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Original Article

Electrophysiological responses to Kabat motor control re-education on Bell's Palsy: A randomized controlled study

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Abstract

Objectives: to investigate the Electrophysiological responses post-Kabat Motor Control Re-education in Bell's palsy which might restore the neuromuscular circuit and normal function of the nerve. **Methods**: Thirty children diagnosed with Bell's palsy were equally divided into two groups; the study group that received Kabat Motor Control Re-education and the physical therapy selected designed program, and the control group that received physical therapy selected designed program. The outcomes included Electroneurography (ENoG) measuring distal latency, amplitude, and percentage of degenerations, and the Sunnybrook facial grading system (SFGS), as pre and post-treatment, all parameters were evaluated. **Results**: The ENoG findings approved that post-intervention there was a significant improvement in the study group more than the control group ($p<0.05$), as the percent of change of latency, amplitude, and percent of degeneration for both frontalis and orbicularis oris of the study group was 18.12-13.6%, 88.3-107.8%, and 74.4-78.9% respectively and that of the control group was 10.8-7.7%, 63.4-69.4%, and 54.9-54.8% respectively, also the percent of change of SFGS post-treatment, for study and control groups was 234.1% and 209.1% respectively. **Conclusion**: The Electrophysiological responses approved that the advanced Kabat rehabilitation combined with motor control re-education training using extrinsic feedback cues had a valuable effect in the treatment of Bell's Palsy. Clinical trials.gov ID: NCT04894513.

Keywords: Bell's Palsy, Electrophysiology, Facial Palsy, Kabat, Motor Control

Introduction

Peripheral facial palsy is considered the most common cranial neuropathy, typically due to compressive, traumatic, infective, metabolic, or inflammatory causes. Hence bell's palsy is a paralysis or weakness that leads to a unilateral weakness or paralysis of the face[1], as it is a disorder with several consequences, mainly when affecting children[2], it is considered an acute lower motor neuron lesion in origin, which could begin with pain in the mastoid area and leads to partial or complete paralysis[3,4].

The physical therapy management for bell's palsy has a wide range of advantages as it preserves the tone of facial muscle and activates the facial nerve neural transmission[5]. Patients with bell's palsy may benefit from a variety of therapy techniques, including Kabat rehabilitation (KR) paired with functional and expressive facial exercises[6].

The KR is a form of motor control rehabilitation technique that depends on proprioceptive neuromuscular facilitation, as the principles of KR rely coordination, and optimum body movements power, mainly because they are performed along diagonal lines regarding the body sagittal axis, thus producing a 'rotational' effect[6].

KR stimulates the voluntary response of the weakened

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muscle over the entire muscular section pattern that experiences resistance, this technique is the most appropriate for facial muscles, as most of the muscle fibers of the face run diagonally, with easy irradiation to the superior section of the face owing to the cross innervations of the facial nerve[7].

Thus, in KR, there are three basic regional fulcrums: the upper, intermediate, and lower fulcrums. The upper fulcrum reflects the eyes and forehead, which is related to the intermediate one, which reflects the nose, via a vertical axis, and the lower mimic-chewing-articulatory fulcrum is connected to the horizontal axis, while the action on the upper fulcrum also encompasses the further two fulcra[7].

Bell's palsy management could be reinforced by enhancing motor control and learning cues. As neuromuscular facial re-education is a guidance process for the patient relearning that activates the desired response of the facial muscles and eliminates the undesired contractions. This assumed method of brain reorganization recruits adequate neurons to enhance facial movement and restricts the recruitment of synkinetic movement neurons[8].

Electrophysiological results of the facial nerve can identify the severity and give decision-making for various disorders, which makes the facial nerve electrodiagnosis investigation an important tool in the diagnosis and follow-up for facial nerve palsy[9].

Therefore the most appropriate investigation is electroneurography (ENoG), also known as neurography, electroneuronography, or evoked electromyography, which uses transcutaneous stimulation of the main trunk of the facial nerve to analyze a specific muscle of the face, particularly after the onset of the lesion[9,10].

However no previous study investigated the facial nerve Electrophysiological responses measuring distal latency, amplitude, and percentage of degenerations post-Kabat rehabilitation combined with the motor control re-education post bell's Palsy as the previous studies depends only on evaluation scales, also previous researches used only KR in the treatment program hence the goal intended to be attained by the present study was to analyze the Electrophysiological responses combined with the functional outcomes in children with bell's palsy post combination of KR and the motor control re-education training using extrinsic feedback.

Materials and Methods

Design of the study

The study includes two groups represented at randomized controlled single blind trial design with pre- and post-evaluation as the study group received Kabat Motor Control Re-education combined with the physical therapy selected designed program and the control group got the physical therapy selected designed program.

Participants

Thirty children were recruited from several hospitals in Cairo, Egypt, for this study. Both sexes were included in the study with unilateral acquired bell's palsy within the first two weeks from onset, and all cases were diagnosed by a pediatric neurologist. The children's ages ranged from 12 to 16, and their facial disability scores were not less than 20 points according to The Sunnybrook facial grading system (SFGS)[11]. Children with oral dentures, facial metal implants, skin infection, facial sensory impairment, recurrent bell's palsy, any other syndromes or neurological abnormalities, cognitive deficits, difficulty communicating or understanding program instructions, non-cooperative patients, patients with a history of ear and face surgery, or pain from any source, all were excluded from the study.

Randomization

Before the study began, all of the patients' parents or caregivers read and signed a consent form, anonymity and confidentiality were guaranteed, and the research studies ethics committee accepted all procedures, which were carried out in compliance with applicable laws and institutional rules. The study was single-blind with a concealed allocation. Children were randomized in a 1:1 ratio to one of two treatment arms every arm included 15 patients: the study arm intervention included (Kabat rehabilitation with the selected designed program), as the patients' mean age and standard deviation (SD) were (13.81±1.04) or the control arm intervention included (the selected designed program only) as their mean age and SD were (13.74±1.03). An independent researcher was responsible for the randomization procedure. The children were randomly divided using the opaque closed envelope method. Following randomization and intervention, no subjects dropped out of the trial (Figure 1).

Outcomes measures

Primary outcome measurement

Electroneurography (ENoG)

The Neuropack S1 MEB9004 EMG (NIHON KODEN, JAPA) was used to measure Electroneurography (ENoG) response by assessing the specific facial muscle evoked compound muscle action potential (CMAP), which was assessed using a bipolar pair of surface electrodes on the muscle. The nerve damage or degeneration of nerve fiber was represented by a reduced CMAP. The damaged side's CMAP amplitude was compared to the non-affected side and a percentage score was assigned (amplitude of the affected side divided by the amplitude of the nonaffected side)[12]. The ENoG application was performed by a bipolar surface stimulator sited on the stylomastoid foramen and recorded from surface electrodes over the frontalis and orbicularis oris muscles, as the CMAP was obtained from both muscles to measure amplitude degeneration ratio, and to measure degeneration index using the following equation: $[100-(\text{ENoG amplitude affected/unaffected side})\times 100]$[9,13].

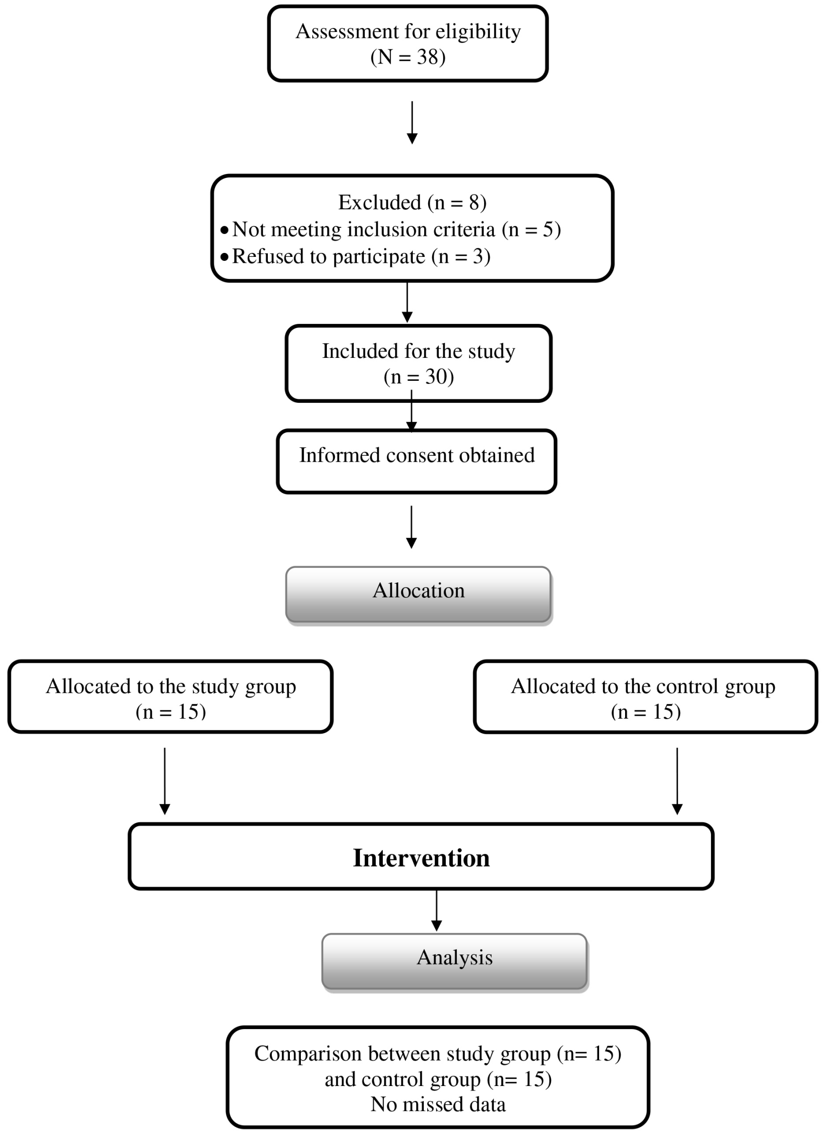

Figure 1. Flow chart showing the experimental design of the study.

Secondary outcome measurement

The Sunnybrook facial grading system (SFGS) was developed to measure the recovery of bell's palsy. It consists of three sections: resting symmetry, degree of voluntary excursion of facial muscles, and degree of synkinesis. On a point scale, the following five facial expressions were evaluated: eyebrow raise, eye closure, open mouth smile, lip pucker, and snarl/show teeth, as a cumulative composite score was generated, with a maximum score of 100 corresponding to full facial function with no synkinesis[11].

Interventions

The treatment program was given to both groups three times a week for six weeks, total duration 60 minutes/session. In the study group, the children received the selected designed program combined with Kabat motor control re-education including the upper, intermediate, and lower regional fulcra.

The stimulation of proprioception was performed by facilitating the contractions of the non-affected side with the manual contact and maximum resistance, from the therapist with verbal signals as follows: the frontalis, corrugators, and orbicularis muscles were stimulated in the upper fulcrum, while the common elevator muscle of the ala nasi and the upper lip was stimulated in the intermediate fulcrum, and the lower fulcrum included exercises for the zygomaticus major, risorius, and orbicularis oris muscles in a horizontal plane, and the mentalis muscle in a vertical plane[14].

The exercises were done with resistance for the non-

Table 1. Participants' characteristics, using the unpaired t-test and the Chi-squared statistical tests.

	Study group	Control group	p-value
	Mean ± SD	Mean ± SD	
Age (years)	13.81 ± 1.04	13.74 ± 1.03	0.86
Duration of symptoms (days)	5.93 ± 0.88	6 ± 1	0.84
Sex, n (%)			
Girls	9 (60%)	7 (47%)	0.46
Boys	6 (40%)	8 (53%)	
Affected side, n (%)			
Right	8 (53%)	8 (53%)	1
Left	7 (47%)	7 (47%)	

n; the number of children, SD, standard deviation; p-value, probability value, The level of significance p<0.05.

affected side, as each contraction or resistance, for 3-5 repetitions was performed per muscle for 2-3 sets[6].

The next step, simultaneously at the same time during the KR performance, the motor control reeducation training for the patient was performed by extrinsic feedback as visual cues by performing all exercises in front of the mirror and verbal cues inform of the therapist instructions with the tactile cues inform of manual contact of therapist and tapping that guided and learned the patient to contract muscles on the affected side and to detect the error and correct the muscles contraction as follow: stimulating the correct contraction of every muscle and prevent the incorrect muscle contraction[8]. The treatment duration for Kabat motor control re-education was 20 minutes/session.

The selected designed therapy program

A physical therapy program was provided to both groups in the manner of (1) electrical stimulation (Faradic current) on the affected muscles was applied from a seated position, as the positive electrode was placed on the nerve trunk, while the negative one was applied on the motor point of the (frontalis, orbicularis occuli, nasalis, zygomatic major, orbicularis oris and mentalis) muscles, under the following parameters: Pulse rate: 100 Hz, stimulate time: 10sec, polarity: +, ramp up: 3 seconds, ramp down: 3 seconds, pulse time: 100 μs, pause time: 1ms and the intensity was raised till the appearance of visible contraction, for two minutes at every point, with a total duration 15 minutes[15] (2) exercises program of facial expression in front of the mirror including closing and opening eye in both light and tight manner, raising eyebrows, smiling, snarling and widening nose, lips puckering/pouting, with 5-10 repetitions/exercise, for 15 minutes for study group and 35 minutes control group. Both groups received total rest periods of 10 minutes between interventions (3) Patients and carers were also encouraged to do facial expressive exercises twice a day at home[16,17].

Statistical Analysis

An unpaired t-test was employed to compare subject characteristics between groups. The Chi-squared test was used to compare the sex and affected side distributions between groups. To ensure that the data had a normal distribution, the Shapiro-Wilk test was utilized. Levene's test for homogeneity of variances was used to determine group homogeneity. Mixed design MANOVA was used to examine the ENoG outcomes including frontalis and orbicularis oris latency, amplitude, and percent of degeneration, and also the SFGS within and between groups. For subsequent multiple comparisons, post-hoc tests via the Bonferroni correction were performed. For all statistical tests, the significance level was set at $p<0.05$. All statistical analysis was conducted through the statistical package for social studies (SPSS) version 25 for windows (IBM SPSS, Chicago, IL, USA).

Subject characteristics

The participants in this study were thirty children. Between groups, there was no significant difference in age, duration of symptoms, sex, or affected side distribution ($p>0.05$) (Table 1).

<u>Effect of treatment on ENoG (latency, amplitude, and percent of degeneration) and SFGS</u>

Treatment and time had a significant interaction ($F(7,22)=5.25$, $p=0.001$, $\eta^2=0.62$). There was a significant main effect of time ($F(7,22)=280.23$, $p=0.001$, $\eta^2=0.98$). There was a significant main effect of treatment ($F(7,22)=3.77$, $p=0.008$, $\eta^2=0.54$).

- Within-group comparison

The latency and percent of degeneration were both significantly reduced, while the amplitude of frontalis and orbicularis oris was significantly increased in the study and control group comparing the post-treatment to the pre-treatment ($p<0.05$).

Table 2. Mean frontalis latency, amplitude, and percent of degeneration pre- and post-treatment of study and control groups, using the Mixed design MANOVA statistical tests:

	Study group	Control group	MD (95% CI)	p value
	Mean ±SD	Mean ±SD		
Frontalis Latency (msec)				
Pre treatment	5.63 ± 0.31	5.55 ± 0.20	0.08 (-0.11:0.27)	0.39
Post treatment	4.61 ± 0.38	4.95 ± 0.42	-0.34 (-0.64:0.04)	0.02
MD (95% CI)	1.02 (0.81: 1.23)	0.6 (0.38: 0.81)		
% of change	18.12	10.81		
	p = 0.001	***p = 0.001***		
Amplitude (mV)				
Pre treatment	0.86 ± 0.08	0.82 ± 0.11	0.04 (-0.02:0.12)	0.2
Post treatment	1.62 ± 0.29	1.34 ± 0.41	0.28 (0.01:0.55)	0.04
MD (95% CI)	-0.76 (-0.96: -0.55)	-0.52 (-0.73: -0.31)		
% of change	88.37	63.41		
	p = 0.001	***p = 0.001***		
Percent of degeneration (%)				
Pre treatment	54.38 ± 6.09	56.19 ± 7.16	-1.81 (-6.78:3.17)	0.46
Post treatment	13.89 ± 5.14	25.32 ± 5.59	-11.43 (-15.45: -7.41)	0.001
MD (95% CI)	40.49 (36.33: 44.65)	30.87 (26.71: 35.02)		
% of change	74.46	54.94		
	p = 0.001	***p = 0.001***		

SD, Standard deviation; MD, Mean difference; CI, Confidence interval; p-value, probability value, The level of significance p<0.05.

Table 3. Mean orbicularis oris latency, amplitude, percent of degeneration, and SFGS pre- and post-treatment of study and control groups using the Mixed design MANOVA statistical tests.

	Study group	Control group		p value
	Mean ±SD	Mean ±SD	MD (95% CI)	
Orbicularis Oris Latency (msec)				
Pre treatment	5.26 ± 0.16	5.32 ± 0.22	-0.06 (0.21:0.09)	0.43
Post treatment	4.54 ± 0.3	4.91 ± 0.47	-0.37 (-0.67:0.07)	0.01
MD (95% CI)	0.72 (0.54: 0.91)	0.41 (0.23: 0.59)		
% of change	13.69	7.71		
	p = 0.001	***p = 0.001***		
Amplitude (mV)				
Pre treatment	0.89 ± 0.11	0.85 ± 0.08	0.04 (-0.03:0.11)	0.29
Post treatment	1.85 ± 0.32	1.44 ± 0.41	0.41 (0.13:0.68)	0.005
MD (95% CI)	-0.96 (-1.14: -0.76)	-0.59 (-0.76: -0.39)		
% of change	107.87	69.41		
	p = 0.001	***p = 0.001***		
Percent of degeneration (%)				
Pre treatment	57.06 ± 5.21	54.73 ± 5.01	2.33 (-1.49: 6.16)	0.22
Post treatment	12.02 ± 5.25	24.73 ± 6.8	-12.71 (-17.26: -8.17)	0.001
MD (95% CI)	45.04 (40.55: 49.53)	30 (25.51: 34.47)		
% of change	78.93	54.81		
	p = 0.001	***p = 0.001***		
SFGS				
Pre treatment	24.86 ± 3.52	22.86 ± 4.98	2 (-1.22: 5.22)	0.21
Post treatment	83.06 ± 7.01	70.66 ± 10.27	12.4 (5.82: 18.97)	0.001
MD (95% CI)	-58.2 (-63.76: -52.63)	-47.8 (-53.36: -42.23)		
% of change	234.11	209.1		
	p = 0.001	***p = 0.001***		

SFGS, Sunnybrook facial grading system; SD, Standard deviation; MD, Mean difference; CI, Confidence interval; p-value, the probability value, The level of significance p<0.05.

The percent of change of frontalis latency, amplitude, and percent of degeneration of the study group was 18.12, 88.37, and 74.46% respectively and that of the control group was 10.81, 63.41, and 54.94% respectively (Table 2). The percent of change of orbicularis oris latency, amplitude, and percent of degeneration of the study group was 13.69, 107.87, and 78.93% respectively and that of the control group was 7.71, 69.41, and 54.81% respectively (Table 3).

There was a significant increase in SFGS of the study and control group post-treatment compared with that pre-treatment ($p<0.05$). The percent of change of SFGS of study and control groups was 234.11 and 209.1% respectively (Table 3).

- Between groups comparison

There was a significant increase in amplitude and a significant decrease in latency and percent of degeneration of frontalis and orbicularis oris of the study group compared with that of the control group post-treatment ($p<0.05$). There was a significant increase in SFGS of the study group compared with that of the control group post-treatment ($p<0.05$) (Tables 2-3).

Discussion

Bell's palsy is considered a sudden impairment of muscle control on one side of the face that could lead to functional and motor impairment, which is common in children so, the primary goal of this research was to assess electrophysiological responses after Kabat Motor Control Re-education in children with bell's palsy, as they were randomly assigned to the control group which received the selected designed therapy program, and the study group which received the same program in addition to the KR, as the ENoG measurements revealed a significant decreased in the percentage of degeneration and latency with increased in amplitude while there was a significant increase in SFGS in the study group compared with the control group, these results supported by Adhikari et al[6], who evaluated the earlier and potential recovery of KR in combination with facial expressive and functional exercises (FEFE) in bell's palsy, as the results showed improvement in SFGS score from 12/100 to 68/100, hence the KR that leads to a contralateral contraction and facilitation of weakened muscles which was achieved by resistance, irradiation, reciprocal inhibition and stretch, which facilitate the contraction of muscles by a movement pattern using multisensory inputs.

The current study found that KR application employing traction and pressure on the face facilitates both proprioceptive and somatic sensitivity, which is enforced by the patient's attempt to retain or contract the muscles, resulting in re-estimulation of the affected muscles, as KR comprises the principal techniques including manual contact, stretching, resistance, and verbal command, according to a prior study by Giacalone et al[18], who revealed that the KR for bell's palsy had a significant improvement effect on facial neurokinetic recovery as the mean results of the SFGS, before rehabilitation was 14.8, while the three subscales showed a significant increase post-treatment with a score of 86.

Khanzada et al[4] compared the effects of KR and exercises of facial muscles combined with nerve stimulation in patients with bell's palsy and found that after 3 weeks of treatment, the KR group showed more improvement in SFGS, with a mean post-treatment of 81.58, while the facial exercises group had a mean post-treatment of 63.77, In the early stages of bell's palsy, also both Monini et al[7], and Barbara et al[14], stated that the KR was found to provide better and faster recovery, especially in severe instances, due to its effect in avoiding any other issues such as synkinesis.

In agreement with the primary and secondary outcomes of the present study, a previous study by Sumathi et al[19], who investigated the influence of facial nerve electrical stimulation with KR and facial exercises in bell's palsy in the study group, compared with the control group that received electrical stimulation and facial exercises only for two weeks as the results showed that the study group was more effective in enhancing the function of the face and decreasing disability of the face. In a comparative study by Qamar et al[20], the study group received KR with electrical stimulation and Kinesio taping while the other group received electrical stimulation plus home exercises, for bell's palsy patients and the outcomes revealed improvement in both groups but the KR group showed a significant improving effect on facial asymmetry, as the KR improves circulation and both the gross and precise activation of facial muscles.

The influence of facial neuromuscular motor control re-education in a previous study by Manikandan[21] revealed its significant improving effect compared to the conventional therapy in enhancing facial symmetry in bell's palsy patients, as the neuromuscular facial re-education relies on patient motor learning and the extrinsic feedback usage to realize a physical reeducation, this aims to accomplish the neuroplasticity by decreasing the abnormal movement pattern, hence the facial motor control re-education exercises leads to neurologically accurate movement pattern learning to activate suitable motor units for intended actions or expressions and prevent unwanted movement, to improve facial symmetry[8].

The electrophysiological examination is one of the most important methods for diagnosing the neural-muscular system, as its major goal is to determine the severity and exact location of the lesion inside the nerve, as well as to identify whether the affected nerve is degenerating or regenerating, because of in bell's palsy, conduction block and axonal degeneration occur simultaneously; even so, ENoG's major advantage is its ability to estimate prognosis in the initial stages of acute facial palsy[10].

Because the validity of the studies is increased when they are repeated during the acute phase of the disease, the ENoG facial electrodiagnostic tests are most beneficial for studying individuals with acute peripheral facial palsy, additionally, the ENoG compares the neurophysiologic response of the normal side of the face to that of the abnormal side, so the ENoG is the most useful if performed post-onset[9]. The ENoG is also the most commonly utilized electrophysiological test in bell's palsy to determine whether the facial nerve is degenerating or regenerating[13], thus, the principal findings of this research matched those of a study conducted by Khedr et al[22], who used a 50% cutoff point to measure the rate of degeneration in the frontalis and orbicularis muscles in 59 patients with bell's palsy, as reevaluation after three months revealed that the patients who had a facial nerve degeneration ratio of less than 50% (38 cases) had a higher percentage of good post-treatment recovery, also in bell's palsy, ENoG results revealed that a percentage degeneration of 95% within 2 weeks was associated with a 50% chance of poor recovery[10].

However, the current study outcomes agreed with a previous study which approved that the prognosis of bell's palsy in children showed greater recovery scores after the physical therapy intervention[23], as a previous retrospective study reported that 89.3% of children with bell's palsy, could recover completely[24].

Otherwise, Tuncay et al[15], also performed a treatment program for three weeks, in patients with bell's palsy including electrical stimulation in addition to traditional therapy, inform of facial expression exercises, and the results showed improvement effect in both the electrophysiologic outcomes and the functional facial movements. Limitation of the present study includes the inability to follow up the long-term electrophysiological responses post KR intervention on bell's palsy because of deficiency of follow up after the rehabilitation period. For future study, it is recommended to investigate the effect of KR combined with other physical therapy modalities in adult patients, investigate the long term effect of KR and to study other electrophysiological measures such as Electromyography (EMG) after KR in bell's palsy.

Conclusion

It is possible to conclude that, the KR combined with the physical therapy selected designed program in children with bell's palsy, leads to a faster and better electrophysiological response and physical recovery than the selected designed therapy only, thus it would be valuable to include this method of physical rehabilitation in bell's palsy patients.

Ethics approval

The study was approved by the Faculty of Physical Therapy, Cairo University, Institutional Ethics Committee (No: P.T./REC /012/003143). Clinical trials.gov ID: NCT04894513.

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