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Effectiveness of Bilateral and Unilateral Sensorimotor Exercises on Motor Performance of Students with Spastic Cerebral Palsy

Abstract

Hand function is vital for daily life activities in patients with hemiplegic cerebral palsy. This study compared the impact of bilateral and unilateral sensorimotor exercises on the motor performance of students with spastic cerebral palsy.

In this randomized clinical trial study, the studied population included all students with hemiplegic cerebral palsy. Thirty students aged 7-11 years were enrolled in the study as available samples and randomly divided equally into two 15 experimental and 15 control group individuals. The exercise program included bilateral sensory and motor exercises that were performed over eight weeks, 75 minutes per session, and thrice a week. SPSS software, independent t-test, and paired tests at a significance level of 0.05 were used for statistical data analysis.

As indicated by the results, the upper limbs' motor function had significant improvement after bilateral sensory-motor exercises ($p = 0.00$). The experimental group's mean change was from 14.00± 4.01 to 18.26± 3.32 and in the control group was from 13.00 ± 3.01 to 13.73± 2.96 respectively.

Conclusion: Combined bilateral sensory-motor exercises can significantly improve hand function in children with hemiplegic cerebral palsy.

Keywords: *bilateral sensorimotor exercises, motor ability, cerebral palsy, hemiplegic spasticity*

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Introduction

CP [1] is a group of persistent developmental-motor disorders that are non-progressive and occur in the developing fetus or the baby's brain. It falls and continues throughout life. Cerebral palsy restricts a person's movement and posture and has a significant effect on various areas of a person's life (1). The most common type of CP is hemiplegic CP, which is the 2nd most prevalent kind in babies that are premature and is the reason for thirty-six percent of CP cases. (2). The relevant motor injuries are mainly one-sided, and the upper limbs are the most common disorders following cerebral palsy. The function of the upper limb is affected and limited by these disorders (3). Compared to their normal peers, children with CP do not have adequate sensory experience, which affects movements, manual skills, and the emergence of protective reactions. These children have difficulty maintaining the joints in weight-bearing situation and reducing the injured hand's strength. (4).

Many pieces of research have shown that sensorimotor disorders exist in different degrees in children having CP, and there is a close correlation among sensory-motor elements and functional performance. In a research, Mohammadi et al. (5) examined the impact of deep and superficial sensory stimuli on hand roughness of children with Down syndrome. The results indicated that to improve the manual skills of these children and other patients with upper limb dysfunction as a result of impaired motor control, using a variety of sensory stimuli is the best.

The influence of sensory retraining to improve upper limb function in stroke patients was investigated by Azad et al. (6). The findings indicated that 4 of the 5 patients demonstrated significant improvement in upper limb skills and performance and motor defects.

Moreover, Kerry and colleagues (7) investigated the impact of deep sensation and tactile rehabilitation in 4 stroke patients in the individual disease study. The results indicated significant progress of the patients regarding sensory function, which remained even months after the treatment; however, the patients' motor improvement was not assessed. Smania et al. (8) did a study on stroke patients and investigated the impact of rehabilitating the sense of the body and the imperfections of its motor evidence. The findings demonstrated that this program results in improving the deep sensory defects, motor evidence defects, and also some functional improvement in them.

Hence, we can say that the findings of this research only consider using sensory exercises to be beneficial to better the motor function of the upper limb; however, motor exercises have an agitating effect on the nervous system, and motor poverty resulted from the sensory-motor. In children with cerebral palsy, disorders result in uncoordinated movements and weaken and disrupt their performance, and negatively affect all aspects of their development. (3). Therefore, this study considers the use of simultaneous bilateral, sensory, and motor exercises. So, this research investigates the influence of bilateral exercises on the motor performance of students with spastic CP, because of the sensory-motor defects burdened on

[1] Cerebral palsy

the mentioned children as well as functional disorders resulting from sensorimotor impairments caused by deprivation of sensory stimuli and no appropriate motor control in children, hemiplegia and its impact on their life quality.

Method

In a randomized clinical trial, among students with cerebral palsy in rehabilitation centers, 30 children, aged 7-11, having spastic hemiplegic CP were chosen according to the convenience sampling method by taking into regard the exclusion and inclusion criteria listed below. The participants were introduced to Kermanshahi hospital, affiliated with Kermanshah University of Medical Sciences, Iran. After obtaining the parents' consent, the children were divided into control and experimental groups, randomly (n=15 in each group).

In the experimental group, bilateral simultaneous sensorimotor exercises on the affected and healthy hand and in the control group, simultaneous unilateral sensorimotor exercises on the affected hand were performed in rehabilitation centers. The children (7-11 years old with IQ score of ≥ 90%) who were diagnosed with hemiplegic CP by a pediatric neurologist, were the inclusion criteria. None of the children had a prior background of intramuscular botulinum injections at least during the last three months. Further, the children fell into the groups of Manual Ability Classification System (MACS) levels 1 and 2. Its level is specified according to awareness about the actual performance of the child in daily life, and classified into five levels, where higher scores stand for weaker function. Its levels are as follows:

1. Objects are managed successfully and easily.
2. Manages a majority of objects but with some decreased speed and quality.3. The child controls the difficulties hard and requires assistance to modify or prepare activities.
3. Manages objects with difficulty – the child will require assistance to prepare and/or modify activities.
4. Handles a restricted number of easily handled objects and always needs other people's assistance.
5. The child is not able to manage objects or complete even simple actions with their hands.

The reliability for this test is 0.97 between test takers and the reliability between parents and therapists is 0.96 (9). Another criterion for entering the study was the intensity of spasticity of the fingers and elbow between 0 and 2 on the corrected Ashworth standard. This scale is utilized to specify muscle resistance to passive stretching in spasticity evaluation, and categorization levels:

0. No muscle tone enhancement
1. Little enhancement in muscle tone, indicated by a release and catch or by minimal resistance at the end of the range of motion when the influenced part(s) is moved in extension or flexion
2. marked enhancement in muscle tone indicated by an arrest in the middle range and resistance throughout the remainder of the ROM but influenced part(s) are easily moved
3. Remarkable enhancement in muscle tone makes passive movement difficulty
4. Influenced part(s) are rigid in extension or flexion.

The reliability of test-retest of this scale for the upper extremity's spasticity was reported as good (0.75) and very good (0.9) (10).

To measure motor capability, Box and block were used (11). The test consists of a wooden box consisting of 2 sections and 150 cubes placed on one side. This is a time-tested pair test, and the test is performed in such a way that the test is carried out within 1 minute and the number of displaced cubes is recorded. If the child carries more than 1 cube in his hand at a time, 1 will be registered for him, and if the cube falls out of the child's control during uncontrolled movement or is placed outside the designated area, it will be considered a cube. It can't be. The more the number of cubes moved over time, the better the child's hand function. The test-retest reliability is 0.976 for the right and 0.937 for the left and the reliability between the testers is 1.000 for the right and 0.999 for the left (12-14).

The training program included 3 sensory (deep and tactile sensory) and motor movements (15). The period of the treatment was 8 weeks (3 sessions of 75 minutes per week), from which 5 minutes of rest between the affected and healthy hand exercises and 30 minutes for sensorimotor exercises, and 75 seconds of rest between sets were considered, from 30 minutes, for sensorimotor exercises, each of the deep, tactile, and motor exercises took 10 minutes, or one-third of the duration of each session. In each session, 20 minutes were allocated to deep and superficial sense exercises and 10 minutes were related to motor exercises. 35 minutes of sensorimotor training was considered in 5 sets of 6 minutes, of which 2 minutes were superficial sense exercises, 2 minutes were deep sense exercises and 2 minutes were related to motor exercises, and the rest between sets was 75 seconds and during one session. On one hand, each exercise lasted 10 minutes and was repeated three times a week, and in the control group, only unilateral exercises were performed in rehabilitation centers. Before each exercise, the procedure was performed orally and the children were introduced to the exercises. The researchers monitored all the exercises and provided the necessary medical support if necessary.

Exercises contain the sensory section, that includes sponge exercises, play dough, walking sprinting, finger painting,

pressure games with dough, and the movement part, which involves throwing and catching activities, aiming the ball, hitting the ball, moving the ball between the two hands, hitting the ball against the wall and grabbing it, and hitting the ball to the ground.

The Shapiro-Wilk test was utilized to indicate the data's normality, then the paired T-test was utilized to compare the intragroup between the pretest and posttest tests, and the independent T-test was applied to compare the intergroup variables in the posttest. SPSS software version 22 was also used for statistical operations.

Findings

Table 1 demonstrates the subjects' demographic characteristics, such as standard deviation and mean of weight, height, and age.

Table 1: Demographic characteristics of subjects (n = 30)

Groups	**Age**		**Height**		**Weight**	
	Mean	SD	Mean	SD	Mean	**SD**
Experimental	9.93	1.48	135.08	8.23	32.82	**6.19**
Control	10.06	1.38	133.09	5.51	32.58	**5.06**

According to Table 2, to check the normality of the data, the Shapiro-Wilk test was applied.

Table 2: The Shapiro-Wilk normalization test results

	Experimental group			**control group**		
Variables	Mean	SD	P value	Mean	SD	**P value**
Motor test (pre-test)	14.00	4.01	0.532	13.00	3.01	0.154
Motor test (post-test)	18.26	3.32	0.237	13.73	2.96	0.435

Based on the results presented in Table 2, the distribution of scores for control and experimental groups had a normal distribution, and hence, parametric tests must be used to examine the independent variable's effectiveness and to evaluate the differences between external and intragroup.

Table 3: Pair t-test and significant level of mobility before and after exercise in control and experimental groups (n = 30)

Groups	**Mean**	**SD**	**t**	**df**	**p-value**
Experimental group	4.26-	2.01	-8.19	14	0.00*
control group	-6.66	1.49	1.72	14	0.106

As Table 3 shows, pre and post-capability mobility in the experimental group was significant, but this mean difference in the control group was not significant

Table 4 Results of the test comparing the average mobility of the experimental and control groups

			Levene's Test		**T**	**DF**	**p-value**
			F	p-value			
Mobility	Pre-test	Assuming equality of variances	0.619	0.438	0.720	28	0.478

	Post-test	Assuming equality of variances	0.098	0.757	3.041	28	0.00*

In the table above, the results of Levene's Test to measure the equality of variances show the equality of mobility variances in both control and experimental groups, because Levene's statistical index is not statistically significant.

The independent T-test's significant level in Table 4 indicates no significant difference between the motor ability of the two control and experimental groups pre-exercise because the significant level of the test is greater than $\alpha = 0.05$, but this difference after treatment between control and experimental groups is significant.

Discussion

The results showed that the hand mobility of students with spastic cerebral palsy improved by simultaneous bilateral exercises of superficial-deep sensation and motor exercises. A research review has shown that no similar study has been performed on bilateral sensorimotor training in cerebral palsy. Mohammadi et al. (5) examined the impact of deep and superficial sensory stimuli on the hand roughness of children with Down syndrome. They have shown that using various sensory stimuli for improving the mental health of children with Down syndrome and possibly other patients with upper extremity dysfunction is the best. Alberg et al. (16) also showed that vibratory sensory stimulation is effective in reducing spasticity and improving fine motor skills in hand manipulation tests and purdue pegboard tests in patients with diplegic cerebral palsy. Hunter et al. (17) investigated the effect of a mobilization rehabilitation program and tactile stimuli to improve upper limb function in stroke patients. The study results indicated significant progress in people's performance, and Azad et al. (6) investigated the impact of sensory retraining to improve stroke patients' upper limb function. The findings indicated that 4 of the 5 patients had significant improvement in upper limb skills and performance and also motor defects. As shown by the findings, the methods applied in the above research are different from the ones used in this research or patients' group. Nevertheless, the significant and common point of the findings of our study with the mentioned research is that applying two categories of Sensory exercises, specifically the sense receptors' stimulation proprioceptive, has better effects on the performance of patients of cerebral origin. Hence, the present findings concentrate on motor exercises, in addition to focusing on exercises and sensory, and so, offer novel information on the prevalent use and synergy of their simultaneous use on the subjects. The function of the hand and its components, and many functions of the body may be impaired by brain lesions. Using the hand demands information about touch, deep sense, coordinated movement, and vision; however, sensorimotor disorders in children with CP result in damaged functions and motor skills (18).

In theory, we can mention that sending information via the sensory receptors of the upper limbs can be enhanced with the ability and awareness to direct sensory information and integrate this multiple sensory information to create functional behavior. Therefore, more neurons are involved and the intra-network communication is improved. Though the motor cortex receives sensory data from all parts of a limb, most of the sensory data transferred to this area are received from the distal areas of the limbs. Thus, the performance deficit and sensory integration and as a result, the lack of motor evidence in these children can be improved to some degree (19). So, with comprehensive and targeted sensory stimulation and through creating motor experiences and emphasizing the simultaneous stimulation, the sensory and motor can increase the awareness of the cerebral cortex from the upper limbs (20). Based on the findings of the present research and others that have applied just one type of exercise as a training method or both training methods only in the affected hand to improve hand performance, it seems that bilateral practice, sensory and motor simultaneous, are the strengths of the present study. Therefore, it is possible to provide sensory-motor bilateral exercises in the form of a comprehensive training program, sending information via sensory receptors in the upper limbs can be enhanced, and consequently, more neurons are included, following these alterations in processing, function, and integration integrity finds and results in motor skills and improves motor skills and functions. Hence, we can mention that hemiplegic spasticity is better than this type of combination exercises, through enhancing the sensory receptors' information in the form of a comprehensive training program based on sensorimotor exercises, developing opportunities and experiences to better the hand motor function in children with cerebral palsy.

The present research had limitations such as the age of the subjects of the study to 7 to 11 years, the lack of gender segregation, the small number of subjects, and so in generalizing the findings of the present study, we must be cautious and it is better to do research similarly with larger population and long-term follow-up. Moreover, future studies should investigate the impact of this treatment in enhancing functional independence and improving ability in daily life activities.

Conclusion

The results of the research indicate that the progress of these children in mobility is indicative of the fact that they can grow if they create sensory-motor experiences with safety tips. Considering the importance of hand skills in the rehabilitation of these children and the important role of these skills in the independence and interaction of the child with the environment, it is suggested that this method be used in the rehabilitation of this group of cerebral palsy children along with other common methods.

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Footnotes

Authors' Contribution: All authors made substantial contributions to conception and design; and Akram Ahmadi Barati, made contributions to the acquisition of data, analysis, and interpretation of data; with Akram Ahmadi Barati making a substantial contribution in participating in drafting the article; Akram Ahmadi Barati, Mostafa Akbari contributing to revising it. All authors give final approval of the version to be submitted and also any revised version.

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