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The primary aim of *World Journal of Clinical Cases* (*WJCC*, *World J Clin Cases*) is to provide scholars and readers from various fields of clinical medicine with a platform to publish high-quality clinical research articles and communicate their research findings online.

WJCC mainly publishes articles reporting research results and findings obtained in the field of clinical medicine and covering a wide range of topics, including case control studies, retrospective cohort studies, retrospective studies, clinical trials studies, observational studies, prospective studies, randomized controlled trials, randomized clinical trials, systematic reviews, meta-analysis, and case reports.

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Retrospective Study

Retrospective study of effect of whole-body vibration training on balance and walking function in stroke patients

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Abstract

BACKGROUND

Dysfunction in stroke patients has been a problem that we committed to solve and explore. Physical therapy has some effect to regain strength, balance, and coordination. However, it is not a complete cure, so we are trying to find more effective treatments.

AIM

To observe the effect of whole-body vibration training (WVT) on the recovery of balance and walking function in stroke patients, which could provide us some useful evidence for planning rehabilitation.

METHODS

The clinical data of 130 stroke participants who underwent conventional rehabilitation treatment in our hospital from January 2019 to August 2020 were retrospectively analyzed. The participants were divided into whole-body vibration training (WVT) group and non-WVT (NWVT) group according to whether they were given WVT. In the WVT group, routine rehabilitation therapy was combined with WVT by the Galileo Med L Plus vibration trainer at a frequency of 20 Hz and a vibration amplitude of 0+ACY-plusmn+ADs-5.2 mm, and in the NWVT group, routine rehabilitation therapy only was provided. The treatment course of the two groups was 4 wk. Before and after treatment, the Berg balance scale (BBS), 3 m timed up-and-go test (TUGT), the maximum walking speed test (MWS), and upper limb functional reaching (FR) test were performed.

RESULTS

After 4 wk training, in both groups, the BBS score and the FR distance respectively increased to a certain amount (WVT = 46.08 ± 3.41 vs NWVT = 40.22 ± 3.75 ; WVT = 20.48 ± 2.23 vs NWVT = 16.60 ± 2.82), with $P < 0.05$. Furthermore, in the WVT group, both BBS score and FR distance (BBS: 18.32 ± 2.18 ; FR: 10.00 ± 0.92) increased more than that in the NWVT group (BBS: 13.29 ± 1.66 ; FR: 6.16 ± 0.95),

additional data are available.

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with $P < 0.05$. Meanwhile, in both groups, the TUGT and the MWS were improved after training (WVT = 32.64 ± 3.81 vs NWVT = 39.56 ± 3.68 ; WVT = 12.73 ± 2.26 vs NWVT = 15.04 ± 2.27 , respectively), with $P < 0.05$. The change in the WVT group (TUGT: 17.49 ± 1.88 ; MWS: 6.79 ± 0.81) was greater than that in the NWVT group (TUGT: 10.76 ± 1.42 ; MWS: 4.84 ± 0.58), with $P < 0.05$.

CONCLUSION

The WVT could effectively improve the balance and walking function in stroke patients, which may be good for improving their quality of life.

Key Words: Balance function; Berg balance scale; Maximum walking speed test; Stroke; Timed up-and-go test; Vibration training

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Core Tip: It is widely known that stroke victims have problems with walking, standing, balance, *etc.* In these populations, after training with a whole-body vibrator, there were some implications for rehabilitation, as follows: the patient's quality of movement was improved, which included movements such as standing up, sitting down, standing independently, standing with the eyes closed, standing with the arms held out in front of the body, turning around, crossing with both feet, and standing on one leg; and the speed of the patient's movement was faster, such as walking straight, getting up from the chair, and sitting down.

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INTRODUCTION

Stroke is a cardiovascular disease associated with high disability and mortality rates[1, 2]. In recent years, epidemiological studies have shown that the incidence of stroke is increasing and that the age of onset is becoming younger[3]. Stroke patients often have many dysfunctions, such as motor, speech, and swallowing dysfunction. Among them, balance dysfunction is the most common[4,5]. Vibration training can create mechanical vibrations that stimulate proprioceptors, such as Golgi's body, and then trigger the stretch reflex, thereby enhancing muscle function and the adaptability of the nervous system[6-8]. This study aimed to explore the effect of vibration training on the balance ability of stroke patients.

MATERIALS AND METHODS

General information

The study is a retrospective study, which a total of 159 participants with stroke were in the Rehabilitation Department of Chongqing Traditional Chinese Medicine Hospital for treatment from January 2019 to August 2020. There were 5 patients who dropped out during the inpatient stay. Another 24 patients were excluded because no assessment could be performed in all 4 investigations. In total 130 participants were eligible (Figure 1). All the participants underwent conventional rehabilitation treatment and were divided into whole-body vibration training (WVT) group and non-WVT (NWVT) group according to whether they were given WVT. The WVT group included 65 participants, 41 with cerebral hemorrhage and 24 with cerebral infarction. The mean age was 60.42 ± 6.39 years. There were 32 males and 33 females. There were 36 cases of left hemiplegia and 29 cases of right hemiplegia. In the NWVT group, there were 65 participants, including 37 participants with cerebral hemorrhage

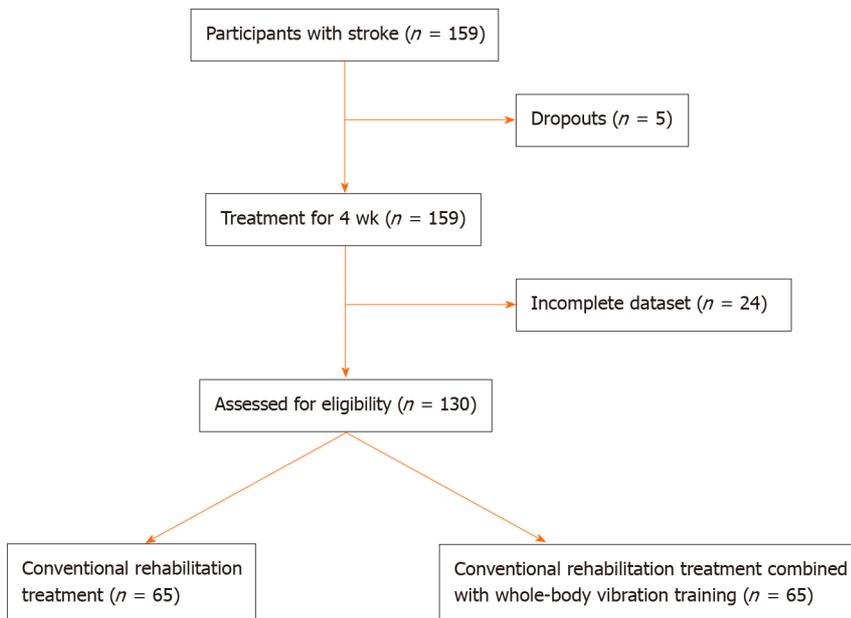


Figure 1 Flow chart on sample selection and criteria.

and 28 participants with cerebral infarction. The mean age was 59.82 ± 6.62 years, and there were 33 males and 32 females. There were 32 cases of left hemiplegia and 33 cases of right hemiplegia. Detailed information on the two groups is provided in [Table 1](#).

Inclusion criteria

All participants were in the recovery phase after cerebral infarction or cerebral hemorrhage, as confirmed by brain computed tomography or magnetic resonance imaging. All cases were of the first onset, the course of disease was within 6 mo, and the conditions of the participants were stable. The inclusion criteria also included stable vital signs, the absence of cognitive impairment, a Mini-mental State Examination score ≥ 24 , a Brunnstrom stage of IV or higher, a modified Ashworth scale score of less than 2, and a standing balance score of 3.

Exclusion criteria

Participants with training contraindications (a fresh fracture, deep venous thrombosis, malignant tumor, *etc.*), unilateral neglect, severe sensory impairment with vestibular or cerebellar dysfunction, the inability to complete training, or changes in the disease during the study period were excluded.

Research methods

For the NWVT group, conventional rehabilitation therapy included acupuncture, physical therapy, occupational therapy, and speech and swallowing therapy, combined with balance board training. For the WVT group, routine rehabilitation therapy was combined with WVT with the Galileo Med L Plus vibration trainer from Germany, with a frequency of 20 Hz[9] and a vibration amplitude of 0 ± 5.2 mm. Each patient stood on the vibrating plate with bare feet, held the handle with both hands, kept their body upright, and maintained a knee flexion angle of 30° to 45° . Each training session included 5 sets of 2 min trials, and a rest interval of 1 min was provided after each set; the sessions were performed 6 d per wk, allowing for 1 d of rest. The participants in both groups trained for 4 wk and underwent tests before and after training.

The indicators

The Berg balance scale (BBS) includes 14 items involving movements such as standing up, sitting down, standing independently, standing with the eyes closed, standing with the arms held out in front of the body, turning around, crossing with both feet, and standing on one leg; each item received a score of 0-4 points, for a total of 56 points. The higher the score was, the better the patient’s balance ability. It is the main scale used to evaluate the balance ability of stroke clinically, with high reliability and

Table 1 Demographics of the groups

	WVT	NWVT	P value
Number	65	65	-
Male/female	32/33	33/32	0.862
Age (yr)	60.42 ± 6.39	59.82 ± 6.62	0.600
Height (cm)	165.71 ± 7.73	165.83 ± 7.16	0.925
Weight (kg)	67.33 ± 7.70	66.03 ± 7.83	0.339
Course of disease	3.22 ± 1.35	3.09 ± 1.01	0.557
Hematencephalon	41	37	0.478
Cerebral infarction	24	28	
Affected side (L/R)	36/29	32/33	0.486

L: Left; NWVT: Non-whole-body vibration training group; R: Right; WVT: Whole-body vibration training group.

validity. All patients' evaluations were performed by the same therapist.

For the timed up-and-go test (TUGT), a chair is set up and a mark is made 3 m in front of the chair. After getting up from the chair, the participants walked forward 3 m, turned around at the marking, walked to the chair, and sat down, and the total time that the patient took to complete this task was recorded. The TUGT involves standing, moving, turning, changing direction, *etc.*, which can reflect a patient's dynamic balance ability well. Each test was performed three times, and the average time across the three trials was used for analysis.

For the maximum walking speed (MWS) test, a 16 m long straight line is marked with brightly colored markers. The starting point, 3 m, 13 m, and the end point of the line are marked. The participants were asked to walk as fast as possible from the start to the end, and a stopwatch was used to record the patient's time between the 3 m and 13 m marks. Each test was performed three times, and the average value was used for analysis.

For the functional reaching (FR) test, the participants stood parallel to the wall on both feet, with their hands in the Bobath handshake and the shoulder flexed to 90°. A scale was fixed parallel to the patient's upper limb, and then the patient bent forward as far as possible. The upper limb was stretched to the critical point of balance, with the patient's middle finger as the measurement point, and the patient's forward stretching distance was measured. FR can reflect the maximum stress deviation of a patient's balance pressure center and static balance ability well. The test was performed three times, and the average value was used for analysis.

Statistical analysis

SPSS 21 was used for statistical analysis. The measurement data are expressed as (mean ± SD), and the data met the requirements for normality and homogeneity of variance. Independent samples *t* tests were used for intergroup comparisons, and paired samples *t* tests were used for intragroup comparisons. $P < 0.05$ was considered statistically significant.

RESULTS

Before training, there were no statistically significant differences in the BBS score between the two groups (WVT = 27.75 ± 2.87; NWVT = 26.92 ± 3.24). After 4 wk of training, the BBS score in both groups increased (WVT = 46.08 ± 3.41; NWVT = 40.22 ± 3.75), with $P < 0.05$. The BBS score of the WVT group after training was higher than that of the NWVT group (WVT = 18.32 ± 2.18; NWVT = 13.29 ± 1.66), as shown in Table 2 and Figure 2.

There were no statistically significant differences in the TUGT time between the two groups before training (WVT = 50.13 ± 3.91; NWVT = 50.32 ± 3.38). After 4 wk, both groups exhibited shorter TUGT times (WVT = 32.64 ± 3.81; NWVT = 39.56 ± 3.68), with $P < 0.05$. The change of TUGT time in the WVT group was more than that in the NWVT group (WVT = 17.49 ± 1.88; NWVT = 10.76 ± 1.42) (Table 2 and Figure 3).

Table 2 Assessment of balance and functional mobility parameters

	WVT		NWVT		WVT vs NWVT
	mean ± SD	P value	mean ± SD	P value	P value
Berg balance scale					
Baseline	27.75 ± 2.87	0.000 ¹	26.92 ± 3.24	0.000 ¹	0.124
After treatment	46.08 ± 3.41		40.22 ± 3.75		0.000
Amount of change	18.32 ± 2.18		13.29 ± 1.66		0.000
Time up-and-go (s)					
Baseline	50.13 ± 3.91	0.000 ¹	50.32 ± 3.38	0.000 ¹	0.768
After treatment	32.64 ± 3.81		39.56 ± 3.68		0.000
Amount of change	17.49 ± 1.88		10.76 ± 1.42		0.000
Maximum walking speed (s)					
Baseline	19.52 ± 2.03	0.000 ¹	19.89 ± 2.10	0.000 ¹	0.307
After treatment	12.73 ± 2.26		15.04 ± 2.27		0.000
Amount of change	6.79 ± 0.81		4.84 ± 0.58		0.000
Functional reaching (cm)					
Baseline	10.47 ± 1.95	0.000 ¹	10.44 ± 2.61	0.000 ¹	0.930
After treatment	20.48 ± 2.23		16.60 ± 2.82		0.000
Amount of change	10.00 ± 0.92		6.16 ± 0.95		0.000

¹Baseline vs after treatment. NWVT: Non-whole-body vibration training group; SD: Standard deviation; WVT: Whole-body vibration training group.

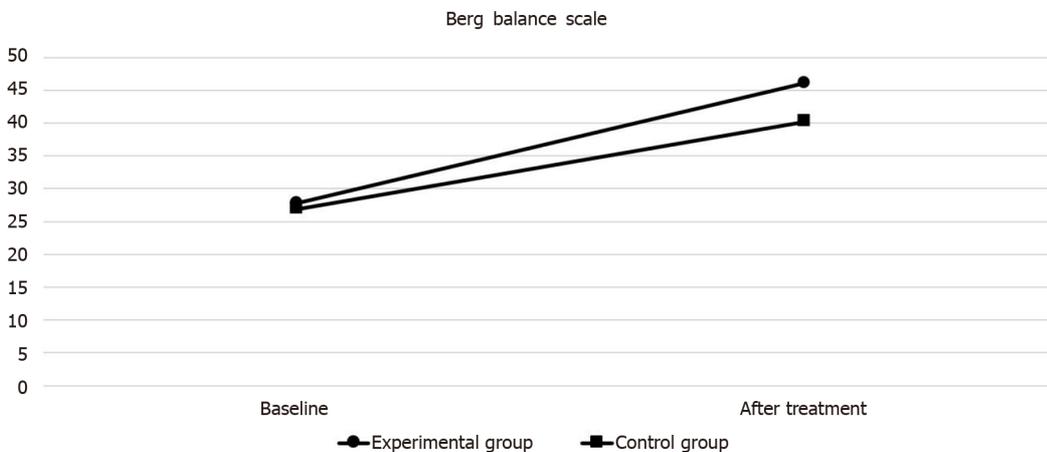


Figure 2 Berg balance scale. Experimental group: whole-body vibration training group; Control group: non-whole-body vibration training group.

There were no statistically significant differences in the MWS between the two groups before training (WVT = 19.52 ± 2.03; NWVT = 19.89 ± 2.10). Training for 4 wk, the MWS in both groups decreased (WVT = 12.73 ± 2.26; NWVT = 15.04 ± 2.27), with *P* < 0.05. The change of MWS in the WVT group was greater than that of the NWVT group (WVT = 6.79 ± 0.81; NWVT = 4.84 ± 0.58) (Table 2 and Figure 4).

Before training, there were no statistically significant differences in FR between the two groups (WVT = 10.47 ± 1.95; NWVT = 10.44 ± 2.61). After training, the FR distance increased in both groups (WVT = 20.48 ± 2.23; NWVT = 16.60 ± 2.82), and the increased FR distance in the WVT group was longer than that in the NWVT group (WVT = 10.00 ± 0.92; NWVT = 6.16 ± 0.95), with *P* < 0.05, as shown in Table 2 and Figure 5.

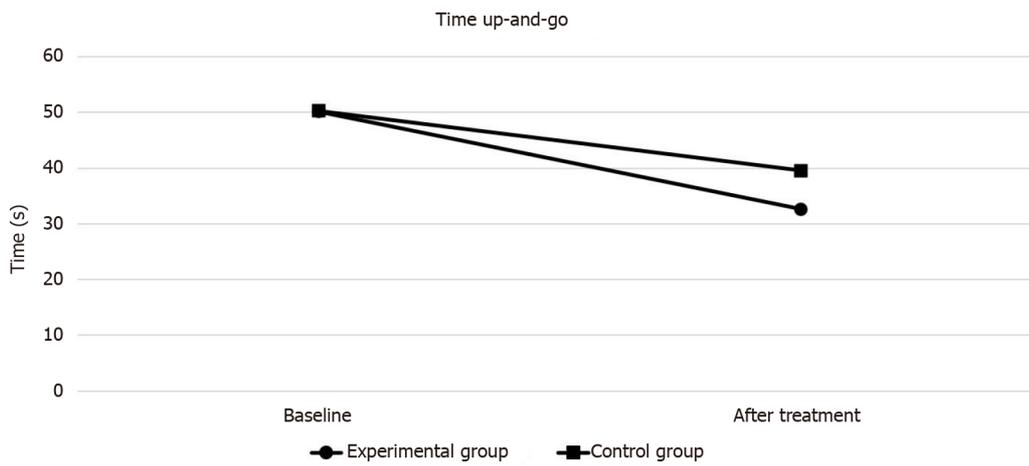


Figure 3 Timed up-and-go test. Experimental group: whole-body vibration training group; Control group: non-whole-body vibration training group.

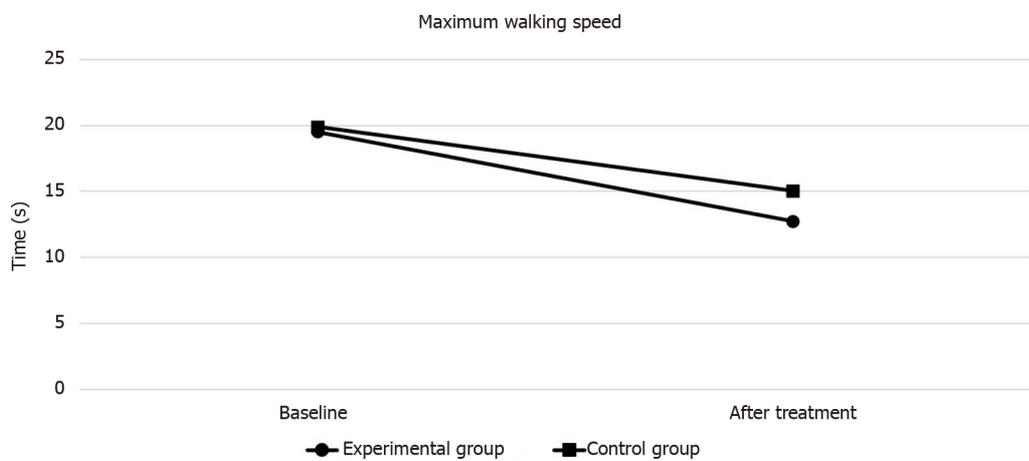


Figure 4 Maximum walking speed test. Experimental group: whole-body vibration training group; Control group: non-whole-body vibration training group.

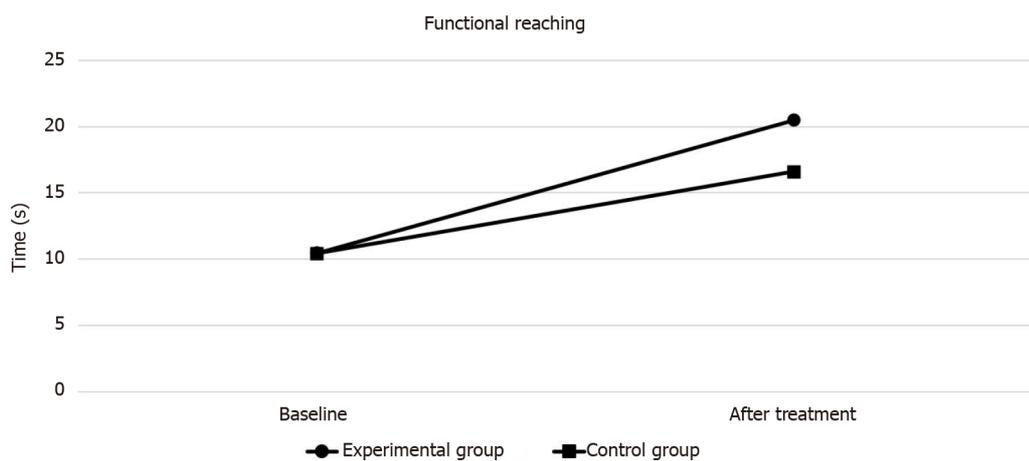


Figure 5 Functional reaching test. Experimental group: whole-body vibration training group; Control group: non-whole-body vibration training group.

DISCUSSION

Strokes are often accompanied by balance dysfunction. The main types of balance are dynamic and static balance. Good balance function is crucial for patients to resume walking and freely move their upper limbs[10]. Improvements in balance ability can effectively prevent patients from falling and reduce their risk of reinjury[11]. Kerse *et*

al[12] conducted return visits with patients who had strokes within 6 mo in New Zealand and found that the incidence of falls was 37%, which was twice that in the general elderly population. Pouwels *et al*[13] reported that people with stroke have a three times higher risk of fall-related fractures than do those without stroke. Weerdesteyn *et al*[14] showed that among stroke patients who experienced fractures, only 38% could regain the ability to walk independently, which was far lower than the rate in the general population.

Vibration training can induce neuromuscular adaptation by mechanical vibration, and this method has been widely used in balance and lower limb function training programs in recent years[15]. Currently, there are no standards for the frequency and amplitude of vibration training[16]. Rittweger *et al*[17] conducted a systematic review and reported that when the vibration frequency of total-body vibration training was between 20-45 Hz, its influence on muscles was mostly positive. Moreover, Rittweger *et al*[18] studied young subjects and found that when the vibration frequency was less than 20 Hz, the muscle relaxation effect was better. When the vibration frequency was higher than 50 Hz, muscle pain and hematomas occurred; when the vibration frequency was 26 Hz, neural-muscle excitability was particularly high. Gusi *et al*[19] applied vibration training with a vibration frequency of 12.6 Hz and vibration amplitude of 3 mm in postmenopausal women for a period of 8 mo. The results showed that WVT improved hip bone density and balance ability in postmenopausal women. Zhang *et al*[20] performed 6-26 Hz full-body vibration training in elderly people. After training, knee extension strength increased by 4.3 kg on average, and the TUGT time decreased by 19 s on average.

All participants in this study had a course of disease of less than 6 mo, were in the Brunnstrom stage III or higher, and had a stable condition. In the analysis of the balance and gait of the participants at this stage, some specific conditions were observed: when a patient stands, the center of gravity compensates by shifting toward the healthy side; and the affected foot cannot carry weight well, so the static balance is poor. During walking, due to poor weight transfer, the center of gravity does not completely transfer to the affected side, resulting in a shorter swing time on the healthy side and abnormal gait; abnormal muscle tone in the lower extremities and abnormal gait increase the risk of falling during weight transfer and walking. This vibration training study is based on the above situation, and the results show that the BBS, 3 m TUGT, 10 m MWS test, and FR test results were better in the WVT group than in the NWVT group after training. For this reason, it can be concluded that whole-body vibration can improve the dynamic and static balance ability and walking ability of patients and is a safe and effective treatment for patients with stroke.

WVT can improve patient balance and walking ability due to the following factors. First, WVT can deliver bilateral vibrations repeatedly and continuously to the brain and compensate for the limitations and discontinuity of weight training. Moreover, the training is relatively convenient and easy for patients to understand and perform[21]. Second, during vibration training, the patient's feet are required to have direct contact with the treatment plane, which directly stimulates proprioceptors in the plantar fascia, thereby increasing the patient's sensory input and enhancing the excitability and coordination of motor nerves, ultimately improving the patient's balance ability [22]. Third, vibration stimulation repeatedly squeezes the hip, knee, and ankle, produces traction for the ligaments and surrounding tendons, and increases proprioceptive stimuli, causing extensor muscle spindle excitement in muscles, such as the quadriceps, glutes, and back muscles. This process accelerates the sarcoplasmic reticulum release of Ca^{2+} , promoting motor unit recruitment, enhancing muscle strength, strengthening the weight-bearing capacity of the lower limbs, and improving the patient's balance and walking abilities[23]. Fourth, it has been reported that WVT for stroke patients can reduce muscle tension in the hip adductor, hamstring, and soleus muscles[24]. Vibration stimulation can induce presynaptic inhibition in Ia afferent fibers and hinder the release of neurotransmitters. Moreover, when the knee is bent to 30°-45°, the quadriceps femoris, triceps of the lower leg, and Achilles tendon are pulled, thus reducing the stretch reflex myotatic reflex of the lower limb and inhibiting the spasm mode of the lower limb; thus, patients can complete alternate swinging motions in a more effective and coordinated way when walking[25]. Fifth, at the central level, vibration can transmit stimulations to the brain through bones, activate the precentral motor area, establish new synapses, and cause central remodeling, which reinnervates the lower limbs on the affected side, increasing the coordination between bilateral muscle groups and allowing patients to effectively walk at all stages, ultimately improving their walking ability[17].

CONCLUSION

It is concluded that WVT can effectively improve the dynamic and static balance ability and the walking ability of stroke participants, so this training is worthy for clinical application.

ARTICLE HIGHLIGHTS

Research background

Dysfunction is a serious problem in stroke patients. Physical therapy is the most common treatment, which has some effect to regain strength, balance, and coordination. However, the effects of physical therapy have not yet met our wishes, so we are trying to find more effective treatments.

Research motivation

Kinds of physical means and brace therapy are important ways to improve function for stroke patients. However, it is well known that limb dysfunction in stroke patients is due to denervation, so we expected to find a treatment that could enhance neuromuscular reflex.

Research objectives

The aim of this study was to observe the effect of whole-body vibration training (WVT) on the recovery of balance and walking function in stroke patients, which could provide us some useful evidence for planning rehabilitation. The plan of the WVT, such as the training time and vibration frequency, is worth further exploration.

Research methods

The clinical data of 130 stroke participants who underwent conventional rehabilitation treatment in our hospital from January 2019 to August 2020 were retrospectively analyzed. The participants were divided into the WVT group and non-WVT (NWVT) group according to whether they were given WVT. In the WVT group, routine rehabilitation therapy was combined with WVT by the Galileo Med L Plus vibration trainer at a frequency of 20 Hz and a vibration amplitude of 0+ACY-plusmn+ADs-5.2 mm, and in the NWVT group, routine rehabilitation therapy only was given. The treatment course of the two groups was 4 wk. Before and after treatment, the Berg balance scale, 3 m timed up-and-go test, the maximum walking speed test, and upper limb functional reaching test were performed.

Research results

After 4 wk of training in the WVT group, both Berg balance scale score and functional reaching distance increased more than that in the NWVT group. Meanwhile, the timed up-and-go test and the maximum walking speed test were improved after training, and the change in the WVT group was greater than that in the NWVT group. Although there were further improvements in these indicators mentioned above, most patients still did not fully return to normal.

Research conclusions

The WVT could be routinely used for stroke patients if they are able to complete the treatment program.

Research perspectives

To improve the limb function of stroke patients, we think that it is better to be treated by enhancing the neuromuscular reflex. There should be more basic research on neuromuscular reflex in the future.

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