ISSN 2307-8960 (online)

World Journal of *Clinical Cases*

World J Clin Cases 2020 December 26; 8(24): 6213-6545

Published by Baishideng Publishing Group Inc

World Journal of Clinical Cases

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ABOUT COVER

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The *WJCC* is now indexed in Science Citation Index Expanded (also known as SciSearch®), Journal Citation Reports/Science Edition, PubMed, and PubMed Central. The 2020 Edition of Journal Citation Reports® cites the 2019 impact factor (IF) for *WJCC* as 1.013; IF without journal self cites: 0.991; Ranking: 120 among 165 journals in medicine, general and internal; and Quartile category: Q3.

RESPONSIBLE EDITORS FOR THIS ISSUE

NAME OF JOURNAL
World Journal of Clinical Cases

ISSN
ISSN 2307-8960 (online)

LAUNCH DATE
April 16, 2013

FREQUENCY
Semimonthly

EDITORS-IN-CHIEF
Dennis A Bloomfield, Sandro Vento, Bao-gan Peng

EDITORIAL BOARD MEMBERS
https://www.wjgnet.com/2307-8960/editorialboard.htm

PUBLICATION DATE
December 26, 2020

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World J Clin Cases 2020 December 26; 8(24): 6282-6295

DOI: 10.12998/wjcc.v8.i24.6282

ISSN 2307-8960 (online)

ORIGINAL ARTICLE

Clinical Trials Study

Effects of different acupuncture methods combined with routine rehabilitation on gait of stroke patients

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Author contributions: All authors made significant contributions to the research in this study, and approved the submitted version of the manuscript and the authorship list; Zhen XC and Lou YT contributed to data acquisition, interpretation, and analysis; Zhen XC contributed to writing of the manuscript; Lou YT contributed to critical revision of the manuscript for important intellectual content; Yang JJ and Ma YF contributed to conception and design of the study, and critical revision of the manuscript for important intellectual content; Yang JJ contributed to final approval of the submitted manuscript.

Supported by Research Scholarship of the Educational Department of Liaoning Province, No. LJC2019ST04.

Institutional review board statement: The study was reviewed and approved by the Liaoning Thrombus Treatment Center of Integrated Chinese and Western Medicine.

Clinical trial registration statement:

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Abstract

BACKGROUND

Stroke refers to a group of cerebrovascular diseases associated with organic brain injury. It is characterized by the sudden and rapid onset of focal or diffuse dysfunction. In recent years, in addition to routine treatment, Chinese medicine acupuncture has been administered to patients with hemiplegia, and it can be considered a new treatment for rehabilitation.

AIM

To investigate the effects of eye acupuncture needle retention and body acupuncture combined with routine rehabilitation on gait performance and plantar pressure in patients recovering from stroke.

METHODS

Thirty-two stroke patients who met the inclusion criteria were randomly divided into an experimental group and a control group, with 16 patients in each group. Both groups underwent routine rehabilitation. The experimental group was treated by eye acupuncture needle retention, and the control group was treated by body acupuncture. Before and after 4 wk of treatment, both groups underwent kinematic and plantar pressure synchronous tests to assess gait performance.

RESULTS

The step length, gait speed, step frequency, joint angles of the lower limbs, and ground reaction force impulse in the anterior region of the affected foot in both groups significantly increased from before to after treatment ($P < 0.05$); the center

This registration policy applies to prospective, randomized, controlled trials only.

Informed consent statement: All study participants, or their legal guardian, provided informed written consent prior to study enrollment.

Conflict-of-interest statement: The authors declare that they have no conflict of interest to disclose.

Data sharing statement: No additional data are available.

CONSORT 2010 statement: The authors have read the CONSORT 2010 statement, and the manuscript was prepared and revised according to the CONSORT 2010 statement.

Manuscript source: Unsolicited manuscript

Specialty type: Medicine, research and experimental

Country/Territory of origin: China

Peer-review report's scientific quality classification

Grade A (Excellent): 0
Grade B (Very good): B, B
Grade C (Good): C
Grade D (Fair): 0
Grade E (Poor): 0

Received: September 1, 2020
Peer-review started: September 1, 2020
First decision: September 13, 2020
Revised: September 26, 2020

of mass displacement, peak pressure values, and impulse in the anterior region of the healthy foot and posterior regions of both the affected and healthy feet significantly decreased from before to after treatment ($P < 0.05$). The patients in the experimental group showed greater improvement in the following parameters than the control group: Step length, gait speed, step frequency, lower extremity joint angles, center of gravity displacement, and peak pressure values and impulse in the anterior and posterior regions of both the affected and healthy feet ($P < 0.05$).

CONCLUSION

Eye acupuncture needle retention and body acupuncture combined with routine rehabilitation can effectively improve the gait performance of patients recovering from stroke. Between these two treatments, eye acupuncture needle retention combined with routine treatment is better than body acupuncture, and it can be considered a practical and effective clinical treatment.

Key Words: Stroke; Eye acupuncture; Body acupuncture; Gait performance; Spasm; Patients

Core Tip: Chinese medicine acupuncture has been administered to patients with hemiplegia, and it can be considered a new treatment for rehabilitation. Acupuncture for hemiplegia is broadly divided into eye acupuncture and conventional body acupuncture. However, the independent effects of eye acupuncture and body acupuncture on the gait performance of patients with stroke are still unclear. In the present study we report that eye acupuncture needle retention and body acupuncture combined with routine rehabilitation can effectively improve the gait performance of patients recovering from stroke.

Citation: Lou YT, Yang JJ, Ma YF, Zhen XC. Effects of different acupuncture methods combined with routine rehabilitation on gait of stroke patients. *World J Clin Cases* 2020; 8(24): 6282-6295
URL: https://www.wjgnet.com/2307-8960/full/v8/i24/6282.htm
DOI: https://dx.doi.org/10.12998/wjcc.v8.i24.6282

INTRODUCTION

Stroke refers to a group of cerebrovascular diseases associated with organic brain injury. It is characterized by the sudden and rapid onset of focal or diffuse dysfunction[1-2]. Patients have varying degrees of dysfunction or deficiency after stroke[3]. The disability rate in patients with stroke is as high as 75%[4], and stroke has become the third leading cause of death in the world[5]. One of the main clinical symptoms of stroke is hemiplegia, and gait abnormalities constitute the main dysfunction of stroke patients, which seriously affects their quality of life. Primarily, patients exhibit temporal and spatial asymmetry during gait[6]. An asymmetric gait pattern can increase individuals' energy expenditure, their risk of falls, and the loss of bone density[7]. Therefore, improving walking ability (achieving good gait performance) is an important goal for stroke rehabilitation[8-9]. A large number of clinical studies have shown that rehabilitation is an effective method to improve the physical function of patients with stroke, and it is also the most widely used modern treatment for hemiplegia[10]. The treatment goal for patients with hemiplegia is mainly to help restore their physical functions, including speech function, nerve function, balance function, and gait performance. At present, routine walking training is mainly based on physical therapy, including the Bobath approach, task-oriented training techniques, and body weight support treadmill training. However, for most patients with stroke, routine gait training does not effectively restore a normal gait pattern[11].

In recent years, in addition to routine treatment, Chinese medicine acupuncture has been administered to patients with hemiplegia, and it can be considered a new

Accepted: October 20, 2020
Article in press: October 20, 2020
Published online: December 26, 2020

P-Reviewer: Chen Y, Currie IS, Ward J
S-Editor: Gao CC
L-Editor: Wang TQ
P-Editor: Zhang YL

treatment for rehabilitation. Acupuncture for hemiplegia is broadly divided into eye acupuncture and conventional body acupuncture. Studies have shown that acupuncture reduces limb shaking[12], controls tremor[13], changes the human antioxidant enzyme system[14], and increases dopamine levels[15]. Eye acupuncture is a micro-needling therapy that was developed by Professor Peng Jingshan at the Liaoning University of Traditional Chinese Medicine. It is based on the Zang-Fu (viscera) theory, meridians used in traditional Chinese medicine, and the relationships between the eyes, five Zang organs, six Fu organs, and fourteen meridians. The nature and location of the disease are determined on the basis of the changes in the shape and color of blood vessels on the conjunctiva of the eye, and differential acupuncture at specific points around the eyes is used to treat systemic diseases[16]. Acupuncture is easy to perform, has significant effects, is not associated with obvious adverse reactions, and is easily tolerated by patients. It has gradually become a widely used therapy for stroke treatment[17]. Studies have shown that eye acupuncture with needle retention can significantly improve the neurological and balance functions of patients with stroke[18] and significantly improve aspects related to gait performance, such as muscle strength, balance and coordination, spasm, central control, and sensory function[19].

Regarding body acupuncture, to treat diseases, filiform needles are used as acupuncture tools, and the meridians and acupoints of the patient's limbs are stimulated by different operating techniques to dredge meridians, reconcile Qi and blood, and regulate the functions of Zang-Fu[20]. Body acupuncture can effectively improve the blood supply to the brain[21], inhibit neuronal apoptosis[22], and improve cerebral blood flow[23]. It has a significant effect in patients with stroke and hemiplegia during rehabilitation and patients with cognitive impairment.

Given the above findings, when acupuncture is combined with routine treatments during rehabilitation, what are the independent effects of eye acupuncture and body acupuncture on the gait performance of patients with stroke? This question remains unanswered. In particular, there are no studies in the literature on the effect of eye acupuncture needle retention combined with routine treatment on the functional recovery of lower limbs. By conducting a clinical trial study, we aimed to investigate the effects of eye acupuncture needle retention and body acupuncture combined with routine rehabilitation therapy on the gait performance of stroke patients, and we used lower limb kinematics and plantar pressure as the main outcomes. This study will provide a theoretical basis and practical guidelines for the rehabilitation of gait performance in stroke patients.

MATERIALS AND METHODS

Participants

Forty-two stroke patients who were admitted to the Liaoning Thrombus Treatment Center of Integrated Chinese and Western Medicine from December 2017 to May 2018 were selected. The patients were informed of the study details, and written consent was obtained. Ten of the 42 patients were lost to follow-up (2 patients experienced stroke recurrence, and 8 were unable to continue due to being discharged from the hospital), and the remaining 32 patients were divided into an experimental group and a control group, with 16 patients in each group; the patients were aged 45 to 65 years and had been confirmed to have had a stroke by a computed tomography (CT) or magnetic resonance imaging (MRI) examination of the skull. We used a simple random number table to randomly divide the selected patients into an experimental group and a control group.

Inclusion criteria: The patients who met the following criteria and were first diagnosed with initial ischaemic stroke according to the "Chinese Guidelines for the Prevention and Treatment of Cerebrovascular Diseases (2010)"[24] proposed by the Cerebrovascular Division of Neurology Branch in Chinese Medical Association were included: (1) First onset and unilateral lesions; (2) Disease course of 5 wk to 3 mo (recovery period); (3) 45-65 years old, either sex (for women, having reached menopause was required); (4) Conscious and able to cooperate during the examination; (5) Brunnstrom stage III to IV, and a Holden score of 3 or higher for gait performance; and (6) Willing to participate in the study and sign the informed consent form.

Exclusion criteria: Patients who met any of the following criteria were excluded: (1) Used drugs that affect muscle strength and muscular tension; (2) Had Alzheimer's

disease or severe cognitive dysfunction; (3) Had complications that limit movements, such as severe emphysema and myocardial infarction; (4) Had osteoarticular diseases or a deformity in any of the lower limb joints; (5) Had severe visuospatial disorders (*e.g.*, hemianopsia, unilateral neglect, and dumping syndrome); and (6) Had any contraindications to eye acupuncture, such as infection, bleeding, mental disorders, or the use of anticoagulants.

Treatment

Routine rehabilitation therapy was provided for both groups. In addition, the experimental group was treated by eye acupuncture needle retention, while the control group was treated by body acupuncture. The specific treatments were as follows:

Routine rehabilitation plan: (1) The basic clinical medications that were prescribed were selected on the basis of the "Chinese Guidelines for the Prevention and Treatment of Cerebrovascular Diseases (2010)"[24]. Aspirin enteric-coated tablets were given for 4 wk (Bayer Healthcare Company, National Medicine Permission Number H20120236, 100 mg × 30 tablets), once a day and once a piece; (2) The exercise therapy prescribed included passive exercises for the joints of the affected limbs, sit-up training, standing training, standing balance training, kneeling position training, ascending and descending stairs training, and walking training; there was a focus on the relaxation training of the spastic muscle group. In addition, non-spasmodic muscle groups were exercised following anti-spasmodic techniques to enhance their strength. Exercise therapy was performed for 30 min a day from Monday to Friday every week; Saturday and Sunday were rest days, and the course of treatment was 4 wk; (3) The occupational therapy prescribed included training of the shoulder, elbow, and wrist joints; forearm pronation or supination training; fine finger movements; training to improve the coordination and balance functions of the upper limbs; and training for daily activities such as bed and chair transfer, dressing, and eating. Occupational therapy was performed 30 min a day from Monday to Friday every week; Saturday and Sunday were rest days, and the course of treatment was 4 wk; and (4) Regarding the physical treatments prescribed, neuromuscular electrical stimulation treatment was performed for 20 min a day from Monday to Friday every week; Saturday and Sunday were rest days, and the course of treatment was 4 wk.

All the above treatments were performed by two therapists at the same time. According to the double-blind principle, human biases were eliminated as much as possible.

Experimental group: During eye acupuncture needle retention, exercise therapy was performed (the exercise therapy scheme was the same as that performed by the control group), and then the remaining portion of routine rehabilitation was performed. The division and acupoint locations for eye acupuncture were selected on the basis of the "Chinese Eye Acupuncture" standards[25]. The major acupuncture points were located in the bilateral lower energizer, and the adjunct points were located in the hepatic and renal regions (Figure 1). After the skin and needles were disinfected with alcohol, the external orbital horizontal needling method was used to pierce the skin 5-7 mm from the starting point to the end point of the corresponding acupoint area, which was located 2 mm away from the inner edge of the orbit; the needle handle was gently scraped 10 times at each acupoint area to acquire Qi. During the needle retention period, exercise therapy was performed for 30 min, and the needles were removed after the exercise therapy. The treatment was performed every day from Monday to Friday every week, and it was not performed on Saturday and Sunday. The course of treatment was 4 wk.

Control group: In addition to routine rehabilitation, body acupuncture was performed. The locations of the body acupuncture points used were as follows: The Juxian (GB29), Ququan (LR8), Yinbao (LR9), Zusanli (ST36), Fenglong (St40), Xuanzhong (GB39), and Taichong (LR3) acupoints of the lower limbs on the affected side (Figure 2)[26]. After piercing, a moderate reinforcing-reducing technique was used to acquire Qi; the needle was retained for 30 min, and needle manipulation was performed every 5 min. Treatments were conducted from Monday to Friday every week; they were not performed on Saturday or Sunday, and the course of treatment was 4 wk. Exercise therapy was performed immediately after acupuncture (the exercise therapy protocol was the same as that performed by the experimental group).

Figure 1 Eye acupuncture point location.

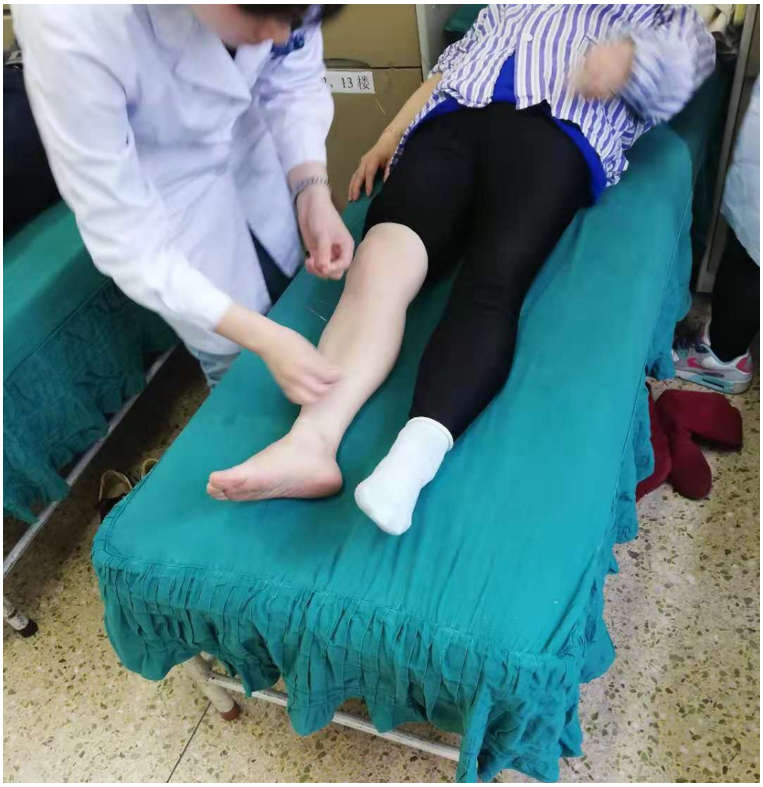

Figure 2 Body acupuncture point location.

Experimental methods

Instruments: The following materials were used: (1) Cotton ball covered with 75% alcohol; No. 30 1.5-inch stainless steel alloy filiform needles; No. 32 0.5-inch stainless steel alloy filiform needles (Hwato, Suzhou, China); (2) Routine rehabilitation equipment, such as a treatment couch, frosted boards, rollers, and neuromuscular electrical stimulators; (3) Two high-speed cameras (Troubleshooter 250CE, 250 HZ) and 3D PEAK calibration frames (PEAK, United States, 28 Marker points) for motion capture; and (4) A plantar pressure plate test system (Footscan, Belgium, 500 Hz) measuring 2 m long for collecting plantar pressure distribution data.

Experimental protocol: The cameras were placed on the extension lines of the two adjacent diagonal lines on the side and front of the plantar pressure plate. The two

cameras were at an angle of 90°, and the shooting distances were 12 m and 14 m, respectively. The motion for at least three gait cycles needed to be captured at the same time. Before the experiment, the patient performed walking exercises on the plantar pressure plate (on the affected side) approximately five times at the normal speed, and then, the data collection started. The patients were required to walk on the plantar pressure plate at a comfortable speed with bare feet. The interval between each experiment was 2 min. In different experimental procedures, each patient walked three times. The average value for the selected parameters was calculated. During the experiment, family members and therapists protected the patient on both sides without physical contact.

Kinematics and dynamics data were collected using an out-of-machine synchronization method. The dynamics instrument was operated by a remote control, which also controlled a light; that is, clicking the remote control would turn on the pressure measuring insole and a light at the same time. The light was placed in a range that could be captured by both cameras in fixed positions. In the kinematic videos, the moment when the flash was turned on was also the start time of the pressure measuring insole[27]. The experiment was carried out in the Key Laboratory of Technical Evaluation and Functional Diagnosis of Winter Sports Event of the General Administration of Sport of China at Shenyang Sport University.

In our research, the gait cycles from the second step of the trial to when the subject was standing on both feet were selected; a gait cycle was defined as the period from right heel strike to the next right heel strike, and the double support phase was selected.

Data processing: The APAS analysis system (United States) was used for video image analysis. The system-provided DEMPSTER human body model was used, which includes 16 points on the left and right sides of the foot, ankle, knee, hip, shoulder, elbow, wrist, and hand. Low-pass digital filtering was used to smooth the original data, and second-order Butterworth low-pass filtering (cut-off frequency of 8 Hz) was used to filter the original data.

Footscan Gait Scientific analysis software was used to assess the plantar pressure distribution. There are ten subdivisions of the sole of the foot: Phalange 1, phalanges 2-5, metatarsals 1-5, the midfoot, the medial pedal region, and the lateral pedal region. In our research, the anterior foot region consisted of phalange 1, phalanges 2-5, and metatarsals 1-5, and the posterior foot region consisted of the medial and lateral pedal regions. All the data are expressed as the mean ± standard deviation.

Statistical analysis

Statistical analyses were performed using SPSS 21.0 software. The independent-samples *t*-test was used to compare the measurement data between groups, the paired-samples *t*-test was used to compare the data within the group, the chi-square test was used to compare the categorical data, and the rank-sum test was used to compare ranked data. Differences with $P < 0.05$ were considered statistically significant.

RESULTS

Clinical data

The general survey administered to the two groups is shown in Table 1, and the data collected included sex, age, the affected side (left/right), height, weight, course of the disease, and Brunnstrom stage. There was no significant difference in clinical data between the two groups before treatment ($P > 0.05$).

Basic spatiotemporal gait performance

As shown in Table 2, there was no statistically significant difference between the two groups before treatment ($P > 0.05$). After 4 wk of treatment, the step length, gait speed, and step frequency of the two groups significantly increased compared to those before treatment. The magnitude of increase within the experimental group was larger than that within the control group, especially in step frequency.

Changes in the joint angle of the lower limbs and the center of mass trajectory

As shown in Table 3, there was no difference between the two groups before treatment ($P > 0.05$). After 4 wk of treatment, the ankle dorsiflexion angle and knee flexion angle

Table 1 Clinical data

	Gender (M/F)	Age (yr)	Affected side (left/right)	Height (cm)	Weight (kg)	Course (d)	Brunnstrom stage (III/IV)
Experimental group	8/8	50.00 ± 5.66	6/10	162.89 ± 7.55	65.78 ± 5.59	45.63 ± 8.09	4/12
Control group	8/8	52.13 ± 6.77	8/8	168.13 ± 14.04	66.25 ± 5.82	41.88 ± 5.54	4/12
P value	1.000	0.507	0.614	0.372	0.870	0.298	1.000

Except for gender, affected side, and Brunnstrom stage, the rest of the data are expressed as the mean ± standard deviation. M: Male; F: Female.

Table 2 Changes in step length, pace, and frequency before and after treatment

Parameter	Experimental group		Control group	
	Before	After	Before	After
Step length (m)	0.30 ± 0.14	0.39 ± 0.11[a,c]	0.29 ± 0.08	0.33 ± 0.07[a]
Step frequency (step/min)	53.79 ± 7.45	98.02 ± 12.97[b,d]	55.01 ± 10.08	77.85 ± 11.15[b]
Step pace (m/s)	0.31 ± 0.15	0.46 ± 0.13[a,c]	0.30 ± 0.11	0.38 ± 0.10[a]

Comparison with before treatment: [a]$P < 0.05$, [b]$P < 0.01$; comparison with the control group: [c]$P < 0.05$, [d]$P < 0.01$.

Table 3 Changes in the lower limb joint angle and the displacement of center of mass before and after treatment

Parameter	Experimental group		Control group	
	Before	After	Before	After
Ankle joint angle (°)	17.81 ± 4.50	25.42 ± 4.85[b,c]	18.83 ± 2.31	22.49 ± 3.38[a]
Knee joint angle (°)	34.72 ± 9.80	50.21 ± 14.34[b,c]	34.82 ± 10.20	42.29 ± 11.12[a]
Centre of gravity lateral displacement (left-right direction, cm)	13.35 ± 3.16	8.15 ± 2.31[b,c]	12.63 ± 2.87	9.97 ± 3.27[a]

Comparison with before treatment: [a]$P < 0.05$, [b]$P < 0.01$; comparison with the control group: [c]$P < 0.05$.

of both groups increased significantly, and the difference between the groups was statistically significant ($P < 0.05$). The increase in the experimental group was larger, and the difference between the two groups in the magnitude of increase was statistically significant ($P < 0.05$). After 4 wk of treatment, the lateral displacement (right-left direction) of the center of mass (COM) in both groups significantly decreased, and the magnitude of decrease was statistically significantly different between groups ($P < 0.05$). The patients in the experimental group had a smaller lateral displacement of the COM than the control group.

Characteristics of plantar pressure peak value

After 4 wk of treatment, the peak pressure value of the 1st phalange on the affected side increased significantly in both groups, and the values in the experimental group were significantly higher than those in the control group. The peak pressure values in the anterior region of both the affected and healthy feet in the experimental group significantly decreased, and those in the experimental group were significantly smaller than those in the control group.

The peak pressure values of the medial and lateral heels of the healthy and affected sides significantly decreased in the two groups, except for those on the healthy side in the control group. The magnitude of decrease in the experimental group was significantly larger, and the values in the experimental group were significantly lower than those in the control group (Table 4).

Impulse characteristics of plantar pressure

After 4 wk of treatment, the impulse of the 1st phalange of the affected side significantly increased in both groups, and the impulse of the experimental group was significantly higher than that of the control group. The impulse in the anterior foot

Table 4 Changes in the peak plantar pressure values (*n*)

Parameter	Experimental group		Control group	
	Before	After	Before	After
1st phalange (AS)	41.25 ± 5.09	49.75 ± 5.80[b,c]	39.56 ± 5.78	43.75 ± 5.52[a]
1st phalange (HS)	59.88 ± 9.23	54.25 ± 6.50[a]	58.25 ± 6.46	53.63 ± 11.51
Anterior foot (AS)	442.89 ± 24.45	410.02 ± 26.72[b,c]	439.01 ± 31.04	429.89 ± 28.35
Anterior foot (HS)	496.78 ± 35.88	455.01 ± 31.77[b,c]	495.14 ± 34.69	472.64 ± 31.93[a]
Midfoot (AS)	102.63 ± 8.57	96.38 ± 11.83	105.38 ± 12.75	100.88 ± 10.66
Midfoot (HS)	125.50 ± 15.41	115.75 ± 16.37	129.13 ± 17.13	127.25 ± 16.46
Medial heel (AS)	160.38 ± 22.25	137.25 ± 13.38[b,d]	164.25 ± 16.83	153.13 ± 14.00[a]
Medial heel (HS)	184.88 ± 15.63	166.63 ± 14.38[b,c]	191.00 ± 20.29	178.63 ± 16.94[a]
Lateral heel (AS)	190.25 ± 16.57	168.63 ± 10.11[b,d]	196.88 ± 13.08	182.63 ± 14.29[b]
Lateral heel (HS)	226.25 ± 15.00	203.88 ± 13.38[b,c]	232.25 ± 13.83	222.50 ± 18.51

Comparison with before treatment: [a]$P < 0.05$, [b]$P < 0.01$; comparison with the control group: [c]$P < 0.05$, [d]$P < 0.01$. AS: Affected side; HS: Healthy side.

region increased significantly on the affected side in both groups, and that of the experimental group was significantly higher than that of the control group; however, the impulse in the anterior foot region of the healthy side decreased significantly in both groups, and that of the experimental group was significantly lower than that of the control group.

In the posterior foot region of the two groups, the impulse of the medial and lateral heels of the affected and healthy sides significantly decreased, except for that of the medial heel in the control group. Among these changes, the decrease in the experimental group was more obvious than that in the control group, and the values of the experimental group were significantly lower than those of the control group.

After 4 wk of treatment, the total impulse of the affected feet increased significantly in both groups, and the experimental group values were significantly higher than the control group values; the total foot impulse of the healthy side significantly decreased, and the experimental group values were significantly lower than the control group values (Table 5).

DISCUSSION

From the perspective of modern medicine, the principle of eye acupuncture treatment of stroke is to penetrate the skin and superficial fascia through acupuncture, stimulate the sensory nerves located in the superficial fascia, enter the nerve center, and finally reach the orbicularis oculi muscle[28]. In the process, eye acupuncture can enhance the contractility of the corresponding muscles by stimulating the sensory nerves and changing the muscle tension by adjusting the abnormal excitability of the sensory nerves[29], thereby normalizing the contraction patterns of muscles. The goal of eye acupuncture in the treatment of stroke is to modify and reinforce the liver and kidney functions, so the liver and renal regions are selected for acupuncture sites according to the Zang-Fu dialectical principles of acupuncture point selection. Acupuncture in these areas regulates liver and renal functions, promotes the recovery of the brain, and accelerates the healing process of the disease[30]. The reason that acupuncture is performed in the liver region is because the liver governs conveyance and dispersion, which regulates and smooths the Qi flow and makes it accessible; acupuncture in the liver region can promote the blood flow of the body, and promote the functions of and blood flow to the brain. Acupuncture in the kidney region can promote the vigorous growth of the brain, support the muscles and bones, and accelerate the healing process of the body after stroke[31].

Body acupuncture is a conventional Chinese medical treatment. It is believed that under the guidance of the bio-holographic theory, by directly stimulating areas that correspond to the limbs and language functions and adjusting the transportation of local Qi-blood around the lesion, the patient's lesion can be effectively reduced. At the

Table 5 Impulse changes in different foot regions (N· S)

Parameter	Experimental group		Control group	
	Before	After	Before	After
1st phalange (AS)	13.41 ± 3.36	24.67 ± 6.27[b,d]	11.19 ± 5.11	14.68 ± 5.66[a]
1st phalange (HS)	34.85 ± 4.22	29.28 ± 4.04[a]	32.61 ± 5.04	27.80 ± 5.19
Anterior foot (AS)	222.54 ± 22.34	259.24 ± 24.02[b,d]	215.21 ± 23.80	239.07 ± 22.97[a]
Anterior foot (HS)	269.11 ± 27.88	235.20 ± 32.56[b,d]	282.45 ± 31.87	257.73 ± 30.21[b]
Midfoot (AS)	60.14 ± 15.49	72.08 ± 8.78	53.65 ± 14.52	60.31 ± 14.75
Midfoot (HS)	82.54 ± 10.97	77.51 ± 12.75	74.98 ± 13.64	73.64 ± 14.71
Medial heel (AS)	93.13 ± 10.16	85.08 ± 9.81[b,c]	100.44 ± 10.93	97.16 ± 12.31
Medial heel (HS)	113.30 ± 13.01	97.11 ± 14.51[b,c]	118.03 ± 10.86	110.34 ± 11.69[a]
Lateral heel (AS)	118.04 ± 11.29	108.55 ± 11.28[b,c]	122.51 ± 9.77	116.38 ± 8.49[a]
Lateral heel (HS)	134.64 ± 17.12	119.58 ± 15.90[b,c]	140.10 ± 14.48	130.36 ± 11.91[a]

Comparison with before treatment: [a]$P < 0.05$, [b]$P < 0.01$; comparison with the control group: [c]$P < 0.05$, [d]$P < 0.01$. AS: Affected side; HS: Healthy side.

same time, body acupuncture can affect patients' yang-ming Qi and blood, strengthen their muscles, relieve muscle spasm, promote Qi-blood flow, vitalize joints, balance the yin and yang aspects, and nourish the skin and meridians[32]. Body acupuncture combined with scalp acupuncture therapy can eliminate pathogenic factors, strengthen the body's resistance to harmful factors, and activate blood and dredge collaterals. It can penetrate the Qi-blood in the upper and lower limbs of the affected side, and increase cerebral blood circulation[33].

Cerebral lesions obstruct nerve conduction channels in stroke patients, making them unable to control the low-level systems, and patients appear to have balance disorders, decreased muscle strength, and decreased coordination among muscle groups and other clinical symptoms[34]. Patients with hemiplegia after stroke have pelvic post-condensation, and the knee joint on the affected side cannot reach a normal flexion angle, which leads to the hip joint on the affected side being lifted up. The affected foot is in a state of varus and plantar flexion for a long time, thus forming a typical compensatory "circle gait"[35]. Step pace and frequency are slow and the energy consumption is increased.

Step length, pace, and frequency are the basic spatiotemporal parameters of gait analysis[36]. Gait speed is closely related to lower limb motor function, balance function, and individual's ability to perform daily living activities; step length and frequency determine the walking speed[37]. After 4 wk of treatment, the step length, pace, and frequency of the two groups increased compared with those before treatment. The treatment effect in the group who underwent eye acupuncture needle retention combined with routine rehabilitation was better than that in the control group. The reason may be that eye acupuncture can improve coordination between the agonistic and antagonist muscles of the lower limbs, thereby improving the strength of lower limb muscle groups and the patient's overall step frequency and pace.

In stroke patients, abnormal lower limb joint angles are an important factor affecting gait performance in patients with hemiplegia[38]. Normal human knee joints will never fully straighten during the entire gait cycle[39], and most of them remain flexed to approximately 10° to 30°[40], which is conducive to absorbing shock and maintaining a certain level of potential energy. Patients with hemiplegia have weak lower limb strength[41], irregular COM trajectories, abnormal levels of muscle tension, and a poor locking mechanism of the knee joint[42], which can easily cause knee instability, knee recurvatum, and foot drop. Studies have shown that[43] hemiplegic patients have foot varus caused by high triceps surae muscle tension, shortened Achilles tendons, and decreased ankle dorsiflexion; moreover, in addition to increased knee extensor tension and limited joint flexion, hemiplegia patients present a typical circular gait. After 4 wk of treatment, the knee flexion and ankle dorsiflexion ranges in the two groups improved significantly, and the knee flexion angle in the experimental group improved to a greater extent. The reason may be that eye acupuncture can continuously stimulate the rich sensory nerves around the eyes and transmit the signal to the center and the damaged local blood flow of the brain improves, the injury to the

central nervous motor area is healed, and the correct motor pattern is reconstructed and stored in the cerebral cortex[44]. The theory of eye acupuncture needle retention is the same as the theory of inducing active limb movement and promoting brain remodeling in neurodevelopmental therapy[45]. On the other hand, it relieves the spasm of the triceps surae, and combined with routine rehabilitation training, the strength of ankle dorsiflexion is more easily induced. It further strengthens joint stability and coordination through repeated lower limb movements, increases muscle strength, and thereby improves the overall physical performance of the lower limbs.

The displacement of a person's COM in the left and right directions is an important factor affecting energy consumption during walking[46]. Abnormal muscle tone in patients with hemiplegia results in an increase in body displacement, which considerably increases the risk of falling. Hamacher *et al*[47] found that the input impulse of a normal motor pattern, proprioception, and cutaneous sensation to the central nervous system of stroke patients can accelerate the reorganization or compensation of their brain functions and effectively promote the recovery of their gait performance. Our research showed that the displacement of the body COM in the sagittal plane decreased in both groups, and the magnitude of improvement in the experimental group was larger than that in the control group. The reason may be that eye acupuncture can improve lower limb muscle strength[48] and enhance the patient's ability to control the knee joint, thereby improving gait stability, balance function, and ultimately, gait performance.

During walking, in hemiplegia recovery patients, the stress is mainly in the posterior and midfoot regions[49], and the stress distribution differs drastically between the two sides; the peak pressures in all regions of the healthy side are greater than those on the affected side. There are two reasons for this finding: First, the patient has poor balance control and poor weight loading ability on the affected side when walking, resulting in different loads on the two feet[50]. Second, due to factors such as decreased neural control and weakened muscle strength during walking, the affected side strives to complete the support phase as quickly as possible, which shortens the support time.

Compared with the control group, the experimental group had a larger reduction in the peak pressure values in the anterior and posterior regions of both the affected and healthy sides, indicating that the stroke patients in the experimental group exhibited greater improvement than those in the control group. Chen *et al*[51] found that the peak values of plantar pressure in the metatarsal and toe regions of stroke patients were much lower than normal, and their step pace was also lower, which is consistent with our results. We found that the peak pressure values and impulse of the 1st phalange on the affected side increased after treatment and the total plantar impulse of the affected side increased in both the experimental group and the control group, while the total plantar impulse of the healthy side decreased, and the difference in impulse between the affected side and the healthy side gradually decreased. As the left-right displacement of the COM decreased after treatment, the gait asymmetry of the patient decreased, and the gait stability increased. The reasons are as follows: First, after treatment, when the affected side thrusted against the ground, the driving force increased, resulting in a corresponding increase in the peak pressure value of the 1st phalange. Second, spasm in the extensor group of the affected lower limb became suppressed, the muscle strength of the corresponding antagonist muscle group increased[19], the motion range of the lower limb joints increased, and strephenopodia improved, along with other factors, which improved the load bearing capacity of the affected lower limb.

Our research also showed that in other regions of the foot, the peak plantar pressure values showed a decreasing trend in the anterior and posterior regions, but the plantar impulse increased in the anterior region and decreased in the posterior region. In addition, after treatment, the patient's COM gradually shifted from the original healthy side support to the affected side, so the patient's full foot impulse on the healthy side decreased after treatment. The plantar impulse (N·S) is the integral of the plantar pressure over time during landing ($I = \int_{F\times\Delta t}$). Its increase in the anterior foot region indicates that the duration of load bearing in that region increased after treatment. After the eye acupuncture treatment, the patient's walking speed increased, and the ground reaction force increased. The stress on the sole of the foot during walking tended to gradually change from heel strike to when the anterior foot region contacted the ground. The reasons are as follows: First, the acupuncture points used in eye acupuncture are close to the brain's motor center and sensory center. Second, eye acupuncture stimulation can quickly affect the central nervous system of the brain because the central peripheral conduction path is short. Third, somatic movements, including walking functions, are performed by the interaction of the cerebellum,

spinothalamic tract, pyramidal tract, extrapyramidal system, and peripheral nerves[52]. There are abundant nerves and vessels around the eyes, and stimulation produced by acupuncture can be introduced into the spinal cord through the action site; the muscles can be stimulated and produce corresponding contractile responses through the excitement of the primary motor center in the spinal cord[53]. Through continuous stimulation to excite the brain center, the normal motor reflex arc is eventually restored and re-established.

During eye acupuncture needle retention combined with routine rehabilitation, it stimulates the sensory nerves of the superficial fascia and then transmits the stimulation to the central nervous system, thereby causing the affected limb to move. It is targeted more for patients with proprioceptive disorders. In addition, poststroke neurological damage is caused by multiple factors and is difficult to improve with a single medication; the effect of eye acupuncture on stroke is comprehensive. In addition to exogenous stimulation, it also produces endogenous biological effects[54].

CONCLUSION

In conclusion, eye acupuncture needle retention and body acupuncture combined with routine rehabilitation can effectively improve the gait performance of patients recovering from stroke. Between these two treatments, eye acupuncture needle retention combined with routine treatment is better than body acupuncture and can be considered a practical and effective treatment that can be performed in the clinic.

ARTICLE HIGHLIGHTS

Research background

For most patients with stroke, routine gait training does not effectively restore normal gait.

Research motivation

To provide a theoretical basis and practical guidance for the rehabilitation of walking ability in stroke patients.

Research objectives

To investigate the effects of eye acupuncture retaining needle and body acupuncture combined with routine rehabilitation on walking ability and plantar pressure in patients with stroke recovery.

Research methods

Thirty-two stroke patients who met the inclusion criteria were randomly divided into an experimental group and a control group, with 16 patients each. Both groups were treated by routine rehabilitation. On the basis of this, the experimental group was treated by eye acupuncture retaining needle, and the control group was treated by body acupuncture. Before and after 4 wk of treatment, gait tests were performed on both groups by kinematic and plantar pressure synchronous testing.

Research results

Eye acupuncture retaining needle effectively improved the patients in step length, speed, frequency, lower extremity joint angle, gravity center swing scope, peak pressure values, and impulse in the anterior and posterior regions of both the affected and healthy feet.

Research conclusions

This study demonstrated that eye acupuncture retaining needle and body acupuncture combined with routine rehabilitation can effectively improve the walking ability of patients.

Research perspectives

The results for long-term treatment are unknown, so whether there will still be similarities in intergroup changes at longer time points remains to be studied in the future.

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