AIM OF THE WORK

To assess the effect of hyperbaric oxygen on cerebral palsy children.

SUBJECTS

The study included 75 cerebral palsy patients attending the outpatient clinic of Physical Medicine, Rheumatology and Rehabilitation Elshatby University Hospital. They were assessed and divided randomly into two groups, group I (50 patients) referred to Naval Hyperbaric Medical Institute- Military Medical Institute- to receive HBOT sessions, in addition to their conventional rehabilitation program. Group I was divided into two groups: (group I a) less than five years and (group I b) more than five years. And group II (25 patients) received their conventional rehabilitation program only in the form of sessions of physical therapy three times per week for the treatment period (three months). The two groups were advised to continue their usual medical regimen.

Inclusion criteria:

Cerebral palsy with a history of perinatal hypoxia or traumatic brain injury.

Exclusion criteria:

1. Children who had one recent episode (within 1 month) of acute otitis.
2. Children with chronic otitis (3 episodes or more) within the previous year.
3. Children with any condition that put them at risk of complications of HBOT as uncontrolled asthma or active convulsions.
4. Children with behavioral problems.
5. Children who were treated with botulinum toxin or orthopedic surgery within the past 6 month or dorsal rhizotomy within the past 2 years.
6. Previous exposure to HBOT.

METHODS

The following data were determined for each patient:

I. **Demographic data**: (name- age- sex)
II. **Past history**: as epilepsy, asthma, etc.
III. **Drug history:** as anticonvulsants, muscle relaxants and multivitamins.
IV. **Clinical examination:** stressing on:

- Topographic involvement (hemiplegic, diplegic and quadriplegic)

V. **Associated deficits**: as behavioral problems, visual problems, drooling cognitive problems and sleep disturbance.

VI. **Written consent was taken from all the patients.**

Treatment protocol

The studied patients were classified into two groups:

Group I: 50 patients received 40 HBOT sessions, in addition to their conventional rehabilitation program.

(Hyperbaric oxygen therapy was performed in multiplace hyperbaric chamber from ETC Company Paramed 6-2-6 built in 2005 with 240 cm diameter and made in USA)

- Patients was compressed and decompressed at 2-3 psi/minute (pounds per square inch) with air, the rate depending on patient comfort and tolerance.
- Depth of pressurization is 5 meters depth which equals 1.5 Absolute Atmosphere ATA.
- Total oxygen breathing time is 60 minutes with one 5 minutes air break after 30 minutes oxygen breathing.
- Treatment was once/day, 5 days/week.

Group II: 25 patients received the conventional rehabilitation program day after day all through the treatment period (three months). The program is individualized depending on the child's demand, in the form of exercises (range of motion, stretching and strengthening), standing and walking training and hydrotherapy.

Assessment of group I was done before starting the sessions, after 20, 40 sessions and one month after stopping the sessions.

Assessment of group II was done before starting the program and repeated at the end (after three months).

For each of the following:

1. Spasticity by Modified Ashworth's Scale.(MAS) (Appendix I). [77]
2. Gross Motor Functional Classification System (GMFCS) (Appendix II).[78, 79]

3. The Manual Ability Classification System (MACS) to assess the hand functions (Appendix III). [80]
4. Sensory Profile Caregiver Questionnaire. (Appendix IV). [81]
5. Global parent's assessment about their children (parent's own words).

Statistical analysis of the data

Data were fed to the computer and analyzed using IBM SPSS software package version 20.0. Qualitative data were described using number and percent. Quantitative data were described using range (minimum and maximum), mean, standard deviation and median. Comparison between different groups regarding categorical variables was tested using Chi-square test. When more than 20% of the cells have expected count less than 5, correction for chi-square was conducted using Fisher's Exact test or Monte Carlo correction. The distributions of quantitative variables were tested for normality. If it reveals normal data distribution, parametric tests was applied. If the data were abnormally distributed, non-parametric tests were used. For normally distributed data, comparison between two independent populations were done using independent t-test, also paired t-test is used to analyse two paired data. For abnormally distributed data, comparison between two independent populations were done using Mann Whitney test. To compare between the different periods Wilcoxon signed ranks test was applied. Significance of the obtained results was judged at the 5% level. [82, 83]

RESULTS

This study included 75 cerebral palsy patients (42 males and 33femals) divided into two groups, (group I) 50 patients (29 males and 21 females) received HBOT sessions, in addition to their conventional rehabilitation program. And a control group (group II) 25 patients (13 males and 12 females) received the conventional rehabilitation program only.

I) Demographic findings:

1) Age:

The age range was between 1.5 - 11 years among group I with a mean age of 4.85 ± 2.56 years and 1.5-12 among group II with a mean age of 4.84 ± 3.04 years.

2) Urban rural ratio:

Regarding the residence 18% of the group I were from urban while 82% were from rural, and 20% of the group II were from urban and 80% were from rural origin. There was no statistically significant difference between both groups regarding the age and the residence as shown in table (1).

Table (1): The studied groups according to their demographic data.

	Group I (n = 50)		Group II (n = 25)		Test of sig.	P
	No.	%	No.	%		
Gender						
Male	29	58.0	13	52.0	χ^2= 0.244	0.622
Female	21	42.0	12	48.0		
Residence						
Urban	9	18.0	5	20.0	χ^2= 0.044	^{FE}p=1.000
Rural	41	82.0	20	80.0		
Age						
≤5	29	58.0	16	64.0	χ^2= 0.250	0.617
>5	21	42.0	9	36.0		
Min. – Max.	1.50 – 11.0		1.50 – 12.0			
Mean ± SD.	4.85 ± 2.56		4.84 ± 3.04		Z= 0.316	0.752
Median	4.50		4.0			

χ^2: Chi square test
FE: Fisher Exact test
Z: Z for Mann Whitney test

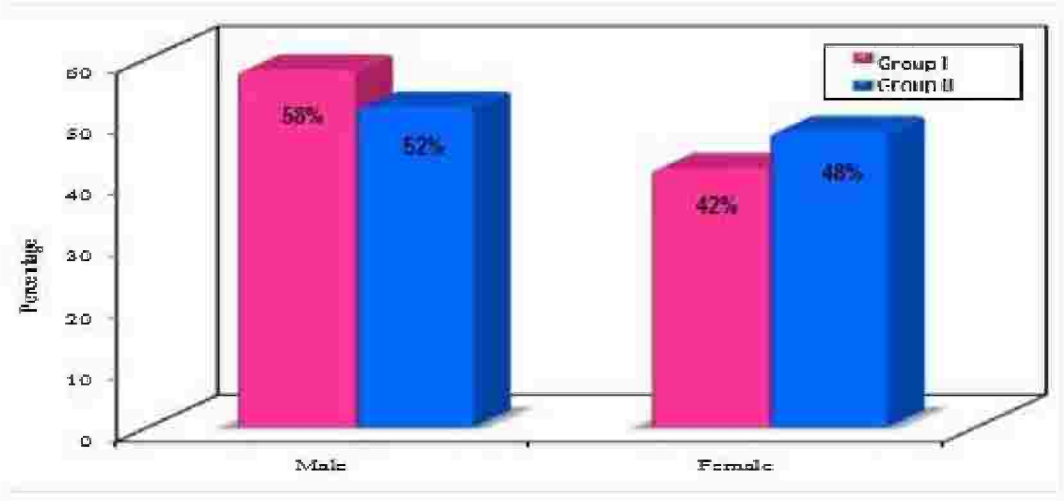
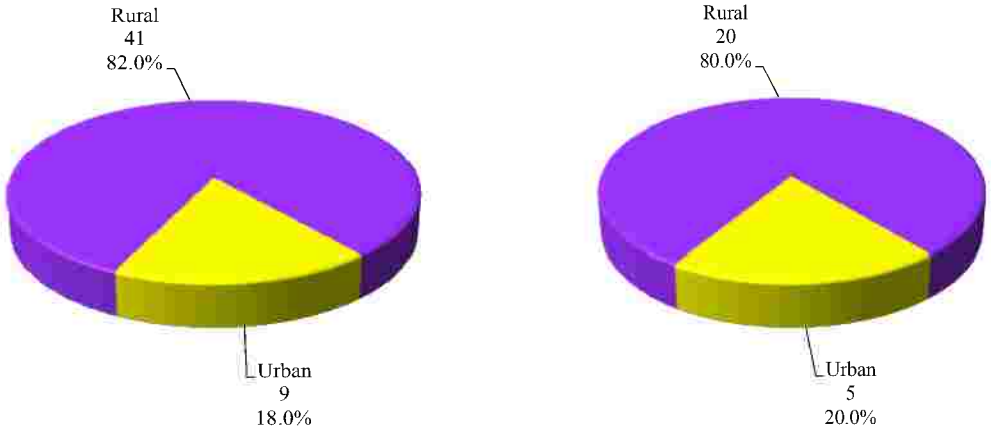
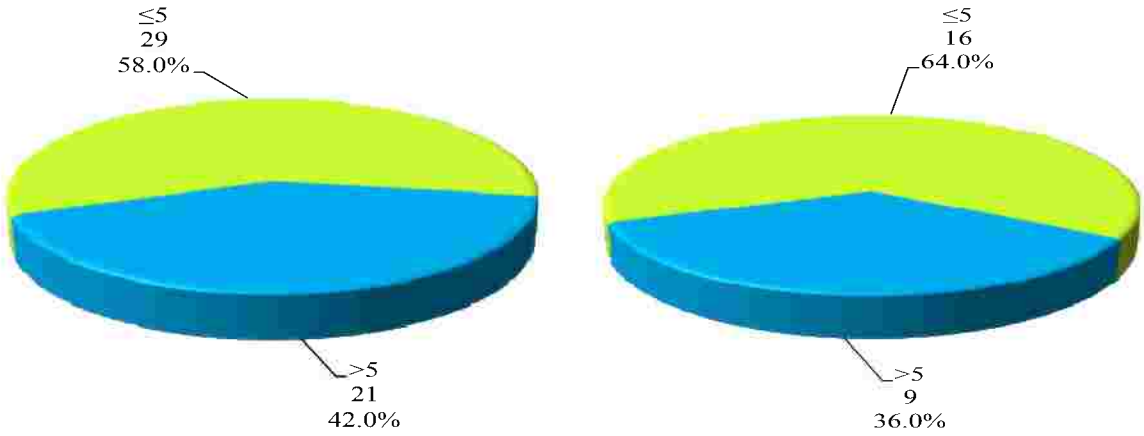


Figure (1): Male to female ratio among both groups.



(a) Urban rural ratio among group I (b)Urban rural ratio among group II

Figure (2): Urban rural ratio among both groups.



(a) (group I) (b) (group II)

Figure (3): percentage of patients up to and more than 5 years

Table (2): Comparison between both groups according to perinatal history.

	Group I (n = 50)		Group II (n = 25)		χ^2	P
	No.	%	No.	%		
Perinatal history						
Normal vaginal delivery	34	68.0	15	60.0	0.471	0.493
Cesarean section	17	34.0	10	40.0	0.260	0.610
Obstructed labour	13	26.0	8	32.0	0.298	0.585
Preterm	8	16.0	5	20.0	0.186	0.750

χ^2: Chi square test

Regarding perinatal history 68% of group I and 60% of group II had normal vaginal delivery, while 32% and 40% of group I and group II respectively had Cesarean section, 26% of group I and 32% of group II suffered from obstructed labor, 16% of group I and 20% of group II were delivered before the date. There was no statistical significant difference between the both groups as shown in the table (2).

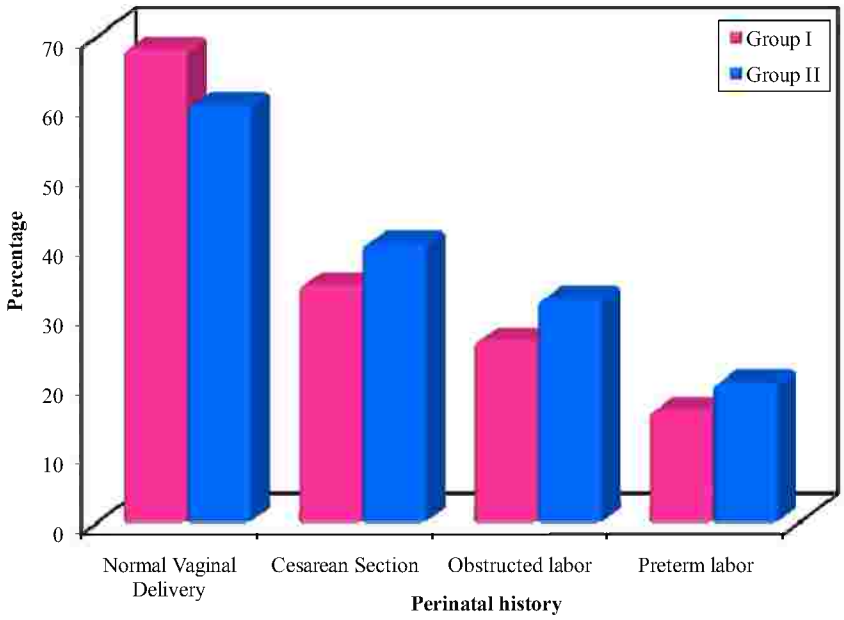


Figure (4): Perinatal history of both groups.

II) Clinical data:

Table (3): Postnatal history of both groups.

	Group I (n = 50)		Group II (n = 25)		χ^2	P
	No.	%	No.	%		
Postnatal						
perinatal hypoxia	46	92.0	23	92.0	0.276	0.600
Prolonged Postnatal jaundice	7	14.0	4	16.0	0.053	$^{FE}p=1.000$
Admission to neonatal intensive care unit	22	44.0	12	48.0	0.108	0.743

χ^2: Chi square test
FE: Fisher Exact test

Of both groups 92% suffered from postnatal hypoxia, while 14% of group I and 16% of group II suffered from prolonged neonatal jaundice and 44% and 48% from group I and group II respectively were admitted to neonatal intensive care unit, There was no statistical significant difference between the both groups as shown in the table (3).

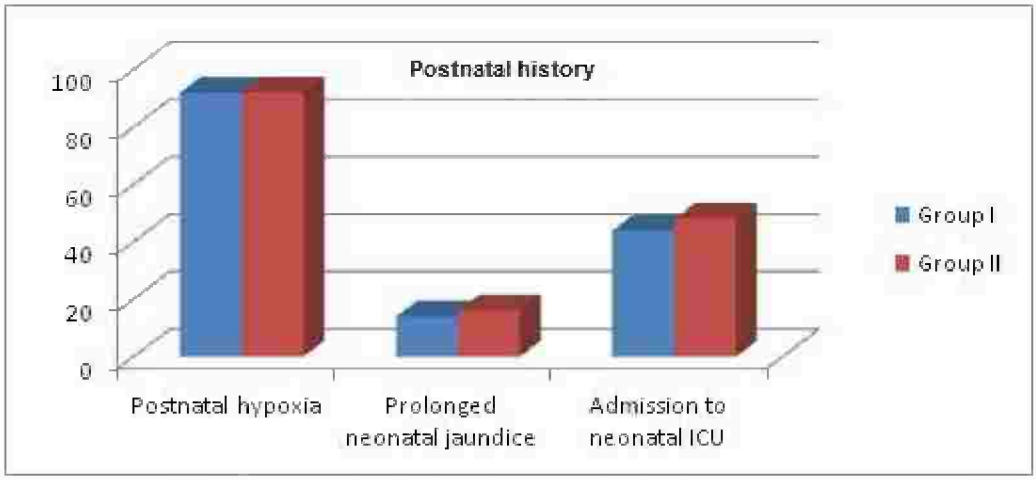


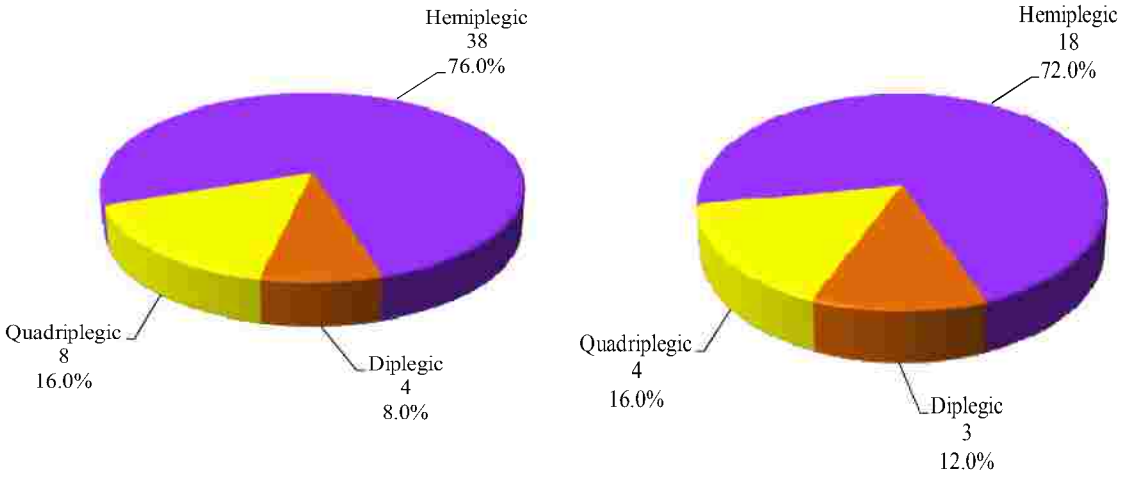
Figure (5): Postnatal history of both groups.

Table (4): Topographic pattern of both groups.

	Group I (n = 50)		Group II (n = 25)		χ^2	P
	No.	%	No.	%		
Type of CP						
Hemiplegic	38	76.0	18	72.0		
Diplegic	4	8.0	3	12.0	0.514	$^{MC}p=0.918$
Quadriplegic	8	16.0	4	16.0		

χ^2: Chi square test
MC: Monte Carlo test

Table (4) and figure (6) show that the most common type of CP among group I and group II is the hemiplegic type 76% and 72% respectively, followed by the quadriplegic type 16% for both and the least is the diplegic type 8% among group I and 12% among group II. And also shows that there was no statistical significant difference between both groups.



(a) Topographic pattern among group I (b) Topographic pattern among group II

Figure (6): Topographic pattern of both groups.

Table (5): Associated problems in both groups.

	Group I (n = 50)		Group II (n = 25)		χ^2	P
	No.	%	No.	%		
Associated problems						
Controlled epilepsy	32	64.0	17	68.0	**0.118**	0.731
Controled Asthma	7	14.0	5	20.0	0.446	$^{FE}p=0.519$

χ^2: Chi square test
FE: Fisher Exact test

Table (5) demonstrates the percentage of associated problems among the studied groups and there was no statistical significant difference between group I and group II.

Table (6): Drug history of both groups.

	Group I (n = 50)		Group II (n = 25)		χ^2	P
	No.	%	No.	%		
Drug History						
Anti-convulsants	32	64.0	17	68.0	0.118	0.731
Muscle relaxant	46	92.0	22	88.0	0.315	$^{FE}p=0.680$
Vitamins	18	36.0	10	40.0	0.114	0.736

χ^2: Chi square test
FE: Fisher Exact test

Table (6) represents the drug history of the group I and group II, there was no statistical significant difference between them.

Table (7): Associated deficits in both groups:

	Group I (n = 50)		Group II (n = 25)		χ^2	P
	No.	%	No.	%		
Associated deficit						
Visual problems	9	18.0	3	12.0	0.446	^{FE}p=0.740
Auditory problems	5	10.0	2	8.0	0.079	^{FE}p=1.000
Cognitive impairments	24	48.0	13	52.0	0.107	0.744
Drooling	22	44.0	10	40.0	0.109	0.741
Sleep Disturbances	16	32.0	6	24.0	0.515	0.473

χ^2: Chi square test
FE: Fisher Exact test

Table and figure (7) show the number and the percentage of the associated deficits among both groups cognitive impairments, drooling and sleep disturbances were the most common deficits, there was no statistical significant difference between both groups.

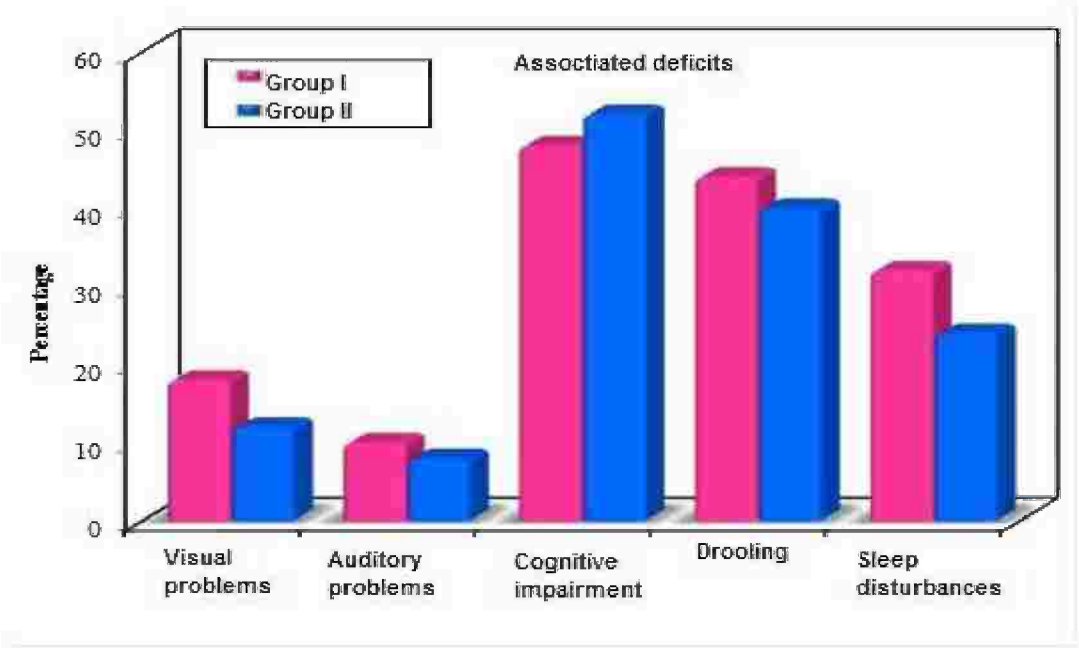


Figure (7): Associated deficits in both groups.

Table (8): Clinical findings in both groups.

	Cases (n = 50)		Control (n = 25)		χ^2	P
	No.	%	No.	%		
Clinical findings						
Increased tone	50	100.0	25	100.0	-	-
Exaggerated reflexes	46	92.0	22	88.0	0.315	$^{FE}p=0.680$
Contractures	11	22.0	4	16.0	0.375	0.540
-psoas	2		1			
-hamstring	2		-			
-gastrocnemius	3		2			
-biceps and pronator	2		1			
-forearm flexors	2		-			

χ^2: Chi square test
FE: Fisher Exact test

Table and figure (8) show that 100% of the group I and the group II had increased tone and 92% and 88% of group I and group II respectively had exaggerated reflexes while 22% of group I and 16% of group II suffered from contracture (at least around one joint). And there was no statistical significant difference between both groups.

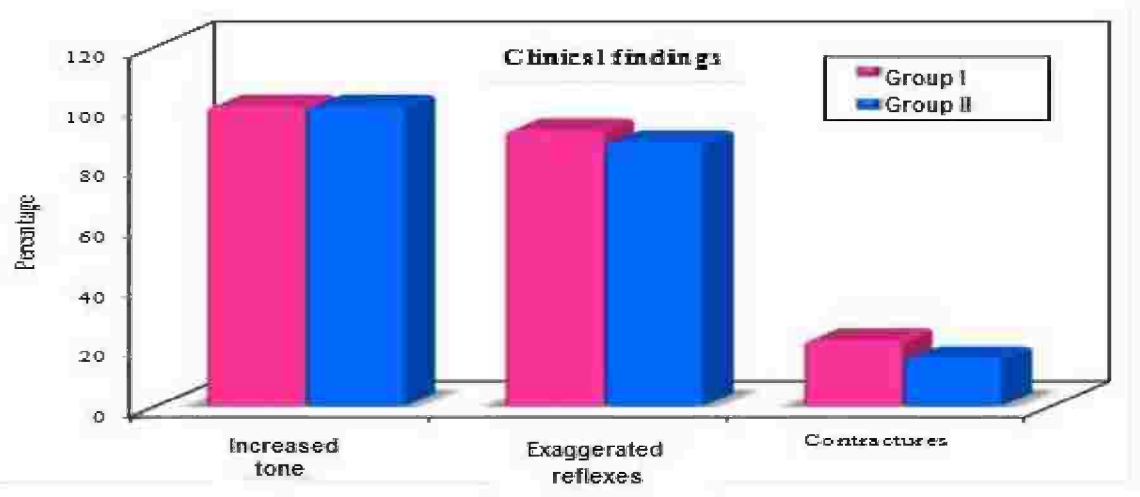


Figure (8): Clinical findings in both groups.

III) Assessment tools:

Table (9): Comparison between the studied groups according to the assessment scales before and after the treatment period.

		Child assessment		Z	p
		Group I (no=50)	Group II (no=25)		
MAS	**Before treatment period**				
	Min. – Max.	2.0 – 5.0	2.0 – 5.0		
	Mean ± SD.	3.44 ± 0.99	3.40 ± 0.91	0.176	0.860
	Median	3.0	3.0		
	After treatment period				
	Min. – Max.	1.0 – 4.0	2.0 – 5.0		
	Mean ± SD.	2.34 ± 1.04	3.16 ± 0.85	3.138*	0.002*
	Median	2.0	3.0		
GMFCS	**Before treatment period**				
	Min. – Max.	2.0 – 5.0	2.0 – 5.0		
	Mean ± SD.	3.20 ± 0.99	3.64 ± 0.86	1.926	0.054
	Median	3.0	4.0		
	After treatment period				
	Min. – Max.	1.0 – 5.0	2.0 – 5.0		
	Mean ± SD.	2.68 ± 1.06	3.32 ± 0.90	2.701*	0.007*
	Median	2.0	3.0		
MACS	**Before treatment period**				
	Min. – Max.	1.0 – 4.0	1.0 – 4.0		
	Mean ± SD.	2.62 ± 0.83	2.64 ± 0.76	0.048	0.962
	Median	3.0	3.0		
	After treatment period				
	Min. – Max.	1.0 – 4.0	1.0 – 4.0		
	Mean ± SD.	2.04 ± 0.78	2.44 ± 0.82	2.069*	0.039*
	Median	2.0	2.0		
Sensory profile caregiver questionnaire	**Before treatment period**				
	Min. – Max.	165.0-215.0	165.0-216.0		
	Mean ± SD.	188.98±13.46	188.08±12.44		0.388
	Median	190.0	188.0		
	After treatment period				
	Min. – Max.	164.0-210.0	160.0-210.0		
	Mean ± SD.	187.87±13.40	187.06±12.02		0.387
	Median	189.0	188.0		

Z: Z for Mann Whitney test *: Statistically significant at $p \leq 0.05$

p: p value for Paired t-test for comparing between Sensory profile caregiver questionnaire before and after treatment

Table (9) shows that there was no statistical difference between the both groups regarding MAS, GMFCS , MACS and sensory profile caregiver questionnaire in before treatment period assessment, while statistical significant difference was found regarding MAS, GMFCS and MACS in after treatment period assessment (three months).

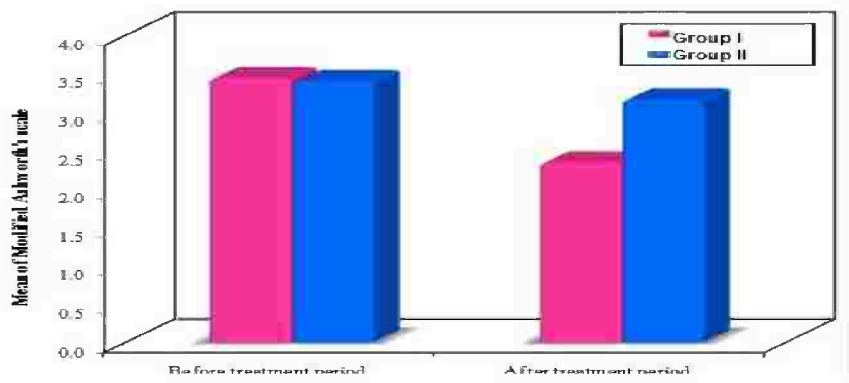


Figure (9): Comparison between MAS before and after treatment period among both groups.

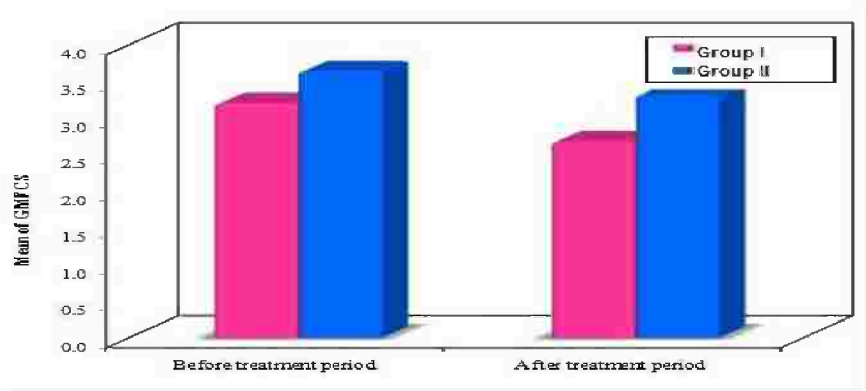


Figure (10): Comparison between GMFCS before and after treatment period among both groups.

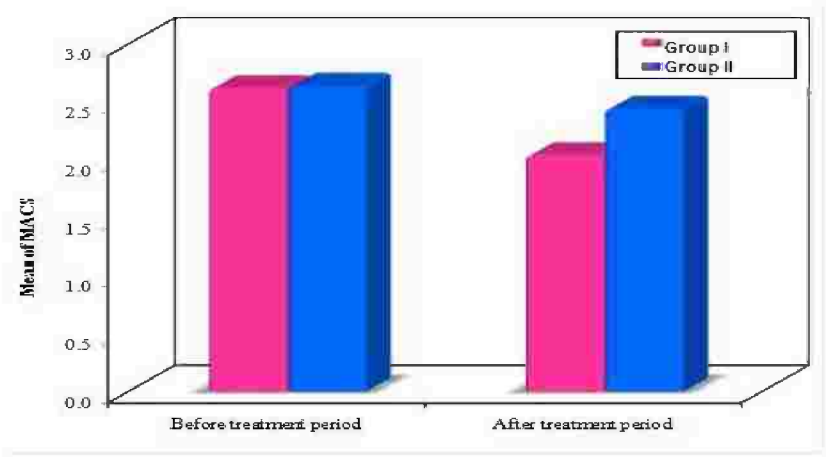


Figure (11): Comparison between MACS before and after treatment period among both groups.

Table (10): Comparison between before and after treatment according to the assessment scales in group II.

	Child assessment	
	Before rehabilitation program	**After rehabilitation program**
Modified Ashworth's scale		
Min. – Max.	2.0 – 5.0	2.0 – 5.0
Mean ± SD.	3.40 ± 0.91	3.16 ± 0.85
Median	3.0	3.0
p	0.014*	
GMFCS		
Min. – Max.	2.0 – 5.0	2.0 – 5.0
Mean ± SD.	3.64 ± 0.86	3.32 ± 0.90
Median	4.0	3.0
p	0.059	
MACS		
Min. – Max.	1.0 – 4.0	1.0 – 4.0
Mean ± SD.	2.64 ± 0.76	2.44 ± 0.82
Median	3.0	2.0
p	0.166	

p: p value for Wilcoxon signed ranks test for comparing between Before sessions with After 40 sessions
*: Statistically significant at $p \leq 0.05$

Table (10) shows that the mean value of MAS decreased significantly after the rehabilitation program, while there was no statistical significant difference regarding GMFCS and MACS after the treatment period.

Table (11): Comparison between before and after treatment according to Child assessment in group I.

	Child assessment			
	Before sessions	**After 20 sessions**	**After 40 sessions**	**1 month later**
Modified Ashworth's scale				
Min. – Max.	2.0 – 5.0	0.0 – 5.0	1.0 – 4.0	0.0 – 5.0
Mean ± SD.	3.44 ± 0.99	2.78 ± 1.09	2.34 ± 1.04	2.26 ± 1.21
Median	3.0	3.0	2.0	2.0
p_1		<0.001*	<0.001*	<0.001*
p_2			<0.001*	<0.001*
p_3				0.285
GMFCS				
Min. – Max.	2.0 – 5.0	2.0 – 5.0	1.0 – 5.0	1.0 – 5.0
Mean ± SD.	3.20 ± 0.99	3.16 ± 0.96	2.68 ± 1.06	2.60 ± 1.09
Median	3.0	3.0	2.0	2.0
p_1		0.157	<0.001*	<0.001*
p_2			<0.001*	<0.001*
p_3				0.046*
MACS				
Min. – Max.	1.0 – 4.0	1.0 – 4.0	1.0 – 4.0	1.0 – 4.0
Mean ± SD.	2.62 ± 0.83	2.52 ± 0.91	2.04 ± 0.78	2.0 ± 0.76
Median	3.0	3.0	2.0	2.0
p_1		0.025*	<0.001*	<0.001*
p_2			<0.001*	<0.001*
p_3				0.317

p_1: p value for Wilcoxon signed ranks test for comparing between Before sessions with each other periods
p_2: p value for Wilcoxon signed ranks test for comparing between After 20 sessions with After 40 sessions and 1 month later
p_3: p value for Wilcoxon signed ranks test for comparing between After 40 sessions and 1 month later
*: Statistically significant at $p \leq 0.05$

Table (11) shows that there was statistical significant difference as regarding MAS between before sessions and after 20 sessions assessment, also it shows statistical significant difference between after 20 sessions and after 40 sessions assessment, while there was no statistical significant difference between after 40 sessions and one month after stoppage of the sessions.

As regarding GMFCS the table shows that there was no statistical significant difference between before sessions assessment and after 20 sessions, but there was statistical significant difference between after 20 sessions and after 40 sessions, also between 40 sessions and one month later there was a statistical significant difference.

MACS shows statistical significant difference between before sessions assessment and after 20 sessions assessment and also between after 20 and 40 session but there was no statistical significance between after 40 sessions assessment and after one month.

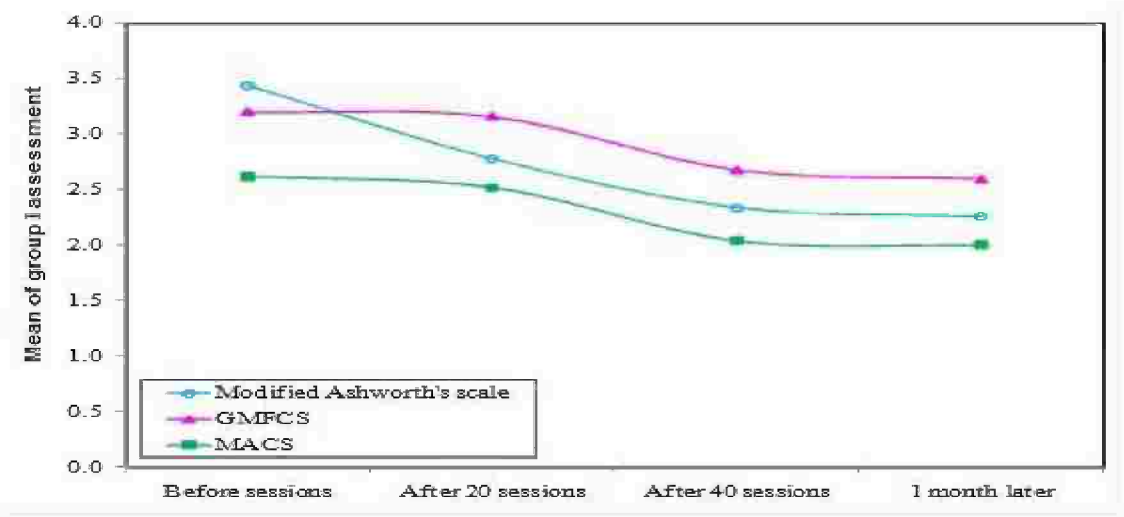


Figure (12): Comparison between before and after treatment period assessment in group (I).

Table (12): Before and after treatment according to the assessment scales in group (I a).

	Child assessment			
	Before sessions	**After 20 sessions**	**After 40 sessions**	**1 month later**
Modified Ashworth's scale				
Min. – Max.	2.0 - 5.0	0.0 – 5.0	1.0 – 4.0	0.0 – 5.0
Mean ± SD.	3.48 ± 1.02	2.66 ± 1.14	2.10 ± 1.05	2.07 ± 1.25
Median	3.0	3.0	2.0	2.0
p_1		<0.001*	<0.001*	<0.001*
p_2			<0.001*	<0.001*
p_3				0.705
GMFCS				
Min. – Max.	2.0 – 5.0	2.0 – 5.0	1.0 – 5.0	1.0 – 5.0
Mean ± SD.	3.28 ± 0.96	3.21 ± 0.90	2.59 ± 1.02	2.45 ± 1.06
Median	3.0	3.0	2.0	2.0
p_1		0.157	<0.001*	<0.001*
p_2			<0.001*	<0.001*
p_3				0.046*
MACS				
Min. – Max.	1.0 – 4.0	1.0 – 4.0	1.0 – 4.0	1.0 – 4.0
Mean ± SD.	2.45 ± 0.87	2.31 ± 0.97	1.90 ± 0.82	1.90 ± 0.82
Median	2.0	2.0	2.0	2.0
p_1		0.046*	<0.001*	<0.001*
p_2			0.001*	0.003*
p_3				1.000

p_1: p value for Wilcoxon signed ranks test for comparing between Before sessions with each other periods
p_2: p value for Wilcoxon signed ranks test for comparing between After 20 sessions with After 40 sessions and 1 month later
p_3: p value for Wilcoxon signed ranks test for comparing between After 40 sessions and 1 month later
*: Statistically significant at $p \leq 0.05$

Table (12) shows the statistical analysis for group (I a) there was statistical significance as regarding MAS comparing between before sessions and after 20 sessions assessment, also it shows statistical significant difference between after 20 sessions and after 40 sessions assessment while there was no statistical significant difference between after 40 sessions and one month after stoppage of the sessions.

As regarding GMFCS the table shows that there was no statistical significant difference between before sessions assessment and after 20 sessions but there was statistical significant difference between after 20 sessions and after 40 sessions also between 40 sessions and one month later there was statistical significant difference.

MACS shows statistical significant difference between before sessions assessment and after 20 sessions assessment also there was statistical significant difference between after 20 and 40 session but there was no statistical significant difference between after 40 sessions assessment and after one month.

Table (13): Before and after treatment according to the assessment scales in group (I b).

	Child assessment			
	Before sessions	**After 20 sessions**	**After 40 sessions**	**1 month later**
Modified Ashworth's scale				
Min. – Max.	2.0 – 5.0	1.0 – 5.0	1.0 – 4.0	1.0 – 5.0
Mean ± SD.	3.38 ± 0.97	2.95 ± 1.02	2.67 ± 0.97	2.52 ± 1.12
Median	4.0	3.0	3.0	2.0
p_1		0.003*	0.001*	0.001*
p_2			0.014*	0.007*
p_3				0.257
GMFCS				
Min. – Max.	2.0 – 5.0	2.0 – 5.0	1.0 – 5.0	1.0 – 5.0
Mean ± SD.	3.10 ± 1.04	3.10 ± 1.04	2.81 ± 1.12	2.81 ± 1.12
Median	3.0	3.0	3.0	3.0
p_1		1.000	0.014*	0.014*
p_2			0.014*	0.014*
p_3				1.000
MACS				
Min. – Max.	1.0 – 4.0	1.0 – 4.0	1.0 – 4.0	1.0 – 3.0
Mean ± SD.	2.86 ± 0.73	2.81 ± 0.75	2.24 ± 0.70	2.14 ± 0.65
Median	3.0	3.0	2.0	2.0
p_1		0.317	<0.001*	<0.001*
p_2			0.001*	<0.001*
p_3				0.157

p_1: p value for Wilcoxon signed ranks test for comparing between Before sessions with each other periods
p_2: p value for Wilcoxon signed ranks test for comparing between After 20 sessions with After 40 sessions and 1 month later
p_3: p value for Wilcoxon signed ranks test for comparing between After 40 sessions and 1 month later
*: Statistically significant at $p \leq 0.05$

Table (13) the statistical analysis of group (I b) shows that there was statistical significant difference regarding MAS comparing between before sessions and after 20 sessions assessment, also it shows statistical significant difference between after 20 sessions and after 40 sessions assessment while there was no statistical significant difference between after 40 sessions and one month after stoppage of the sessions.

As regarding GMFCS the table shows that there was no statistical significant difference between before sessions assessment and after 20 sessions but there was statistical significant difference between after 20 sessions and after 40 sessions and between 40 sessions and one month later there was no statistical significant difference.

MACS shows no statistical significant difference between before sessions assessment and after 20 sessions assessment but there was a statistical significance between after 20 and 40 session and no statistical significant difference was found between after 40 sessions assessment and after one month.

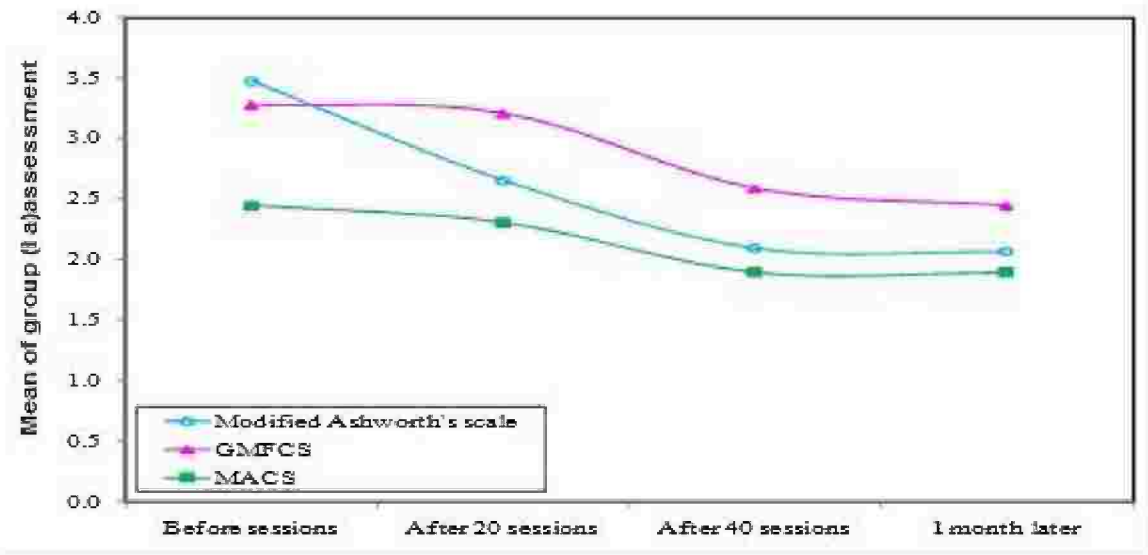


Figure (13): Before and after treatment period assessment in group (I a).

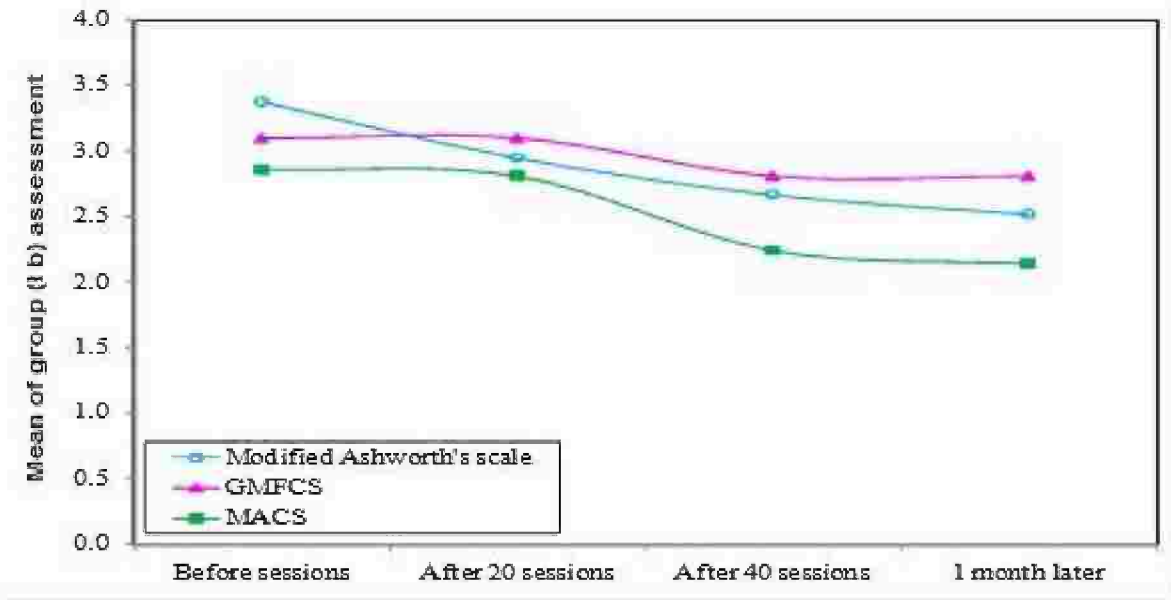


Figure (14): Before and after assessment in group (I b).

Table (14): Comparison between group (I a) and group (I b) according to MAS.

Modified Ashworth's scale	Age		Z	p
	Group I a (n = 29)	Group I b (21)		
Before sessions				
Min. – Max.	2.0 - 5.0	2.0 – 5.0		
Mean ± SD.	3.48 ± 1.02	3.38 ± 0.97	0.246	0.806
Median	3.0	4.0		
After 20 sessions				
Min. – Max.	0.0 – 5.0	1.0 – 5.0		
Mean ± SD.	2.66 ± 1.14	2.95 ± 1.02	0.837	0.402
Median	3.0	3.0		
After 40 sessions				
Min. – Max.	1.0 – 4.0	1.0 – 4.0		
Mean ± SD.	2.10 ± 1.05	2.67 ± 0.97	1.953	0.051
Median	2.0	3.0		
1 month later				
Min. – Max.	0.0 – 5.0	1.0 – 5.0		
Mean ± SD.	2.07 ± 1.25	2.52 ± 1.12	1.348	0.178
Median	2.0	2.0		

Z: Z for Mann Whitney test *: Statistically significant at $p \leq 0.05$

Table (14) and figure (15) show that spasticity decreased among group (I a) more than group (I b) but not reaching the statistical significance.

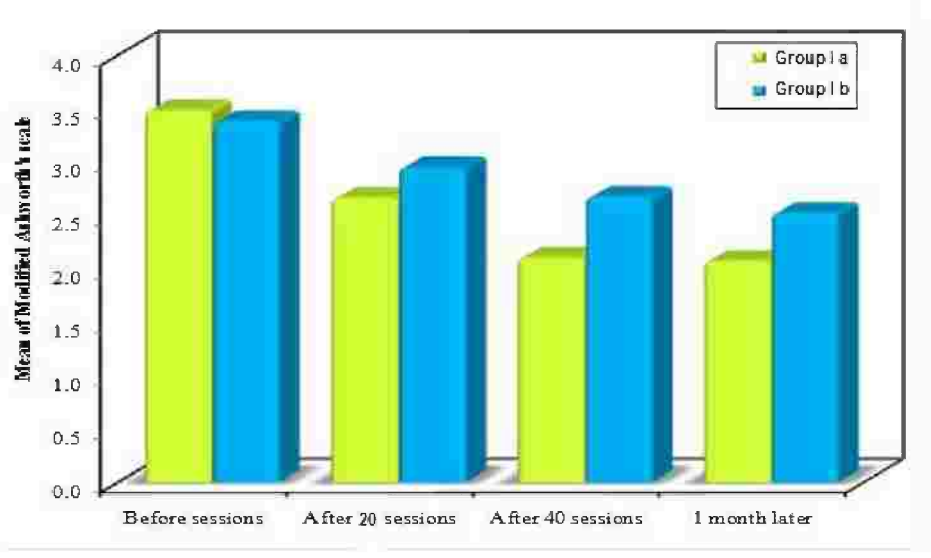


Figure (15): Comparison between group (I a) and group (I b) according to the MAS.

Table (15): Comparison between group (I a) and group (I b) according to GMFCS.

GMFCS	Age		Z	p
	Group I a (n = 29)	Group I b (21)		
Before sessions				
Min. – Max.	2.0 – 5.0	2.0 – 5.0		
Mean ± SD.	3.28 ± 0.96	3.10 ± 1.04	0.657	0.511
Median	3.0	3.0		
After 20 sessions				
Min. – Max.	2.0 – 5.0	2.0 – 5.0		
Mean ± SD.	3.21 ± 0.90	3.10 ± 1.04	0.464	0.643
Median	3.0	3.0		
After 40 sessions				
Min. – Max.	1.0 – 5.0	1.0 – 5.0		
Mean ± SD.	2.59 ± 1.02	2.81 ± 1.12	0.833	0.405
Median	2.0	3.0		
1 month later				
Min. – Max.	1.0 – 5.0	1.0 – 5.0		
Mean ± SD.	2.45 ± 1.06	2.81 ± 1.12	1.263	0.207
Median	2.0	3.0		

Z: Z for Mann Whitney test *: Statistically significant at $p \leq 0.05$

Table (15) and figure (16) show no statistical significant difference between both age groups regarding the GMFCS, but the younger age group responded in a better way than the older one.

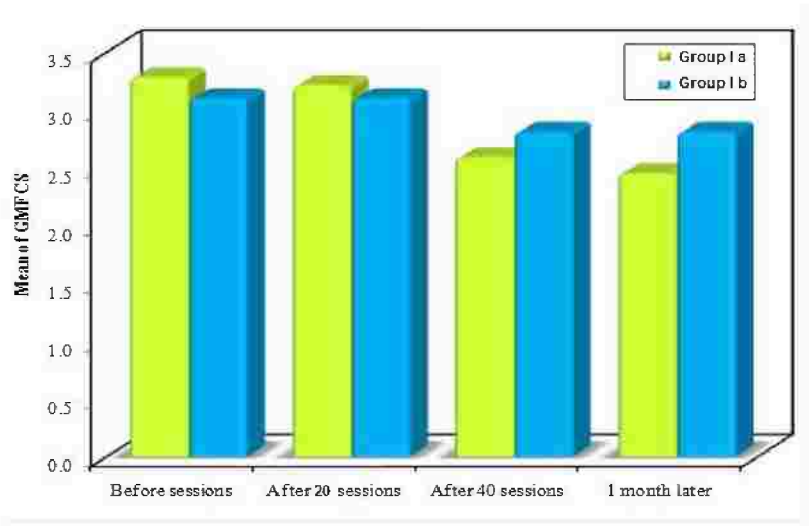


Figure (16): Comparison between group (I a) and group (I b) according to GMFCS.

Table (16): Comparison between group (I a) and group (I b) according to MACS.

MACS	Age		Z	p
	Group I (n = 29)	Group II (21)		
Before sessions				
Min. – Max.	1.0 – 4.0	1.0 – 4.0		
Mean ± SD.	2.45 ± 0.87	2.86 ± 0.73	1.911	0.056
Median	2.0	3.0		
After 20 sessions				
Min. – Max.	1.0 – 4.0	1.0 – 4.0		
Mean ± SD.	2.31 ± 0.97	2.81 ± 0.75	2.019*	0.043*
Median	2.0	3.0		
After 40 sessions				
Min. – Max.	1.0 – 4.0	1.0 – 4.0		
Mean ± SD.	1.90 ± 0.82	2.24 ± 0.70	1.632	0.103
Median	2.0	2.0		
1 month later				
Min. – Max.	1.0 – 4.0	1.0 – 3.0		
Mean ± SD.	1.90 ± 0.82	2.14 ± 0.65	1.313	0.189
Median	2.0	2.0		

Z: Z for Mann Whitney test *: Statistically significant at $p \leq 0.05$

Table (16) shows that there was a statistical significant difference between both groups after 20 sessions while after 40 sessions and after one month no statistical significant difference was found, and figure (17) shows also that the younger age group responded better to the sessions.

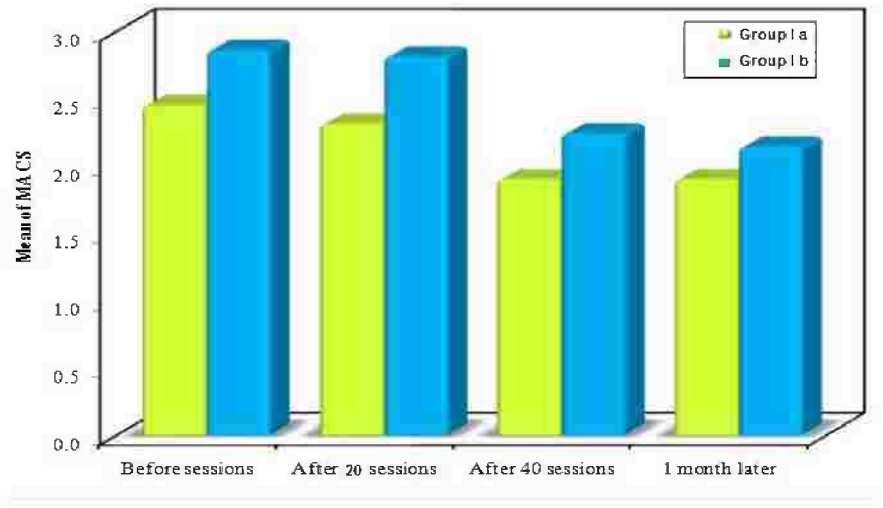


Figure (17): Comparison between group (I a) and group (I b) according to MACS.

Table (17): Improvement of cognitive problems, drooling and sleep disturbance before and after the sessions among group I.

	Cognitive impairments	Drooling	Sleep disturbance
Before sessions	24	22	16
After 40 sessions	11	14	8
Percentage of improvement	46%	64%	50%

Table (17) and figure (18) show that the percentage of improvement considering the cognitive impairments, drooling and sleep disturbance was 46%, 64% and 50% respectively among group I.

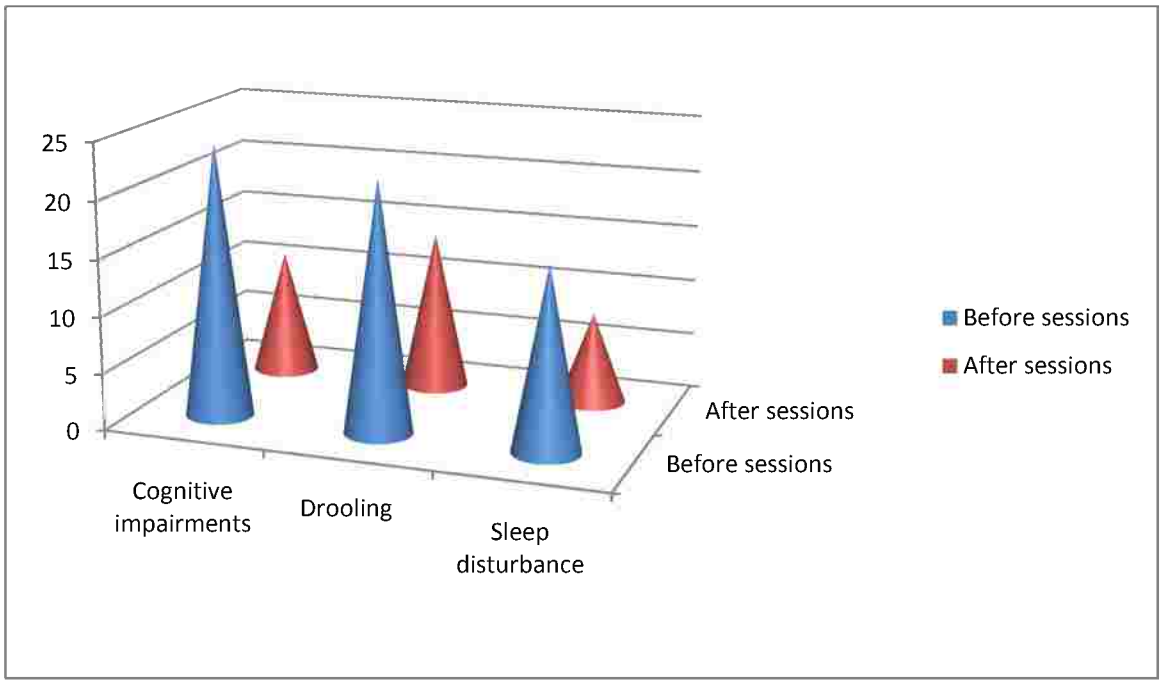


Figure (18): Shows the improvement among group I considering cognitive problems, drooling and sleep disturbance before and after the sessions.

And at last we are honored to present some of little stories that we heard during the study (in parents or caregiver own words)

- Jana, 3 years old female, her mother said that after 20 sessions Jana started to flex her affected arm and after 40 sessions she was able to reach her mouth to eat solid stuffs.
- Seif, 1.5 years old male, his parents reported that he begin to be curious and he started to explore the surrounding environment, and after 40 sessions he became able to catch the cell phone trying to reach his ears.
- Abdel-Rahman, 5 years old male, his mother mentioned that he started to tell lies and begin to insist on his choices.
- Maha, 10 years old female, her teacher reported that her attention span was increased and by reaching 40 sessions she also reported an improvement in Maha's hand writing.
- Muhammed, 2 years old male, by 20 sessions his mother reported that Muhammed started to pull to stand and by 40 sessions he succeeded to support his knees. And also she reported that he started to recognize familial persons and to be uncomfortable with strangers.
- Ezz-Elden, 3.5 years old male, he started to prefer and reject some food stuffs.
- Zakaria, 4 years old, his grandmother reported that after 20 sessions he started to pass things from hand to hand and after 40 sessions he started to wave bye bye.
- Ali, 5 years old, the father said that Ali started to count using his fingers and also he started to compose a two words sentence.
- Rojaida, 1.5 years old female, after 40 sessions she started to follow moving objects by her eye and she is trying to support her neck, she also started to respond to her name when called as mentioned by her mother.
- Hossam, 7.5 years old male, his father reported better knee support and decreased knee flexion during walking, he also succeeded to turn the door handle to open and to close.
- Fahmy, 2.5 years old male, his mother reported that at the end of sessions Fahmy was able to reach his mouth, and also she reported that he started to smile when he tickled.
- Mahmoud, 3 years old male, his father said that Mahmoud started to pronounce his name and his father's name and he became much more calm than usual.
- Rodaina, 5.5 years old female, her mother said that she started to express some needs by pointing to what she wants, she also started to recognize three colors (red- blue – green) by pointing and drooling was decreased.
- Hana, 4 years old female, her father reported better sleeping pattern as she started to sleep at night after the 5^{th} sessions, after 40 sessions she was able to say some new words, make two to three blocks tower and started to show better trunk control.