +/- 3.9	15	6.8 +/- 7	0.1	N.S.
MnZn	15	0.02 +/- 0.01	15	0.09 +/- 0.08	0.006	S.
MgMn	16	149.9 +/- 94.6	18	131 +/- 115.9	0.6	N.S.
MgCu	16	30.9 +/- 31.3	18	32.6 +/- 23.5	0.8	N.S.

Table (19): T-Test of febrile epileptic patients and controls.

	Febrile		Control		Significance	
	N	Mean	N	Mean	P	
Glutamate	16	11 +/- 21.7	18	8.3 +/- 10.7	0.6	N.S.
Isocitrate	16	5.9 +/- 4.1	18	7.1 +/- 6.8	0.5	N.S.
GOTL	16	9.3 +/- 7.7	18	7.6 +/- 6.2	0.4	N.S.
GOTR	16	0.64 +/- 0.75	18	0.7 +/- 0.7	0.8	N.S.
Cu	16	1.7 +/- 0.8	18	1.8 +/- 0.7	0.6	N.S.
Zn	10	18.7 +/- 13.8	15	13 +/- 8.1	0.2	N.S.
Mn	16	0.33 +/- 0.14	18	0.6 +/- 0.4	0.03	S.
Mg	16	45.6 +/- 22.7	18	50.6 +/- 23.2	0.5	N.S.
CuZn	10	0.14 +/- 0.13	15	0.3 +/- 0.3	0.1	N.S.
MgZn	10	3.1 +/- 1.9	15	6.8 +/- 7	0.07	N.S.
MnZn	10	0.02 +/- 0.02	15	0.09 +/- 0.08	0.02	S.
MgMn	16	149.8 +/- 88.3	18	131 +/- 115.9	0.6	N.S.
MgCu	16	58.3 +/- 120.6	18	32.6 +/- 23.5	0.3	N.S.

Table (20): T-Test of generalized epileptic patients and controls.

	Generalized		Control		Significance	
	N	Mean	N	Mean	P	
Glutamate	45	7.5 +/- 7.7	18	8.3 +/- 10.7	0.8	N.S.
Isocitrate	45	4.7 +/- 3.9	18	7.1 +/- 6.8	0.1	N.S.
GOTL	45	6.5 +/- 5.7	18	7.6 +/- 6.2	0.6	N.S.
GOTR	45	0.7 +/- 0.7	18	0.7 +/- 0.7	0.6	N.S.
Cu	44	2.1 +/- 1.4	18	1.8 +/- 0.7	0.1	N.S.
Zn	32	13.4 +/- 13.3	15	13 +/- 8.1	0.6	N.S.
Mn	45	0.5 +/- 0.4	18	0.6 +/- 0.4	0.2	N.S.
Mg	44	48.4 +/- 22.8	18	50.6 +/- 23.2	0.9	N.S.
CuZn	32	0.12 +/- 0.07	15	0.3 +/- 0.3	0.01	S.
MgZn	32	3.3 +/- 2.1	15	6.8 +/- 7	0.03	S.
MnZn	32	0.04 +/- 0.04	15	0.09 +/- 0.08	0.02	S.
MgMn	44	129.2 +/- 84.4	18	131 +/- 115.9	0.7	N.S.
MgCu	44	29.8 +/- 24.3	18	32.6 +/- 23.5	0.8	N.S.

Table (21): T-Test of idiopathic epileptic patients and controls.

	Idiopathic		Control		Significance	
	N	Mean	N	Mean	P	
Glutamate	50	7.04 +/- 7.1	18	8.3 +/- 10.7	0.6	N.S.
Isocitrate	50	5.09 +/- 3.9	18	7.1 +/- 6.8	0.2	N.S.
GOTL	50	6.9 +/- 6.2	18	7.6 +/- 6.2	0.8	N.S.
GOTR	50	0.7 +/- 0.6	18	0.7 +/- 0.7	0.7	N.S.
Cu	48	2.1 +/- 1.3	18	1.8 +/- 0.7	0.1	N.S.
Zn	37	20.5 +/- 12.7	15	13 +/- 8.1	0.1	N.S.
Mn	50	0.4 +/- 0.3	18	0.6 +/- 0.4	0.04	S.
Mg	47	48.3 +/- 25	18	50.6 +/- 23.2	0.8	N.S.
CuZn	37	0.1 +/- 0.1	15	0.3 +/- 0.3	0.03	S.
MgZn	36	3.4 +/- 2.9	15	6.8 +/- 7	0.04	S.
MnZn	37	0.02 +/- 0.02	15	0.09 +/- 0.08	0.001	S.
MgMn	47	132.5 +/- 82.8	18	131 +/- 115.9	0.6	N.S.
MgCu	47	29.2 +/- 27.7	18	32.6 +/- 23.5	0.7	N.S.

Table (22): T-Test of symptomatic epileptic patients and controls.

	Symptomatic		Control		Significance	
	N	Mean	N	Mean	P	
Glutamate	14	7.08 +/- 5.6	18	8.3 +/- 10.7	0.7	N.S.
Isocitrate	14	4.8 +/- 3.7	18	7.1 +/- 6.8	0.3	N.S.
GOTL	14	6.8 +/- 5.8	18	7.6 +/- 6.2	0.8	N.S.
GOTR	14	0.7 +/- 0.8	18	0.7 +/- 0.7	0.6	N.S.
Cu	14	1.9 +/- 0.9	18	1.8 +/- 0.7	0.3	N.S.
Zn	11	21.1 +/- 13.4	15	13 +/- 8.1	0.1	N.S.
Mn	14	0.5 +/- 0.4	18	0.6 +/- 0.4	0.4	N.S.
Mg	14	49.8 +/- 19.7	18	50.6 +/- 23.2	0.9	N.S.
CuZn	11	0.13 +/- 0.08	15	0.3 +/- 0.3	0.04	S.
MgZn	11	3.3 +/- 2.04	15	6.8 +/- 7	0.1	N.S.
MnZn	11	0.04 +/- 0.06	15	0.09 +/- 0.08	0.2	N.S.
MgMn	14	142 +/- 102.4	18	131 +/- 115.9	0.5	N.S.
MgCu	14	30.5 +/- 17	18	32.6 +/- 23.5	0.9	N.S.

Table (19): T-Test of febrile epileptic patients and controls.

	Febrile		Control		Significance	
	N	Mean	N	Mean	P	
Glutamate	16	11.07 +/- 21.7	18	8.3 +/- 10.7	0.6	N.S.
Isocitrate	16	5.9 +/- 4.1	18	7.1 +/- 6.8	0.5	N.S.
GOTL	16	9.3 +/- 7.7	18	7.6 +/- 6.2	0.4	N.S.
GOTR	16	0.6 +/- 0.7	18	0.7 +/- 0.7	0.8	N.S.
Cu	16	1.7 +/- 0.8	18	1.8 +/- 0.7	0.6	N.S.
Zn	10	18.7 +/- 13.8	15	13 +/- 8.1	0.2	N.S.
Mn	16	0.3 +/- 0.1	18	0.6 +/- 0.4	0.03	S.
Mg	16	45.6 +/- 22.7	18	50.6 +/- 23.2	0.5	N.S.
CuZn	10	0.1 +/- 0.1	15	0.3 +/- 0.3	0.1	N.S.
MgZn	10	3.1 +/- 1.9	15	6.8 +/- 7	0.07	N.S.
MnZn	10	0.02 +/- 0.02	15	0.09 +/- 0.08	0.02	S.
MgMn	16	149.8 +/- 88.3	18	131 +/- 115.9	0.6	N.S.
MgCu	16	58.3 +/- 120.6	18	32.6 +/- 23.5	0.3	N.S.

Table (23): Correlations between variables of controls.

	GD	ID	GOTL	GOTR	Cu	Zn	Mn	Mg	CuZn	MgZn	MnZn	MgMn	MgCu
GD	1	0.28	0.01	0.2	0.21	0.01	0.66*	0.18	0.09	0.22	0.41	0.1	0.15
ID	0.28	1	0.34	0.48	0.24	0.29	0.06	0.07	0.37	0.39	0.26	0.22	0.39
GOTL	0.01	0.34	1	0.12	0.21	0.08	0.38	0.15	0.14	0.03	0.12	0.14	0.03
GOTR	0.2	0.48	0.12	1	0.01	0.28	0.24	0.23	0.09	0.08	0.32	0.19	0.23
Cu	0.21	0.24	0.21	0.01	1	0.26	0.47	0.13	0.31	0.13	0.31	0.44	0.66*
Zn	0.01	0.29	0.08	0.28	0.26	1	0.16	0.14	0.78**	0.72*	0.75**	0.21	0.2
Mn	0.66*	0.06	0.38	0.24	0.47	0.16	1	0.21	0.06	0.16	0.55	0.66*	0.32
Mg	0.18	0.07	0.15	0.23	0.13	0.14	0.21	1	0.24	0.16	0.35	0.59	0.7*
CuZn	0.09	0.37	0.14	0.09	0.31	0.78*	0.06	0.24	1	0.81**	0.68*	0.19	0.31
MgZn	0.22	0.39	0.03	0.08	0.13	0.72*	0.16	0.16	0.81**	1	0.56	0.05	0.05
MnZn	0.41	0.26	0.12	0.32	0.31	0.75*	0.55	0.35	0.68*	0.56	1	0.5	0.35
MgMn	0.1	0.22	0.14	0.19	0.44	0.21	0.66*	0.59	0.19	0.05	0.5	1	0.58
MgCu	0.15	0.39	0.03	0.23	0.66*	0.2	0.32	0.7*	0.31	0.05	0.35	0.58	1

* = Significant

** = Highly significant

Table (24): Correlations between variables of treated patients.

GD	ID	GOTL	GOTR	Cu	Zn	Mn	Mg	CuZn	MgZn	MnZn	MgMn	MgCu
GD	1	0.36	0.2	0.31	0.18	0.2	0.18	0.15	0.24	0.12	0.21	0.16
ID	0.36	1	0.76**	0.06	0.05	0.3	0.37	0.15	0.25	0.12	0.08	0.19
GOTL	0.2	0.76*	1	0.13	0.09	0.4	0.32	0.03	0.08	0.11	0.09	0.24
GOTR	0.31	0.06	0.13	1	0.23	0.3	0.04	0.16	0.05	0.07	0.05	0.2
Cu	0.18	0.05	0.09	0.23	1	0.3	0.14	0.1	0.59*	0.37	0.33	0.17
Zn	0.16	0.27	0.37	0.25	0.31	1	0.27	0.58	0.65*	0.57	0.55	0.2
Mn	0.18	0.37	0.32	0.04	0.14	0.3	1	0.2	0.07	0.03	0.5	0.66*
Mg	0.15	0.15	0.03	0.16	0.1	0.6	0.2	1	0.19	0.12	0.14	0.46
CuZn	0.24	0.25	0.08	0.05	0.59*	0.65*	0.07	0.19	1	0.84**	0.66*	0.19
MgZn	0.12	0.12	0.11	0.07	0.37	0.6	0.03	0.12	0.84**	1	0.65*	0.04
MnZn	0.21	0.08	0.09	0.05	0.33	0.6	0.5	0.14	0.66*	0.65*	1	0.58
MgMn	0.16	0.19	0.24	0.2	0.17	0.2	0.66*	0.46	0.19	0.04	0.58	1
MgCu	0.29	0.1	0.01	0.05	0.5	0.65*	0.1	0.78*	0.49	0.08	0.24	0.43
												1

* = Significant

** = Highly significant

Table (25): Correlations between variables of untreated patients.

	GD	ID	GOTL	GOTR	Cu	Zn	Mn	Mg	CuZn	MgZn	MnZn	MgMn	MgCu
GD	1	0.46*	0.27	0.09	0.1	0.1	0.13	0.31	0.01	0.21	0.07	0.55**	0.03
ID	0.46*	1	0.38*	0.03	0.09	0.2	0.19	0.23	0.05	0.18	0.18	0.4*	0.08
GOTL	0.27	0.38*	1	0.02	0.06	0	0.09	0.06	0.16	0.12	0.05	0.09	0.1
GOTR	0.09	0.03	0.02	1	0.15	0	0.18	0.1	0.08	0.07	0.22	0.05	0.005
Cu	0.1	0.09	0.06	0.15	1	0.3	0.06	0.02	0.22	0.09	0.15	0.09	0.38*
Zn	0.13	0.23	0.04	0.04	0.28	1	0.21	0.08	0.63**	0.59**	0.5**	0.03	0.01
Mg	0.31	0.23	0.06	0.1	0.02	0.1	0.26	1	0.01	0.49**	0.13	0.61**	0.49**
Mn	0.13	0.19	0.09	0.18	0.06	0.2	1	0.26	0	0.16	0.88**	0.37*	0.06
CuZn	0.01	0.05	0.16	0.08	0.22	0.63*	0	0.01	1	0.75**	0.35	0.1	0.2
MgZn	0.21	0.18	0.12	0.07	0.09	0.59*	0.16	0.49*	0.75**	1	0.39*	0.45*	0.14
MnZn	0.07	0.18	0.05	0.22	0.15	0.5**	0.88*	0.13	0.35	0.39*	1	0.3	0.001
MgMn	0.55*	0.4*	0.09	0.05	0.09	0	0.37*	0.61*	0.1	0.45*	0.3	1	0.26
MgCu	0.03	0.08	0.1	0.005	0.38*	0	0.06	0.49*	0.2	0.14	0	0.26	1

* = Significant

** = Highly significant