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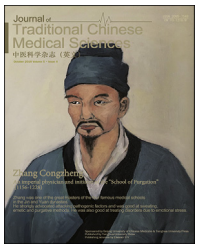

Effects of cardiac rehabilitation qigong exercise in patients with stable coronary artery disease undergoing phase III rehabilitation: A randomized controlled trial (with video)

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KEYWORDS
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Rehabilitation;
Cardiac rehabilitation qigong exercise;
Cardiopulmonary aerobic capacity

Abstract *Objective:* To explore the effectiveness and safety of cardiac rehabilitation qigong exercise in stable coronary artery disease (CAD) patients undergoing phase III rehabilitation. *Methods:* This was a randomized controlled trial. A total of 59 stable CAD patients undergoing phase III rehabilitation treated in Sports Medicine Hospital from March 2017 to September 2017 were enrolled after meeting the inclusion criteria and then divided into cardiac rehabilitation qigong exercise group (n = 30) receiving a 12-week intervention and control group (n = 29). All participants were assessed at baseline and at 12-week intervention for the primary outcome, that was treadmill test parameter and the secondary outcomes including physical fitness, body composition, bone mineral density, and cardiac ultrasound B-mode imaging. *Results:* There were no significant differences in baseline demographics between the two groups. After a 12-week cardiac rehabilitation qigong exercise intervention, compared with the control group, ΔVO_2 (initial 1352.63 ± 340.95 vs 12 weeks 1594.57 ± 467.14) vs (initial 1363.83 ± 322.90 vs 12 weeks 1323.76 ± 318.92) ($P = .003$), ΔVO_2/kg (initial 21.23 ± 3.56 vs 12 weeks 24.75 ± 5.11) vs (initial 21.01 ± 3.71 vs 12 weeks 20.35 ± 3.66) ($P = .002$), ΔMETS (initial 6.19 ± 1.12 vs 12 weeks 7.16 ± 1.60) vs (initial 6.00 ± 1.19 vs 12 weeks 5.86 ± 1.23) ($P = .001$), ΔVO_2/HR ($P = .027$), ΔSV ($P = .014$), ΔOUES ($P = .012$), Δhand-grip strength ($P = .002$), Δflexibility ($P = .001$), Δbalance ($P = .002$), ΔT-score ($P = .042$), ΔBQI

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($P = .018$). However, Δresting systolic blood pressure ($P = .004$) and Δresting diastolic pressure ($P = .012$) decreased in the cardiac rehabilitation qigong exercise group.
Conclusion: Cardiac rehabilitation qigong exercise can improve cardiopulmonary aerobic capacity, physical fitness, bone mineral density in patients with stable CAD, suggesting that certain effect and safety for stable CAD patients undergoing phase III rehabilitation can be obtained.

Introduction

Risk factors of cardiovascular diseases (CVD) are rising in China, leading to high morbidity and mortality of CVD patients. Among them, take coronary heart disease (CHD) as an example, the number of CHD populations reached 11 million in 2016. The mortality rate of CVD tops the list, higher than that of tumors and other diseases. Therefore, the prevention and treatment of CVD is of great significance.[1] Rehabilitation of stable coronary artery disease (CAD) is defined as different stages of stable angina pectoris or stable asymptomatic acute coronary syndrome, or 2—3 months after hospital discharge in CHD patients in a long, static, and prior to symptom onset, or lifelong rehabilitation period.[2]

Currently, rehabilitation measures for stable CAD patients mainly include drugs, smoking cessation, psychological therapy, nutrition and exercise. Previous studies have proved that effective cardiac rehabilitation strategies can improve the quality of life for stable CAD patients, help them return to normal life, and prevent the relapse of relevant CVD. Among these strategies, exercise rehabilitation is of great significance.[3,4] For stable CAD patients, regular physical exercise is able to enhance cardiovascular function, reduce risk factors of heart diseases, ameliorate functional capacity and coronary flow, exert effects of anti-inflammation, fibrinolysis, and anti-thrombosis, and decrease the recurrence of CAD and its death rate.[5] Cardiac rehabilitation exercise for stable CAD patients aims to improve the cardiopulmonary aerobic capacity, reduce the risk factors associated with CAD, enhance the ability of daily living and regulate mental state.[6—8] Among them, cardiopulmonary aerobic capacity is the main assessment outcome for the prognosis of stable CAD patients, which is closely associated with the mortality of CAD.[9] Meanwhile, the risk factors of CAD, ability of daily living, and mental state are also associated with the death of stable CAD.[10,11]

Qigong exercise is classified into the exercise rehabilitation in traditional Chinese medicine (TCM) rehabilitation. It is a traditional Chinese sport item and also a part of profound Chinese culture characterized by the integration of physical activity, breathing, and psychological adjustment. Previous studies proved that qigong is beneficial for improvement of physical and mental health, self-care of daily living, heart rate (HR) variability, and peripheral vasomotion, risk factors control, and blood pressure (BP) and catecholamine reduction. These studies, to some extent, provide the basis for the application of traditional Chinese exercise rehabilitation to modern clinical cardiac rehabilitation.[12—14]

Based on the records of qigong exercise for heart diseases in ancient TCM literature combined with modern physical fitness qigong textbooks, our team created a set of TCM qigong exercise particular for stable CAD patients, yet the effectiveness and safety of the exercise need further verification. Here, we would like to have a try by exploring the effects of cardiac rehabilitation qigong exercise on phase III rehabilitation in stable CAD patients, in order to provide some evidence for the intervention of TCM exercise rehabilitation in modern cardiac rehabilitation in clinical practice.

Methods

Ethical approval

All procedures performed in studies involving human participants were in accordance with the 1964 Helsinki declaration and its later amendments, and regulations for Chinese clinical trials. The Ethics Committee of Sports Medicine Hospital Affiliated to General Administration of Sport of China reviewed and approved the protocol (2017020). All participants signed written informed consent before enrollment.

Trial design

This was a randomized controlled trial. According to the random number table, patients were assigned to either cardiac rehabilitation qigong exercise group or control group. All participants met the consecutive inclusion criteria. The program was registered in the China Clinical Trial Registry (ChiCTR1800015823).

Participants

Diagnostic criteria for stable CAD

According to the European Society of Cardiology (ESC) Guideline in 2013: (i) episodes of reversible myocardial demand/supply mismatch, related to ischemia or hypoxia, which are usually inducible by exercise, emotion or other stress and reproducible—but, which may also be occurring spontaneously; (ii) such episodes of ischemia/hypoxia are commonly associated with transient chest discomfort (angina pectoris); (iii) stable CAD also includes the stabilized, often asymptomatic, phases that follow an acute coronary syndrome.[15] Those who met one of the above three items were diagnosed as stable CAD.

Inclusion criteria

The inclusion criteria for this trial were as follows: (i) meet the diagnostic criteria for stable CAD; (ii) 2—3 months or even loner after hospital discharge; (iii) heart function evaluated as class I—III by NYHA; (iv) aged 18—70 years old; (v) educational level is at least junior high school; (vi) no participation in structured exercise for the preceding 6 months; (vii) accomplish informed consent.

Exclusion criteria

Patients with the following past medical histories were excluded: (i) uncontrollable tachycardia (resting HR $>$ 120/min); (ii) uncontrollable tachypnea (resting respiratory rate $>$ 30/min); (iii) uncontrollable respiratory failure (oxyhemoglobin saturation $\leq$ 90%); (iv) uncontrollable hypertension (systolic blood pressure (BP) $>$ 180 mmHg or diastolic pressure $>$ 110 mmHg before exercise); (v) body weight change $>$ $\pm$1.8 kg 72 hours before enrollment; (vi) unstable hyperglycemia (random blood glucose $>$ 18 mmol/L); (vii) uncontrollable malignant arrhythmia leading to unstable hemodynamics; (viii) diagnosed or suspected pseudoaneurysm or preoperative aortic dissection; (ix) uncontrolled septic shock and sepsis; (x) preoperative severe valve disorders or acute stage of heart failure of myocardia cardiac disorders; (xi) nervous and motor system disorders and rheumatism possibly aggravated after exercises evaluated by clinical physicians; (xii) patients were unable or unwilling to cooperate.

Rejection criteria

Participants were rejected when they voluntarily withdrew from the trial, failed to stick, or lost the cardiopulmonary exercise testing data, due to objective or subjective reasons.

Data collection site

These participants undergoing phase III rehabilitation were recruited from the Department of Functional Testing of the Sports Medicine Hospital (Beijing, China) from March 2017 to September 2017.

Interventions

Patients in the control group received routine cardiologic medication without any special intervention. On the basis of the control group, patients in the cardiac rehabilitation qigong exercise group were provided additionally with a 12-week TCM cardiac rehabilitation qigong exercise training (6—7 times a week, 3—6 sets of exercises each time for 40—60 minutes in total). The training was guided by a qualified martial arts instructor with many years of experience. They did the exercise collectively in the Beijing gymnasium supervised by two doctors from our team. After completing the training, they were asked to fill out the sports record form delivered by our team members.

The cardiac rehabilitation qigong exercise we created involves upper extremities, lower extremities, breathing, self-massage, and even the whole body. The exercise is of moderate intensity, in line with the principles of modern exercise physiology. Besides the preparation and ending postures (leading qi to its origin), the whole set of exercise consists of other eight postures, that is, Lotus Nirvana posture, cardiac protection posture, respiratory opening and closing posture, heart channel massage posture, Taiji single whip posture, left-right glance posture, left and right turning posture, and wild goose flying posture (Fig. 1 or Supplementary data for exercise video). With the consideration of modern sports rehabilitation, the exercise is designed to improve cardiopulmonary function, muscle strength, flexibility, and balance.

Outcomes

The primary outcome in this trial was cardiopulmonary treadmill test parameters.

Experimental devices used in the cardiopulmonary treadmill test included COSMED ECG (electrocardiogram), cardiopulmonary function analysis software, and h/p/cosmos treadmill (Rome, Italy), three breathing masks at large, middle and small sizes, and American Sun Tec Tango ambulatory BP monitors (Morrisville, North Carolina). Using these devices, resting and motor data from these participants were collected, and then presented in the forms of gas and metabolic parameters after dealing with cardiopulmonary function analysis software. The detailed process of collecting the parameters during cardiopulmonary treadmill exercise was that participants took a standing position and wore fixed oxygen masks. After checking for no leakage, the masks were connected to relevant assessment system, COSMED ECG, and BP monitoring system. Modified Bruce Protocol was adopted to conduct incremental cardiopulmonary exercise testing (CPET), and their HR and BP at the last minute in each level exercise were collected. Meanwhile, we asked about their subjective fatigue like ratings of perceived exertion (RPE), and observed the changes of ST segment in ECG.

Secondary outcomes included physical fitness, body composition, bone mineral density (BMD), and cardiac ultrasound B-mode imaging. These above-mentioned parameters were assessed at baseline (1 week before intervention) and the end of 12-week intervention. The data were input twice by two members (LDZ and FRZ) back to back using Epidata 3.0 (The EpiData Association, Odense, Denmark). Disagreements were solved by re-checking the original data.

Sample size

According to previous studies, VO_2/kg@peak, an important index of primary outcome, can be increased by about 30% after physical exercise intervention.[16] By EmpowerStats, we set 90% power; 5% significance level in two-sided log-rank test and after calculation, 29 stable CAD patients at phase III rehabilitation were necessary for each group. With the consideration of 10% dropout rate (about 6 cases), so the final sample size was 64 in the two groups.

Randomization

According to a random number table, randomization sequence was concealed for all experimental intervention personnel. Participants were randomly assigned to either cardiac rehabilitation qigong exercise group or control group.

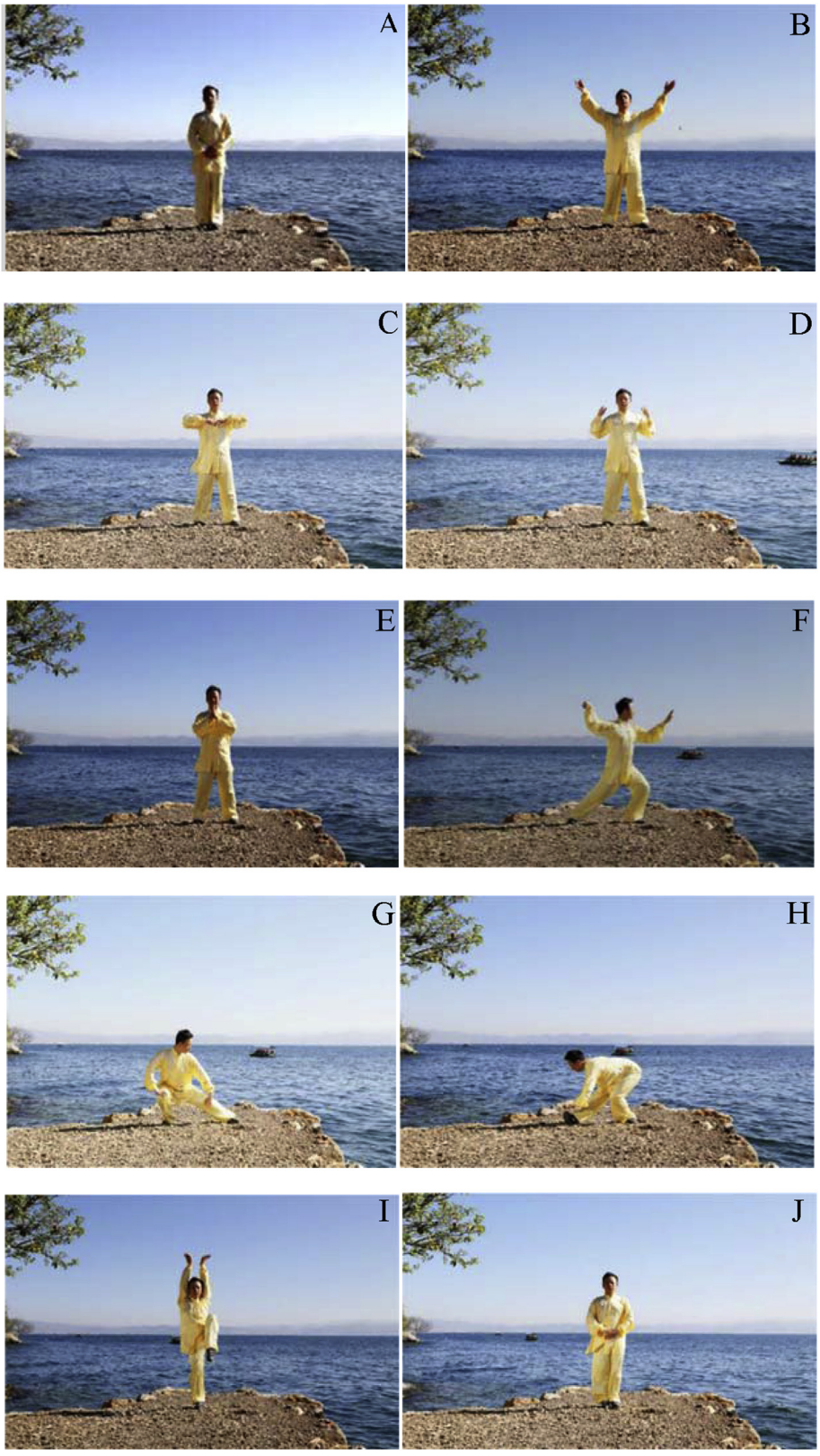

Figure 1 Presentation of cardiac rehabilitation qigong exercise (10 postures in total). A: preparation posture; B: Lotus Nirvana posture; C: cardiac protection posture; D: respiratory opening and closing posture; E: heart channel massage posture; F: Taiji single whip posture; G: left-right glance posture; H: left and right turning posture; I: wild goose flying posture; J: ending posture.

Allocation
A total of 85 stable CAD patients undergoing phase III rehabilitation who visited Sports Medicine Hospital Affiliated to General Administration of Sports of China from March to September 2017 were recruited in this trial.

Quality control for cardiac rehabilitation qigong exercise
The training lasted for 13 weeks. For the first week, the cardiac rehabilitation qigong exercise was instructed by qualified doctors in our team for 40 minutes daily. The doctors gave the participants in the cardiac rehabilitation qigong exercise group a teaching manual composed of pictures and texts and guided them to perform the cardiac rehabilitation qigong exercise following the video for 40 minutes. In the end of the first week, the trained participants needed to pass the performance of the whole set of cardiac rehabilitation qigong exercise correctly, after that, they were allowed to continue the 12-week intervention.

During all these 12-week intervention, collective training thrice weekly was required. For the rest time, participants need to accomplish the performance record form indicating they finished the cardiac rehabilitation training 40–60 minutes daily (detailed time for each trainee is attached).

Safety measurements
The criteria for experimental termination conformed to the guidelines of American College of Sports Medicine. The treadmill test was terminated immediately after occurrence of the following symptoms: abnormal ECG or blood pressure. The assessment was ended after the presence of maximum HR, exhaustion, or discomforts such as typical chest oppression and pain, and dyspnea, or ST-T segment depression in ECG, or reactive hypotension.

Statistical analyses
Kolmogorov–Smirnov test was used to assess the normality of data distribution. Continuous variables at baseline and at 12 weeks of the two groups (cardiac rehabilitation qigong exercise group and control group) were compared using the Student *t* test and Mann–Whitney *U* test (if data are in normal distribution, Student *t* test is used, and Mann–Whitney *U* test for disobeying normal distribution), while classified variables of the two groups were compared at baseline by the chi-squared test. The difference of variable in the cardiac rehabilitation qigong exercise group was compared at baseline and at 12 weeks after intervention using Student *t* test and Mann–Whitney *U* test. Enumeration data were presented as percentage. The measurement data were expressed as mean (standard deviation). Data were analyzed using software SPSS 20.0 (IBM, Armonk, NY). $P < .05$ was considered significant.

Results

Participant flow diagram

Of the 85 cases, 9 ones were not eligible for the inclusion criteria. Two patients could not finish cardiovascular exercise tests and another 6 participants were excluded due to contact loss. Finally, 68 patients were included and randomly assigned to the cardiac rehabilitation qigong exercise group (n = 34) and the control group (n = 34). Four patients in the cardiac rehabilitation qigong exercise group quit the study due to unable to stick to training for their own reasons, and the rest 30 patients accomplished the 12-week training program. Five patients in the control group discontinued because their phone couldn't be connected. So, the remaining 29 participants finished the study (Fig. 2).

Demographic characteristics

There were no significant differences in demographic characteristics, including gender, age, course of disease, height, weight, body mass index (BMI), surgical history, comorbidity, and CVD medications between the two groups ($P > .05$) (Table 1). Drug therapy did not change during the intervention.

From Tables 2–5, we found no significant differences in physical fitness, body composition, BMD, cardiac ultrasound B-mode imaging, or cardiopulmonary treadmill test at baseline data in the two groups.

Intervention effects

Similarly, we compared the indexes mentioned above before and after intervention.

Comparison of cardiopulmonary treadmill test parameters@peak before and after intervention
After 12-week intervention, ΔVO_2@peak, ΔVO_2/kg@peak, ΔMETs@peak, ΔVO_2/HR@peak, ΔSV@peak, $\Delta VE/VO_2$@peak and ΔOUES@peak of the CRQ group were higher than those of the control group ($P < .05$). The resting systolic BP and resting diastolic BP were lower in the cardiac rehabilitation qigong exercise group than the control group ($P < .05$). After 12-week intervention, speed@peak, grade@peak, VO_2@peak, VO_2/kg@peak, METs@peak, VE@peak, BR@peak, VT@peak, Rf@peak, VO_2/HR@peak and SV@peak of the cardiac rehabilitation qigong exercise group were higher than those of the control group ($P < .05$) (Table 2).

Comparison of the basic physical parameters before and after intervention
After 12-week intervention, Δhand-grip strength, Δflexibility and Δbalance of the cardiac rehabilitation qigong exercise group were higher than those of the control group with statistical differences ($P < .05$). Meanwhile, results displayed the hand-grip strength and flexibility of the cardiac rehabilitation qigong exercise group were higher than those of the control group after 12-week intervention ($P < .05$) (Table 3).

Comparison of the body composition before and after intervention
As displayed in Table 4, after 12-week intervention, all body composition parameters and their differences of the cardiac rehabilitation qigong exercise group didn't display significant differences when compared with those of the control group ($P > .05$).

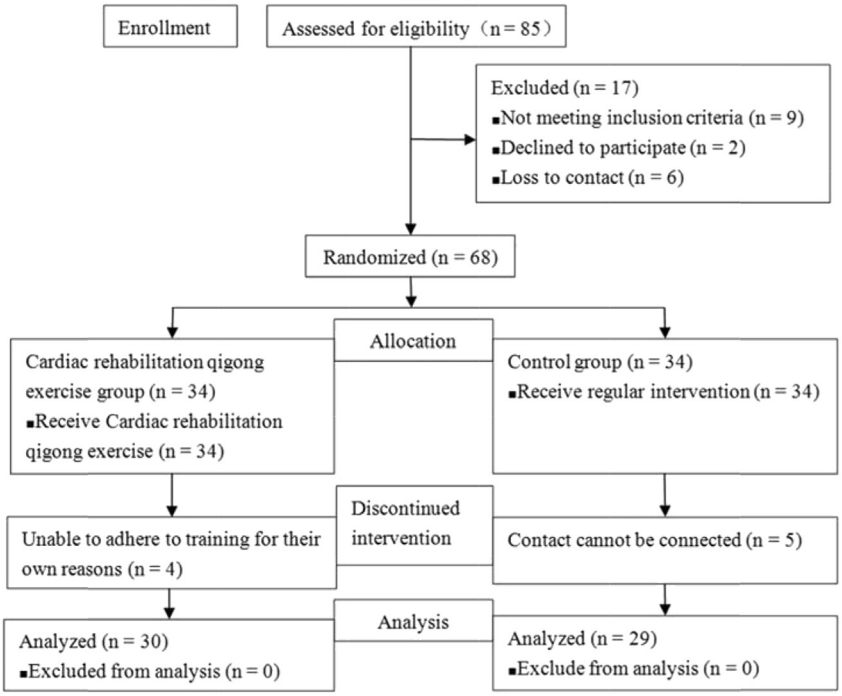

Figure 2 Flow diagram of study subject recruitment.

Comparison of BMD parameter before and after intervention

After 12-week intervention, ΔT-score, ΔBQI (bone quality index), ΔBUA (broadband ultrasound attenuation) and Δsame age ratio of the cardiac rehabilitation qigong exercise group were higher than those of the control group ($P < .05$). However, these BMD indexes including T-score, BQI, BUA, and same age ratio were not displayed significant differences between the two groups after 12-week intervention ($P > .05$) (Table 5).

Comparison of UCG parameters before and after intervention

After 12-week intervention, all ultrasonic cardiogram (UCG) parameters and their differences of the cardiac rehabilitation qigong exercise qigong group didn't display significant differences when compared with those of the control group ($P > .05$) (Table 6).

Safety assessment

No adverse reactions related with the cardiac rehabilitation qigong exercise were reported.

Discussion

In this study, we verified the effectiveness of cardiac rehabilitation qigong exercise for stable CAD patients undergoing phase III rehabilitation by increase of the indexes of treadmill test, physical fitness, and BMD to some extent after 12-week intervention.

Modern comprehensive cardiac rehabilitation mainly focuses on three aspects like body, psychologic sociology, and education. In present study, we aim to overcome the limitations of cardiovascular and musculoskeletal systems due to lack of exercise, improve asymptomatic sports, and control risk factors of CVD in the scope of body. The exercise modes for modern cardiac rehabilitation include brisk walking, riding a bicycle, swimming, and climbing, which can bring beneficial effects on cardiovascular tolerance, muscle strength, body composition, flexibility and coordination.[16] Research demonstrated that aerobic endurance exercise can improve sports ability and asymptomatic sports tolerance, and long-term regular aerobic endurance exercise is beneficial for the improvement of risk factors of CVD such as hypertension, hyperlipidemia, diabetes mellitus, and abdominal obesity, etc.[17] In the study, we also find several important parameters during cardiopulmonary exercise testing such as ΔVO_2, ΔVO_2/kg, ΔMETs, ΔVO_2/HR, ΔSV, $\Delta VE/VO_2$, ΔOUES, resting BP, physical fitness, and BMD increased significantly in the cardiac rehabilitation qigong exercise group compared with the control group, suggesting that the exercise can improve maximal aerobic metabolic capability, cardiovascular efficacy, heart pumping function, the ability of physical activity, body coordination, flexibility, and hand-grip strength. The effects obtained are tantamount to that by modern sports intervention. Cardiopulmonary exercise tolerance increase can slow the disease progression and improve the prognosis.[18] The potential mechanism may be regular change of thoracoabdominal pressure improves the respiratory function when practicing cardiac rehabilitation qigong exercise in moderate intensity following the rhythm of expiration and inspiration in CHD patients. When practicing cardiac rehabilitation qigong exercise, increase of circulating blood volume enlarges the blood volumetric loading, and muscle movement accelerates the blood backflow and reduces the

Table 1 Comparison of baseline demographics.

	Total (n = 59)	Cardiac rehabilitation qigong exercise (n = 30)	Control group (n = 29)
Gender (M/F)	17/42	10/20	7/22
Age, years	60.95 (5.50)	61.23 (5.24)	60.66 (5.85)
Course of disease, years	4.36 (2.02)	4.73 (2.08)	3.97 (1.92)
Height, cm	163.34 (6.89)	163.5 (7.48)	163.17 (6.34)
Weight, kg	63.86 (10.01)	63.04 (10.53)	64.71 (9.56)
BMI, kg/m^2	23.81 (2.52)	23.47 (2.47)	24.17 (2.58)
Surgical history, n (%)			
CABG	8 (13.6%)	5 (16.7%)	3 (10.3%)
CAI	19 (32.2%)	11 (36.7%)	8 (27.6%)
No surgery	32 (20.3%)	14 (46.7%)	18 (62.1%)
Comorbidity, n (%)			
Hypertension	51 (86.4%)	28 (93.3%)	23 (79.3%)
Diabetes mellitus	12 (20.3%)	7 (23.3%)	5 (17.2%)
Dyslipidemia	46 (78.0%)	26 (86.7%)	20 (69.0%)
Cerebrovascular disease	8 (13.6%)	3 (10.0%)	5 (17.2%)
Smoking	33 (56.0%)	18 (60.0%)	15 (51.7%)
Alcohol consumption	30 (50.8%)	14 (46.7%)	16 (55.2%)
Sleep disorders	38 (64.4%)	17 (56.7%)	21 (72.4%)
Mental stress	21 (35.6%)	11 (36.7%)	10 (34.5%)
CVD drugs, n (%)			
Aspirin	47 (79.7%)	26 (86.7%)	21 (72.4%)
Clopidogrel	18 (30.5%)	10 (33.3%)	8 (27.6%)
ACE-inhibitors	33 (55.9) %	17 (56.7%)	16 (55.2%)
ARB	14 (23.7%)	8 (26.7%)	6 (20.7%)
CCB	18 (30.5%)	10 (33.3%)	8 (27.6%)
Diuretic	6 (10.2%)	4 (13.3%)	2 (6.9%)
Beta-blockers	29 (49.2%)	15 (50.0%)	14 (48.3%)
Statins lipid-lowering drugs	35 (59.3%)	15 (50.0%)	20 (69.0%)
Oral antidiabetic drugs	2 (28.8%)	2 (6.7%)	0 (0%)
Insulin	3 (3.4%)	2 (6.7%)	1 (3.4%)
Others	19 (32.2%)	10 (33.3%)	9 (31.0%)

Note: CABG: coronary artery bypass graft; CAI: coronary artery intervention; CVD: cardiovascular diseases; ACE: angiotensin-converting enzyme; ARB: angiotensin receptor blocker; CCB: calcium channel blockers.
Data are expressed as mean (SD) or n (%).

resistance of peripheral arteries, causing the increase of cardiac contraction amplitude. After a long-term adaptation, cardiac output increases with improved myocardial oxygen consumption and more powerful cardiac contraction.[19,20] Improvement in hand-grip strength, flexibility, balance, and BMD is critical for the prevention of musculoskeletal injures and fall-over in elder patients and those who didn't take exercises for a long time. However, the exercise fails to improve the traditional risk factors of CHD such as body weight, body fat mass, visceral fat, and basal metabolic rate. Meanwhile, improvement of the indexes reflecting heart function are not remarkable, either, which may be associated with incomplete study design on the intensity, duration, and frequency of the cardiac rehabilitation qigong exercise, intervention period, patient's compliance, and supervision, and provide the foundation for further improvement of study design.

After analysis, we believe the cardiac rehabilitation qigong exercise characterized by simple forms and moderate intensity in clinical practice could benefit for stable CAD patients undergoing phase III rehabilitation. The potential mechanism to explain cardiac rehabilitation benefits from traditional Chinese cardiac rehabilitation qigong exercise can be summarized as physical regulation, respiratory regulation, and mental regulation. Physical regulation refers to the systematic and regular physical exercises under the guidance of mind, to keep every part of the body in the optimal physiological status. To be specific, relax, limb stretch, and hand grip can enhance the grip strength; single leg standing exercise can improve patient's balance and muscle strength when combined with resistance training of the limbs.[21] Respiratory regulation is defined as breathing following the rhythm of exercise in an active or automatic way to meet the metabolism and energy demand, which can decrease the metabolic rate, regulate vegetative nervous system, improve visceral physiologic activity and cardiovascular function, and enhance cardiopulmonary exercise tolerance and aerobic

Table 2 Changes of cardiopulmonary treadmill test parameters@peak of the two groups.

	Cardiac rehabilitation qigong exercise group (n = 30)			Control group (n = 29)			*P*
	Baseline	End of 12th week	Difference	Baseline	End of 12th week	Difference	
Resting indicators							
Resting systolic BP	133.9 (9.36)	119.03 (13.71)	−14.87 (16.81)	129.55 (14.21)	127.52 (12.90)	−2.03 (15.65)	.004[b]
Resting diastolic BP	79.37 (10.09)	71.30 (5.92)	−8.07(10.55)	75.34 (9.42)	73.72 (8.72)	−1.62 (8.48)	.012[b]
Resting HR	74.77 (10.53)	67.43 (8.68)	−7.33 (8.92)	73.66 (10.61)	69.86 (9.97)	−3.79 (13.07)	.219
Exercise testing@peak							
T, hh:mm:ss	12.02 (1.66)	13.33 (1.64)	1.33 (2.11)	11.87 (2.13)	12.65 (2.18)	0.72 (1.85)	.243
Speed, kmh*10	48.40 (8.26)	55.60 (6.10)[a]	7.20 (8.60)	47.31 (11.10)	50.86 (9.93)	3.55 (9.02)	.117
Grade, %	13.13 (1.14)	14.13 (1.17)[a]	1.00 (1.26)	12.97 (1.57)	13.45 (1.40)	0.48 (1.27)	.122
Metabolic response							
VO_2, mL/min	1352.63 (340.95)	1594.57 (467.14)[a]	241.93 (349.34)	1363.83 (322.90)	1323.76 (318.92)	−40.07 (344.04)	.003[b]
VO_2/kg, mL/min/kg	21.23 (3.56)	24.75 (5.11)[a]	3.40 (4.74)	21.01 (3.71)	20.35 (3.66)	−0.65 (4.86)	.002[b]
MET_S	6.19 (1.12)	7.16 (1.60)[a]	1.13 (1.31)	6.00 (1.19)	5.86 (1.23)	−0.14 (1.60)	.001[b]
Cardiovascular response							
HR, bpm	125.43 (13.26)	135.93 (12.86)	10.50 (15.34)	128.97 (13.74)	131.83 (20.82)	2.85 (14.68)	.056
VO_2/HR, mL/bpm	11.01 (2.86)	11.85 (3.37)[a]	0.93 (2.10)	10.61 (2.46)	10.22 (2.50)	−0.34 (2.22)	.027[b]
SV	66.90 (16.58)	72.60 (19.98)[a]	5.70 (12.84)	65.24 (14.79)	62.69 (15.21)	−2.55 (12.06)	.014[b]
ST V5, mm	−0.61 (0.55)	−0.83 (0.50)	−0.10 (0.55)	−0.51 (0.57)	0.57 (0.77)	0.03 (0.63)	.384
Gas exchange							
VE/VO_2	30.53 (4.06)	33.52 (4.56)	3.97 (4.74)	31.26 (3.06)	31.75 (3.44)	0.45 (3.61)	.025[b]
VE/VCO_2	30.10 (2.79)	30.49 (3.15)	0.37 (3.16)	29.87 (3.56)	29.28 (2.81)	−0.72 (2.17)	.127
Other indexes							
VE/VCO_2 slope	24.96 (4.00)	26.45 (3.66)	2.32 (4.33)	27.00 (3.83)	26.14 (2.63)	1.05 (5.96)	.460
Lowest VE/VCO_2	28.07 (2.05)	27.67 (2.63)	−0.31 (1.96)	28.07 (3.09)	27.25 (2.50)	−0.71 (1.68)	.414
OUES, L/min	1997.03 (518.72)	2071.52 (546.49)	51.59 (268.78)	1886.69 (444.08)	1846.86 (404.78)	−82.54 (322.92)	.012[b]
HRRecov, bpm	19.00 (23.92)	34.62 (46.93)	14.12 (54.24)	19.68 (18.84)	25.52 (36.70)	6.52 (41.63)	.560
VO_2@LT/VO_2max pred (%)	65.07 (25.55)	67.85 (28.59)	1.74 (29.48)	66.03 (27.35)	63.97 (20.35)	−2.07 (35.29)	.664

Note: BP: blood pressure; HR: heart rate; SV: stroke volume; METs: metabolic equivalents; ST V5: ST segment level at V 5 lead; VE/VO_2: ventilation volume/oxygen uptake; VE/VCO_2: ventilation volume/ratio of ventilation over carbon dioxide elimination; OUES: oxygen uptake efficiency slope; HRRecov: heart rate recover; VO_2@LT/VO_2max pred: predicted oxygen uptake@ lactate anaerobic threshold/ oxygen uptake maximum.

Data are expressed as mean (SD).

[a] $P < .05$ indicates the end of 12th week comparison between the two groups.

[b] $P < .05$ indicates differences comparison between the two groups.

Table 3 Comparison of the basic physical parameters in the two groups.

	Cardiac rehabilitation qigong exercise group (n = 30)			Control group (n = 29)			*P*
	Baseline	End of 12th week	Difference	Baseline	End of 12th week	Difference	
Hand-grip strength, kg	24.70 (6.0)	28.97 (7.14)[a]	4.27 (5.72)	23.11 (7.06)	22.88 (7.15)	−0.14 (4.82)	.002[b]
Flexibility, cm	6.12 (6.77)	12.71 (6.19)[a]	6.6 (4.80)	4.96 (5.35)	6.46 (6.82)	1.48 (6.11)	.001[b]
Balance, s	5.04 (4.13)	13.18 (6.46)	8.03 (8.72)	8.86 (11.00)	10.23 (10.70)	1.38 (6.06)	.002[b]

Data are expressed as mean (SD).

[a] $P < .05$ indicates the end of 12th week comparison between the two groups.

[b] $P < .05$ indicates differences comparison between the two groups.

Table 4 Changes of body composition parameters of the two groups.

	Cardiac rehabilitation qigong exercise group (n = 30)			Control group (n = 29)			*P*
	Baseline	End of 12th week	Difference	Baseline	End of 12th week	Difference	
Weight, kg	63.04 (10.53)	63.16 (10.54)	0.07 (1.14)	64.71 (9.56)	65.07 (10.15)	0.17 (0.60)	.660
BMI, kg/m^2	23.47 (2.47)	24.31 (4.86)	0.17 (1.13)	24.17 (2.58)	25.37 (2.66)	0.11 (0.61)	.803
Body fat mass	17.67 (5.59)	18.01 (5.48)	−0.77 (2.11)	19.60 (6.91)	18.01 (5.48)	−1.03 (2.15)	.631
Basal metabolic rate	1285.73 (218.92)	1279.23 (216.94)	−6.5 (32.31)	1288.03 (205.06)	1282.00 (210.51)	−6.03 (25.17)	.951
Visceral fat rating	9.1 (3.75)	9.30 (3.79)	0.2 (0.95)	9.28 (3.48)	9.69 (3.65)	0.41 (1.12)	.434

Note: *P* value indicates difference in the two groups.
Data are expressed as mean (SD).

Table 5 Comparison of BMD parameter of the two groups.

	Cardiac rehabilitation qigong exercise group (n = 30)			Control group (n = 29)			*P*
	Baseline	End of 12th week	Difference	Baseline	End of 12th week	Difference	
T-score	−2.11 (0.78)	−1.83 (0.60)	0.17 (0.60)	−1.71 (0.83)	−1.88 (0.84)	−0.17 (0.66)	.042[a]
BQI	65.69 (14.82)	70.37 (11.36)	4.69 (10.75)	72.61 (15.55)	70.22 (15.29)	−3.03 (13.23)	.018[a]
BUA	34.59 (15.99)	37.20 (12.10)	2.55 (13.97)	42.54 (14.41)	36.95 (16.04)	−5.79 (14.28)	.028[a]
Same age ratio	80.22 (17.76)	86.78 (13.56)	6.62 (13.04)	90.11 (19.27)	87.43 (19.27)	−3.59 (15.39)	.011[a]

Note: BQI: bone quality index; BUA: broadband ultrasound attenuation; BMD: bone mineral density.
Data are expressed as mean (SD).
[a] $P < .05$ indicates differences comparison between the two groups.

Table 6 Changes of UCG parameters of the two groups.

	Cardiac rehabilitation qigong exercise group (n = 30)			Control group (n = 29)			*P*
	Baseline	End of 12th week	Difference	Baseline	End of 12th week	Difference	
EDV, mL	93.47 (20.87)	94.46 (28.08)	2.29 (19.74)	98.71 (19.28)	98.04 (18.65)	−0.09 (26.92)	.706
ESV, mL	29.32 (12.02)	31.82 (10.42)	1.93 (9.48)	28.48 (7.80)	31.25 (9.04)	1.90 (10.71)	.995
EF, %	67.00 (8.94)	66.13 (5.20)	−0.93 (9.23)	69.86 (5.75)	66.58 (5.36)	−2.38 (7.74)	.618
FS, %	37.68 (9.08)	35.92 (3.69)	−1.79 (6.69)	39.71 (4.88)	37.00 (4.52)	−2.33 (6.92)	.818
CO, L/min	4.18 (0.77)	4.21 (0.98)	0.29 (0.83)	4.39 (1.07)	4.67 (1.05)	−0.10 (1.61)	.365

Note: UCG: ultrasonic cardiogram; EDV: end diastolic velocity; ESV: end systolic velocity; EF: ejection fraction; FS: fractional shortening; CO: cardiac output.
P value indicates difference in the two groups.
Data are expressed as mean (SD).

exercise.[22–24] Mental regulation refers to the mind concentration to avoid the stressors from outside environment, which can prevent the excessive secretion of angiotensin, alleviate stress state, regulate the hypothalamic pituitary adrenal axis, improve the level of related hormones, reduce the excitability of the nervous system, and promote great psychologic effect, in order to decrease BP and HR.[25–30] Results obtained in this study can provide a theoretic foundation for cardiac rehabilitation qigong exercise applied to phase III rehabilitation in stable CAD patients in clinical practice.

There are still some limitations for the study, such as small sample size, failure to follow up, short intervention, inability to assess the long-term effect, and uncertainty of

results replication. Additionally, we didn't assess the physiologic function, mental health, and social ability in this study. Likewise, we cannot ascertain that cardiac rehabilitation qigong exercise is associated with outcome improvement in stable CAD patients. Therefore, further studies are warranted to explain the specific mechanism of cardiac rehabilitation qigong exercise on stable CAD patients undergoing phase III rehabilitation with involvement of these factors.

Conclusion

To sum up, cardiac rehabilitation qigong exercise, to some extent, improves cardiopulmonary treadmill test parameters, physical fitness, and BMD. The exercise has certain application value and is safe for stable CAD patients undergoing phase III rehabilitation, which can be considered as a supplementary and alternative therapy for the prevention and rehabilitation of stable CAD.

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Conflicts of interest

All authors of this paper declare no conflicts of interest.

CRediT authorship contribution statement

Fengrun Zhao: Conceptualization, data curation, formal analysis, investigation, and writing – original draft. **Yin Lin:** Methodology, funding acquisition, Writing – review & editing. **Chen Liang:** Methodology, supervision, and funding acquisition. **Lindan Zhai:** Investigation, data curation, and methodology. **Can Gao:** Resources. **Jianhong Zhang:** Project administration. **Qun Ye:** Visualization. **Christopher John Zaslawski:** Writing – review & editing. **Fangfang Ma:** Software. **Yichen Wang:** Software.

Appendix A. Supplementary data

Supplementary data to this article can be found online at https://doi.org/10.1016/j.jtcms.2018.10.003.

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