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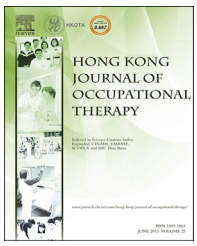

ORIGINAL ARTICLE

# Effects of Neuromuscular Electrical Stimulation on Swallowing Functions in Children with Cerebral Palsy: A Pilot Randomised Controlled Trial

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**KEYWORDS**
cerebral palsy;
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**Summary** *Objective/Background:* Oral-motor and sensory dysfunctions are primary reasons for difficulties with swallowing in children with cerebral palsy (CP). Neuromuscular electrical stimulation (NMES) has been shown to provide positive effects on the swallowing function in adult populations with various neurological disorders. However, there is a lack of studies regarding the effects of NMES in children with dysphagia. The aim of the present study was to investigate the effects of NMES and oral sensorimotor treatment (OST) by occupational therapists in children with CP and dysphagia.
*Methods:* The present study was a two-group experimental design. Participants were randomly assigned to either the experimental group ($n = 10$) or the control group ($n = 10$). The NMES group received both NMES and OST, with NMES on the pharyngeal level for 20 minutes after OST, while the control group received OST and sham–NMES only. The treatment sessions occurred twice a week for 8 weeks.
*Results:* The experimental group demonstrated a significant improvement in: lip closure while swallowing, ability to swallow food without excess loss, ability to sip liquid, ability to swallow liquid without excess loss, and ability to swallow without cough ($p < .05$).
*Conclusion:* This study demonstrated that OST and NMES facilitated swallowing functions than OST and sham–NMES in children with CP and dysphagia. Future studies need to utilise

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video fluoroscopy swallowing study for outcome measurements in a large participant group.


## Introduction

Cerebral palsy (CP) is a chronic movement disorder resulting from an abnormal development or injury in the immature brain. Children with CP demonstrate various movement disorders, including muscle weakness, abnormal postural responses, coordination failure, and slow muscle contraction, which cause functional problems, including abnormal gait (Shkedy Rabani et al., 2014), hand dysfunction (Klingels et al., 2012), and dysphagia (Arvedson, 2013; Scott, 2014). These functional dysfunctions frequently limit participation in daily activities. In children, eating is one of the most important activities of daily living, especially for development and quality of life (Kitazumi, 1998). Dysphagia causes malnutrition and negatively impacts development in patients with CP. Approximately 75% of children with CP have dysphagia, and that statistic increases to 86% in patients with quadriplegia (Morris & Klein, 1987). Children with CP have some difficulty with postural balance, postural control, and oral-motor control, which are all necessary for proper eating. Oral-motor and sensory dysfunctions are primary reasons for difficulties with swallowing in children with CP (Arvedson, 2013).

Oral sensory dysfunction causes dysphagia in children with CP (Arvedson, 2013; Arvedson, Rogers, Buck, Smart, & Msall, 1994). Children with CP have a difficulty recognizing oral sensation for localization of the input, because the sensory threshold is different from normal (Arvedson et al., 1994; Erasmus et al., 2009). Due to an abnormal oral sensory threshold, it is difficult to determine where the stimulation occurs within the oral area, including the lips, cheeks, tongue, and oral plates (Weindling, Cunningham, Glenn, Edwards, & Reeves, 2007). During the oral phase of swallowing, sensory information is essential for chewing and controlling the bolus of food. The touch and pressure receptors of the tongue and oral-cavity surfaces transmit sensory information to the brainstem and cerebral cortex to guide tongue shape and pharyngeal pressure according to bolus volume and viscosity (Ali, Cook, Laundl, Wallace, & de Carle, 1997). In a study of oral sensory dysfunction, an oral splint blocking sensory stimuli from the bolus significantly decreased pharyngeal pressure, and delayed the onset of hyoid motion and relaxation of upper oesophageal sphincter (Ali et al., 1997). The sensory stimuli thus modulate the swallowing process (Steele & Miller, 2010). Therefore, various sensory modalities have been used to treat dysphagia in CP (Arvedson, Clark, Lazarus, Schooling, & Frymark, 2010b).

Oral sensory stimulation by occupational therapists has been applied to improve the feeding ability in children with CP (Arvedson et al., 2010b). Vibration stimuli in the oral region normalise the abnormal muscle tone during feeding activities. Oral sensory stimulation, including thermal, tactile, and pressure stimuli, was also shown to reduce tongue thrust and the bite reflex disturbing the swallowing process, and to improve the chewing and swallowing functions in children with CP (Arvedson, Clark, Lazarus, Schooling, & Frymark, 2010a; Arvedson et al., 2010b; Erasmus et al., 2009; Scott, 2014). Oral-sensory-stimulation protocols have been widely used to treat dysphagia in children (Arvedson et al., 2010a). In addition, peripheral electrical stimuli have been applied as an intervention protocol to improve oropharyngeal swallowing in neurological disorders, including stroke (Carnaby-Mann & Crary, 2007), traumatic brain injury (Clark, Lazarus, Arvedson, Schooling, & Frymark, 2009), Parkinson's disease (Baijens et al., 2012), and CP (Christiaanse et al., 2011; Rice, 2012). In brain-imaging studies, electrical pharyngeal sensory stimulation induced the activation of areas in the cerebral cortex related to swallowing, such as the sensorimotor cortex (Fraser et al., 2002). Additionally, the amplitude of pharyngeal electromyography significantly increased after a 10-minute peripheral sensory stimulation with 10 Hz (Hamdy, Rothwell, Aziz, Singh, & Thompson, 1998).

In adults with neurological disorders, previous studies have demonstrated that neuromuscular electrical stimulation (NMES) improved swallowing functions. In stroke patients, NMES improved the ability to safely swallow, as measured by the functional oral intake scale (FOIS), and reduced feeding tube-dependent dysphagia in acute stroke (Kushner, Peters, Eroglu, Perless-Carroll, & Johnson-Greene, 2013). In Parkinson's disease with oropharyngeal dysphagia, NMES improved the quality of life in swallowing disorder (Heijnen, Speyer, Baijens, & Bogaardt, 2012). A few previous studies have suggested that NMES might provide positive effects on swallowing function in paediatric patients (Christiaanse et al., 2011; Rice, 2012). However, there remains a lack of studies investigating the effects of NMES on oral functions related to feeding in CP with dysphagia. Therefore, the aim of this study was to investigate the therapeutic effects of oral sensorimotor treatment (OST) and NMES on oral functions in children with CP and dysphagia.

## Methods

### Participants and study design

A total of 20 children participated voluntarily in this study. The participants were recruited in 50 outpatient settings of a university hospital by convenience sampling. All of them were diagnosed as having CP with dysphagia. The inclusion criteria were as follows: (a) diagnosed with CP by a rehabilitation doctor, (b) dysphagia confirmed by video fluoroscopy swallowing study (VFSS) or rehabilitation doctors, (c) no disorder in vision or hearing, (d) no seizure disorders,