Original Article

Effect of EMG Biofeedback to Improve Hand Function in Children with Cerebral Palsy: A Randomized Controlled Trial

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Background: Cerebral palsy has pathology in immature brain problem; ischemic brain, hypoxic brain. The cause of pathology can be prenatal, perinatal and postnatal. Electromyographic (EMG) biofeedback is muscles training by using electrical stimulation modality to train specific weakness muscles or pathologic side. Feedback response to the patients by visual or evidence supporting sound can make the patients to train themselves specifically. However, there is only few evidences supporting efficacy of EMG biofeedback to train muscles in cerebral palsy.

Objective: To study the effect of EMG biofeedback on upper extremity to improve hand function in children with cerebral palsy.

Materials and Methods: Forty children with cerebral palsy who had impairment of upper extremity and hand function. They were randomly assigned into two groups. The biofeedback group consisted of 20 patients, each received EMG biofeedback training of 3 muscles for 30 minutes plus three-task training for 30 minutes. The conventional group consisted of 20 patients, each received three-task training for 60 minutes. Upper extremity and hand function were evaluated before starting training, at 4 weeks and 8 weeks.

Results: The biofeedback group displayed statistically significant improvement regarding 3 subtest of Jebsen hand function test (JHFT) (p=0.004, 0.017, 0.004), respectively. Comparing with before starting training, mean decreasing of time spending at 4th week were 15.03±4.01, 232.42±74.52 and 14.24±3.80, and at 8th week were 13.32±2.70, 251.85±80.25 and 10.34±3.28. There were significant improvement in almost all aspect of range of motion (ROM) of elbow and wrist joints (p<0.05) and modified tardieu scale (MTS) of elbow flexors and wrist flexors (p<0.005). Conventional group displayed statistically significant improvement regarding 1 subtest of JHFT (p=0.006). Comparing with before starting training, mean decreasing of time spending at 4th week were 174.90±49.20. Biofeedback group showed statistically significant progress over conventional group in 1 subtest of JHFT (p=0.002, 0.005), MTS of elbow flexors (p<0.001, 0.007) and ROM of elbow extension (p=0.018).

Conclusion: The effect of EMG biofeedback on upper extremity and hand function in children with cerebral palsy especially in large muscle trained by EMG biofeedback is superior to conventional therapy.

Keywords: EMG biofeedback, Electromyographic biofeedback, Upper extremity and hand function, Cerebral palsy

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Cerebral palsy has pathology in immature brain, caused by prenatal, perinatal and postnatal(1-3). Most of the patients have movement disorder and poor function, development, perception, communication, behavior and also musculoskeletal problems(4). Most common problems (>50 percents) are weakness and spasticity in both upper and lower extremities that can effect to soft tissue around the joints and bone growth and development, caused the cerebral palsy children have impairment and disability(5). In present studies, there were many techniques and treatment to improve function in cerebral palsy children(6) such as: Neurodevelopmental therapy (NDT), Hand-arm bimanual intensive training (HABIT) to improve both hands function; normal and pathological side, Constraint-induced movement therapy (CIMT) to improve pathological side and limit function of normal side, Electromyographic (EMG) biofeedback, Botulinum toxin A injection in spastic muscles. However, there is only few evidences supporting efficacy of EMG biofeedback to train upper extremities muscles in cerebral palsy. There is no any definite study that concludes to improve hand function of cerebral palsy patients(7).

The EMG biofeedback is muscles training by using electrical stimulation modality to train specific weakness muscles or pathologic side. Feedback response to the patients by visual or evidence supporting sound can make the patients to train

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themselves specifically. The patients can learn how to adapt and practice themselves to achieve their goals to improve their functions, motor power and decrease spasticity[8]. The patient can learn to move their specific muscles to improve their function by decreasing spasticity and increasing muscles relaxation[9]. There are many studies about the effect of EMG biofeedback in the patients who have weakness and spasticity in upper extremities[10-13] and lower extremities[14-16] in many groups of patients such as stroke[17,18], traumatic brain injury, spinal cord injury patients[19].

In 1983, Wolf and Binder-MacLeod studied about the effectiveness of EMG biofeedback in 31 hemiparesis; 22 patients used EMG biofeedback had more significantly statistic improvement in motor power range of motion and decreasing spasticity and also upper extremities hand function than 9 control patients[11]. In 1989, Crow et al studied the effectiveness of EMG biofeedback to improve upper extremities function in stroke patients. There is statistically significant EMG biofeedback training group improved upper extremities and hand function score[13]. In 1998, Moreland et al study[20] included 12 meta-analysis EMG biofeedback training studies and/or with or without conventional therapy (randomized controlled trials) to measure lower extremities function, improvement of motor power (strength and endurance, range of motion). Results showed that EMG biofeedback group significantly improved strength of ankle dorsiflexion muscles strength when compared with conventional group[20]. In 1998, Toner et al studied EMG biofeedback treatment in 5 cerebral palsy children and a case of tip toe walking, there was significantly improvement in strength of muscles and active range of motion of joints[22].

In 2003, Armagan et al[21] studied EMG biofeedback treatment of hand muscles weakness in 27 hemiparesis stroke patients. The EMG biofeedback group had statistically significant improvement in range of motion of wrist joint and also strength of wrist extensor and finger extensor muscles group when compared with placebo EMG biofeedback[21]. In 2004, Dursun et al[23] studied 36 cerebral palsy patients; 21 cases for gait training by using EMG biofeedback and 15 cases with conventional physical therapy. The study showed significantly more improvement in muscle strength of ankle plantar flexion muscles, range of motion and also gait pattern in EMG biofeedback groups than conventional group[23]. Conclusion, Rehabilitation by EMG biofeedback statistically significant improves effectiveness of musculoskeletal system e.g., range of motion and strength of muscles.

The EMG biofeedback can improve the effectiveness of outcome of treatment in cerebral palsy children and also safety for the children. The children have limitation of intention to cooperate tasks or activities especially cerebral palsy children, therefore EMG biofeedback stimulation is one quite interesting technique to precipitate the children to succeed more activities.

The present study was designed to evaluate the effectiveness of EMG biofeedback to upper extremities and hand function of cerebral palsy compared with conventional therapy.

Materials and Methods

Participants

Cerebral palsy children 5 to 14 years old: Inclusion criteria referenced by HABIT study who could do wrist extension more than 20 degrees and metacarpopharyngeal joint extended more than 10 degrees from full finger flexion, lifting arm from the table more than 6 inches. Intelligence quotient (Raven's progressive matrices) was more than 70. Exclusion criteria were others healthy problems, in adequate treatment and/or uncontrolled seizure or epilepsy, vision problems, spasticity (modified Ashworth score >3), previous surgery in pathological upper extremity or hand within a year, botulinum toxin A therapy in pathological upper extremity within 6 months or during study period or deny to continue.

Sample size calculations

Calculated from Gordon et al study[24] by using two independent group CI = 95%, power 90% and drop out 20%. Calculated number was 19 cases per group, total 38 cases.

Study designs

Single-blind controlled trial, block of 4 randomization was devided into 2 groups; first was EMG biofeedback and second was conventional group.

Group I: EMG biofeedback

The patients were trained by EMG biofeedback Delsys Myomonitor IV. The surface electrode was put at the movement muscles of upper extremities and hands muscles by the same occupational therapist. First, surface electrodes were applied at finger extensors for 10 minutes; second, surface electrodes were applied at wrist extensors for 10 minutes; third, surface electrode applied at Triceps for 10 minutes. The patients had to do three tasks, first was painting, second throwing the ball in the basket and third putting red bean in cup by spoon. The patients had to do every task, 10 minutes per task. Total time was 60 minutes per day for 3 days per week for 4 weeks.

Group II: conventional therapy

These patients had to do same three tasks; painting, throwing the ball in the basket and putting red bean in cup by spoon. The patients had to do every task, 20 minutes per task. Total time was 60 minutes per day for 3 days per week for 4 weeks. Both groups were trained by expert occupational therapist.

All patients had to be examined by single blinded evaluator. Age, sex, upper extremity lesion side, history of healthy condition, epilepsy or seizure treatment, vision problems, history of surgery in one year and/or history of botulinum toxin A injection at upper extremity lesion side in 6 months. And, also the patients were evaluated Intelligent test, Raven's progressive matrices by psychologist. They were evaluated pre-training and post training at 4 and 8 weeks.

Outcome measurement

Jebsen-Taylor hand function test (JHFT) was the hand function test. For the present study, the author chose 6 from 7 evaluation score tests; card turning, picking up small common objects (pennies, paper clips bottle caps), stimulated feedings (putting red bean by spoon), stacking checkers, moving light objects (empty cans), moving heavy objects (1 pound weight cans). Subtest score was the time (seconds) to complete task. Total score was sum of times for each subtests.

The second measurement score was Hand-held dynamometry for measurement hand grisp strength by using hand-held dynamometer and score to be pounds. Active range of motion of wrist extension, elbow flexion, extension, supination, pronation measured by goniometer. Spasticity, Modified Ashworth scale (MAS) and Modified Tardieu scale (MTS) were used to evaluate spasticity by measure spastic angle to assess the muscle's response to stretch at various given velocities. They were scales for measuring spasticity that took into account resistance to passive movement at both slow and fast speed.

Statistical analysis

Data were analyzed by SPSS (cities version 15.0). Data analysis was blinded. Basic data were analyzed to compared between 2 groups. Age analyzed by Independent t-test, sex, classification of cerebral palsy, trainable pathologic side and Chi-square test. Analyzed pre and post training by repeated measured ANOVA with post-hoc analysis. Analyzed treatment outcome compared between the two groups by mean difference and Mann-Whitney U test.

Results

Basic data showed both biofeedback and conventional groups had average age of 10.5 years old and 9.3 years old, respectively. Both groups had equal male and female. Trainable weakness upper extremities and hand side was left side more than right side in both groups. They were mostly cerebral palsy diplegia. There was no significant difference in basic data in both groups (Table 1).

From 51 cerebral palsy cases, there was 40 cases in the include criteria in the present study. These 40 cases were devided into two groups, and all cases could complete the study with no drop out (Figure 1).

The Biofeedback group succeeded to do JHFT for three subgroup items: card turning, stimulated feedings (putting red bean by spoon) and moving heavy objects by taking time statistically less than the conventional group, (at week 4: p=0.004, 0.017, 0.004; and at week 8: p<0.001, 0.016, 0.016) (Table 2, 3).

Conventional group succeeded to do JHFT for only one subgroup item, stimulated feedings (putting red bean by spoon statistically decreased less time (at week 4, p=0.006, and at week 8, p=0.014) (Table 2, 3). The biofeedback group had significant statistically less

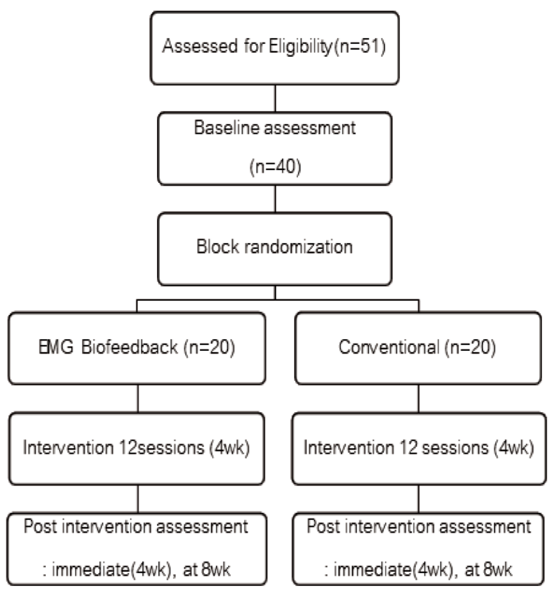

Figure 1. Flow chart.

Table 1. Basic data of participants

Characteristics	Biofeedback (n = 20)	Conventional (n = 20)	*p*-value
Age, mean ± SE	10.500±2.35	9.300±2.54	0.738*
Sex, n			1.000†
Girl	10	10	
Boy	10	10	
Trained side, n			0.748†
Right	7	9	
Left	13	11	
Type, n			0.139†
Spastic diplegia	15	18	
Spastic quadriplegia	5	1	
Spastic hemiplegia	0	1	

* Independent t-test, † Chi-square, *p*-value is not significant

Table 2. Average duration spending time of JHFT pre and post training at week 4 and 8 and mean difference between two groups

Measures	Intervention		Mean difference between group *p*-value
	Biofeedback	Conventional	
JHFT: page turning			
Pretest (I)	35.61±5.99	48.82±14.99	
Immediate posttest (II)	20.57±2.57	33.21±8.61	
At 8-week (III)	22.29±4.08	30.36±6.36	
I-II (diff.)	15.04±4.01	15,61±6.69	0.267
I-III (diff.)	13.32±2.70	18.45±9.15	0.279
p-value I-II (diff.)	0.004*	0.092	
p-value I-III (diff.)	<0.001*	0.174	
JHFT: lifting small object			
Pretest (I)	142.56±60.22	129.14±60.30	
Immediate posttest (II)	89.77±46.23	87.18±38.54	
At 8-week (III)	89.19±38.82	95.56±46.22	
I-II (diff.)	52.80±29.61	41.95±28.49	0.088
I-III (diff.)	53.37±25.47	33.58±27.95	0.066
p-value I-II (diff.)	0.272	0.472	
p-value I-III (diff.)	0.149	0.733	
JHFT: simulate feeding			
Pretest (I)	342.70±85.60	486.11±78.44	
Immediate posttest (II)	110.28±23.78	311.21±66.14	
At 8-week (III)	90.85±21.26	315.04±71.42	
I-II (diff.)	232.42±74.52	174.90±49.20	0.892
I-III (diff.)	251.85±80.25	171.07±53.33	0.626
p-value I-II (diff.)	0.017*	0.006*	
p-value I-III (diff.)	0.016*	0.014*	

JHFT = Jebsen Hand Function Test; diff. = difference

* Repeated measure ANOVA with post-hoc analysis for within group analysis, p-value is significant

time to do tasks at week 4 and week 8 when compared pre-training and post training in one subgroup item; moving heavy subject and significant statistically better than conventional group (p=0.002 and 0.005) (Table 3).

At week 4th, the biofeedback group had significant statistic increasing improvement of elbow flexion and extension range of motion, elbow supination and pronation, wrist flexion extension and hand grip muscles strength (p=0.003, 0.043, 0.046, 0.001) (Table 4, 5, 8); and modified Tardiau scale (MTS) of elbow flexor and wrist flexor muscles group were significantly statistic decreased (p<0.001, 0.001) (Table 6). At week 8th biofeedback group had statically significant increasing of range of motion of elbow flexion, wrist extension and hand grip strength, (p=0.002, 0.020, <0.001) (Table 4, 5, 8), but MTS of elbow flexor and wrist flexor groups were significant statistic decreasing (p=0.005, 0.004) (Table 6).

Table 3. Average duration spending time of JHFT of pre and post training at week 4 and 8 and mean difference between two groups

Measures	Intervention		Mean difference between group *p*-value
	Biofeedback	Conventional	
JHFT: checkers			
Pretest (I)	56.72±23.35	63.76±20.12	
Immediate posttest (II)	41.97±22.49	46.25±12.05	
At 8-week (III)	41.73±22.56	55.53±16.99	
I-II (diff.)	14.75±6.10	17.51±17.10	0.027
I-III (diff.)	14.99±8.28	7.73±16.63	0.298
p-value I-II (diff.)	0.272	0.472	
p-value I-III (diff.)	0.149	0.733	
JHFT: large, light object			
Pretest (I)	34.57±6.69	46.75±13.48	
Immediate posttest (II)	20.34±3.57	37.32±10.78	
At 8-week (III)	24.23±4.16	34.43±9.63	
I-II (diff.)	14.24±3.80	9.43±7.90	0.105
I-III (diff.)	10.34±3.28	12.32±8.70	0.330
p-value I-II (diff.)	0.004*	0.742	
p-value I-III (diff.)	0.016*	0.519	
JHFT: large, heavy object			
Pretest (I)	168.54±71.90	106.88±40.35	
Immediate posttest (II)	78.78±44.80	70.72±30.73	
At 8-week (III)	72.30±41.48	52.96±23.54	
I-II (diff.)	89.76±52.20	36.16±23.23	0.002†
I-III (diff.)	96.24±52.16	53.87±26.91	0.005†
p-value I-II (diff.)	0.305	0.408	
p-value I-III (diff.)	0.242	0.179	

JHFT = Jebsen Hand Function Test; diff. = difference

† Mann-Whitney U test for between group analysis, *p*-value is significant

* Repeated measure ANOVA with post-hoc analysis for within group analysis, *p*-value is significant

Biofeedback group had statistically significant increasing of mean different degree of range of motion of elbow flexion and extension of pretraining and post training at week 8th when compared with convention group (p=0.023, 0.006) (Table 4), and MTS of elbow flexor muscle had statistically significant decreasing of pre training and post training at week 4th and week 8th when compared with conventional group (p<0.001, 0.007, 0.018) (Table 6).

Table 4. Average of range of motion of joint of pre and post training at week 4 week 8 and mean difference between two groups

Measures	Intervention		Mean difference between group *p*-value
	Biofeedback	Conventional	
ROM of elbow flexion			
Pretest (I)	144.25±1.55	146.25±1.35	
Immediate posttest (II)	150.00±0.63	147.50±1.12	
At 8-week (III)	148.25±0.91	148.00±0.84	
I-II (diff.)	4.00±1.00	1.75±0.83	0.051
I-III (diff.)	5.75±1.46	1.25±1.14	0.023†
p-value I-II (diff.)	0.003*	0.860	
p-value I-III (diff.)	0.002*	0.148	
ROM of elbow extension			
Pretest (I)	174.50±2.11	177.25±1.68	
Immediate posttest (II)	177.50±1.28	177.00±1.79	
At 8-week (III)	175.75±1.89	177.00±2.07	
I-II (diff.)	1.25±7.14	0.25±2.00	0.122
I-III (diff.)	3.00±1.11	0.25±0.25	0.006†
p-value I-II (diff.)	0.043*	0.990	
p-value I-III (diff.)	0.288	1.000	
ROM of supination			
Pretest (I)	53.50±9.29	67.50±7.56	
Immediate posttest (II)	57.00±8.47	69.00±7.12	
At 8-week (III)	55.25±8.96	68.75±7.28	
I-II (diff.)	3.50±1.31	1.50±1.03	0.144
I-III (diff.)	1.75±1.16	1.25±0.71	0.657
p-value I-II (diff.)	0.046*	0.488	
p-value I-III (diff.)	0.446	0.288	

ROM = range of motion; diff. = difference

† Mann-Whitney U test for between group analysis, *p*-value is significant

* Repeated measure ANOVA with post-hoc analysis for within group analysis, *p*-value is significant

Table 5. Average of range of motion of joint of pre and post training at week 4 week 8 and mean difference between two groups

Measures	Intervention		Mean difference between group *p*-value
	Biofeedback	Conventional	
ROM of pronation			
Pretest (I)	90.00±0.00	87.50±2.50	
Immediate posttest (II)	90.00±0.00	87.75±2.25	
At 8-week (III)	90.00±0.00	87.75±2.25	
I-II (diff.)	0.00±0.00	0.25±0.25	0.317
I-III (diff.)	0.00±0.00	0.25±0.25	0.317
p-value I-II (diff.)	-	0.990	
p-value I-III (diff.)	-	0.990	
ROM of wrist flexion			
Pretest (I)	78.75±2.92	75.50±3.38	
Immediate posttest (II)	76.25±3.79	74.75±3.49	
At 8-week (III)	80.00±2.29	75.00±3.87	
I-II (diff.)	2.50±1.23	0.75±1.04	0.398
I-III (diff.)	1.25±1.73	0.50±1.20	0.684
p-value I-II (diff.)	0.169	1.000	
p-value I-III (diff.)	1.000	1.000	
ROM of wrist extension			
Pretest (I)	50.260±5.28	55.290±4.55	
Immediate posttest (II)	57.890±6.79	61.180±5.54	
At 8-week (III)	56.320±5.39	57.350±6.19	
I-II (diff.)	7.631±1.35	5.882±1.04	0.290
I-III (diff.)	6.052±1.25	2.058±1.05	0.290
p-value I-II (diff.)	0.001*	0.003*	
p-value I-III (diff.)	0.020*	0.701	

ROM = range of motion; diff. = difference

* Repeated measure ANOVA with post-hoc analysis for within group analysis, *p*-value is significant

There was no significant statistically change of modified asthworth score of elbow flexor extensor muscles group (Table 9).

Discussion

From the other previous studies, in 1998, Toner et al studied the effectiveness of EMG biofeedback in cerebral palsy and concluded that biofeedback machine statistically significant help to increase degree of active range of motion of joints and also increase ankle dorsiflexion muscles group[22].

In 2004, Dursun et al[23] studied the effectiveness of EMG biofeedback statistically significant improved strength of ankle plantar flexion group, degree of active range of motion of ankle joint and develop gait pattern better than convention group. In 2010, Bloom et al studied that biofeedback help to improve upper extremities function[26].

Form the present study, EMG biofeedback group statistically significant decreased duration succeed in spending time of 3 subgroups tasks of hand function test (JHFT) and also decreased spasticity of elbow flexor and wrist flexor muscles group (MTS) but increased of elbow range of motion in flexion, extension, pronation and supination, wrist extension. For conventional group that had three tasks specific activities, there was statistically significant decreasing of one specific task activity of subgroup of hand function test (JHFT), increasing of wrist extensor range of motion and also decreasing of spasticity of elbow flexor muscles group.

The biofeedback technique was the muscle training control to specific task activities of upper extremities and hand muscles training. This technique stimulated more neuroplasticity mechanism. When compared between two groups studies, Biofeedback group statistically significant decreased duration of spending time to success one subgroup of hand function test (JHFT) by training large muscles by biofeedback technique to increase range of motion of elbow flexion and extension and decrease spasticity.

In the present study, there is developing biofeedback technique to do neurological and musculoskeletal system rehabilitation and also more advance in the

Table 6. Average of spasticity (MTS) of pre and post training at week 4 week 8 and mean difference between two groups

Measures	Intervention		Mean difference between group *p*-value
	Biofeedback	Conventional	
MTS elbow flexors			
Pretest (I)	74.00±8.58	60.25±9.04	
Immediate posttest (II)	59.25±7.34	57.00±8.48	
At 8-week (III)	63.75±7.17	56.50±8.46	
I-II (diff.)	14.75±2.07	3.25±0.98	<0.001†
I-III (diff.)	10.25±2.77	3.75±1.49	0.007†
p-value I-II (diff.)	<0.001*	0.011*	
p-value I-III (diff.)	0.005*	0.063	
MTS elbow extensors			
Pretest (I)	10.00±2.90	4.50±2.11	
Immediate posttest (II)	8.75±2.61	3.75±1.74	
At 8-week (III)	9.75±2.82	2.25±1.56	
I-II (diff.)	1.25±1.01	0.75±0.55	0.624
I-III (diff.)	0.25±0.92	2.25±1.47	0.427
p-value I-II (diff.)	0.703	0.559	
p-value I-III (diff.)	1.000	0.429	
MTS wrist flexors			
Pretest (I)	39.25±4.61	38.75±4.66	
Immediate posttest (II)	31.25±4.47	36.50±4.56	
At 8-week (III)	31.75±4.23	37.25±4.25	
I-II (diff.)	8.00±1.75	2.75±0.85	0.032
I-III (diff.)	7.50±1.97	2.00±1.22	0.018†
p-value I-II (diff.)	0.001*	0.074	
p-value I-III (diff.)	0.004*	0.748	

MTS = modified Tardieu scale; diff. = difference

† Mann-Whitney U test for between group analysis, p-value is significant

* Repeated measure ANOVA with post-hoc analysis for within group analysis, *p*-value is significant

Table 7. Average of spasticity (MTS) of pre and post training at week 4 week 8 and mean difference between two groups

Measures	Intervention		Mean difference between group *p*-value
	Biofeedback	Conventional	
MTS wrist extensors			
Pretest (I)	4.50±3.28	1.50±1.50	
Immediate posttest (II)	3.75±2.64	1.00±1.00	
At 8-week (III)	3.75±2.74	1.25±1.25	
I-II (diff.)	0.75±0.75	0.50±0.50	0.971
I-III (diff.)	0.75±0.55	0.25±0.25	0.534
p-value I-II (diff.)	0.990	0.990	
p-value I-III (diff.)	0.559	0.990	

MTS = modified Tardieu scale; diff. = difference

Table 8. Average of hand grisp strength of pre and post training at week 4 week 8 and mean difference between two groups

Measures	Intervention		Mean difference between group *p*-value
	Biofeedback	Conventional	
Dynamometry			
Pretest (I)	0.60±0.23	0.66±0.20	
Immediate posttest (II)	0.99±0.22	0.95±0.19	
At 8-week (III)	0.99±0.25	1.03±0.25	
I-II (diff.)	0.39±0.08	0.30±0.05	0.202
I-III (diff.)	0.39±0.08	0.38±0.15	0.303
p-value I-II (diff.)	0.001*	<0.001*	
p-value I-III (diff.)	<0.001*	0.059	

diff. = difference

† Mann-Whitney U test for between group analysis, *p*-value is significant

* Repeated measure ANOVA with post-hoc analysis for within group analysis, *p*-value is significant

Table 9. Average of spasticity (MAS) of pre and post training at week 4 week 8 and mean difference between two groups

Measures	Intervention		Mean difference between group *p*-value
	Biofeedback	Conventional	
MAS elbow flexors			
Pretest (I)	1.211±0.96	1.147±0.13	
Immediate posttest (II)	1.211±0.96	1.147±0.13	
At 8-week (III)	1.211±0.96	1.147±0.13	
I-II (diff.), I-III (diff.)	0.000	0.000	-
p-value I-II (diff.), I-III (diff.)	-	-	
MAS elbow extensors			
Pretest (I)	0.526±0.12	0.059±0.12	
Immediate posttest (II)	0.526±0.12	0.059±0.12	
At 8-week (III)	0.526±0.12	0.059±0.12	
I-II (diff.), I-III (diff.)	0.000	0.000	-
p-value I-II (diff.), I-III (diff.)	-	-	
MAS wrist flexors			
Pretest (I)	1.026±0.81	1.088±0.11	
Immediate posttest (II)	1.026±0.81	1.088±0.11	
At 8-week (III)	1.026±0.81	1.088±0.11	
I-II (diff.), I-III (diff.)	0.000	0.000	-
p-value I-II (diff.), I-III (diff.)	-	-	

MAS = modified Ashworth scale; diff. = difference

future[25]. Task-oriented biofeedback therapy is new technology to develop real situation and environment to train the patient more effective and reality, but this technology is more expensive and inadequate research.

From the present study showed that biofeedback muscle training of upper extremities and hand muscles in cerebral palsy patients had more success work and function superior to conventional group therapy. The objective of the present study was to stimulate cerebral palsy children to improve their upper extremities and hand function, to be more independent and do more activities of daily living or more advance hand function activities with minimal assistance or without any assistance. The benefit from this study, physician, physical therapist and occupational therapist can use this technique to rehab cerebral palsy patient with safety and not expensive. The author has plan to do more specific biofeedback muscles training to do more specific tasks to improve functions for cerebral palsy patient.

Conclusion

The EMG biofeedback in upper extremities and hand function training in cerebral palsy has statistically significant improvement of upper extremities and hand function superior to conventional group. The present study can conclude that biofeedback muscles training technique is one of the great technique to train cerebral palsy children to improve and develop their upper extremities and hand function to succeed their independent activities with low cost technology.

What is already known on this topic?

The EMG biofeedback can increase strength and decrease spasticity in stroke and cerebral palsy patient.

What this study adds?

The EMG biofeedback has rarely side effect in children and can increase hand and upper extremities function in cerebral palsy patient. That can further be used in disability or training hand and upper extremities muscles to increase their function and improve them to be independent as much as possible.

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Potential conflicts of interest

The authors declare no conflict of interest.

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