RESEARCH

Cardiovascular Therapeutics

Pilates in Heart Failure Patients: A Randomized Controlled Pilot Trial

Guilherme Veiga Guimarães,[1,2] Vitor Oliveira Carvalho,[1,2] Edimar Alcides Bocchi,[1] & Veridiana Moraes d'Avila[1,2]

1 Heart Institute do Hospital das Clínicas da Faculdade de Medicina da Universidade de São Paulo, São Paulo, Brazil, (InCor-HCFMUSP)
2 Laboratory of Physical Activity and Health, Centro de Práticas Esportivas da Universidade de São Paulo, São Paulo, Brazil (LAtiS/CEPEUSP)

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Correspondence
Guilherme Veiga Guimarães
Rua Dr Baeta Neves, 98
CEP 05444—050
São Paulo SP, Brazil.
Tel.: 55-11-3069-5419;
Fax: 55-11-3069-5502;
E-mail: gvguima@usp.br

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Background: Conventional cardiac rehabilitation program consist of 15 min of warm-up, 30 min of aerobic exercise and followed by 15 min calisthenics exercise. The Pilates method has been increasingly applied for its therapeutic benefits, however little scientific evidence supports or rebukes its use as a treatment in patients with heart failure (HF). **Purpose:** Investigate the effects of Pilates on exercise capacity variables in HF. **Methods:** Sixteen pts with HF, left ventricular ejection fraction 27 ± 14%, NYHA class I–II were randomly assigned to conventional cardiac rehabilitation program (n = 8) or mat Pilates training (n = 8) for 16 weeks of 30 min of aerobic exercise followed by 20 min of the specific program. **Results:** At 16 weeks, pts in the mat Pilates group and conventional group showed significantly increase on exercise time 11.9 ± 2.5 to 17.8 ± 4 and 11.7 ± 3.9 to 14.2 ± 4 min, respectively. However, only the Pilates group increased significantly the ventilation (from 56 ± 20 to 69 ± 17 L/min, $P = 0.02$), peak VO_2 (from 20.9 ± 6 to 24.8 ± 6 mL/kg/min, $P = 0.01$), and O_2 pulse (from 11.9 ± 2 to 13.8 ± 3 mL/bpm, $P = 0.003$). The Pilates group showed significantly increase in peak VO_2 when compared with conventional group (24.8 ± 6 vs. 18.3 ± 4, $P = 0.02$). **Conclusions:** The result suggests that the Pilates method may be a beneficial adjunctive treatment that enhances functional capacity in patients with HF who are already receiving standard medical therapy.

Background

Heart failure (HF) is considered to be the last stage of heart diseases and a worldwide cause of mortality and morbidity [1,2]. It is characterized by a persistent overactivity of the neurohormonal system [3], endothelial dysfunction [4], exercise intolerance [5,6], high mortality [7], and a poor quality of life [8].

Exercise training has been recommended as an important tool in HF treatment. It improves exercise capacity [9], quality of life [10], besides reducing endothelial dysfunction [11], catecholamine levels [12], and morbity [13].

Pilates is a particular exercise approach that was founded on the teachings of Joseph Pilates (1880–1967) and was initially practiced almost exclusively by athletes and dancers. Pilates has become a fast-growing, popular trend in rehabilitation and fitness programs in recent years. The goal of Pilates training is improvement of general body flexibility and health, emphasizing core (truncal) strength, posture, and coordination of breathing with movement. Anecdotal evidence suggests that as the Pilates method increases core strength, the natural flexibility of the spine and limbs returns [14,15,16].

Despite this promising method, there is little scientific research on the effectiveness of Pilates. The purpose of this study was to investigate the effects of Pilates on exercise capacity variables in HF patients.

Methods

Study Population

A total of 26 outpatients with HF were recruited from a tertiary cardiology hospital with the following criteria: clinical and optimized farmacological treatment (for at least 3 months), left ventricular ejection fraction ≤40% (determined by echocardiography), NYHA functional class I–II and no previous participation in an exercise training program. Patients with a pacemaker, atrial fibrillation, Chagas' disease, submaximal cardiopulmonary exercise tests (CPET) or noncardiovascular functional limitations, such as stroke or chronic obstructive pulmonary disease, were excluded. Patient characteristics are shown in Table 1.

The study protocol was approved by the ethics committee of the study institution. All patients provided informed consent prior to participation.

Study Design

This clinical trial was designed to evaluate the exercise capacity variables after Pilates in HF patients. First, all patients performed

Table 1 Patient's characterization

	Conventional	Pilates	*p*	95% CI
Etiology (%)				
Ischemic	30	14	0.210	−0.098 to 0.0435
Non Ischemic	70	86	0.210	−0.098 to 0.0435
NYHA functional class (%)				
I	50	65	0.291	−0.761 to 0.233
II	50	35	0.291	−0.761 to 0.233
Peak VO_2 ($mLO_2.Kg^{-1}.min^{-1}$)	17.4 ± 4	20.9 ± 6	0.309	−1.432 to 4.416
Sex (%)				
Male	81	62	0.381	−0.151 to 0.388
Female	19	38	0.381	−0.151 to 0.388
Age (years)	44 ± 11	46 ± 12	0.730	−10.67 to −1.08
LVEF (%)	27 ± 5.6	27 ± 2.3	0.606	−5.262 to 3.107
Body Mass Index (Kg/m^2)	25 ± 10	25 ± 1	0.836	−5.298 to 4.307
Current medications: % (mg/day)				
Diuretics	45	45		
ACE inhibitor	90	87		
Losartan	10 (100 ± 0)	20 (100 ± 0)	—	Few Case
Carvedilol	100 (54 ± 32)	100 (60 ± 32)	0.547	−26.289 to 14.149
Spironolactone	45 (25 ± 0)	50 (25 ± 0)	0.357	−0.123 to 0.323
Digoxin	40 (0.25 ± 0)	45 (0.25 ± 0)	0.374	−19.448 to 9.148
Isosorbide 5-mononitrate	10 (100 ± 0)	10 (80 ± 0)	—	Few Case
Hydralazine	0	10 (50 ± 0)	—	Few Case

NYHA, New York Heart Association; VO_2, Oxygen consumption; LVEF, Left ventricular ejection fraction (echo); ACE, Angiotensin Converting Enzyme.

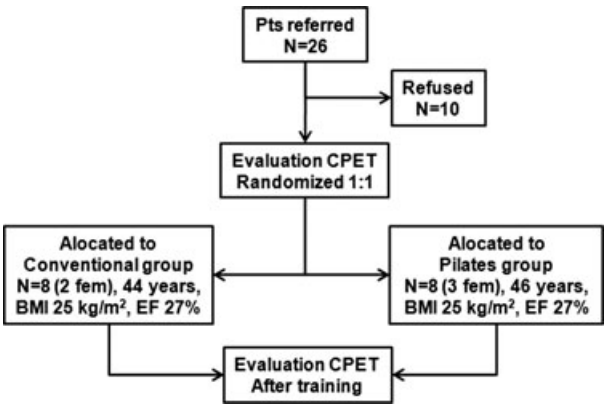

Figure 1 Study design.

a CPET to evaluate the baseline exercise capacity variables. When the CPET was completed, patients were randomized one by one to the Pilates group or conventional exercise training group. Between 3 and 5 days after the randomization, patients began the exercise training. Two days after the last exercise session, all patients performed another CPET for comparison. (Figure 1)

Cardiopulmonary Exercise Test

All patients were asked to refrain from both strenuous physical activity and the consumption of any stimulants (e.g., coffee, tobacco, and alcohol) that could influence heart rate for 24 h before the CPET. The patients' last meal was ingested at least 2 h before the start of the test. All subjects underwent the test on a programmable treadmill (Series 2000, Marquette Electronics, Milwaukee, WI, USA) in a temperature-controlled room (21–23°C) between 10 am and 15 pm with a standard 12-lead continuous ECG monitor (Max 1, Marquette Electronics). Blood pressure monitoring was performed by the auscultation method. Minute ventilation, oxygen uptake, carbon dioxide output, and other cardiopulmonary variables were acquired breath-by-breath by a computerized system (Vmax 229 model, SensorMedics, Yorba Linda, CA, USA). Resting oxygen consumption and HR were computed as the mean of the final 30 s of the resting period, whereas peak effort (peak of oxygen consumption) and peak heart rate were the mean values of the final 30 s of effort before exhaustion. The respiratory exchange ratios were recorded as the averaged samples obtained during each stage of a modified Naughton protocol. A satisfactory CPET was characterized by a peak of respiratory exchange ratio >1.05 and symptoms of maximum effort. The respiratory compensation point was determined when VE/VCO_2 reached their minimum values before rising and the carbon dioxide partial end-tidal pressure reached its maximum level before starting to decrease.

Aerobic Exercise Training Protocol

All HF patients performed the aerobic exercise training protocol (walking on a treadmill) in a controlled temperature room 20 ± 1°C, two sessions a week for 16 weeks under the supervision of an exercise specialist. All subjects were instructed not to add any

leisure exercise during the study period. The exercise sessions consisted of 5 min of warm-up, 30 min of aerobic training followed by 5 min of cold down, and 20 min of exercise protocol (Pilates or conventional training). Aerobic exercise intensity was determined according to the workload in the respiratory compensation point reached during the CPET. All subjects exercised using a heart rate-monitoring device during every training session to ensure that the subjects were training on their corresponding heart rate to 90% of respiratory compensation point in association with the perceived exertion between "relatively easy and slightly tiring" [17]. The speed of the treadmill was continually adjusted as training adaptations occurred to ensure that all training sessions were carried out at the desired heart rate throughout the 16-week training period. An exercise training compliance of 70% was set as a criterion for completing the study.

Pilates Protocol

Patients allocated to Pilates group performed the same aerobic exercise training protocol of the conventional group (as previously described) and more 20 min of mat Pilates class two sessions a week for 16 weeks under supervision Pilates instructor specialist in cardiac rehabilitation. Each session lasted 60 min. The exercises were categorized into strengthening, stretching, range of motion, and balance. They included exercises for thoracic extension and general abdominal strengthening, and lumbar (core) stabilization exercises for the deep abdominal muscles (transversus and internal oblique). Postural education was also part of the exercise program, and in the additional focus on breathing a concentration during the execution of these exercises. Exercises were performed on mats accessories such as thera-band, magic circle, fitball, wobble board, and foam rollers. In the mat class, patients did the exercise sitting or standing and used gravity to help stabilize the powerhouse [14].

Conventional Protocol

The exercise conventional program was supervised by exercise specialist and consisted of two sessions per week for 16 weeks; each session lasted 60 min. Exercise conventional session included aerobic exercise, flexibility exercise, resistance exercise, and calisthenics. Aerobic exercise, as previously described, was performed for 30 min on a treadmill. The flexibility exercises focused on range of motion and included exercises designed to stretch the cervical and lumbar spine and the upper and lower extremities. The resistance exercise included a set of 8–10 different exercises that train the major mucle groups. A repetition range of 10–15 at a low relative resistance was performed with small free weights (0.5–2 kg), elastic bands, and ankle weights. The weight was adjusted in accordance with the patient's feeling (11–13 the Borg scale) [17]. Calisthenics exercise were included a variety of simple movements using own body weight for resistance.

Statistical Analysis

The descriptive analysis was presented as mean and standard deviation. To compare baseline data between two groups, we used unpaired *t* test. To compare exercise capacity variables before and after protocol between Pilates and conventional groups, we used the two-way ANOVA with *post hoc* Bonferroni test.

Data were analyzed using the Statistical Package for Social Sciences for Windows, 11.5 (SPSS Inc, Chicago, IL, USA). Statistical significance was defined as $P < 0.05$.

Table 2 Hemodynamic and metabolic results

	Conventional		Pilates		
	pre	post	pre	post	*p*
HR rest	72 ± 18	71 ± 18	78 ± 17	76 ± 13	ns
HR max	125 ± 23	125 ± 18	135 ± 27	144 ± 24	ns
SBP rest	113 ± 24	108 ± 17	106 ± 16	101 ± 24	ns
SBP max	134 ± 21	127 ± 18	125 ± 17	143 ± 21	ns
DBP rest	69 ± 9	67 ± 12	73 ± 14	67 ± 17	ns
DBP max	64 ± 15	64 ± 21	68 ± 19	69 ± 13	ns
Peak VO_2	17.4 ± 3.9	18.3 ± 4.2*	20.9 ± 6.6	24.8 ± 6.0	0.02
Pulse O_2	11.6 ± 4	12 ± 4	11.9 ± 3	13.8 ± 3	ns
RER	1.1 ± 0.07	1.1 ± 0.07	1.1 ± 0.1	1.1 ± 0.07	ns
Slope VE/VCO_2	31 ± 6	32 ± 6	29 ± 5	29 ± 4	ns
Exercise Time	11.7 ± 3.9	14.2 ± 4	12.8 ± 2.5	17.8 ± 4	ns

HR, heart rate, in bpm; SBP and DBP, systolic and diastolic blood pressure; in mmHg; peak VO_2, oxygen consumption, in mlO_2/kg/min; Exercise time, in minute; Pulse O_2, in mlO_2/bpm; RER, respiratory exchange ratio. *p by* ANOVA two-way test for intergroup comparisons. NS, not significant.

Results

Both groups were well matched for age, sex, LVEF, body mass index, HF etiology, NYHA functional class, peak oxygen consumption and current medications (Table 1). Ten patients refused to participate in the study for personal reasons.

Comparing each group before and after exercise training protocol, the conventional group showed improvement only in exercise tolerance (Figure 2). The Pilates group showed improvements in peak oxygen consumption (peak VO_2) (from 20.9 to 24.8 mLO_2/kg/min, $P = 0.01$), tolerance during the CPET (from 11.9 to 17.8 min, $P < 0.0003$), O_2 pluse (from 11.9 to 13.8 mLO_2/bpm, $P = 0.003$) and ventilation at peak effort (from 56.5 to 69.4 L/min, $P = 0.02$), in at rest decrease dyastolic blood pressure (from 72 to 66 mmHg, $P = 0.02$; Figure 3).

Comparing both groups, the Pilates group showed the greater improvement on peak VO_2, $P = 0.02$ (Table 2).

Discussion

This study is the first to include the Pilates method in physical training program in patients with HF in NYHA class I and II. The results of the present investigation demonstrated that mat Pilates training provided an extra gain on functional capacity compared to conventional exercises training program in patients with HF. No adverse events were observed in both groups.

Despite only 20 min of mat Pilates per class, some interesting insights into the potencial benefits were observed in this

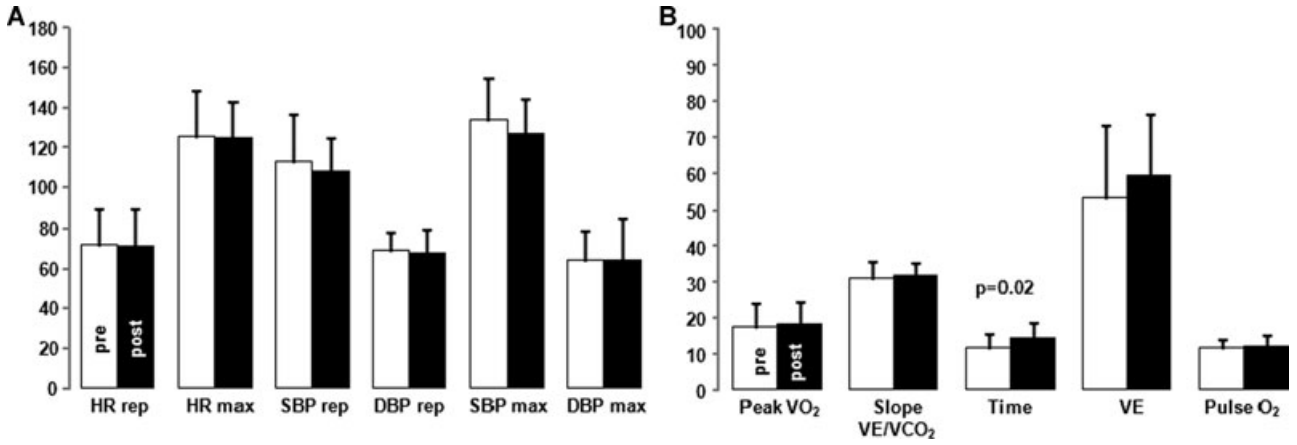

Figure 2 Response to exercise before and after the conventional training: (**A**) heart rate, in bpm; systolic and diastolic blood pressure, in mmHg at rest and maximum. (**B**) peak VO_2, in mLO_2/kg/min; slope VE/VCO_2; exercise time, in minute; VE, in L/min; Pulse O_2, in mLO_2/bpm at maximum.

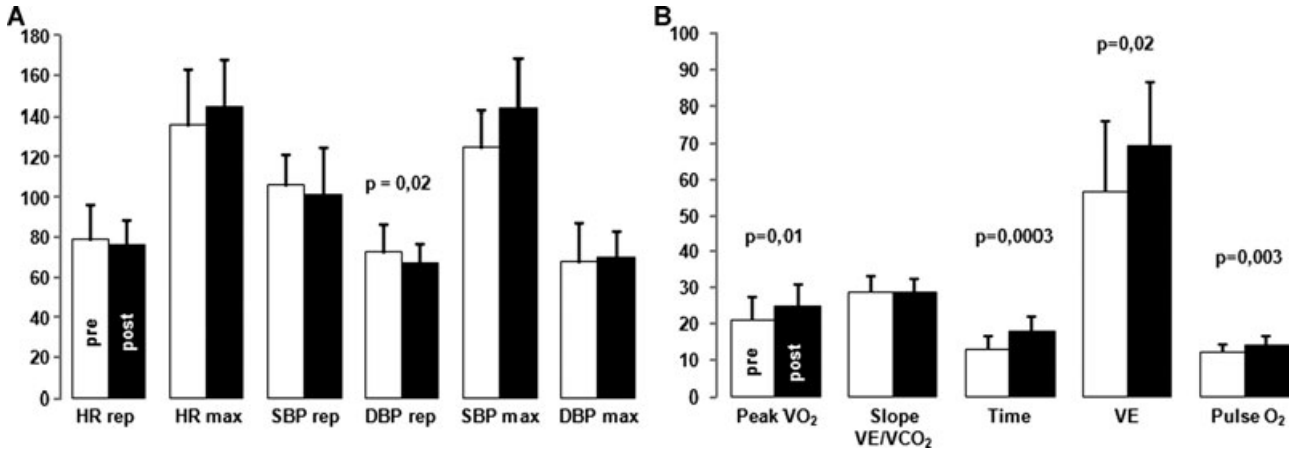

Figure 3 Response to exercise before and after the Pilates training: (**A**) heart rate, in bpm; systolic and diastolic blood pressure, in mmHg at rest and maximum. (**B**) peak VO_2, in mLO_2/kg/min; slope VE/VCO_2; exercise time, in minute; VE, in L/min; Pulse O_2, in mLO_2/bpm at maximum.

study. Peak VO_2 increased by 20% in the Pilates training and 6% in the conventional training. The range of improvement in peak VO_2 in Pilates group was similar to waltz dancing in patients with HF [18]. On the other hand, the amount of improvements in peak VO_2 in conventional group was similar to HF-ACTION [19] that studied 2331 patients with similar characteristics. Smart et al. [20] showed in patients with HF that low and high intensity aerobic exercise were associated with a maximum increase of 17% and 23% in functional capacity, respectively. In our study, the volume of aerobic training was the same for both groups. Moreover, the baseline physical fitness level of the patients in this study was relatively good, which may limit a moderate-to-large improvement in functional capacity. Recent studies with combination of endurance and strength training in HF demonstrate to be more effective in terms of submaximal exercise capacity, gain in resistance and tolerance on the exercise test than the gain in peak VO_2 [21,22]. Is important to note that exercise capacity is associated with prognosis in patients with left ventricular dysfunction [23]. In this study, both groups increased the exercise tolerance, but only the Pilates group was accompanied by a significant increase in ventilation and O_2 pulse. These changes indicate improvements on metabolic adaptation to exercise working muscles, what could suggest an increase of stroke volume, arteriovenous oxygen difference, or both. The Pilates method involves essentially isometric and respiratory exercises, which may contribute to improved ventilatory efficiency and reduced energy requirements for movement. These effects are mediated by the attenuation of the inspiratory muscle metaboreflex, with consequent improvement of blood flow to the exercising muscle [24].

The response of heart rate and blood pressure during Pilates and conventional training were not studied. A symptom-limited CPET was performed by all patients before and after 16 weeks of training, a decrease in diastolic blood pressure was found at rest only after mat Pilates training. Previously, our group demonstrated that aerobic exercise did not change in 24-h blood pressure in patients

with HF [9]. The results of this study are not in agreement with previous evidences. However, we did not observe hemodynamic differences between Pilates and conventional training. The reduction in blood pressure after exercise training has been associated with decrease in mortality from cardiovascular disease [25], what could reflect attenuation of the sympathetic system. Sympathetic overactivity has been ascribed a pivotal role in the pathophysiology of HF. Moreover, exercise training is associated with enhance parasympathetic tone and improve exercise capacity [26].

Patients enrolled in cardiac rehabilitation programs have a significant improvement in quality of life that is of clinical importance [27]. However, the multidisciplinary intervention, which did not include exercise training, reported an improvement in quality of life scores in the short-term only [28]. On the other hand, the adherence in physical training programs is relatively low [19]. Patients involved in conventional cardiac rehabilitation program are generally poorly motivated to continue the program for long-term, with a high rate of withdrawal. However, other methods of exercises with the greatest challenge to perform, providing more plasticity to the body movements, balance and concentration can improve adherence of patients with HF in cardiac rehabilitation programs [18,29,30,31]. In this study, there were no differences in the adherence of the patients in exercise session between mat Pilates and conventional groups (95% and 89%, respectively).

The Pilates method is a form of mind-body exercise focusing on controlled movement, posture and breathing. A complex exercise routine requires considerable practice to become proficient. Compared with convenional exercise training mat Pilates appears to be an efficient method of training [14–16]. However, both exercise training methods can provide cardiovascular adaptations, mainly in the trained muscles. The concept to hold and balance in challenging Pilates exercise, patients gain a better kinesthetic awareness, become more flexible, increase joint mobility, decompress the spine and learn new skills [14–16]. A total body workout could be one more option of exercise training to motivated patients with HF to continue the program and increase compliance as we observed in this study. Additionally, subjects reported no side effects of the mat Pilates method.

Limitations

This is study is a randomized and propective involving a small population with HF in NYHA I and II. Therefore, these results could be replicated in a large study including also patients in class III and IV. We did not monitor heart rate during mat Pilates and conventional training. However, heart rate was monitored during aerobic training, which should presumably reflect the heart rate during mat Pilates and conventional sessions. The control of exercise intensity in Pilates was not used, as in conventional exercise (11–13 the Borg scale), due to the method principles. Finally, we did not investigate clinical orthopedic conditions of patient's spine. The postural change can lead an impaired pulmonary function, reduced physical function, and increased body sway. The Pilates method is recommended to improve posture by enhancing body awareness.

Conclusion

The results of this study demonstrate the feasibility of a combined aerobic training and mat Pilates method by its safe and functional capacity improvements in patients with HF. The enhanced functional capacity was observed also in conventional group. However, only patients involved in the mat Pilates had increase in peak VO_2, O_2 pulse and ventilation, and decrease at rest dyastolic blood pressure. On the basis of the results of the study, mat Pilates method may be used as an alternative in patients with HF who prefer to other forms of exercise. Further studies are needed involving large sample sizes, controlled design, and consider assessing postural alterations in cardiac rehabiltation program.

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Conflicts of Interest

The authors declare no conflict of interest.

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