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Research Article

Effect of Sensory Interventions on Motor Function of Upper Limb in 8-12 Years Old Children with Spastic Hemiplegia

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ABSTRACT

Introduction: Spastic hemiplegia is one of the most common types of cerebral palsy. Pathology of the central nervous system can alter normal development of the somatosensory cortex and develop sensory deficits. These deficits can decrease upper limp motor performances and skills and reduce the tendency to use the affected upper limp, so the quality of life is impaired in these children. Therefore, in this study, the effect of sensory interventions (as part of occupational therapy services that impact on the performance of these children have been less reported) on motor function of affected upper limb children with spastic hemiplegia was investigated.

Material and Methods: In this study, three children with spastic hemiplegia participated using single-subject (A-B) design. During the baseline phase, motor function was measured by Box and Block for three sessions a week to record changes pattern. After an initial assessment, treatment phase began. In this phase, children received sensory training interventions in 12 sessions and 3 times a week. Treatment program was included two parts: tactile and proprioceptive stimulation as active, passive and playfulness. Training for each child was provided according to his/her condition and was graded so that progress, activities got more difficult with the child's progress. At the end of each week, evaluation was done to record regularly changes after the treatment phase. As follow-up, children were evaluated in three sessions, every other day. Then results of 3 phases were analyzed.

Results: In a visual analysis for each three children, slope in both treatment and baseline phases was accelerating but in treatment was more than baseline. The effect size was large in all of them. In 2SD method, the results of second and third subjects were approved. However, it was not significant for the first one.

Conclusion: Sensory interventions as training program based on sensory deficits can be effective in upper limb motor function in spastic hemiplegia.

Keywords: Sensory intervention; Motor function; Cerebral palsy; Spastic hemiplegia

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Introduction

Cerebral palsy is a neurodevelopmental disorder caused by non-progressive lesions in one or several areas of immature brain in the womb, during or shortly after birth (1). Total prevalence is equal to 2-2.5 per 1000 children born alive (2) and is one of the most common physical disorders in childhood (3). Cerebral palsy is a stable medical condition, and the disabling aspects of the disease will affect the whole part of the child's life and lead to restrictions on the activities (4). Spastic hemiplegia is one type of cerebral palsy with clinical pattern of sensory-motor involvement in one side of the body (5), in which the following injury of upper extremity in these children, made impossible the functional use. This injury in children with hemiplegia prevents them from participating in recreational activities and the educational system. Hence, it affects the level of independence in doing daily activities (6).

Hands are taken into account as a crucial tool in the performance of everyday life. So with different brain damages, their function becomes disturbed, and the weakness and inability of them can have a negative effect on the relationship between the individual and the environment. Furthermore, they are important for humans in the various aspects of cognitive, emotional, protective, balance, sensory and motor particularly. According to studies hand and arm, function are impaired in the majority of children with cerebral palsy and almost the main problem of half of these children is the same problem, that depends on multiple factors including the severity of paralysis, sensory disorder, and the degree of spasticity (2, 7, 8).

Cerebral palsy is a neurological deficiency in the central nervous system that might disrupt the natural growth of somatosensory cortex. In addition to physical defects, sensory deficits are caused as well (9). According to studies, there is a risk of sensory damage in the hemiplegic group rather than the other cerebral palsy groups and in accordance with strong evidence; this disorder is more common in lower limbs than the upper ones (10). The prevalence of upper extremity sensory damage is different in these children from 50% to 96% in at least one of the sensory modalities.

Sensory system discovers and explores the features such as material, weight, and size using manipulation. These capabilities and characteristics are based on object recognition, and eventually it leads to motor control. Upper extremity needs somatosensory information to produce coordinated, adjusted, and controlled force movement while manipulating objects. In general sensory function is essential for motor learning (11). In 2013, Borstad and his colleagues did a study to determine the relationship between sensation and movement in hemiplegic children and they came to the conclusion that children who had a better sensory function, had better motor function too (12).

In addition, in 2012, Auld and his colleagues (13) carried out a study to determine the relationship between tactile sensation with upper limb function in hemiplegic children. According to the results of this study, the researchers suggested that it is better to bring the tactile sensation assessment into the assessment list of these children and plan special therapy for the tactile sensation defects.

Due to sensory damage, these children have imperfection in their skills and motor functions and delay in motor learning. They often neglect the affected side, and this leads to progressive loss of function in their limbs, this phenomenon is called learned non-use. Because of this phenomenon sense of security has declined in these children.

Moreover, the quality of life of these people is affected eventually (10). Despite sensory disorders in children with hemiplegia and its effects on motor performance, predominantly, rehabilitation interventions focused on motor impairments in these children (14) and few studies have been performed on the impact of sensory training programs on upper limb function improvement, and there is no clear evidence of the impact of these interventions. In a study conducted by Barrett et al. (15), a multi-sensory training program was applied in six children with hemiplegia by using the opposite senses (soft/hard, flat/sharp, cold/warm). After the intervention, these children became aware of their upper limbs, and they used their affected side more often.

Considering dysfunction caused by sensory damage, the aim of this study was effect of sensory interventions on motor function of affected upper limb children with spastic hemiplegia.

Materials and methods

In the current study, was used single subject study method (single-subject) with A-B-A design. It approved by the Ethics Committee of Tehran University of Medical Sciences (IR.TUMS.REC.1394.2129). The study populations were 8-12-year-old children with spastic hemiplegia, selected by available sampling from rehabilitation centers affiliated to Tehran University of Medical Sciences. Children were recruited according to the inclusion and exclusion criteria. Inclusion criteria for this study were the child had a diagnostic criteria of hemiplegia, with IQ above 70 according to the Raven Intelligence Test, Be at level 1 or 2 in terms of Manual Ability Classification System: MACS scale, No surgery history in the upper extremity, No history of seizures, not having botulinum toxin injections in 3 months before study entry, Not having comorbid physical diseases such as myopathy, neuropathy, and other central and peripheral nervous system disorders and the spasticity should be between 0 and 2 based on modified Ashworth spasticity scale.

After identifying patients fulfilled the inclusion criteria, the way of work implementation and procedures were fully explained to parents, and their written consent was obtained. Three children were entered after parental consent. Three children were entered after parental consent. At first in the baseline phase, to record pattern changes, children were assessed for three sessions in a week every other day. Box and Block were used to evaluate the hand function of these people. After completion of the initial assessment, treatment phase began. This phase consisted of 12 therapy session (45-minute), which was held in three sessions per week. The assessment would be done again at the end of each week to record changes of the child regularly. In the follow-up stage which was started immediately after treatment, three assessment sessions were held again every other day. It should be mentioned that during the study, common treatment of children who were receiving them before starting the study, were continued and the sensory type of their treatment was under controlled and supervised by the researcher. Treatment program included two parts; tactile sensation and proprioception stimulation programs. Each of them accounted half of the session and in terms of the type of activity it was divided into three categories: active, passive, and as a play. Before performing any exercise, the method was demonstrated orally and practically, so the children were familiar with the exercises. The researcher supervised all the exercises. Exercises for each child were provided according to his condition and were graded so that the activities became more difficult as the child developed and time of the exercises was adjusted based on the severity of the injury and the child's need. At the end of each session, the therapist's observations and comments about the child's behavior during the intervention were recorded and were used in later sessions to provide better treatment.

Instruments used in this study were:

1. Demographic questionnaire was included demographic information such as age, sex, and educational level.

2. The MACS, which classify how children with cerebral palsy use their hands while handling objects in daily activities. This scale consists of five levels that are reported by the caregiver. The inter-rater reliability for this test is 0.97, and the reliability between parents and therapists is 0.96 (16). This test was used for determining the inclusion criteria.

3. Raven IQ test that measures the general intelligence (IQ) that is used for the age group of 5-65 years. This test was used for determining the inclusion criteria. Reliability of Raven colored form in children is 0.2-0.8 (17). This test was used for determining the inclusion criteria.

4. Box and Block motor test is a simple, fast, and valid test which measures bilateral gross manual dexterity. Grading is based on the number of cubes transferred over 1 minute. The more number of transferred cubes over time indicates better performance of the child. The test - retest reliability for the right hand is 0.976 and 0.937 for the left hand and inter-rater reliability for the right hand is 1.000 and 0.999 for the left hand (18).

At the end of the study, the results of the assessments in baseline phase and treatment were analyzed statistically to determine the effects of the treatment and also the results of treatment phase and follow-up were compared in order to determine the lasting effects. Visual Analysis was used to investigate the pattern changes and the rate of changes was studied through statistical analysis 2SD and D Cohen. The final results were reported based on visual and statistical analysis.

Results

As mentioned above three children were entered into the study and passed all phases. Male to female ratio was 2 to 1. An 8-year-old boy with the left hemisphere damage was our first participant. The second one was an 11-year-old girl with the involvement of the left hemisphere and the last one was a 12-year-old boy who suffered brain damage in the right hemisphere. All the three participants were at level 2 of the MACS. At first, the results for each individual were collected and presented in separate charts. Each graph consisted of points based on the time and the resulting data. The pattern of changes is presented in the figures 1-3.

The data were analyzed by visual analysis and interpretation. It is very practical, acceptable, and useful in single case studies and it is commonly used in most of these types of studies. In this analysis, the data examined in terms of the level, slope, aspect, or changes. After visual analysis to evaluate statistical results and rate of changes more accurate, the two 2SD and D Cohen analytical methods were used. In these two methods, the evaluation is done based on the mean and standard deviation (19).

The first participant: As shown in figure 1, in the first evaluation session and the third treatment session, the score was reduced but then the process of changes has increased and between sessions 6 and 9.

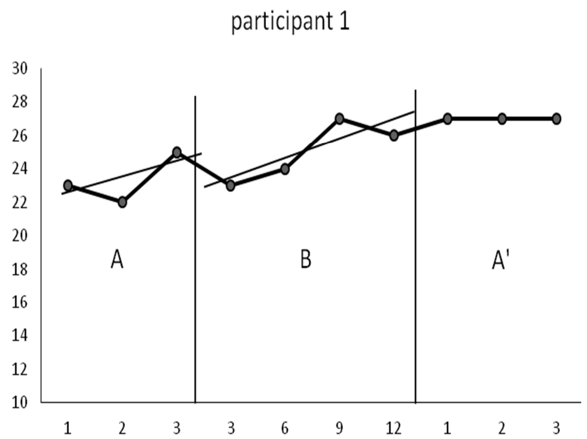

Figure 1. The pattern of changes in Box and Block motor test of the participant number 1, in terms of the number of the displaced cubes in 1 minute, A: Baseline, B: Treatment, A': Follow up

In the participant 1, maximum changes have occurred, and the graph was steep slopped. Again there been a reduction in the 12th treatment session. Despite the fluctuations occurred, the scores are rising with a gentle slope in the treatment phase. Since the slope treatment is slightly more than baseline phase, recovery has occurred. Changes in the follow-up phase remained constant.

The second participant: There was no observable change in the first session after the assessment phase started. A big change occurred after the intervals of sessions 3 and 6, and the graph has a sharp upward slope, but then a small decrease occurred in ninth session, and after that it remains a constant slope until the end of the treatment. In total, the scores were rising gradually with a very gentle slope, and according to the baseline phase, it is a sign of recovery. Changes in the follow-up phase remained constant (Figure 2).

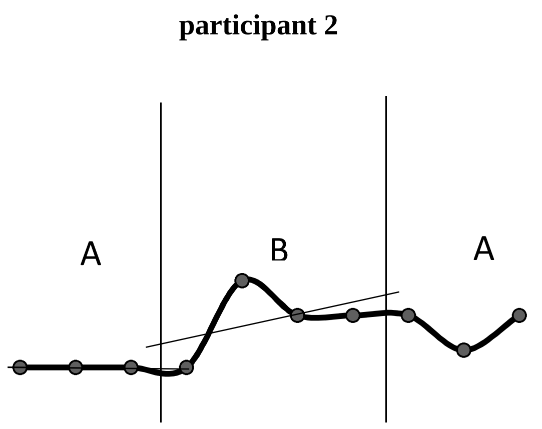

Figure 2. The pattern of changes in Box and Block motor test of the participant number 2, in terms of the number of the displaced cubes in 1 minute, A: Baseline, B: Treatment, A': Follow up

The third participant: The treatment phase was initiated increasingly by little changes, but the treatment has not changed between sessions 3 and 6, and the slope of the graph remained constant. Again the graph raised with sudden and large slope between sessions 6 and 9 and the peak of changes can be seen in the ninth treatment session, but the changes cannot be seen again between sessions 9 and 12. Recovery was occurred due to constant slope in the baseline phase and increase in the scores of the baseline phase. In the follow-up phase not only the changes preserved but also the slope has been increased to improve the performance of the individual (Figure 3).

Table 1 summarizes the statistical and visual analysis. According to the investigations and the data obtained from the table, in the first participant, the line treatment slope is ascending and greater than the baseline phase, also based on the calculation of two standard deviations with the mean of 23.33 and standard deviation 3.04, there is no significant difference between the two phases and the effect size is 0.97, which shows the great impact. Considering that there have been changes in the visual analysis and effect size, we suggested that the recovery has occurred. The treatment phase slope is greater than the baseline phase in the second and third participants and the effect size of these two participants, based on the two standard deviations method, are 1.72 and 1.86 in order which represents a big effect size. Therefore, improvement in motor function in these two participants is observed.

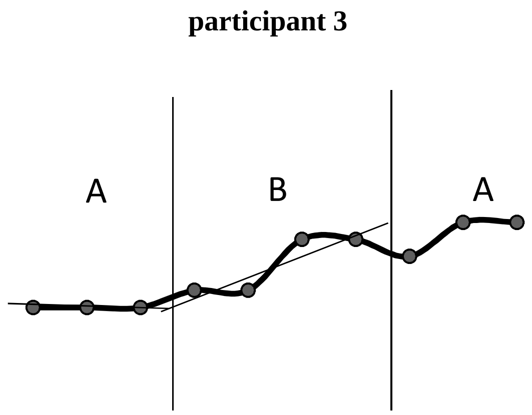

Figure 3. The pattern of changes in Box and Block motor test of the participant number 3, in terms of the number of the displaced cubes in 1 minute, A: Baseline, B: Treatment, A': Follow up

As can be observed, all three participants changed from the baseline phase, but it is more clearly for the third one.

Discussion

Spastic hemiplegia is one of the most common types of cerebral palsy which creates disturbance in motor function and development of upper extremity due to sensory injuries. Sensory disorders in children with cerebral palsy is one of the factors affecting the performance of motor function of upper limb and impairing the use of limbs in everyday life and consequently affected the growth and development of the child. Moreover, it causes learning disorders; including reading, writing, and behavioral disorders. Unfortunately, despite disabilities and their implications on the performance of children with cerebral palsy, there are limited studies on the treatment of these kinds of disorders (20). Frequent assessments in this study, show improvement in upper extremity function in all the three participants.

Table 1. The effect of the treatment on the upper extremity's motor function in all of the participants

Participant number	Average of the baseline phase	Amount 2SD +,-	Effect size D Cohen Base-treatment line	D Cohen interpretation Base-treatment line
1	23.33	3.04+, -	0.97	Big effect
2	13.00	0+, -	1.72	Big effect
3	16.00	0+, -	1.86	Big effect

The greatest improvement was achieved in the third participant. Since the sensory function affects motor function and this participant had severe sensory damage, it is assumed that due to the further improvement in sensory performance compared with other participants; improvement in motor function increased. On the other hand, constant grades and lack of fluctuation in the baseline phase, absence of receiving continuous rehabilitation interventions before the study in this subject could affect the results. In addition to these factors, motivation, interest, and the child cooperation for this test were in a good level. All of these factors could be justifications for the changes. According to the results, the first participant compared to the others had the least variations that it might be caused by a number of factors like the great fluctuations in scores in the baseline and treatment phases, receive long-term rehabilitation interventions before the study and the better motor performance of this person compared to the others.

In 2014, Auld and his colleagues (20) carried out a study to determine therapeutic interventions for tactile sensation injuries in upper extremity in children with cerebral palsy. The results showed that the children with cerebral palsy require tactile sensation interventions which integrated with the effective methods in adults with stroke and have the ability to run in children.

Auld and his colleagues (13) in 2012 conducted a study with the aim of determination the relationship between the tactile sensation and upper limb function in hemiplegic children. According to the results of this study, the researchers suggested that it is better to bring the tactile sensation assessment routinely into the assessment list of these children and plan special therapy for the tactile sensation defects.

Borstad and his colleagues performed the study in 2013. The two purposes of this study were as follows: to determine the relationship of sensation and motor learning and evaluation of the persistence of kinematic movements' improvement of the upper extremity in children with cerebral palsy in the reach and grasp activities and the ability to generalize them to the similar tasks. The results showed that targeted activities to improve the kinematic movements of upper extremity in children with cerebral palsy, leads to better learning of motor patterns, the other finding indicated a tremendous impact of sense on motor learning in children with cerebral palsy (12).

In 2003, Smania and her colleagues (21) studied the impact of sensory rehabilitation interventions on somatosensory deficits and the control of it related to stroke patients. This study indicated that sensory training programs could be effective to improve the performance of somatosensory and motor control in stroke patients with cortical and subcortical sensory injuries.

In another study that was conducted in 2003 by BYL et al., the impact of sensory and motor training on upper limb recovery and also on the level of functional independence in stroke patients (which they lived in the 6th month until the 7th year after the stroke) were evaluated. Most of the patients showed significant improvements in motor function and functional independence of upper extremity after a period of sensory and motor retraining (22).

As it could be observed the results of these studies expressed the importance of sensation and related disorders on motor function, they also showed that the improvement of motor function could be done through the provision of rehabilitation interventions, which they are aligned with the results of this study.

The somatosensory system is one of the systems that affect the performance and motor skills. In other words, sensory stimuli through sensory map of the body influence on learning the new movement patterns and reforming movements in the brain and are lead to sustainable changes in motor behaviors (12). Therefore, sensory deficits reduce the sensory feedback and have an effect on motor behaviors (23). It is probable to provide sensory stimulation in the form of a comprehensive treatment program which focuses on the sense; the information sent through sensory receptors in upper limb will be increased and involve more neurons to build-up internal connections and increases awareness of the cerebral cortex. Following these variations, dysfunction, processing, and sensory integration will improve in the brain and will lead to motor control, skill improvements and motor functions.

Hand skills are patterns which need proprioceptive, tactile sensation, and visual information for making accurate, coordinated, and fast movements. The superior hand skills are depended on how well the somatosensory works. Thus, the role of somatosensory information and feedback in many aspects of children's hand skills is essential (24). On the other hand, the brain motor cortex receives sensory input from all parts of the limb, but the most sensory inputs transferred to this area are received from the distal parts of the extremities. Therefore, it can be concluded that the sensory afferents of the environment, are connected especially with fine motor of hands and fingers through controlling the distal extremities. All of these factors could have an impact on the incidence of the results (25).

Conclusion

According to the results of this study, using sensory exercises in a training program could lead to improvement in motor performance. Although these rates of change are significant scientifically and statistically, its effectiveness in terms of clinical use requires further investigations. Furthermore, this single case study was carried out with a few participants, but it could be the starting point for other researches with more samples and generalization power. In addition, the motor performance is a term with broad meanings and includes various components that manual dexterity is one of them so that the impact of this treatment on other components of motor function could be examined through later studies.

Conflict of Interests

Authors have no conflict of interests.

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