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Rehabilitation with a combination of scalp acupuncture and exercise therapy in spastic cerebral palsy

Jing Gao[a,*,1], Luna He[a,1], Xuefeng Yu[b,**], Lina Wang[a], Haozhi Chen[a], Bin Zhao[a], Yangyun Jiang[a]

[a] Children Rehabilitation Center of Huai'an Maternal and Child Health Care Hospital, No.104 People South Road, Huai'an, 223002, China
[b] The Fourth Affiliated Hospital of Nanchang University, No. 133 South Square Road, Nanchang, 330009, China

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ABSTRACT

Purpose: To use Traditional Chinese Medicine (TCM) and Western approaches to improve gross motor function and activities of daily living (ADL) in children with spastic cerebral palsy.
Methods: Children were randomly divided into a treatment group, which received scalp acupuncture combined with exercise therapy and conventional rehabilitation training, and a control group, which received conventional rehabilitation training alone. Study subjects' gross motor function (gross motor function measure-88 [GMFM-88]) and ADL were evaluated before and after therapy.
Results: GMFM-88 and ADL scores were significantly improved in both groups after therapy, but the within group differences in post- and pre-therapy GMFM-88 and ADL scores were significantly higher in the treatment group compared to the control group.
Conclusion: Scalp acupuncture combined with exercise therapy and conventional rehabilitation training can significantly improve gross motor function and the ability to perform ADLs in children with spastic cerebral palsy compared to conventional rehabilitation training alone.

1. Introduction

Cerebral palsy is the leading cause of physical disability in children. Despite advancements in obstetric and perinatal medicine and neonatal resuscitation, the incidence of cerebral palsy has not been significantly reduced, and there is a rising trend in some regions [1,2]. There is no curative treatment for cerebral palsy; therefore, with the exception of some surgical procedures, the goal of therapy is to manage the condition using multidisciplinary rehabilitation. Currently, there are urgent unmet rehabilitation needs to improve limb function and movement in cerebral palsy and facilitate children's integration into society.

In May 2001, the World Health Organization (WHO) issued the International Classification of Functioning, Disability and Health (ICF) [3]. The ICF represents a paradigm shift with regards to health and diseases, as it transforms the concept of injury and disability into health, participation and ability, emphasizes that the purpose of treatment is not only to repair disability but also to promote functional activity, and recognizes personal and environmental factors as integral to an individual's ultimate well-being [4]. This point of view had a huge impact on rehabilitation of children with cerebral palsy, and the direction of clinical research has altered. Gradually, there has been a shift from functional and structural studies focusing on controlling muscle tension, increasing muscle strength, and improving gait to the core concept of the ICF, promoting functional activity and facilitating a child's participation in all aspects of life. Under the guidance of the ICF-Child and Youth (ICF-CY), the therapeutic objective and management of cerebral palsy has changed from treatment of injuries and disabilities to integrating elements of health, mobility, and participation in daily life. Therefore, in recent years, research on the functional well being of children with cerebral palsy has evolved.

Some evidence suggests that Traditional Chinese Medicine (TCM) combined with Western approaches has potential as a successful therapy in children with cerebral palsy [5,6]. TCM is continually developing and improving, and TCM, acupuncture, and massage, alone or in combination, have a curative effect and are safer than Western medicine. In cerebral palsy, the combination of TCM, acupuncture, massage, and rehabilitation therapy has therapeutic potential. Our clinical experience indicates that a strategy using scalp acupuncture combined with exercise therapy and conventional rehabilitation training can promote functional improvement in children with spastic

* Corresponding author.
** Corresponding author.
E-mail addresses: gaojing392@163.com (J. Gao), yxf_1958@sina.com (X. Yu).
[1] Jing Gao and Luna He contributed equally to this work.

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cerebral palsy. Therefore, the objective of the present study was to explore the feasibility of using TCM and Western medicine in a practical and effective rehabilitation program to improve gross motor function and the ability to perform activities of daily living (ADL) in children with spastic cerebral palsy. We hypothesize that rehabilitation with a combination of scalp acupuncture and exercise therapy improves gross motor function and the ability to perform ADL in these children.

2. Methods

2.1. Study design

This randomized controlled trial was conducted in Huai'an (Jiangsu Province, China estimated resident population in 2013: 4.8 million) over an 18-month period between January 2013 and December 2016. Children with cerebral palsy who received rehabilitation training were selected from the Department of Children Rehabilitation, Huaian Maternity and Child Health Care Hospital, which is affiliated with Yangzhou University School of Medicine.

2.2. Study subjects

Inclusion criteria were: 1) diagnosis of spastic cerebral palsy according to the diagnostic and classification criteria established by the Sixth National Children's Rehabilitation Conference [7]; 2) ability to understand and follow instructions provided by a therapist; 3) increased muscle tension in the lower limbs; and 4) absence of a fixed joint contracture.

Exclusion criteria were 1) an open fontanel; 2) current use of antispasmodic drugs; 3) botox injections during the 6 months before rehabilitation training; or 4) uncontrolled epilepsy despite the use of medication. The study was performed in accordance with international, national, and institutional rules governing clinical studies and patients' rights. The study protocol was approved by the Ethics Committee of the Huai'an Maternal and Child Health Care Hospital, Huai'an.

Study subjects were allocated into two groups according to the order of treatment. The treatment group received scalp acupuncture combined with exercise therapy and conventional rehabilitation training. The control group received conventional rehabilitation training alone.

2.3. Rehabilitation

All study subjects received conventional rehabilitation training 5 days per week for 3 months. This included neurodevelopmental promotion techniques, massage therapy, and physical therapy. Neurodevelopmental promotion techniques were performed for 40 min each day using the Bobath concept. This approach includes activation of key points of control (e.g., head, shoulder peak, anterior superior iliac spine and hallux toe), learning to control posture and movement, and stimulating input from proprioceptors and sensory receptors. Massage was performed for 30 min each day, and included rubbing, kneading, stretching, shaking, pushing, and percussion. Physical therapy was performed for 20 min each day, and involved brain electrobionics and neuromuscular stimulation at an intensity and frequency that was individualized for each child.

The treatment group received scalp acupuncture combined with exercise therapy, which was performed once daily 5 days per week for 3 months by a registered TCM practitioner who had seven years of experience with acupuncture. The study subject was seated and acupuncture was administered after needles (0.30 mm × 25 mm, 0.30 mm × 40 mm; Suzhou Medical Supplies Factory Co., Ltd) had undergone routine disinfection. Acupuncture was applied at scalp locations corresponding to the motor area, balance zone, foot motor sensory area, sensory area, and language area. The needle was placed at $< 30^{\circ}$ relative to the scalp, and the scalp was quickly pierced. When the needle arrived at the galea aponeurotica, the needle was positioned parallel to the scalp and inserted to a depth that was 3/4 of the body of the needle. The needle underwent a quick twist after insertion (200 rpm). During manual manipulation of the needle, study subjects were encouraged to make active movements of an affected limb, and the parents could offer assistance due to their young age. The mode of motion included anti-gravity movement of the affected limb, horizontal movement, and flexion movement of the joints. The intensity of training was adjusted based on the study subject's condition. The needle was retained for 1 h during which the child was urged to exercise consciously.

The following precautions were taken during scalp acupuncture: 1) attention was paid to prevent fainting upon acupuncture as the stimulation intensity brought about by the scalp needle was relatively strong. During the first session, the study subject was observed for 30 min for sweating, paleness, and breathing disorders or shortness of breath. If necessary, the needle was removed, the study subject was allowed to lie down, and was provided warm water to drink; 2) to avoid challenges manipulating the needles, study subjects were instructed to relax the body and mind, while the area around the needle was gently massaged and manipulated; 3) a dry cotton ball was used to prevent subcutaneous hematoma when the needle was withdrawn from the scalp.

2.4. Outcomes

Appraisal of therapeutic effects was carried out by a physician with 10 years of experience of pediatric assessments. Data were collected on the day before training began (pre-therapy) and after 3 months of training (post-therapy). Study subjects' gross motor function was evaluated with the gross motor function measure-88 (GMFM-88), which comprises 88 items grouped into 5 dimensions. Each item is scored on a scale of 0–3, where 0 indicates the activity has not been started, 1 indicates the activity is started and $< 10\%$ completed, 2 indicates 10%–90% of the activity is completed, and 3 indicates the entire activity is completed. Changes in score across each dimension reflected improvements in gross motor function [8]. Study subjects' personal hygiene, eating, cognitive communication, movement while sleeping, displacement, walking, and ability to change clothes, defecate, and use appliances was evaluated with the ADL scale, which comprises 50 items. Each item is scored on a scale of 0–2 where 2 points indicates the ability to complete the action independently but over a period of time, 1.5 points indicates that part of the action can be completed independently or the action can be completed with assistance, 1 point indicates the action is difficult to complete even with assistance, and 0 points indicates failure to complete the action [9].

2.5. Statistical analysis

Data were analyzed using SPSS version 17.0 (SPSS, China). Data are expressed as mean ± standard deviation. Within group and between group differences were evaluated using Students'*t*-test, chi-square test, and 2-way repeated measures ANOVA. Statistical significance was set at $P < 0.05$.

3. Results

This study included 52 children aged 15–75 months. Baseline demographic and clinical characteristics of the study subjects are summarized in Table 1. The treatment group included 23 children, consisting of 13 males and 10 females with a mean age of 43.13 ± 18.53 months. The control group included 29 children, consisting of 14 males and 15 females with a mean age of 40.07 ± 13.88 months. There were no significant differences in gender, age, gross motor function classification system (GMFCS) level, weight, height, or body mass index (BMI) between the two groups before therapy. GMFCS levels before and after therapy and changes within and between the treatment and control

Table 1
Baseline demographic and clinical characteristics of the study subjects.

Group	N	Gender		Age (months)	GMFCS Classification					Weight (kg)	Height (cm)	BMI
		Male	Female		I	II	III	IV	V			
Treatment	23	13	10	43.13 ± 18.53	5	5	2	8	3	15.06 ± 5.23	100.10 ± 31.25	15.57 ± 6.38
Control	29	14	15	40.07 ± 13.88	8	4	4	3	10	14.98 ± 5.12	98.24 ± 30.07	15.52 ± 6.27

BMI: body mass index; GMFCS: gross motor function classification system.

Table 2
GMFCS level before and after therapy and comparisons within and between the treatment and control groups.

Group	N	Before Therapy					After Therapy					χ^2	P
		I	II	III	IV	V	I	II	III	IV	V		
Treatment	23	5	5	2	8	3	5	6	1	9	2	0.683	0.953
Control	29	8	4	4	3	10	9	3	5	2	10	0.513	0.972
χ^2		14.093											
P		0.007											

Table 3
GMFM-88 scores before and after therapy and comparisons within and between the treatment and control groups.

Group	N	Before Therapy	After Therapy	95%CI		Change [(POST - PRE)/PRE*100]%	95%CI	
				Lower bound	Upper bound		Lower bound	Upper bound
Treatment	23	133.04 ± 59.60	150.39 ± 61.75[a]	107.89	157.01	16.84[b]	11.11	22.56
Control	29	132.45 ± 70.37	144.66 ± 71.68[a]	119.48	169.83	12.98	8.93	17.03

Data are expressed as mean ± sd.
F within group = 221.777, $P = 0.000 < 0.05$.
F between group = 0.029, $P = 0.865 > 0.05$.
F interaction = 6.710, $P = 0.013 < 0.05$.
[a] Within group comparisons, before and after treatment, $P < 0.05$.
[b] Between group comparisons, change = [after treatment-before treatment/before treatment*100]% -, $P < 0.05$.

groups are summarized in Table 2. There were no significant differences in GMFCS levels within the treatment groups, but there was a significant difference between the two groups after therapy (Table 2). GMFM-88 scores before and after therapy and changes within and between the treatment and control groups are summarized in Table 3. There were no significant differences in GMFM-88 scores between the two groups before therapy. GMFM-88 scores were significantly improved in both groups after therapy (control: 144.66 ± 71.68 vs. 132.45 ± 70.37; treatment: 150.39 ± 61.75 vs. 133.04 ± 59.60; $P < 0.05$), but the percent change in GMFM-88 score with treatment was significantly higher in the treatment group compared to the control group (16.84% vs. 12.98%; $P < 0.05$). ANOVA showed that changes in GMFM-88 score with treatment were statistically significant (F within group = 221.777, $P < 0.05$), there were no significant differences in GMFM-88 scores between the two groups (F between group = 0.029, $P > 0.05$), there was an interaction between treatment and GMFM-88 scores (F interaction = 6.710, $P < 0.05$).

ADL scores before and after therapy and changes within and between the treatment and control groups are summarized in Table 4. There were no significant differences in ADL scores between the two groups before therapy. ADL scores were significantly improved in both groups after therapy (control: 31.35 ± 19.97 vs. 27.66 ± 19.35; treatment: 34.76 ± 16.80 vs. 29.26 ± 15.80; $P < 0.05$), but the percent change in ADL score with treatment was significantly higher in the treatment group compared to the control group (26.55% vs. 25.59%; $P < 0.05$). ANOVA showed that changes in ADL score with treatment were statistically significant (F within group = 226.421, $P < 0.05$), there were no significant differences in ADL scores between the two groups (F between group = 0.243, $P > 0.05$), there was an interaction between treatment and ADL scores (F interaction = 8.787, $P < 0.05$).

4. Discussion

This retrospective study investigated the feasibility of using scalp acupuncture combined with exercise therapy and conventional rehabilitation training (treatment group) vs. conventional rehabilitation training alone (control group) as a practical and effective therapy to improve gross motor function and the ability to perform ADLs in 52 children with spastic cerebral palsy. Findings showed that GMFM-88 and ADL scores were significantly improved in both groups after therapy, but the within group differences in post- and pre-therapy GMFM-88 and ADL scores were significantly higher in the treatment group compared to the control group. These data suggest that both approaches provide effective rehabilitation in children with spastic cerebral palsy, but scalp acupuncture combined with exercise therapy and conventional rehabilitation training provided a more pronounced improvement in gross motor function and ability to perform ADLs.

The prevalence of cerebral palsy is estimated at 2.0 to 3.5 per 1000 live births. Cerebral palsy can be caused by multiple factors, including intrauterine distress, premature birth, kernicterus, asphyxiation, breech presentation, inheritance (twins), and intracranial hemorrhage. Brain lesions are mainly caused by hypoxia or kernicterus, or brain malformation [2,10–12]. If intervention is not timely, or an inappropriate rehabilitation program is implemented, subjects with cerebral palsy may adopt an immobilized abnormal posture and movement pattern and secondary musculoskeletal problems that could adversely affect their quality of life and ability to integrate into society. With medical advances, there are an increasing number of strategies that can be used to improve movement disorders in cerebral palsy. However, as the

Table 4
ADL scores before and after therapy and comparisons within and between the treatment and control groups.

Group	N	Before Therapy	After Therapy	95%CI		Change [(POST - PRE)/PRE*100]%	95%CI	
				Lower bound	Upper bound		Lower bound	Upper bound
Treatment	23	29.26 ± 15.80	34.76 ± 16.80[a]	20.99	34.32	26.55	17.31	35.78
Control	29	27.66 ± 19.35	31.35 ± 19.97[a]	24.39	38.30	25.59	14.98	36.20

Data are expressed as mean ± sd.
F within group = 226.421, $P = 0.000 < 0.05$.
F between group = 0.243, $P = 0.624 > 0.05$.
F interaction = 8.787, $P = 0.005 < 0.05$.
[b]Between group comparisons change = [after treatment-before treatment/before treatment*100]%, $P < 0.05$.
[a] Within group comparisons, before and after treatment, $P < 0.05$.

disease is inherently complex and often refractory to treatment, management must be individualized. Consequently, integrated rehabilitation programs involving a combination of TCM and Western medicine have gained popularity.

According to TCM, cerebral palsy belongs to the categories “five kinds of retardation” and “five kinds of flaccidity” [13], which are mainly caused by congenital defects, deficiencies in the liver and kidney, blood stasis, or insufficient nutrition. Spastic cerebral palsy is characterized by damage to the motor cortex and pyramidal tracts, as evidenced by increased tension in affected limb muscles and hyperactive myotatic reflexes. The upper limbs are usually adducted and pronated, and the lower limbs are adducted and display internal rotation, pronation or pronation and abnormal anteflexion. Spastic cerebral palsy manifests as standing and walking on tip toe and a “scissors” gait, which are characteristic of the category “five kinds of flaccidity”.

In TCM, the brain is considered an important organ for regulating qi, blood, the viscera, and the vital essence of the entire body. The head is the centre of shrewdness. The essence of the viscera converges at the head, and all meridians and collaterals meet in the brain. Thus, the head is the basis for treatment of cerebral palsy. Combining scalp acupuncture and exercise therapy is a novel approach to acupuncture based on the theory of traditional acupuncture. It combines the meridian theory of Chinese medicine with modern concepts of functional location in the cerebral cortex, and has been perfected through an abundance of medical practice. In TCM, the head serves as the confluence of all the yang channels of the body. Therefore, selection of appropriate acupuncture points in the head can regulate and invigorate various yang channels and qi and blood flow, open the orifices, nourish the brain, and promote intellectual growth. In spastic cerebral palsy, a combination of scalp acupuncture and exercise therapy allows children to acquire qi and participate in conscious joint training. A variety of nerve impulses under different external stimuli are transported to the cortex of the brain, which may improve the sensitivity of the cerebral cortex, increase cerebral blood flow, improve the metabolism of brain cells, activate functional networks in the cerebral cortex, evoke compensatory mechanisms in the body and brain, and promote the repair of brain tissue. This can improve neural function, promote gross motor function, and enhance a child's ability to perform ADLs [14]. From the perspective of TCM, this rehabilitation embodies “keeping spirit”, and a child's potential can be fully mobilized.

Modern research [15] has shown that scalp acupuncture in conjunction with exercise therapy is particularly effective for treating diseases of the central nervous system. It could become an effective approach to rehabilitation in cerebral palsy as it is relatively safe for children, convenient, and has been associated with good outcomes. Currently, acupuncture programs taught in China include the international standardized scalp acupuncture program, Jiao's scalp acupuncture, Jin's three-needle system, and Zhu's scalp acupuncture. Previous studies show that scalp acupuncture combined with exercise therapy is effective in rehabilitation in adults. In patients that had experienced an acute cerebral infarction [16] scalp acupuncture combined with exercise therapy promoted better recovery of impaired nerve and limb function than body acupuncture. In patients that had experienced an ischemic stroke [17], limb motor function and ability to perform ADLs was significantly better following 30 days of scalp acupuncture combined with exercise therapy compared to the control group. Reports on the use of scalp acupuncture combined with exercise therapy in the treatment of children with cerebral palsy are sparse. Our clinical experience with a few cases demonstrated that scalp acupuncture combined with exercise therapy and conventional rehabilitation training could reduce the muscle tone of children with spastic cerebral palsy and improve joint mobility [18]. Our previous study [19] revealed that scalp acupuncture exerts a beneficial effect on children by reducing muscle tension and improving joint mobility, which ameliorated gross motor function and enhanced their ability to perform ADLs. Jin et al. [20] used the international standardized scalp-acupuncture program combined with exercise therapy in 60 cases of spastic cerebral palsy. After three months, the treatment group showed a significant improvement on the Ashworth Scale for grading spasticity compared to the control group. Ji et al. [21] used Jiao's scalp acupuncture in children with spastic cerebral palsy and noted a decrease in muscle tone, relief of muscle spasms, and an improvement in gross motor function.

Physiological mechanisms underlying the use of scalp acupuncture in cerebral palsy have been investigated in animal experiments conducted by our research team [22,23]. Findings showed [24,25] that electroacupuncture stimulation to motor areas of the scalp had a protective effect against cerebral hypoxic-ischemic brain damage in rats with cerebral palsy. Furthermore, the PI3K/Akt signaling pathway involved in the pathophysiological process of brain damage in rats with cerebral palsy. Following electroacupuncture, the PI3K/Akt signaling pathway played an important role in reducing apoptosis of hippocampal neurons and the recovery of locomotion.

The present study was associated with several limitations. First, rehabilitation training was investigated in a small case series. Second, only gross motor function and ADL in children with spastic cerebral palsy were studied. Third, this study was based on a convenience sample of children with cerebral palsy who received rehabilitation training at our institution between January 2013 and December 2016. Therefore, an *a priori sample* size calculation was not performed. A post-hoc analysis revealed that the power is 7.9%, suggesting that the study was underpowered (ie < 80%). Future research should include larger studies assessing objective indicators of motor function in children with various types of cerebral palsy.

In conclusion, findings from the present study suggest that scalp acupuncture combined with exercise therapy and conventional rehabilitation training can significantly improve gross motor function and the ability to perform ADLs in children with spastic cerebral palsy compared to conventional rehabilitation training alone. These data provide the basis for exploring a practical, feasible and effective cerebral palsy rehabilitation program that integrates TCM and Western medicine.

Conflicts of interest

None.

Data availability statement

The datasets generated and analyzed during the present study are available from the corresponding author on reasonable request.

Author contributions

JG and LNH designed most of the subject, data analysis and wrote the manuscript; XFY guided the subject; LNW and BZ performed acupuncture on children with CP; BZ evaluated the curative effect of the children; YYJ collected the data. All of the authors have read and approved the manuscript.

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