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Combined effects of myofeedback and isokinetic training on hand function in spastic hemiplegic children

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KEYWORDS

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Abstract *Background and purpose:* Hand function is necessary for activities of daily life. Hemiplegic cerebral palsied children who constitute a large portion in our country show evidence of defective hand function. So, it is worth finding a solution for such a problem. This study was conducted to determine the combined effects of myofeedback and isokinetic training on hand function in spastic hemiplegic children.

Subjects and methods: Thirty spastic hemiplegic children from both sexes ranging in age from five to seven years represented the sample of the study. The degree of spasticity ranged from 1 to 1+ according to the Modified Ashworth Scale. The affected upper limb was free from any structural deformities; however, children demonstrated variable degrees of tightness. They were assigned randomly into two groups of equal number (A and B). Evaluation was conducted for each child of the two groups before and after six months of treatment. The strength of the triceps brachii muscle was evaluated by using the biodex isokinetic dynamometer. The range of motion of wrist extension was evaluated by using digital electro-goniometer. Both groups received a designed physical therapy program with isokinetic training for the triceps brachii muscle for 60 min, in addition group B received myofeedback training.

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Results: The post treatment results revealed significant improvement in the measured variables of both groups when comparing their pre and post treatment mean values, while significant results were observed in favor of group B when comparing the post treatment results of the two groups.

Conclusions: Myofeedback training combined with isokinetic training is an excellent supplement for improving hand function in spastic hemiplegic children.

1. Introduction

Cerebral palsy (CP) describes a group of disorders of posture and movement that occur as a result of a non-progressive disturbance in the developing fetal or infant brain. The neurological disturbance associated with CP is non-progressive. Secondary musculoskeletal impairments, pain, and physical fatigue are thought to contribute to changes in motor functions in children with CP [1]. Spastic hemiplegia accounts for more than a third of all cases of CP, and the resulting impairments to extremities affect functional independence and quality of life [2]. The most common patterns of spasticity taken by the hemiplegic child when standing, include flexion of the head toward the hemiplegic side and rotation so that the face is toward the unaffected side, the upper limb is in flexion pattern with the scapula retracted and the shoulder girdle depressed. The shoulder is adducted and internally rotated. The elbow is flexed with pronation of the forearm (in some cases supination dominates). The wrist is flexed with some ulnar deviation. The thumb and fingers are flexed and adducted. The lower limb assumes an extension pattern: The pelvis is rotated backward on the hemiplegic side and pulled upward. The hip is extended, adducted, and internally rotated. The knee is extended. The foot is planter flexed and inverted. The toes are flexed and adducted [3]. Hand skills are critical to interaction with the environment. It allows us to act on our world through contact with our own and others' bodies and through contact with objects. The child who has a disability affecting hand skills has less opportunity to take in sensory information from the environment and to experience the effect of his or her actions on the world [4]. Limitation in range may occur as a result of abnormal joint structure and muscle weakness. Any of the problems that decrease the range of motion are likely to affect the child's ability to grasp larger objects or to flatten the hand for use in stabilizing materials [5]. The triceps accounts for approximately 60% of the upper arm's muscle mass. The triceps is an extensor muscle of the elbow joint, and is an antagonist of the biceps and brachialis muscles. It also fixates the elbow joint when the forearm and the hand are used for fine movements, as when writing. It has been suggested that the long head fascicle is employed when sustained force generation is demanded, or when there is a need for a synergistic control of the shoulder and elbow or both. The lateral head is used for movements requiring occasional high-intensity force, while the medial fascicle enables more precise, low-force movements [6]. Human muscular strength is the ability of a muscle or muscle group to exert maximal force in a single voluntary effort. It has been considered fundamental to an individual's ability to perform efficient coordinated movements [7]. Sufficient strength is necessary to initiate all types of grasp patterns and to maintain these patterns during carrying. Hemiplegic children are unable to use their hands for reach, grasp and manipulation, which affect many of the activities of daily living such as dressing, eating and handwriting, crawling, walking, recovering balance and protective reaction as the upper extremities also play an important role in gross motor skills [8]. Such children with poor strength are also unable to initiate finger extension or thumb opposition pattern necessary before grasp. They show lack of flexor control to hold a grasp pattern [9]. Myofeedback is a self-regulation technique through which patients learn to voluntarily control what were once thought to be involuntary body processes. This intervention requires specialized equipment to convert physiological signals into meaningful visual and auditory cues, as well as a trained biofeedback practitioner to guide the therapy [10]. The myofeedback unit receives small amounts of electrical energy generated during muscle contraction through an electrode. It then separates or filters this electrical energy from other extraneous electrical activities on the skin and amplifies the electrical energy. The amplified activity is then converted to information that has meaning to the user [11].

2. Subjects and methods

This study was conducted at the outpatient clinic of the Faculty of Physical Therapy, Cairo University. Thirty hemiparetic children from both sexes (15 girls and 15 boys), referred from pediatric neurologist who screened the children to fit the inclusion criteria, participated in this study. Their age ranged from five to seven years, age (mean ± standard deviation) of groups (A) and (B) were 5.83 ± 0.49 and 5.93 ± 0.69 years; respectively. The degree of spasticity ranged from 1 to 1+ according to the Modified Ashworth Scale [12]. All children were able to sit and follow simple verbal commands or instructions which were included in both testing and training sessions. They were free from any associated disorders other than spasticity. The affected upper limb was free from any structural deformities; however, children demonstrated variable degrees of tightness. They had partial volitional control over the antispastic muscle groups. Children with other medical conditions that would interfere with their participation in the study as loss of vision or hearing or cardiac anomalies or musculoskeletal disorders were excluded from the study. Children were assigned randomly into two groups of equal number. Both groups A and B received exercise program and isokinetic training program, in addition group B received myofeedback training. The range of wrist extension was determined using digital electro-goniometer while the strength of the triceps brachii muscle was evaluated using the biodex isokinetic dynamometer. Evaluation was conducted for each child of the two groups before and after six months of treatment. Instructions about testing purpose and methods were provided for each child before each testing session with enough training program for all measurement procedures to make every child familiar with the devices.

3. Treatment procedures

The treatment procedures were explained and demonstrated to the children and their parents who signed the consent form prior to participation. The children were divided randomly into two groups of equal number (A and B). Group (A) received designed physical therapy exercise program and isokinetic training which were conducted three times/week for six successive months. The children performed warmup exercises before starting the training as they were asked to flex and extend their elbows freely, firstly, without using the isokinetic device then while using it performing 3 repetitions at first to become accustomed to the device. The treatment was then started with a speed level of 120/s, progressed to 180/s. Children performed three sets, each set contained eight repetitions for 3 days per week for six months. While the children were seated on a chair with adjustable height with their back erect in front of a table with adjustable height and the therapist sitting in front of them (to demonstrate the required activities), exercises to facilitate hand function including basic reaching, grasping, carrying, release and the more complex skills of in-hand manipulation and bilateral hand use were conducted. These exercises included, grasping a cube, transferring cube, removing and placing pegs, releasing cube and placing cubes. Strengthening exercises of the intrinsic muscles of the hand and mechanical resistance exercise by using biodex isokinetic dynamometer for the triceps brachii muscle were also conducted. Group (B) received myofeedback training in addition to the same designed physical therapy program and isokinetic training given to group A, the treatment program extended for 60 min for six months in the form of three sessions per week (20 min for designed physical therapy program, 20 min for isokinetic training, and 20 for myofeedback training). The treatment was explained to every child and his/her parent emphasizing its benefits, to motivate the child to achieve the most accurate and powerful contraction of the triceps muscle (elbow extensors) which results in increasing auditory and visual signals (on the monitor) of the myofeedback device. The training session was started by placing the child in sitting position in a quiet room to avoid interruption. Then positive and negative electrodes were placed at the muscle bulk after the skin was cleaned by alcohol, conducting gel was used to decrease skin impedance and adhesive tape to secure the electrodes.

4. Data analysis

Study data were analyzed using the SPSS statistical package. Tests applied to the data included the Levene test for equality of variances to determine whether equal variance between groups (A and B) could be assumed. Independent-samples *t* tests and paired *t* tests allowed for comparisons between the pre and post-treatment results between groups and within groups, respectively. Prior to data analysis, the level of significance was established at $P < 0.05$.

5. Results

The baseline results of the Levene test for equality of variances were not significant for the wrist extension measurements ($P > 0.708$) or for the peak torque of triceps brachii muscle measurements ($P > 0.447$), indicating that equal variance between groups could be assumed for both measures. Also when comparing the mean pre-intervention differences for group A and group B, an independent-samples *t* test identified no difference between group A ($X = 36.6°$, SD = 6.725°) and group B ($X = 36.60°$, SD = 5.985°) for the wrist extension measurements ($P > 0.977$) and also for the peak torque of triceps brachii muscle measurements ($P > 0.347$) between group A ($X = 5.12$ N m, SD = 0.613 N m) and group B ($X = 5.35$ N m, SD = 0.719 N m).

As shown in Table 1 and Figs. 1 and 2, a *t* test for paired samples (difference between pre-treatment and post-treatment measures) indicated that subjects included in group A improved after physical therapy and isokinetic interventions with respect to both the wrist extension measurements (mean [±SD] pre-intervention measurement of 36.6° ± 6.725° versus mean post intervention measurement of 39.33° ± 6.229°, $P < 0.015$) and the peak torque of triceps brachii muscle measurements (mean [±SD] pre-intervention measurement of 5.12 ± 0.613 N m versus mean post intervention measurement of 5.553 ± 0.622 N m, $P < 0.00$) and also a *t* test for paired samples indicated that subjects of group B improved after physical therapy, isokinetic and myofeedback interventions with respect to both the wrist extension measurements (mean [±SD] pre-intervention measurement of 36.60° ± 5.985° versus mean post intervention measurement of 46.53° ± 5.316°, $P < 0.00$) and the peak torque of triceps brachii muscle measurements (mean [±SD] pre-intervention measurement of 5.35 ± 0.719 N m versus mean post intervention measurement of 6.306 ± 0.659 N m, $P < 0.06$). The independent-samples *t* test for the post intervention measures identified a difference between group A ($X = 39.33°$, SD = 6.229°) and group B ($X = 46.53°$, SD = 5.316°) for the wrist extension measurements ($P < 0.002$) and also for the peak torque of triceps brachii muscle measurements ($P < 0.003$) between group A ($X = 5.553$ N m, SD = 0.622 N m) and group B ($X = 6.306$ N m, SD = 0.659 N m).

6. Discussion

This study was conducted to determine the effect of myofeedback training when applied with exercise program and isokinetic training for triceps brachii muscle on hand function

Table 1 Mean values of wrist extension (degrees) and peak torque of triceps brachii muscle (N m) in patient groups.

Groups		Wrist extension		Peak torque of triceps brachii muscle (N m)	
		Mean	SD	Mean	SD
Group A	Pre	36.66°	6.725	5.120	0.613
	Post	39.33°	6.229	5.553	0.622
Group B	Pre	36.60°	5.985	5.353	0.719
	post	46.53°	5.316	6.306	0.659

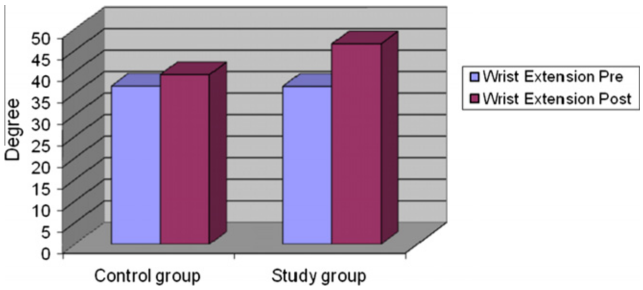

Figure 1 Mean values of wrist extension (degrees) in both groups.

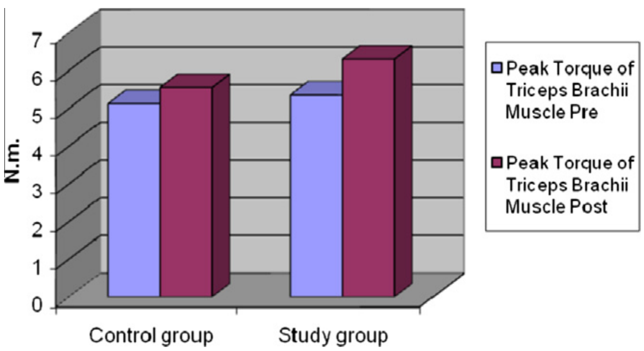

Figure 2 Mean values of peak torque of triceps brachii muscle (N m) in both groups.

in hemiparetic cerebral palsied children. Spastic hemiparetic children exhibit abnormal synergies of movement including deficits that interfere with various motor functions such as gross and fine motor skills. This comes in agreement with Lepage et al. [13] who stated that, children with cerebral palsy suffer from neurological deficits that interfere with motor function. These impairments include neuromuscular and musculoskeletal problems as spasticity, muscle contracture, in coordination, defective motor control and muscle weakness. Also, such children may show a delay in the acquisition of various motor functions such as gross and fine motor skills and this consequently, interfere with the hand function. The data collected from the children of the study sample before starting treatment revealed that hemiplegic cerebral palsied children suffer from problems of hand functions. This finding comes in agreement with Levin [14] who stated that suffering from disruption of coordination of shoulder, elbow and wrist during reaching and grasping results in functional deficits and interferes with the acquisition of all components of prehension. Choosing the age of the children of the present study to be ranging from five to seven years comes in agreement with Myres [15] and Schneck [16] who revealed that, by the age of six years; the grasp patterns become fully matured. Case-Smith [17] confirmed that, by the age ranging between five and seven years, the child can assume hand grip with regular force either to grasp or to lift the object without letting it slipping through the fingers. The pretreatment results of wrist extension were consistent with those reported by Duff et al. [8] who reported that, with mild spasticity, the range of wrist joint angle decreases. Gradual decrease in strength of wrist flexors could be attributed to the effect of weakness of the wrist extensor muscles which in turn limited functional range of motion and the flexion attitude in upper limbs and tend to overcome the normal sequence of wrist joint during grasping. The obtained pre-treatment data may be attributed to the dependence of hemiparetic child on his/her uninvolved hand to accomplish most activities of daily living (ADL), while the involved hand serve as helper in the bimanual activities, this negligence, might increase the weakness of the affected upper extremity and thereby reduces the amount of muscle tension which in turn reduces normal functional activities of motor neurons. The results of the present study after the suggested period of treatment showed significant improvement in the mean values of all measuring variables (range of wrist extension, and triceps brachii muscle tension) for both groups A and B when comparing their pre and post treatment results. High significant improvement was observed in group B when comparing its post treatment results with that of group A. The post treatment results obtained from group A clearly demonstrated the evidence of using isokinetic strengthening program of triceps brachii muscle in addition to the physical therapy program for improving hand function in hemiparetic children. The specially designed exercise program was directed to facilitate hand function through many tasks involving reach, grasp, release and other manipulative skills. These agree with Bulter [18] who confirmed that the aim of physical therapy should promote movement control and functional abilities through effective means. Also, the results obtained from group A showed significant improvement in wrist extension and the peak torque of triceps brachii muscle which may be attributed to the improvement of the muscles that exert force across the joints either at proximal or distal parts. Significant improvement of hand function abilities and movement come in agreement with Ramsey and Weber [19] who reported that proper hand function depend on effective stabilization of shoulder, elbow and wrist. The results of the present study agree with An et al. [20] who stated that, sufficient strength is necessary to initiate all types of grasp patterns and to maintain these patterns during carrying. Children with poor strength may be unable to initiate fingers extension or thumb opposition pattern necessary before grasp. They also may not have flexor control to hold a grasp pattern. This agrees with Sackly [21] who confirmed that, sufficient proximal stability control is integrated with the acquisition of motor milestone. The obtained post treatment results after six months of treatment confirm the findings of Bobath [22] who developed positions (reflex inhibiting patterns) to inhibit hypertonicity and so facilitate postural control and movement. Improvement that occurs in the post treatment results also confirm the findings of Wilton [23] who stated that, the treatment of hand dysfunction is a major focus of physical and occupational therapy for cerebral palsied children, as poor grasp and manipulation have an impact on many aspects of daily living. He added that, there is increasing evidence of the value of therapy that is directed to functional outcomes relevant to the individual. After six months of treatment, the obtained results may be attributed to the enhancement of normal co-contraction around the joints which could be achieved through proprioceptive training either sense of position or the sense of movement. Also these results come in agreement with Kluzik et al. [24] who stated that children with spastic cerebral palsy may exhibit changes in the quality of movement. These qualitative changes include improvements in biomechanical alignment during voluntary movement and postural maintenance, improved gradation of movement with increased eccentric muscular control, and improved stability at proximal body parts to allow distal body parts to move with greater control. Improvement that occurred in group B may be attributed to the combined effects of myofeedback training and isokinetic training using biodex isokinetic dynamometer for the triceps brachii muscle .This comes in agreement with Smith [25] *who* mentioned that recall and recognition schema are the basis for learning new motor skills and the child learns to integrate between the environmental conditions, task requirements, and the previously learned movements. The outcome of performance and sensory consequences help the child establish new motor skills based on an understanding of these relations. The post treatment results confirm the findings of Schmidt et al. [26] who described the motor skill learning as a set of processes associated with practice and experience, leading to permanent changes in the capacity for responding and producing skilled action. Significant improvement of hand function abilities and triceps tension, come in agreement with Frank et al. [10] who established that biofeedback is successful in improving quality of life and clinical status. The obtained results from the present study agree with Prentice [11] who recorded that there are a number of clinical conditions for which biofeedback would be useful as a therapeutic modality. The primary applications for using biofeedback include muscle reeducation, which involves regaining neuromuscular control and increasing muscle-strength; relaxation of muscle spasm or muscle guarding; and pain reduction. The post treatment results support the findings of Frank et al., [10] who established that biofeedback helps to make patients aware of the thoughts, feelings and behaviors related to their physiology. Over time, they can learn to self-regulate without feedback screens in front of them. Lewis and Byblow [27] stated that biofeedback is an intervention typically used to assist patients in recruiting paretic muscles for functional activities. High significant improvement observed in group B may be attributed to the developed proximal control. This comes in agreement with Tax [28] who stated that when strengthening exercises were applied to a certain muscle, the power was improved as well as the power of the muscles acting in the same group or same limb and have the same synergies acting on a certain movement. Improvement in performance observed in the post treatment results comes in agreement with the results of Burridge and Man [29] who concluded that to provide more functional arm movement, activation of the triceps brachii is very useful to gain elbow extension and improve hand sensation. The results obtained after six months of treatment support the findings of Dankert et al. [30] who reported that physical and occupational therapy programs should be directed toward improving fine motor skills through improving visual motor integration and grasping in preschool aged children. Improvement in the peak torque of triceps brachii muscle measurements comes in agreement with Robertson et al. [31] who reported that feedback was proportional to the response. Thus a strong muscle contraction produces a strong signal. The equipment used to provide biofeedback must be sufficiently sensitive and specific to assist the patient to learn what action on their part will change the output. This explanation comes in agreement with Hartveld et al. [32] who reported that when using biofeedback it should be provided as it should be easily recognized and used by the patient. This means that the method of feedback has to be appropriate to the patient and family. The usual methods are visual or auditory. The person needs to see the output reading of a signal, as a number, a bar graph, or on a meter. If auditory, the signal might be adapted to increase in volume or pitch if there is an increased output and decrease if the signal drops. Significant improvement in the results of group B at the end of the treatment agrees with the findings of Brooks [33] who reported that a motor program will be stored within the CNS and recalled, specifying a uniquely organized relationship among the muscles involved. He reported that task-specific motor improvement depends on the manner in which the tissue is trained due to neural adaptation. Changes in motor behavior seen during practice sessions in group B come in agreement with Shumway-Cook and Woollacott [34] who reported that performance is a complex term. Performance, whether observed during practice sessions or during retention and transfer tasks, is the result of a complex interaction among many variables, only one of which is the level of learning. Some other variables that may affect performance include fatigue, anxiety, and motivation. Thus, performance is not solely a measure of absolute learning. This is because changes in performance can reflect not only changes in learning, but changes in other variables as well.

7. Conclusion

From the obtained results of this study and according to the reports of the investigators in the fields related to the present study, it can be concluded that isokinetic training program for strengthening of the triceps brachii muscle combined with myofeedback training for the same muscle may be considered as complement to the traditional therapeutic modalities to improve hand function in spastic hemiparetic cerebral palsy children.

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