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ORIGINAL ARTICLE

Far-infrared stimulation of Neiguan acupoints improves heart rate variability and ameliorate fatigue in hemodialysis patients: A randomized trial

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Abstract

Background: In 2018, 84 615 patients in Taiwan received hemodialysis, of which about 62% to 97% suffered from fatigue. Fatigue caused by hemodialysis may be mental or physical. However, the detailed mechanism remains unclear. This study aimed to evaluate whether far-infrared stimulation of the Neiguan acupoint (P6) could effectively reduce fatigue and improve heart rate variability (HRV) in hemodialysis patients.

Methods: We conducted a two-arm, randomized trial in a hemodialysis center between March 2015 and March 2016. A total of 73 hemodialysis patients were included and were randomly assigned to an experimental group (n = 37) and a control group (n = 36). The experimental group received far-infrared radiation on Neiguan acupoint during hemodialysis for 12 weeks. The outcomes were fatigue level and HRV.

Results: All patients showed moderate fatigue ($M = 26.00 \pm 13.01$, range = 0-78) at baseline. Far-infrared stimulation on Neiguan acupoint significantly reduced overall fatigue ($\beta = 24$, $p < 0.001$) and improved HRV ($\beta = 74.36$, $p < 0.001$). Compared to the control group, the experiment group had significantly reduced fatigue levels in all aspects such as reduced energy and motivation ($\beta = -2.97$, $p < 0.001$), reduced physical strength ($\beta = -1.28$, $p < 0.01$), reduced mental capability ($\beta = -2.38$, $p < 0.001$), reduction in daily activities ($\beta = -1.48$, $p < 0.01$), depressed mood and loss of control ($\beta = -1.21$, $p < 0.05$) as well as increased autonomous nervous system activity ($\beta = 14.71$, $p < 0.01$) in the third month of stimulation.

Conclusion: Far-infrared stimulation of the Neiguan acupoints effectively reduces fatigue and increases autonomic nervous system activity in hemodialysis patients.

Keywords: Autonomic nervous system; Fatigue; Hemodialysis

1. INTRODUCTION

In 2018, 84 615 patients received hemodialysis (HD) in Taiwan, and about 62% to 97% of patients suffered from fatigue.[1,2] Symptoms of HD-induced fatigue encompass tiredness, weakness, and lack of energy.[3] These symptoms not only increase the risk of depression, disability (through sarcopenia), and mortality[4–6] but also positively correlate with factors such as insomnia, social isolation, and inadequate information about their medical conditions.[3] Additionally, HD patients frequently exhibit reduced heart rate variability (HRV), indicating dysregulated autonomous nervous systems.[7] Dysregulated autonomic nervous system (ANS) exacerbates the severity of fatigue via disturbing sleep rhythm and further augment the symptom of fatigue.[8] As a result, effectively monitoring and managing HD-induced fatigue is a crucial concern for HD patients.

In order to manage HD-mediated fatigue, several mental and physical treatments are proposed, such as medications for insomnia and depression (targeting type 2 serotonin receptor), social support (for depression and anxiety), and exercise (for weakness). Studies have demonstrated clinical benefits for HD patients.[9–11] However, the complete therapeutic efficacy of medication on HD-mediated fatigue is not comprehensively understood.[11] Fatigue-related weakness frequently obstacles HD patients during exercise. Besides, using exercising to reduce fatigue is not applicable for disabled patients. Therefore, there is an urgent need for alternative noninvasive treatments for fatigue.

Acupuncture and acupoint stimulation have shown clinical benefits for patients with chronic fatigue.[12,13] Stimulating the Neiguan acupoint (an acupoint on the dorsal side of the wrist) could improve fatigue caused by exercise and driving,[14,15] and therapeutic efficacy in improving HD-mediated fatigue is promising but not assessed yet.

The scheme of International Commission on Illumination (CIE) defines the wavelength of far-infrared (FIR) electromagnetic radiation is distributed in a range from 3 to 1000 μm. FIR affects potential biological mechanisms including the alteration of cell membrane structure and mitochondrial metabolism.

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The evidences have been demonstrated that FIR radiation is an important form of physical therapy to physical and mental states in people. The principle of the machine is based on FIR radiation delivery to perform physical therapy, of which such instruments on the market have WS TY-101N® and WS TY-301R® (WS Far Infrared Medical Technology Co., Ltd., Taipei, Taiwan).[16,17] FIR carry out more the beneficial effects, which one is the reduction of pain, stress, and fatigue. Infrared sauna therapy may help to attenuate the effect caused by chronic fatigue syndrome (CFS), providing a comfortable and relaxing experience.[18] Waon therapy is a FIR dry sauna used to ameliorate fatigue in CFS patients. In particular, FIR sauna therapy has limitations due to the lack of a placebo. Previous studies indicated a lack of objective physical evidences is presented in FIR therapy.[19] Transonic HD (02) monitor accurately measures hemodynamic parameters of autologous arteriovenous fistula (AVF) in FIR therapy. FIR therapy improved blood flow deficiency of HD patients.[20] FIR radiation produces a thermal effect to increase blood flow and dilate blood vessels. FIR radiation also has a nonthermal effect.[18] FIR radiation reduces stress and ameliorates fatigue as so to attribute to nonthermal effects.[21] HRV is used to assess ANS dysregulation in CFS patients. ANS dysregulation may lead to severe fatigue in CFS patients, thus CFS patients have lower HRV.[7] HD patients had lower heart HRV and autonomic nerve activity. The analysis of HRV monitored FIR radiation led to the higher HRV. HD patients suffered from less fatigue.[22] In this study, we conducted a randomized trial to evaluate whether FIR stimulation on Neiguan acupoint can diminish the severity of HD-mediated fatigue.

2. METHODS

2.1. Study population

Subjects were enrolled from the HD center of a regional teaching hospital between March 2015 and March 2016 via invitation of physicians. Inclusion criteria: (1) older than 20 years old and (2) consistently receiving HD three times a week for at least 3 months. Exclusion criteria: (1) patients with arrhythmia, hypoalbuminemia (albumin ≤3.0 mg/dL), or anemia (hematocrit ≤25%), (2) having active infection or any types of malignant tumor, (3) being hospitalized, and (4) patients with conscious disturbance or dysphasia.

2.2. Ethical statements

The designation of the study followed the Declaration of Helsinki, and the studying protocol was reviewed and approved by Taiwan Adventist Hospital Institutional Review Board (No.104-E-02). A signed informed consent was obtained from all participants.

2.3. FIR radiation

Subjects were randomly assigned to the experimental and the control groups. The experimental group received additional FIR radiation on their hands using WS TY-101N® (WS Far Infrared Medical Technology Co., Ltd., Taipei, Taiwan). The control group received no FIR radiation. The protocol was prepared following pervious report.[20,22,23] Each HD patients received the assessment of HRV before and after IFR radiation on Neiguan acupoint. The irradiated site is Neiguan acupoint in the arteriovenous tube that is not performing HD, each time for 40 minutes, three times a week, 20 to 25 cm away from the body surface, and the temperature is maintained at 38°C to 40°C.

2.4. The measurement of HRV

Each HD patient received a 5-minute measurement via the connection of the instrument's probe to HD patient's finger. The time and frequency domain HRV parameters are measured by SA-3000P analyzer (Medicore, Seoul, Korea). Time-domain parameters include mean heart rate (HRT), SD of NN intervals (SDNN), root mean square of the successive differences (RMSSD), and physical stress index (PSI) in the indicated time period. Frequency domain parameters included total power (TP), very lower frequency (VLF), low frequency (LF), and high frequency (HF). RMSSD values reflected the regulation of cardiac parasympathetic regulation; TP values reflected the activity of cardiac sympathetic nervous system. Frequency domain parameters, LF/HF ratio is calculated.

2.5. Fatigue scale

The questionnaire was prepared following the published report. Fatigue scale has been used with the authorization of the researchers.[23] Data pertaining to fatigue in the questionnaire are extracted according to the psychological factors and behavior of HD patients. The questionnaire contained five parts which were used to determine: (1) reduced energy and motivation (eight items), (2) reduced physical strength (five items), (3) reduced mental capability (five items), (4) reduction in daily activities (four items), and (5) depressed mood and loss of control (four items). Fatigue severity in the questionnaire is assessed using a scoring approach, and its scores ranging from 0 to 78 points. A score of 26 or less is considered as low-level fatigue. A score range of 26 to 52 is moderate-level fatigue. Above 52 is severe fatigue. The frequently of the feature is increased with the increase of score. In order to ensure consistency with the actual situation of HD patients, the internal consistency reliability of the questionnaire was evaluated by Cronbach α method. The Cronbach α values of the five subscales was ranged from 0.7 to 0.9, and Cronbach α was 0.9. This indicated that the fatigue scale possessed excellent reliability and validity and could be used as an assessment tool to screen dialysis patients for fatigue, as previously demonstrated. In our study, the Cronbach α value was 0.91 (N = 73), suggesting our results should be trusted.

2.6. Outcomes

The outcomes were evaluated by the result of the measured value of HRV and the questionnaire of fatigue scale before trial, and at the end of first, second, and third months during trial.

2.7. Sample size estimation

Sample size estimation was conducted using Gpower 3.0.10 software to determine the necessary number of participants for this study. The research used a repeated measure analysis of variance (ANOVA) design, consisting of one pretest and three posttests. The effect size (f) chosen for the analysis was 0.25 (medium effect size), and a type I error probability (α) of 0.05 was applied. To ensure adequate statistical power (0.8), the study required a sample size of 86 participants.

2.8. Statistical analysis

All statistical analyses applied in this study were performed by SPSS V.20.0 (SPSS, Chicago, IL). First, we examined the skewness of the data from continuous variables using the Kolmogorov-Smirnov test (or Shapiro-Wilk test). Normal-distributed data from continuous variables were represented as mean ± SD, and statistical significance between the experimental and the control groups was examined by a two-tailed the unpaired Student's *t* test. Skew data are shown in the interquartile range. The statistical significance between the experimental and the control groups was tested using the two-tailed Wilcoxon rank-sum test. Categorical data are shown in n (%), and statistical significance was tested using the chi-square test or Fisher exact test. Variables with statistical significance

($p < 0.05$) were labeled. Later, a generalized estimating equation (GEE) model with an exchangeable correlation structure was used to assess the correlation between the fatigue, HRV, and time-dependent stimulation of Neiguan acupoint.

3. RESULTS

3.1. Basic characteristics of hemodialytic patients

The baseline characteristics of the subjects are summarized in Table 1. A total of 73 patients were included. Among them, 47 patients were women (64.4%), and 26 were men (35.6%). The average age and the median year of HD were 59.97 ± 12.38 years old and 7.83 (3.38-13.25) years, respectively. These subjects were randomly assigned to the experimental group (37 subjects) and control group (36 subjects) with comparable characteristics ($p > 0.05$). The overall fatigue was 26.0 ± 13.0, which was considered moderate fatigue (Table 2). The overall fatigue between the experimental and control groups was comparable (28.0 ± 12.5 vs 24.0 ± 13.4, $p = 0.197$; Table 2), in which most factors attributed to the overall fatigue were commensurate except depressed mood and loss of control (3.8 ± 2.3 vs 2.7 ± 2.0, $p = 0.033$; Table 2). In the comparison of HRV, all indexes were comparable between the two groups. This information indicated that all subjects experienced moderate fatigue, and basal conditions in the experimental and the control groups were similar.

3.2. FIR stimulation on the Neiguan acupoint ameliorated HD-mediated fatigue

We investigated the promoting effect of FIR stimulation on Neiguan acupoints in HD patients and represented the results in Table 3. In the pretest, indicators of fatigue between experimental and control groups had no significant difference ($p > 0.05$). All subjects experienced time-dependent attenuation of overall fatigue. By thoroughly investigating the dynamic of factors belonging to the fatigue, the strength of "Reduced energy and motivation" exhibited a significantly consistent decrease across the treatment, and "Depressed mood and loss of control" decreased from the second month of treatment. In the third month of treatment, all indicators

Table 1

Demographic and clinical characteristics of the study population

Basic information	All subjects (n = 73)	Group: Experimental group (n = 37)	Group: Control group (n = 36)	p
Gender				0.168
Male	26 (35.6)	16 (43.2)	10 (27.8)	
Female	47 (64.4)	21 (56.8)	26 (72.2)	
Age	59.97 ± 12.38	58.16 ± 11.54	61.83 ± 13.09	0.207
Level of education				0.260
Illiterate	4 (5.5)	0 (0.0)	4 (11.1)	
Elementary school	16 (21.9)	6 (16.2)	10 (27.8)	
Junior high school	5 (6.8)	2 (5.4)	3 (8.3)	
High school	19 (26.0)	11 (29.7)	8 (22.2)	
Junior college	10 (13.7)	7 (18.9)	3 (8.3)	
University	16 (21.9)	9 (24.3)	7 (19.4)	
Graduate school and above	3 (4.1)	2 (5.4)	1 (2.8)	
Occupation				0.645
None	44 (60.3)	21 (56.8)	23 (63.9)	
Military	1 (1.4)	0 (0.0)	1 (2.8)	
Civil service	3 (4.1)	3 (8.1)	0 (0.0)	
Education	3 (4.1)	1 (2.7)	2 (5.6)	
Business	13 (17.8)	6 (16.2)	7 (19.4)	
Farming	0 (0.0)	0 (0.0)	0 (0.0)	
Industry	3 (4.1)	2 (5.4)	1 (2.8)	
Services	5 (6.8)	3 (8.1)	2 (5.6)	
Other	1 (1.4)	1 (2.7)	0 (0.0)	
Marital status				0.138
Unmarried	16 (21.9)	12 (32.4)	4 (11.1)	
Married	42 (57.5)	19 (51.4)	23 (63.9)	
Divorced	5 (6.8)	3 (8.1)	2 (5.6)	
Separated	0 (0.0)	0 (0.0)	0 (0.0)	
Cohabiting	1 (1.4)	0 (0.0)	1 (2.8)	
Widow/widower	9 (12.3)	3 (8.1)	6 (16.7)	
Health history				
Hypertension	27 (37.0)	16 (43.2)	11 (30.6)	0.262
Heart disease	12 (16.4)	7 (18.9)	5 (13.9)	0.562
Diabetes	18 (24.7)	11 (29.7)	7 (19.4)	0.308
Cerebrovascular diseases	0 (0.0)	0 (0.0)	0 (0.0)	
Malignant tumor	3 (4.1)	2 (5.4)	1 (2.8)	1.000
Other	5 (6.8)	2 (5.4)	3 (8.3)	0.674
Years of dialysis	7.83 (3.38-13.25)	5.08 (1.58-13.25)	8.42 (4.04-13.73)	0.097

Categorical variables are presented as count and percentage. Continuous data with normal distribution are presented as mean ± SD, otherwise data without normal distribution are presented as median (25th-75th).

Table 2

Level of fatigue and HRV at baseline

Fatigue level item	All subjects (n = 73)	Group: Experimental group (n = 37)	Group: Control group (n = 36)	*p*
Reduced energy and motivation	8.0 (6.0-11.5)	9.0 (7.0-12.0)	8.0 (6.0-11.0)	0.150
Reduced physical strength	3.0 (2.0-5.0)	4.0 (2.0-5.0)	3.0 (1.0-5.0)	0.189
Reduced mental capability	5.6 ± 3.1	6.0 ± 3.1	5.3 ± 3.0	0.336
Reduction in daily activities	4.1 ± 2.5	4.3 ± 2.3	3.8 ± 2.6	0.370
Depressed mood and loss of control	3.3 ± 2.2	3.8 ± 2.3	2.7 ± 2.0	0.033*
Overall fatigue	26.0 ± 13.0	28.0 ± 12.5	24.0 ± 13.4	0.197
HRV				
ANS activity	84.0 (72.5-96.5)	84.0 (50.0-98.5)	85.0 (75.3-96.0)	0.405
Stress resistance	91.0 (50.0-96.5)	75.0 (50.0-96.0)	94.5 (50.0-97.8)	0.371
Stress index	101.0 (92.0-121.0)	103.0 (92.5-123.0)	97.0 (91.3-115.5)	0.410
Fatigue index	116.0 (101.0-150.0)	119.0 (99.5-150.0)	113.5 (101.0-150.0)	0.635
HRV mean HRT	73.9 ± 11.3	73.5 ± 10.7	74.4 ± 12.0	0.743
SDNN	22.5 (14.7-30.2)	21.9 (14.3-29.9)	24.4 (16.2-30.2)	0.329
TP	309.6 (124.8-759.3)	286.3 (99.3-628.8)	315.5 (153.8-745.1)	0.526
VLF	122.3 (49.5-393.9)	137.6 (34.3-414.7)	115.1 (55.2-376.7)	0.934
LF	67.75 (18.02-183.23)	62.90 (18.03-225.35)	90.04 (16.36-171.82)	0.778
HF	56.01 (24.67-156.89)	55.77 (20.84-142.60)	66.18 (33.93-186.66)	0.267
LF/HF	1.29 (0.43-2.37)	1.33 (0.64-3.05)	1.24 (0.27-2.31)	0.267

Continuous data with normal distribution are presented as the mean ± SD, otherwise data without normal distribution are presented as median (25th-75th).
ANS = autonomic nervous system; HF = high frequency; HRV = heart rate variability; HRT = heart rate; LF = low frequency; SDNN = SD of NN intervals; TP = total power; VLF = very lower frequency.
*$p < 0.05$.

Table 3

Effectiveness of experimental intervention at reducing level of fatigue

Predictive variable	Reduced energy and motivation	Reduced physical strength	Reduced mental capability	Reduction in daily activities	Depressed mood and loss of control	Overall fatigue
	Estimated parameters (β)					
Intercept term	8.56***	3.64***	5.28***	3.81***	2.72***	24.00***
Group	1.20	0.44	0.70	0.52	1.09*	3.95
Time point						
3rd month	−3.09***	−1.37***	−1.51***	−0.95**	−0.98***	−7.91***
2nd month	−1.67**	−0.67	−0.81	−0.58	−0.75**	−4.47**
1st month	−1.58**	−0.58	−0.56	−0.39	−0.31	−3.42*
Group × time point						
Experimental group × 3rd month	−2.97***	−1.28**	−2.38***	−1.48**	−1.21*	−9.31***
Experimental group × 2nd month	−1.33	−0.58	−1.01	−0.44	−0.90	−4.26
Experimental group × 1st month	−1.58	−0.80	−1.07	−0.72	−1.05*	−5.20*

Group reference category: control group. Time point reference category: pretest. Group × time point reference category: control group × pretest.
*$p < 0.05$,
**$p < 0.01$, and
***$p < 0.001$.

of fatigue were significantly reduced compared with the pretest. A similar trend could be identified in the time-dependent dynamics of the experimental group, in which decreased range of "overall fatigue", "Depressed mood and loss of control", "Reduction in daily activities", and "Reduced mental capability" were higher than those from all subjects. These results indicated that FIR stimulation of Neiguan acupoints reduced fatigue in HD patients.

3.3. FIR stimulation on the Neiguan acupoint promoted HRV in HD patients

We also evaluated whether FIR stimulation on Neiguan acupoint improved HRV in HD patients and represent the results in Table 4. The HRV and related indicators between the experimental and the control groups were comparable. In investigating time-dependent dynamics of HRV and its related indicators, HRV and related indicators were identical with the pretest except for the SDNN at the third month of treatment (−3.39, $p = 0.039$). In determining the time-dependent dynamics of HRV in the experimental group, significant improvement in ANS activity was observed in the third month of treatment (14.71, $p = 0.008$). The augmented ANS activity (also known as HRV) in the experimental group was correlated with the increase in SDNN (6.94, $p = 0.045$) and HF (94.34, $p = 0.005$). In summary, FIR stimulation on Neiguan acupoint promoted ANS

Table 4

Analysis of effectiveness of experimental intervention at improving HRV

	Estimated parameters (β)										
Predictive variable	**ANS activity**	**Stress resistance**	**Stress index**	**Fatigue index**	**HRV mean HRT**	**SDNN**	**TP**	**VLF**	**LF**	**HF**	**LF/HF ratio**
Intercept term	85.64***	79.89***	105.03***	115.22***	74.36***	25.48***	579.37***	270.74***	156.69***	151.94***	1.49***
Group	−3.61	−3.43	2.78	0.40	−0.87	1.42	672.06	310.19	117.77	−26.16	0.30
Time point											
3rd month	−6.54	−4.27	2.64	1.19	−3.39*	−2.13	−178.46	−91.56	−36.08	−51.31	0.03
2nd month	−0.31	0.44	−1.17	0.52	−2.65	1.64	328.23	331.15	36.62	−38.19	0.21
1st month	1.77	−1.55	−1.34	−6.37	−2.52	1.57	179.44	72.64	64.52	34.64	0.29
Group × time point											
Experimental group × 3rd month	14.71**	12.56	−7.91	−7.78	1.44	6.94*	48.98	63.96	160.93	94.34**	0.45
Experimental group × 2nd month	6.67	5.97	−1.69	−4.35	1.79	0.41	151.23	479.57	−89.23	51.63	0.27
Experimental group × 1st month	1.10	6.39	1.50	3.72	0.28	−1.47	−671.10	−251.09	−128.64	−18.88	−0.16

Group reference category: control group. Time point reference category: pretest. Group × time point reference category: control group × pretest.

ANS = autonomic nervous system; HF = high frequency; HRV = heart rate variability; HRT = heart rate; LF = low frequency; SDNN = SD of NN intervals; TP = total power; VLF = very lower frequency.

*$p < 0.05$,

**$p < 0.01$, and

***$p < 0.001$.

activity in HD patients, which might attribute to SDNN and HF.

4. DISCUSSION

In the current study, we evaluated whether FIR stimulation on Neiguan acupoints could attenuate HD-mediated fatigue and improve HRV. After 3 months of treatment, FIR stimulation of Neiguan acupoint could significantly attenuate HD-mediated fatigue and promote the HRV in HD patients. FIR stimulation on Neiguan acupoint reduced HD-mediated fatigue via ameliorating depressed mood, loss of control, and improving daily activities and mental capability. Furthermore, FIR stimulation of Neiguan acupoints promoted HF and SDNN in HD patients. In summary, FIR stimulation on Neiguan acupoints could decrease symptoms of HD-mediated fatigue via improving mental condition and activity of the parasympathetic nervous system.

Evaluation of the effectiveness of FIR stimulation of the Neiguan acupoints using fatigue scale data indicated significant improvement in fatigue levels achieved in the third month. These results showed that reduction of fatigue via FIR stimulation of Neiguan acupoints needs dose accumulation. This finding is consistent with previous findings that a longer duration of FIR stimulation of acupoints leads to greater effectiveness in reducing fatigue.[21] Using acupuncture to improve HD-mediated complications is not a novel concept.[24] Previous study reported that acupuncture reduces the fatigue and insomnia observed in HD patients.[25] Hadadian[26] apply ST36 (Zusanli), SP6 (Sanyinjiao), and LI4 (Hegu) in attenuating fatigues from HD. Our study increased the list of acupoints suitable for fatigue. In addition, the treatment period of Hadadian[26] and Tsay[27] is around 1 month. Our study monitored a longer treating period (1 month vs 3 months), and the therapeutic efficacy was more endured than in the previous studies. The therapeutic efficacy of stimulation on Neiguan acupoints became significant in the third month of treatment, which was longer than other acupoints.[26] This result revealed that the therapeutic efficacy of stimulation on Neiguan acupoints might be slower than stimulations on the other acupoints, which might be a following treatment of fatigue after acupuncture on ST36, SP6, and LI4. Despite the mechanism of how acupuncture can reduce fatigue being still unclear, a study by Bicer and Tasci[28] revealed that acupuncture increases the blood pressure in HD patients, which is one cause of fatigue. In summary, we demonstrated that stimulation on Neiguan acupoints could relieve fatigue from HD and may be possible to accompany other acupoints such as ST36 and SP6.

We also identified that FIR stimulation on Neiguan acupoints could increase HRV in HD patients. Acupuncture can modulate the activity of the circulating system. Trinh et al[29] applied acupuncture on the left ear of healthy subjects to measure the effect of acupuncture on HRV. They discovered that HRV from the healthy subjects with acupuncture is higher than that from the healthy subjects without acupuncture.[29] Previous study reported that electroacupuncture on LI11 (Quchi) can inhibit the rise of arterial blood pressure by reducing sympathetic nerve activity in the rat model.[30] These studies emphasize the feasibility of using acupuncture to increase HRV. Lu[31] evaluates whether acupuncture on Neiguan acupoints can increase HRV in healthy subjects. Acupuncture on Neiguan acupoints improves HRV, the activity of the parasympathetic nerve system, and reduces systolic blood pressure.[31] Our study explored the feasibility of stimulation on Neiguan acupoints can also improve the HRV in HD patients. Of note, we discovered that HRV improvement only appeared after 3 months of consistent treatment, whereas Lu[31] identified HRV improvement by needle acupuncture was fast reacted. Litscher et al[32] compared the cerebral effect between FIR stimulation and needle acupuncture, discovering no significant difference between FIR stimulation and needle acupuncture. Accordingly, the delayed efficacy on FIR stimulation in our study might rely on the physical conditions of the subjects. In summary, we demonstrated that consistently stimulating Neiguan acupoints could improve HRV.

The observed effects of FIR stimulation on Neiguan acupoints in HD patients evolved over the course of our study. Initially, there were no significant differences in fatigue indicators and HRV between the experimental and control groups. However, as the study progressed, we observed a noticeable reduction in overall fatigue and related factors. This reduction became increasingly evident over the 3-month treatment period. By the third month of treatment, all indicators of fatigue showed significant improvements compared to the pre-test. Similarly, in the case of HRV, we detected a substantial improvement in ANS activity during the third month of treatment, which was reflected in the SDNN and HF components of HRV.

This study has several limitations. The subjects in this study were from only a single HD center. Therefore, due to possible geographical and sample areas, this study's findings only display the current situation and improvement at this HD center and cannot be used to make large-scale inferences. A future investigation is needed involving more HD centers to achieve greater representativeness.

In conclusion, FIR stimulation of the Neiguan acupoint, administered in 40-minute sessions three times a week, effectively alleviates patients' fatigue and increase activities of autonomic nerve and parasympathetic nerve activity. The HD-mediated fatigue is particularly significant among women and older patients. Therefore, applying the FIR stimulation of Neiguan acupoint to those population is recommended.

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