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Research Article

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Effect of Uni-Lateral Motor-Based Priming on Manual Dexterity in Children with Unilateral Cerebral Palsy

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Abstract

Purpose: The purpose of this study was to investigate the effectiveness of applying different forms of Movement-Based Uni-lateral Priming (MBUP) in children with unilateral cerebral palsy on manual dexterity and grip strength.

Methods: Thirty children with unilateral cerebral palsy have been assigned equally into three groups; group A, the control group, and two study groups, B and C.

Group A received a specially designed rehabilitation program; group B received MBUP on the more affected upper limb (cross-training) in addition to the program given to group A while group C received MBUP on the less affected limb in addition to the program given to group A. Each participant received 30 sessions. Box and Blocks test and hand-held dynamometer were used for assessment.

Results: There was no statistically significant difference between all groups regarding post-treatment mean values. On the other hand, the percent of change within groups A, B, and C were 25%, 31.48%, and 35.85%, respectively, with a higher percent improvement in favor of group C rather than groups A and B.

Conclusion: This study shows that applying MBUP causes improvement in manual dexterity and handgrip strength with no statistical difference between different modes of MBUP applied in this study.

Keywords: Unilateral cerebral palsy • Movement-based uni-lateral priming • Manual dexterity • Grip strength

Introduction

Cerebral palsy (CP) is a group of disorders rather than a disease that results in neurodevelopmental delay in gross motor and fine motor development. It results from single or multiple insults affecting the immature brain. The motor delay causes functional deficits that affect all activities of daily living [1,2].

Unilateral cerebral palsy (UCP) represents one of the most types of CP. It is defined by the one side affection, including upper extremities, lower extremities, and trunk, resulting in tone disturbances and secondary musculoskeletal deficits [3].

The functional limitations of the more affected upper extremity are the most persisting problem due to somatosensory dysfunction and functional limitations of the affected side [4,5].

Manual dexterity is using the fingers, hands, and arms to perform a skillful movement. The diminished quality of daily living skills and recreational activities is associated with limited hand function and manual dexterity, which is associated with brain injuries [6].

Different approaches provide interventions for such cases and such problems, but most concentrate on the affected side and on the targeted skills to be learned.

Motor-based priming is a recent approach that focuses on the more affected side or, the less affected side [7]. Cross-training is the type that uses the abilities of the less affected side through muscle strengthening [8]. Also, it could be through training the more affected side before facilitating the fine motor skills [9].

Understanding the neurophysiological reactions of the human body to the application of different interventions will help design the optimum beneficial rehabilitation programs. These reactions need clinical signs to investigate their effects [10].

There is limited information about applying these methods in the rehabilitation of pediatrics, especially when targeting the upper extremity function [9]. The current study aimed to investigate the effect of different forms of motor-based priming on manual dexterity and handgrip strength in children with unilateral cerebral palsy.

Materials and Methods

The current Controlled Randomized Trial (CRT) was followed ethical principles of the Declarations of Helsinki and conducted after approval by the local ethical committee at the faculty of Physical Therapy, Cairo University. Signed informal consent was obtained from each participant's parents.

Sampling

G-Power 3.1.9.4 software (Windows version) was used to determine sample size as follows: it was calculated by assuming the statistical test within three groups. Assuming effect size=0.4, α=0.05, and power of 95%, a sample size of 30 participants would be required.

Participants

Thirty participants, ages 7-10 years, with cerebral palsy of spastic hemiparesis participated in this CRT. They were recruited from different rehabilitation centers. According to the Modified Ashworth Scale, the degree of spasticity ranged from grade 1 to 2. All participants could understand and follow verbal commands and instructions during testing and training sessions. Those with fixed musculoskeletal deformities were excluded,

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including one who had significant cognitive, perceptual, visual, and auditory disorders.

Randomization

Based on equality (1:1:1) in all groups, randomization was allocated to avoid bias in variation in results. Stratification was done by categorizing participants into categories following the initial assessment to ensure equal distribution regarding gender, affected side distribution, and spasticity degree distribution between all groups. The block randomization technique was used.

Children were assigned into three groups, the control group (A) and experimental groups (B and C). Each group consisted of ten participants. Group (A) engaged in a rehabilitation program based on selected occupational therapy training activities. Children in group (B) engaged in movement-based priming applied to the more affected upper extremity followed by the same program received by participants of group A with a break of 5-10 minutes in between. On the other hand, children in group (C) engaged in movement-based priming applied to the less affected upper extremity in the form of cross-training followed by the same program received by group A participants with a break of 5-10 minutes in between.

Each participant received 30 hours of occupational therapy training as the treatment session lasted one hour and was conducted five days a week for six successive weeks. Any absence for more than two successive sessions means exclusion from the study. The assessment protocols were applied twice: pre-and post-treatment.

Evaluation procedure

Box and blocks test (BBT): Manual dexterity was measured using the BBT. The equipment consists of a wooden box divided into two compartments by a separator. All cubes were placed in one compartment. Children were instructed to grasp the blocks individually, transport them over the separator, and release them into the opposite empty compartment of the box as quickly as possible. The allowed time was 60 seconds and was observed by stopwatch. They performed the test with the more affected hand. The measure was detected by counting the cubes transferred [11].

Handgrip strength (Kg): A JAMAR+ hand-held dynamometer was used for measuring handgrip strength (Patterson Medical Inc., China).

Replacing the hydraulic system with a circuit board and electronic load sensors gives a more accurate tool to measure hand strength in clients with hand trauma and dysfunction. The readout displays isometric grip force up to 90 kg.

The child was asked to sit on an adjustable height chair with a supported back. The head was maintained in mid-position, the trunk erect. The hips and knees were right-angled with fully supported feet on the ground. The shoulder joint was maintained beside the body in the neutral position, elbow joint flexed in right angle, forearm in mid-position (midway between supination and pronation) with the wrist joint in slight extension position (15 degrees). Each child was then asked to hold the dynamometer's handle by the affected hand and squeeze it as much as possible, then release it. then the average of three trials was calculated.

Treatment procedure

Selected occupational therapy program: It was designed and applied to all three groups. It usually started with stretching exercises as warming up and aiming for relaxing muscles of the affected upper extremity before task training. It included facilitation for wrist extensors, which was applied using different techniques such as quick stretching and tapping, and active movements. Proprioceptive training through weight-bearing from different positions was applied. It also included exercises to facilitate hand skills based on fine motor developmental sequence with repetitions. These exercises were demonstrated in front of the child before performing them [12].

Homo-lateral motor priming protocol: It was applied in the form of active-resisted exercises of the fingers, wrist, and elbow joints on the more affected side using manual resistance of the therapist's hand before applying the selected occupational therapy program to those participants of group B.

Cross-training protocol: This was applied in the form of resisted exercises on the less affected side before applying the selected occupational therapy program to group C. Design and application of exercises were based on individual repetition maximum for each muscle group. The maximum repetitions reached were 30 repetitions (3 sets of 10 repetitions) for each muscle group. It was applied to fingers extensors, abductors and flexors, wrist flexors and extensors, and elbow flexors and extensors. Sandbags and rubber bands were used to apply resistance [12-18].

Statistical analysis: Data analyses were conducted using SPSS for Windows, version 23 (SPSS, Inc., Chicago, IL). The collected data of demographic and other baseline characteristics were statistically treated to show the mean and standard deviation of measured parameters. One-way ANOVA was used to compare baseline characteristics between groups [19-26].

The current study involved two independent variables (tested group) and (measuring periods). In addition, this test involved two tested dependent variables (BBT and grip strength). Before the final analysis, data were screened for normality assumption, homogeneity of variance, and extreme scores. This exploration was done as a pre-requisite for parametric calculations of the analysis of difference. Accordingly, a 3 × 2 × 2 Mixed MANOVA test compared the tested variables of interest at different measuring periods among three groups. Tukey test was conducted to compare between pairs of data. P-value (<0.05) was considered statistically significant [26-30].

Results

Forty children with spastic unilateral cerebral palsy were initially assessed for eligibility. The control group (n=10) was programmed for a selected physical therapy program, whereas the experimental group B (n=11) received unilateral motor priming in addition to treatment program received by the control group and the experimental group C (n=11) received cross-training in addition to treatment program received by the control group. Of the experimental groups B and C, one withdrew from each group (due to absence for more than 2 consecutive sessions)(Figure 1).

The summary of demographic and other baseline characteristics at entry, including age, weight, and height, are presented in Table 1. There were no significant differences between all groups (p>0.05) [31-34].

Regarding between groups comparisons concerning pre-treatment results, there were not significant statistical differences (p>0.05) in all measured variables.

Regarding within-group pairwise comparisons following six weeks of application of the interventions Table 2, significant statistical differences (p<0.05) were noticed in manual dexterity measure, Box and Blocks test with pre-treatment mean values 10.5 ± 1.96, 10.6 ± 1.89, and 10.4 ± 1.84 for groups A, B, and C respectively. While post-treatment mean values for groups A, B, and C were 13.3 ± 1.49, 13.7 ± 1.16, and 13.8 ± 0.79, respectively [35-37].

Also, there were significant statistical differences (p<0.05) were observed in handgrip strength (Kg) when comparing mean values within each group. Pre-treatment mean values were 2.6 ± 0.52, 2.7 ± 0.59, and 2.65 ± 0.58 for groups A, B, and C, respectively, while post-treatment mean values for groups A, B, and C were 3.25 ± 0.54, 3.55 ± 0.55, and 3.6 ± 0.46 respectively.

The percent of change was calculated between pre-and post-treatment mean values within each group. It is shown in Table 2, which revealed a higher percentage for group C rather than groups A and B.

Regarding between groups comparisons concerning post-treatment results, there were not significant statistical differences (p>0.05) for all measured parameters. Also, testing interaction between variables revealed no significant difference.

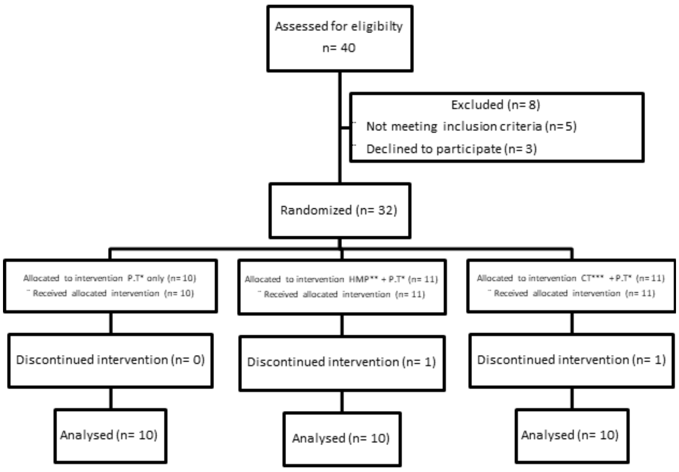

Figure 1. Consort flow diagram.

Table 1. Baseline characteristics.

Item	Group (A)	Group (B)	Group (C)
Age (year)	8.71 ± 1.9	8.53 ± 1.8	8.61 ± 1.6
Weight (Kg.)	30.1 ± 4.7	31.2 ± 4.4	31.1 ± 4.6
Height (meter)	1.36 ± 0.06	1.37 ± 0.02	1.37 ± 0.04

Table 2. Within-group pairwise comparisons for measured variables.

Item	Group (A)		Group (B)		Group (C)	
	Pre	Post	Pre	Post	Pre	Post
BBT (per minute)	10.5 ± 1.96	13.3 ± 1.49*	10.6 ± 1.89	13.7 ± 1.16*	10.4 ± 1.84	13.8 ± 0.79*
% of change	26.67%		29.25%		32.69%	
Grip Strength (Kg)	2.6 ± 0.52	3.25 ± 0.54*	2.7 ± 0.59	3.55 ± 0.55*	2.65 ± 0.58	3.6 ± 0.46*
% of change	25%		31.48%		35.85%	

Note: BBT: Box and Blocks Test, *Significant difference=p-value<0.05.

Discussion

Immature brain insult often results in movement impairment known as cerebral palsy (CP). Injury to one hemisphere generally leads to unilateral spastic CP (USCP), which first impairs hand function on the side opposite to the brain injury. Maximal grip strength is a good index of UE whole strength and even of the overall neuromuscular function, which is concerned with the ability to do activities of daily living.

Cross education is the gained strength in the contralateral limb following a unilateral training program on the corresponding limb. Age selection of this study from 7 to 10 years agrees with Hinder who mentioned that the magnitude of cross-education seems to decrease with age. So it is imperative to start this form of treatment as early as possible to gain its maximum benefits. The results of this study come in the agreement of Stoykov who stated that Unilateral priming is a type of movement-based priming induced by unilateral movement. Unilateral priming can originate from either the affected or less affected limb for stroke survivors. As the effect of MBUP appeared in groups B and C.

The results of this study come in the agreement of Sun who demonstrated the effectiveness of cross-training by applying high-strength isometric resistance exercise to non-paralytic wrist extension muscles in patients with chronic stroke.

The rehabilitative benefits of cross-education are strength gain and prevention of strength loss. Andrushko detailed the preventative effects (sparing of muscle atrophy) of unilateral limb training during a period of contralateral limb immobilization. Alternatively, results have demonstrated the presence of a strength gain in the contralateral (more-affected) limb of patient populations, following unilateral training of the less-affected limb.

The selection of the treatment duration in this study comes in agreement with Manca and Manca who stated that the cross-education effect is observed only after a 6-week intervention and the selected duration of a total of 30 sessions by given 5 sessions/week comes in the agreement of Yurdakul in their study of the effect of cross-education affects muscles of the paretic upper extremity as all patients underwent 30 sessions over 6 weeks of training.

The magnitude of contralateral strength transfer reported in different research papers ranks between 3% to 104% of initial strength. The speed, contraction type, the novelty of the strength task, the intensity used as well as training of the non-dominant or dominant limb play a significant role in the extent of strength transfer.

The finding of this study comes in the agreement of Dorrestijn who mentioned that there is moderate to strong evidence that the phenomenon of cross-education from the less affected side to the more affected side can be applied in hemiplegic patients and has an impact on the recovery of muscle strength. Also, it matched with findings of Ehrensberger who stated that there are indicators that the enhancement of strength following unilateral training of the Less affected limb also translates into motor function recovery.

The combination between the traditional occupational therapy program and motor priming in this study to achieve the maximum amount of improvement comes in agreement with Salehi Dehno who found that A combination of unilateral strength training and conventional physiotherapy seems to be a beneficial therapeutic modality for facilitating cortical excitability and some clinical outcomes in patients with hemiplegia.

In children with hemiplegia, contralateral hand dexterity diminished. Contralateral hand assessment may indicate opportunities for therapeutic intervention that improve fine motor function. So, it was essential to improve manual dexterity in children with unilateral cerebral palsy.

The improvement achieved in this study in a group (B) and group (C) can be attributed to the following two theories according to Ruddy and Carson, who stated that the adaptations that occurred could be attributed to two theories that are hypothesized that, although compatible with each other, try to explain how the neural adaptation mechanisms occur: a) the "cross-activation" model, which postulated that adaptations to unilateral exercise extend to the opposite half of the body, and b) the "bilateral access" model, which retains that the motor schema of a unilateral task is attainable by trying to reproduce the same task in the opposite half of the body.

It can also be explained by Cirer-Sastre who suggested that unilateral strength training produces adaptations in the opposite limb, depending on the characteristics of the intervention performed. The training parameters that might determine a more remarkable effect after a Cross Education program are executing 3-5 sets of 8-15 repetitions of eccentric contractions with rest times of 1-2 minutes between sets. In addition, there seems to be a direct relationship between the training load applied and the effect achieved.

It can be analyzed that there is more than one mechanism that made the achieved improvement in a group (B) and group (C) according to findings of Carroll who stated that there are two opinions of the mechanism by which force-generating capacity could increase in the untrained, opposite limb. First, unilateral strength training could cause a "spillover" of neural drive to the untrained side that induces adaptations in the control system for the opposite limb; and second, unilateral strength training could cause neuromuscular adaptations in the control system for the trained limb that can be accessed by the opposite limb.

One of the factors that may be attributed to the findings of this study was the selected age of the children enrolled in this study which gives a chance for the neural plasticity to work in addition to the effect of training as mentioned by Sun and Zehr, who hypothesized that neural plasticity is amplified, not diminished, after brain injury. More significant strength gains and neural plasticity can facilitate the involving target muscles through the preserved inter-limb neural network.

Hand function skills are severely affected in children with unilateral cerebral palsy, which affects the whole upper limb function and activities of daily living. That is not only involving the more affected side but also, the less affected side. Motor priming is one of the most promising rehabilitation techniques, but it was used commonly on the most affected side. Results of this study show the importance of applying it on the less affected side, which shows good improvement on the more affected side through the effect of cross-training.

Age factor is one of the determinants for gaining the great effect of cross-training, so it is recommended to introduce it in rehabilitation programs of children with cerebral palsy.

Conclusion

Limitations of this study were the small sample size, investigating one type of cerebral palsy, and no time for follow-up. It can be concluded that applying MBUP causes improvement in manual dexterity and handgrip strength with no statistical difference between different modes of MBUP applied in this study. For future research, it is recommended to investigate the effect of MBUP on large sample sizes and different types of cerebral palsy. Also, it is recommended to investigate the effect of MBUP on lower limbs, using other evaluation parameters and investigate the long-term effect of this technique.

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Conflict of Interests

The author has no conflict of interest to report.

Ethical Approval

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