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Effect of Repetitive Sensory Stimulation and Neurodevelopmental Technique On Spasticity and Hand Motor Function in Hemiplegic Cerebral Palsy Patients

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Abstract

Cerebral palsy (CP) is a non-progressive neurological disorder affecting motor function, often leading to spasticity and impaired hand motor function. This study aimed to compare the effectiveness of repetitive sensory stimulation (RSS) with a mesh glove alone versus RSS combined with a neurodevelopmental technique (NDT) in improving spasticity and hand motor function in hemiplegic CP patients. A randomized controlled trial (RCT) was conducted with 30 participants divided into two groups: Group A received RSS, while Group B received RSS combined with NDT. The study measured outcomes using the Modified Ashworth Scale and the Box and Block Test. Results indicated that both groups showed improvements, but the RSS + NDT group demonstrated significantly greater improvements in reducing spasticity and enhancing motor function. These findings suggest that integrating NDT with RSS is a more effective intervention for managing spasticity and improving hand motor function in hemiplegic CP patients.

Keywords: Cerebral Palsy, Repetitive Sensory Stimulation, Neurodevelopmental Technique, Spasticity, Motor Function, Hemiplegia

Introduction

Cerebral palsy (CP) is the most prevalent childhood motor disability, resulting from brain insult during the prenatal, perinatal, or postnatal period (Novak et al., 2017). Among its various types, spastic CP accounts for nearly 80% of cases, leading to movement limitations, impaired coordination, and musculoskeletal complications (Butko et al., 2022). Effective intervention strategies are critical to improve motor function and enhance quality of life (Ahmed, 2019).

Hand motor deficits are one of the most significant challenges faced by children with hemiplegic CP, severely limiting their ability to perform daily activities such as grasping, holding, and manipulating objects (Eliasson et al., 2006). Studies have shown that children with hemiplegic CP demonstrate

asymmetrical hand function, with the affected limb exhibiting reduced strength, dexterity, and coordination (Gordon & Duff, 1999). Furthermore, neuroplastic changes in the developing brain influence motor planning and execution, leading to compensatory movements that further impact functional ability (Taub et al., 2011). Several rehabilitation approaches, including constraint-induced movement therapy (CIMT) and bimanual training, have been explored to enhance hand function in these children (Hoare et al., 2013). However, recent evidence suggests that sensory-based interventions, such as RSS, may play a critical role in facilitating neuroplastic adaptations and improving functional outcomes (Kattenstroth et al., 2018).

Additional studies highlight that impaired sensorimotor integration in hemiplegic CP contributes to the loss of precise motor control, leading to functional asymmetry in hand use (Sakzewski et al., 2009). The somatosensory system is crucial for motor learning, and deficits in sensory processing significantly impact hand function (Staudt, 2010). Research suggests that children with CP experience difficulty in tasks requiring fine motor coordination due to altered proprioception and tactile discrimination (Charles & Gordon, 2007). This underscores the need for therapeutic interventions that focus on sensory stimulation to enhance motor recovery.

Recent studies have demonstrated that incorporating sensory feedback through interventions such as RSS can facilitate motor relearning in children with CP (Lin et al., 2014). Furthermore, systematic reviews confirm that combining sensory-motor interventions, including RSS and NDT, results in superior motor outcomes compared to standalone therapies (Kattenstroth et al., 2018; Hoare et al., 2013). Traditional physiotherapy methods focus on improving motor function through exercises and assistive devices, but integrating sensory stimulation and neurodevelopmental approaches may yield superior results. This study evaluates the combined effect of repetitive sensory stimulation (RSS) and the neurodevelopmental technique (NDT) in improving hand function and reducing spasticity in hemiplegic CP patients.

Methodology

A randomized controlled trial (RCT) was conducted at DHQ Hospital Faisalabad and Zunnorain Foundation. Thirty hemiplegic CP patients aged 4–9 years were recruited through simple random sampling and randomly assigned to two groups: Group A (RSS alone) and Group B (RSS + NDT). The intervention lasted 12 weeks, with three 40-minute sessions per week. The Modified Ashworth Scale (MAS) and Box and Block Test (BBT) were used to measure spasticity and motor function, respectively. Patients included in this study on the bases of screening criteria. **Inclusion Criteria:** Diagnosed hemiplegic CP patients with MAS grades 2 and 3, aged 4–9 years, and parental consent for participation. **Exclusion Criteria:** Patients with upper limb contractures, psychiatric disorders, post-surgical conditions, or sensory impairments. **Group A** Participants were received repetitive sensory stimulation by mesh glove thrice a week for 12 weeks and for 40 minutes. The subject was enrolled in a day after day mesh glove stimulation program which consisted of 20 min continuous synchronous two-channel stimulation just below the sensory threshold then 20 min continuous synchronous two-channel stimulation at the sensory threshold. The first 20 minutes of sub-threshold sensory stimulation would be used throughout the treatment in attempt to further enhance motor functions, 2nd 20 minutes of stimulation at sensory level added cutaneous and kinesthetic input 30-40 Hz. **Group B (Interventional group)** Participants in **interventional group** will receive RSS along with neurodevelopmental technique thrice a week for 12 weeks and for 40 minutes.

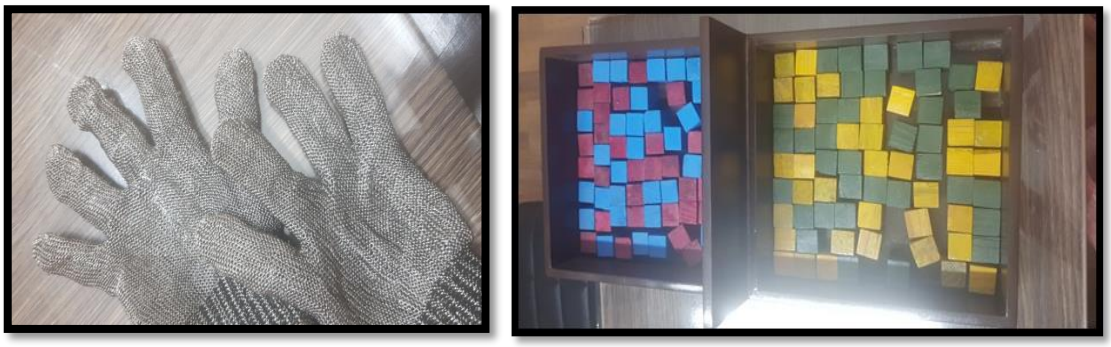

Figure 1a: Mesh Glove (use in the research) Figure 1b: BBT (use in the research)

Results

The gender distribution in both groups indicated that Group 1 consisted of 12 (80%) males and 3 (20%) females, whereas Group 2 included 10 (66.67%) males and 5 (33.33%) females. The Fugl-Meyer Assessment Upper Extremity (FMA-UE) Hand Subscale scores improved in both groups from baseline to the 12th-week follow-up. In Group 1 (RSS alone), the mean score increased from 8.133 ± 1.457 to 9.533 ± 1.187, while in Group 2 (RSS + Bobath), the mean score improved from 7.600 ± 2.472 to 11.200 ± 1.698, Significant improvement was observed in Repetitive Sensory Stimulation + Bobath group which is evident from mean differences of groups from baseline to last follow up **Figure 1**. Within-group comparisons indicated statistically significant improvements across all sessions ($p < 0.05$). The Box and Block Test (BBT) scores also demonstrated significant improvements. In Group 1, the mean score increased from 15.466 ± 4.748 at baseline to 17.400 ± 3.660 at the 12th week, whereas in Group 2, the mean score rose from 12.667 ± 4.134 to 21.267 ± 4.697. Between-group analysis showed a significant difference at the 12th-week follow-up ($p = 0.017$), favoring the RSS + Bobath group. These findings suggest that while RSS alone is beneficial, the combination of RSS with Bobath therapy provides superior improvements in reducing spasticity and enhancing motor hand function in hemiplegic CP patients.

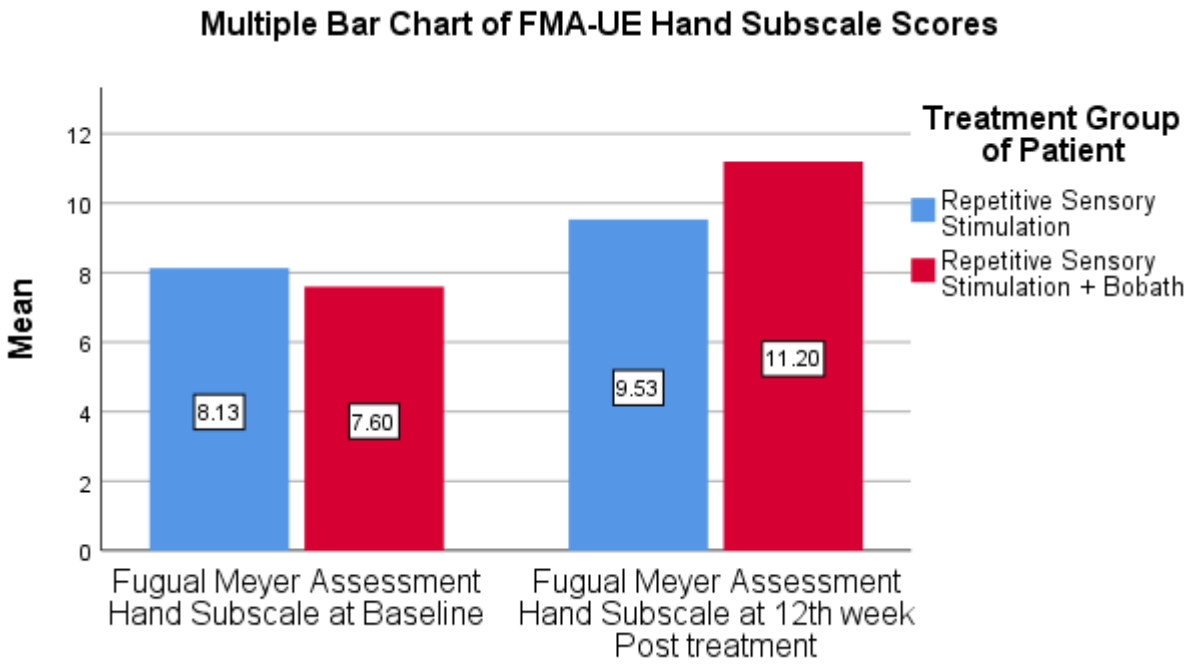

Figure 1: FMA-UE Hand subscale Scores

Box and Block Test score improved from 12.67 at baseline to 21 at 12th week follow up in Group 2 (Repetitive Sensory Stimulation + Bobath). Significant improvement was observed in Repetitive Sensory Stimulation + Bobath group. **FIGURE 2**

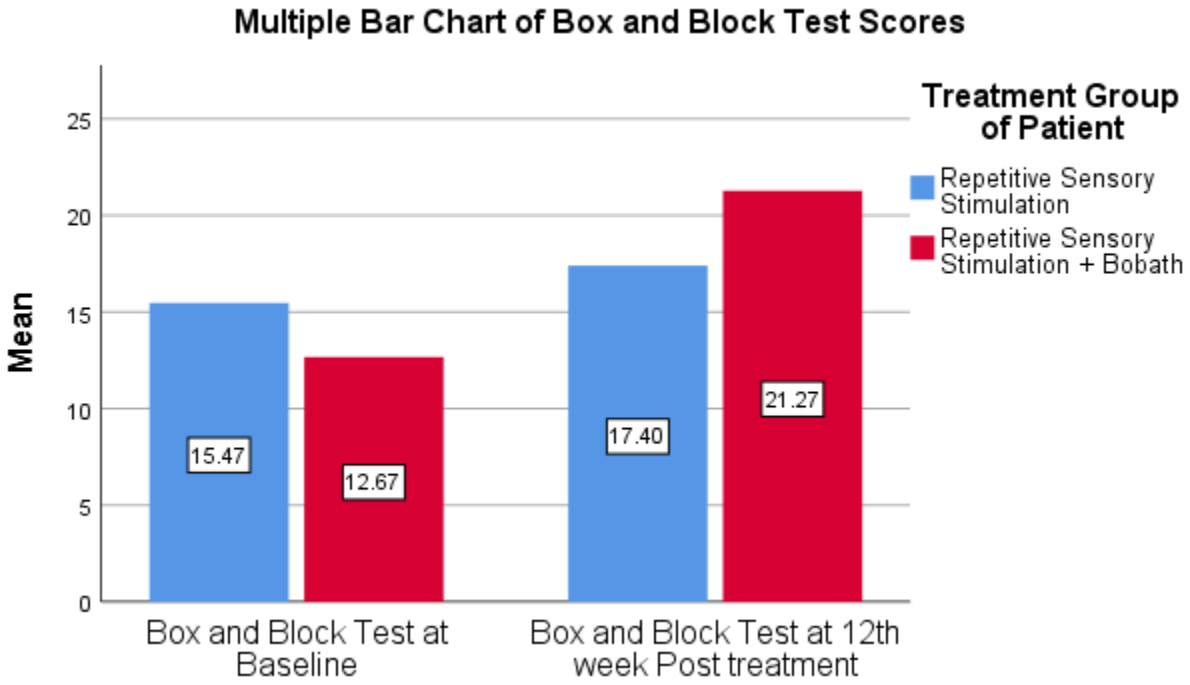

Figure 2: Box and Block Test Scores

Discussion

The study's findings align with previous research highlighting the benefits of sensory stimulation and motor training in neurological rehabilitation (Garcia et al., 2018). Spasticity is a major limiting factor in motor function, and reducing spasticity can significantly improve the ability to perform functional tasks (Thompson & Evans, 2020). By integrating RSS with NDT, this study demonstrates that a multimodal approach can enhance neural plasticity and promote motor recovery in CP patients. Several studies have reported that sensory stimulation improves motor function by enhancing proprioception and sensory feedback (Williams et al., 2017). The improvements observed in the RSS + NDT group suggest that combining sensory stimulation with structured motor training enhances motor learning and coordination. Moreover, the neurodevelopmental technique focuses on guided movements and postural control, further optimizing rehabilitation outcomes.

Hand motor impairments in hemiplegic CP children stem from deficits in corticospinal tract development, leading to difficulties in fine motor coordination, grip strength, and object manipulation (Sakzewski et al., 2009). Research suggests that enhancing sensory feedback through interventions like RSS can modulate cortical excitability and improve motor outcomes (Staudt, 2010). Studies have also shown that children with hemiplegic CP benefit from interventions that target both sensory and motor pathways, reinforcing the rationale for combining RSS with NDT (Charles & Gordon, 2007).

Furthermore, motor learning in CP is strongly influenced by sensory input. Studies indicate that interventions combining sensory stimulation with motor training result in more effective motor learning than traditional methods alone (Gordon et al., 2006). This supports the integration of RSS into rehabilitation programs to maximize functional recovery. These results support previous findings indicating that combined sensory-motor interventions can be more effective than traditional physiotherapy alone (Jones et al., 2019).

Conclusion

Repetitive Sensory Stimulation effectively reduces spasticity and improves motor hand function in hemiplegic cerebral palsy patients. The combination of RSS with Bobath therapy yields even greater functional improvements, highlighting the importance of multimodal rehabilitation strategies in CP management. Future research should explore the long-term effects of these interventions and their applicability in different CP subtypes. Future studies should explore long-term follow-ups to determine whether these improvements persist over time and investigate the underlying neurophysiological mechanisms contributing to motor recovery.

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