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Functional outcomes of modified constraint-induced movement therapy versus Kinesio taping in children with Erb's palsy

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Abstract

Introduction. Functional improvement is the primary goal in chronic cases with neurological deficits. The aim of this study was to compare using modified constraint-induced movement therapy and Kinesio taping to improve functional outcomes in children with Erb's palsy.

Methods. The study investigated 46 children with Erb's palsy aged 5–7 years. They were randomly classified into 2 equal groups. Patients in group A engaged in a modified constraint-induced movement therapy program which included restraining of the movement of the non-involved upper extremity, while those in group B received a selected rehabilitative program based on the Kinesio taping method. The treatment programs were conducted 5 times per week for 6 successive weeks. Measurements obtained included active range of motion of shoulder flexion, abduction, and external rotation, as well as modified Mallet scale scores. These measurements were recorded before and after the application of the treatment program in both groups.

Results. There was a significant improvement in external rotation range of motion and forearm supination when comparing pre- and post-treatment mean values in each study group. There were no differences between the groups regarding any of the measured variables.

Conclusions. According to the applied procedures and collected data, there was no evidence for a superiority of modified constraint-induced movement therapy when compared with Kinesio taping in improving functional outcomes in children with Erb's palsy.

Key words: Erb's palsy, modified constraint-induced movement, Kinesio taping, functional outcomes

Introduction

Obstetrical brachial plexus injury is a form of a cervical nerve injury that frequently results in significant physical disability. Its incidence ranges between 0.15 and 5 per thousand live births, with higher expectations in developing countries [1].

Erb's type is a paralysis of the upper arm caused by an injury to the upper group of nerves supplying it, specifically the upper trunk (C5–C6) of the brachial plexus. It is one of the common neurological birth injuries that most commonly, though not exclusively, arise from the traction on the neck during difficult childbirth [2].

Most children with a brachial plexus lesion recover either deficit-free or with a minor deficit, but it is sure that some will not develop adequate function [3].

Limb impairments associated with obstetric brachial plexus palsy are often long-lasting. Microsurgical nerve reconstruction, muscle transpositions, and physiotherapy are employed with success. The role of either conservative or surgical treatment options should be reviewed regularly. Secondary shoulder surgery becomes necessary if problems develop with shoulder movement and interfere with shoulder joint development, so these complications should be prevented [4].

Rehabilitation management for brachial plexus injuries usually aim to prevent contractures resulting from muscle imbalances and to increase muscle strength, eventually increasing the child's awareness of the paretic limb [5]. If provided with sufficient opportunities to practice, neurologically disabled children may develop better motor performance [6, 7].

Several previous studies concerning different types of modified constraint-induced movement therapy (mCIMT) have proved its efficacy in improving the involved upper limb function and enhancing its development in neurologically disabled children [8–10]. Numerous studies on mCIMT concluded that it contributed to the motor recovery of the upper limbs [11]. However, overall changes of occupational performance should be based on standard clinical tests as objective evidence [12]. Changes in individuals' occupational performance, as indicators of recovery of daily living activities and upper extremity function, must be considered, as well as single measurements of function only [13].

Kinesio taping (KT) enhances strengthening of weak muscles, decreases muscle fatigue by providing support, and improves proprioceptive input to assist awareness. Additionally, it may promote functional improvement through encouraging the child to move in an optimum aligned position [14]. Possible effects of KT on strengthening of weak muscles have been investigated and the research implied that KT generated a concentric pull on the fascia, resulting in an immediate increase in muscle strength [15].

In this context, the purpose of the current study was to compare the functional outcomes of adding either mCIMT or KT to physical therapy programs administered in children with Erb's palsy.

Subjects and methods

Sample size and study design

The G*Power 3.1.9.4 software (Windows version) was used to determine the sample size, which was calculated with the assumption of establishing the difference between

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2 independent means (2 tails, effect size of 1.1). With the adopted α value of 0.05 and power of 95%, a sample size of 46 participants would be required.

On the basis of the comparative study design, the subjects were randomly assigned to 2 equal groups via the block randomization technique.

Participants

The study was conducted in an outpatient clinic, Faculty of Physical Therapy, Cairo University. A total of 46 children of both sexes aged 5–7 years were selected. All participants were diagnosed with unilateral brachial plexus palsy involving C5, C6 injuries, upper Erb's type, or C5, C6, C7 injuries, extended Erb's type in accordance with Narakas classification [16], with the second or third degree of nerve injury in accordance with Sunderland classification for nerve injuries [17]. The subjects were able to understand and follow instructions and cognitively competent, without serious medical complications. They had not received specific interventions within the preceding 6 months. Scapular stabilization with therapeutic taping was appropriate for all participants.

Individuals who had undergone spinal accessory nerve transfers or lower trapezius tendon transfers were excluded because the selected therapeutic taping technique augmented the middle and lower trapezius. Also, poor skin integrity, open wounds, fixed deformities of an upper limb, as well as significant perceptual, cognitive, visual, and auditory disorders were considered as exclusion criteria.

The participants were assigned to 2 groups, each consisting of 23 individuals. Group A engaged in an mCIMT program which involved restraining of movement of the unaffected upper limb. Children in group B received a selected rehabilitative program based on the KT method. There were 30 treatment sessions; each lasted for 2 hours, with a 15-minute rest during the session when requested. The sessions were conducted 5 times per week for 6 sequential weeks. Absence from more than 2 successive sessions meant exclusion from the study. Any missed session was compensated by the end of the sessions.

Evaluation procedure

Range of motion

Active range for shoulder flexion, abduction, and external rotation was measured. A Baseline Absolute 180° Axis digital goniometer (model FAB12-1027-25) was used. Goniometric parameters were evaluated by aligning the goniometer arms with bony landmarks and fixing the fulcrum with the approximate location of the glenohumeral joint axis [18].

For the assessment of active shoulder flexion range of motion (ROM), the participant was seated on a chair with total back support. The arm was actively elevated in strict sagittal plane with full elbow extension, thumb facing forwards to provide neutral rotation. The observer placed the inclinometer on the anterior aspect of the arm [19].

Shoulder abduction active ROM was examined in the seated chair position. The participant was asked to actively elevate the arm in strict coronal plane with thumb pointed up toward the ceiling to avoid impingement of greater tuberosity on the acromion process, providing the required external rotation [20].

Shoulder external rotation active ROM was measured in supine position with hips and knees flexed to approximately 45°. The tested arm was supported on a table, with right angle at shoulder abduction and elbow flexion, and neutrally positioned wrist. A towel roll was placed under the humerus to promote neutral horizontal positioning. Once the position was obtained, rotation of arm back into external rotation was encouraged without discomfort to the end of the available range. Lifting lower back during this measurement was not allowed [19].

The measurements were recorded once the active end-range was obtained. The procedure was repeated 3 times and the average was calculated.

Modified Mallet scale

This scale was applied to evaluate function and arm appearance. All participants were asked to actively perform 5 shoulder movements: abduction, external rotation, placing the hand to the mouth, placing the hand behind the neck, and placing the hand as high as possible on the spine.

In addition to that, supination position was evaluated and scored on a scale of 1–5. A total score was calculated from the scores of the previously mentioned 5 shoulder movements, with a maximum score of 25 [21].

Treatment procedure

Selected exercise program

The exercise program applied in both study groups was designed to improve shoulder function. The treatment protocol consisted of a list of gross, as well as fine motor activities. A range of functional, play, and daily living activities was involved similar to those usually practised in any given day of a child's life to maintain their interest. It included different categories of exercises that enhanced and directed all shoulder movements with either extended or flexed elbows, supinated forearm, and neutrally positioned wrist (as possible), in the sitting and standing position [22].

Modified constrained-induced movement therapy

Group A received an mCIMT program which involved restraining the unaffected upper limb movement for most of the waking hours (6 hours per day for 10 successive days), in accordance with Santamato et al. [23]. The program is suitable for the investigated age group and was followed by a repetitive practice of selected exercises, applied for 60 hours through 6 weeks. An upper extremity sling was used as a constraint and was strapped to the trunk with the distal end sewn.

Kinesio taping program

Study group B engaged in a KT program which involved a repetitive practice of selected exercises while utilizing KT (Figure 1). A certified KT practitioner applied a Kinesio Tex tape, aiming to obtain more stability to the scapula on the affected side through facilitating middle and lower trapezius function [24]. The shoulders were kept in downward and backward position, while the alignment of scapulae was manually maintained during the tape application. KT was set medially at the spinous processes (T2–T3 for middle trapezius and T12 for lower trapezius) and was applied toward the acromion [14].

Figure 1. Application of a Kinesio tape on the affected side through facilitating middle and lower trapezius function

Stretching

In all participants, the treatment session was ended with routine stretching exercise for the susceptible muscles to develop tightness. These muscles included subscapularis, forearm pronators, and wrist flexors. The stretching exercise was performed with 30 seconds on followed by 30 seconds off (rest) with a tolerated ended range. This was repeated 3 times for each group of muscles.

Statistical analysis

The data analysis was performed with the GraphPad Prism 8 software for Windows. Baseline characteristics were statistically treated to show mean and standard deviation. The chi-square test and independent *t*-test were used to compare baseline characteristics.

A parametric statistical test in the form of repeated measures 2-way analysis of variance (ANOVA) was performed to compare changes in the active ROM of shoulder flexion, abduction, and external rotation resulting from the applied rehabilitation programs. The Kruskal-Wallis non-parametric statistical test served to compare changes in the modified Mallet scale scores. To compare the groups in each assessment, the Mann-Whitney test and unpaired *t*-test were used. The *p*-value of < 0.05 was considered significant.

Ethical approval

The research related to human use has complied with all the relevant national regulations and institutional policies, has followed the tenets of the Declaration of Helsinki, and has been approved by the ethics committee of the Faculty of Physical Therapy, Cairo University (approval No.: P.T.REC/012/002625 dated: 9/2/2020).

Informed consent

Informed consent has been obtained from the parents of all individuals included in this study.

Results

Baseline characteristics including age, frequency distribution of gender, and frequency distribution of the affected side are summarized in Table 1. There was no significant difference between the groups ($p > 0.05$).

Table 1. Baseline characteristics

Item		Group A	Group B	*p*
Age (years)	Mean ± *SD*	6.06 ± 0.88	5.96 ± 0.81	0.769
Frequency distribution of gender	Boys	12	13	0.809
	Girls	11	10	
Frequency distribution of the affected side	Right side	13	14	0.809
	Left side	10	9	

After the treatment program application, statistically significant differences were observed in the active glenohumeral joint ROM, including flexion while comparing pre- and post-

Table 2. Mean values of active glenohumeral joint range of motion in the study groups

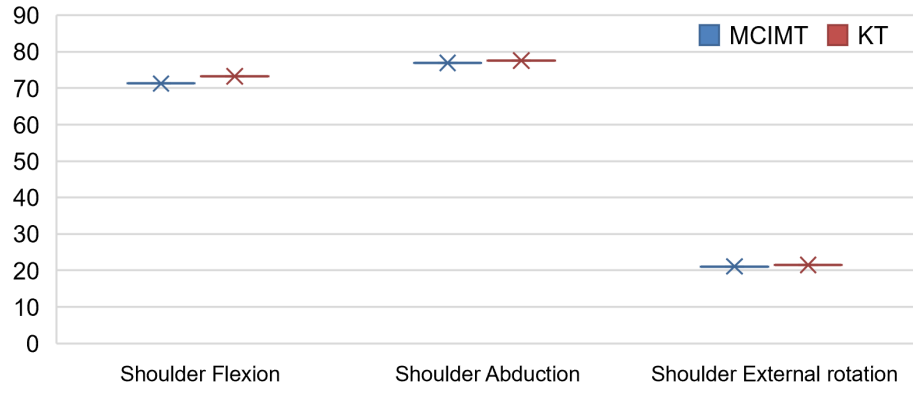
Active shoulder range of motion	mCIMT group		KT group	
	Pre	Post	Pre	Post
Flexion	64.78 ± 10.17	71.3 ± 8.15	63.04 ± 11.26	73.26 ± 7.78*
Abduction	70.22 ± 14.1	76.96 ± 14.83	69.57 ± 12.61	77.61 ± 15.73
External rotation	13.48 ± 4.38	21.09 ± 6.39*	14.35 ± 3.47	21.52 ± 6.11*

mCIMT – modified constraint-induced movement therapy, KT – Kinesio taping
* significant difference

Table 3. Mean values of modified Mallet system components in the study groups

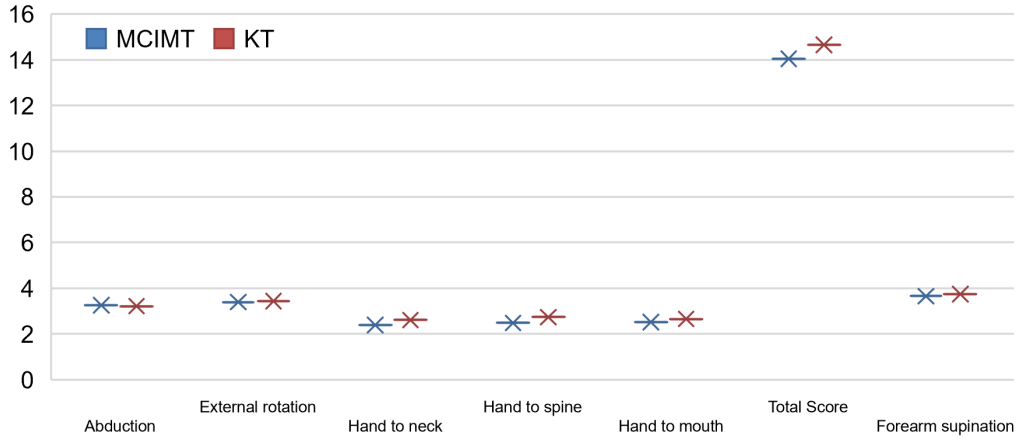
Item	mCIMT group		KT group	
	Pre	Post	Pre	Post
Abduction	3.09 ± 0.42	3.26 ± 0.54	2.96 ± 0.37	3.22 ± 0.52
External rotation	3.04 ± 0.37	3.39 ± 0.49	2.96 ± 0.37	3.43 ± 0.51*
Hand to neck	2.22 ± 0.42	2.39 ± 0.49	2.35 ± 0.49	2.61 ± 0.72
Hand to spine	2.22 ± 0.42	2.47 ± 0.51	2.3 ± 0.56	2.74 ± 0.69
Hand to mouth	2.39 ± 0.49	2.52 ± 0.73	2.43 ± 0.51	2.65 ± 0.71
Total score	12.96 ± 1.58	14.04 ± 1.89	13 ± 1.38	14.65 ± 1.97*
Forearm supination	3.22 ± 0.42	3.65 ± 0.49*	2.96 ± 0.47	3.74 ± 0.45*

mCIMT – modified constraint-induced movement therapy, KT – Kinesio taping
* significant difference



MCIMT – modified constraint-induced movement therapy, KT – Kinesio taping

Figure 2. Post-treatment mean values of the active shoulder range of motion in both groups



MCIMT – modified constraint-induced movement therapy, KT – Kinesio taping

Figure 3. Post-treatment mean values of the modified Mallet system scoring in both groups

treatment mean values of group B and external rotation when comparing pre- and post-treatment mean values of both groups ($p < 0.05$), as shown in Table 2.

Statistically significant differences were observed in the components of the modified Mallet grading system, including external rotation and total score when comparing pre- and post-treatment mean values of group B. There was a significant difference in forearm supination when comparing pre- and post-treatment mean values of both study groups after the treatment program application ($p < 0.05$), as shown in Table 3.

No significant difference was noted when comparing the mean values of all measured parameters after treatment between the groups ($p > 0.05$), as presented in Figures 2 and 3.

Discussion

Residual deficits result from incomplete recovery of nerves after brachial plexus injury between the second and third years of life. These deficits lead to muscle imbalance, as well as joint contractures, which affect function [25]. The affected upper limb function is one of the main goals of rehabilitation of patients with neuromuscular disorders. Many interventions have been examined, with varying degrees of success [26, 27].

In the current study, we compared mCIMT with KT as part of rehabilitation programs in the management of functional limitations of upper limb associated with Erb's palsy. The results revealed no statistically significant difference between the mCIMT group and the KT group for all variables when comparing post-treatment values between the groups. Still, there was a slight improvement between pre- and post-treatment values in both study groups. A significant improvement was obtained in flexion and external rotation active ROM in children receiving KT. The same was observed for the external rotation domain and total score of modified Mallet grading system. Only the forearm supination domain of modified Mallet grading system showed a significant improvement when comparing pre- and post-treatment values within each group.

Modified constraint-induced movement therapy is a promising method of rehabilitation of upper limb function [28–30]. Neuroimaging studies indicate that brain undergoes neuroplastic changes in function, as well as structure in those who participate in mCIMT [31, 32]. Different cortical areas, like primary motor cortex, show increased electrical neuronal activity during mCIMT [33].

A Japanese Dr. Kenzo Kase originated KT more than 25 years ago. It allows for unlimited ROM and reduces the time of recovery [34]. The tape is made of cotton in addition to an antiallergic adhesive layer that ensures evaporation and quick drying. Its properties make it comfortable to be used for a long period of 3–5 days. The tape is water resistant, with elasticity up to 140% [35].

KT is used to increase proprioceptive feedback [36, 37], help support joint and biomechanical alignment [38], and facilitate muscle function [39]. KT may be added to rehabilitation programs in paediatric rehabilitation centres to improve upper limb function [40]. In the case of children with permanent or residual deficits, KT can assist in increasing ROM, which may enhance upper limb function [34, 41].

From our point of view, improvement in both flexion and external rotation is a good indicator that can help overcome the problem of Erb's engram owing to faster recovery of shoulder abductors rather than shoulder flexors. Also, progressed forearm supination will assist action of biceps brachii biomechanically and therefore enhance upper extremity function.

Limitations

This study had some limitations. It was limited to 2 types of brachial plexus injuries and a specific range of age. The inclusion criterion of injury type was implemented to avoid variation in results; in addition, the selected 2 types are the most common. Choosing the 2 types was considered in order to collect the required sample size, and distribution of these types between the study groups was warranted before randomization to ensure balance in results. Moreover, there may have been inter-rater variation in ROM measurements, which could be overcome through calculating the average of 3 trails for each participant. Also, there were 30 treatment sessions and long-term effect was not investigated because of limited time and resources.

Conclusions

It was demonstrated that there was no evidence for an advantageous impact of mCIMT when compared with KT in improving functional outcomes in children with brachial plexus injury of Erb's type. Further investigations are required in a larger sample, for a longer period, with different age groups, and using different assessment and treatment techniques.

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Disclosure statement

No author has any financial interest or received any financial benefit from this research.

Conflict of interest

The authors state no conflict of interest.

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