

Heart Failure: Comparison between Six-Minute Walk Test and Cardiopulmonary Test

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Abstract

Background: Chronic heart failure (HF) is a syndrome characterized by reduced cardiac output in relation to the metabolic needs of the organism, as well as metabolic and neurohormonal axis abnormalities. Symptoms such as fatigue and dyspnoea are notorious and stress tests are widely used to assess functional capacity, prognosis and effectiveness of therapeutic interventions in this syndrome.

Objective: To evaluate the reproducibility of the six-minute walk test (6MW) in patients with HF and correlate the magnitude of the variables reached at peak exercise of the 6MWT with a cardiopulmonary exercise test (CPET).

Methods: We studied 16 patients (12 men and 4 women) diagnosed with HF FC I-II (NYHA). The volunteers underwent two 6MWT (6MWT'1 and 6MWT'2) with 30-minute interval between them; then, they underwent a maximum CPET.

Results: All variables obtained in the two 6MWT' proved to be significant with high correlations: distance walked (DW) ($r = 0.93$, $p < 0.0001$), heart rate (HR) ($r = 0.89$, $p < 0.0001$), oxygen consumption (VO_2) ($r = 0.93$, $p < 0.0001$) and scale of perceived exertion ($r = 0.85$, $p < 0.0001$). In turn, all variables analyzed in the 6MWT' showed significant and moderate correlations with the variables obtained from the CPET, namely: peak HR ($r = 0.66$; $p = 0.005$); VO_2 ($r = 0.57$; $p = 0.02$) and VO_2 in the CPET and DT in the 6MWT'2 ($r = 0.70$; $p = 0.002$).

Conclusion: The 6MWT was reproducible in this group of patients with HF (NYHA - I-II) and correlated with the CPET. Therefore, it is a tool for reliable evaluation, and a suitable, safe and low-cost alternative for the prescription of aerobic exercise in patients with HF. (Arq Bras Cardiol. 2011; [online].ahead print, PP.0-0)

Keywords: Heart failure; exercise; walking; respiratory function tests.

Introduction

Chronic heart failure (HF) is the final common pathway of most heart diseases. It is a complex clinical syndrome characterized by the inability of the heart to generate cardiac output at levels capable of meeting the metabolic needs of the organism¹ associated with metabolic and inflammatory disorders and neurohormonal activation². It is a major public health problem, considering the increasing prevalence and hospitalization rates associated with high morbidity and mortality. Scientific and technological progress and better socioeconomic conditions have led to increased longevity of the general population and also of patients with heart disease, a factor associated with the sharp rise in the incidence of HF in Brazil and in the world³.

Patients with HF usually have exacerbation of symptoms during exercise and exercise tolerance measure is used to assess functional capacity, which correlates with cardiac failure severity. Thus, the use of stress testing for objective measurement of functional capacity is a valuable tool for stratifying the prognosis of patients with heart failure^{4,5}. In this context, the cardiopulmonary exercise testing (CPET) has been established as the reference standard.

The six-minute walk test (6MW), due to its wide availability, security and ease of implementation, is being used increasingly as an alternative to CPET to evaluate the functional capacity of patients with HF⁵⁻⁸. It is considered a submaximal exercise that mimics everyday activities and is generally well tolerated by patients. It should be noted that the distance walked during the 6MWT is an independent predictor of mortality and hospitalizations in patients with HF^{3,9,10}. Additionally, increasing the distance walked in six minutes has been shown to be a sensitive index to assess response to therapeutic interventions in HF¹¹.

Despite its widespread use, there is still controversy whether the results obtained in the 6MWT' show a proper correlation with those derived from the CPET, in patients with different HF severity

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levels¹². Therefore, the objective of this study was to evaluate the reproducibility of the 6MWT' and compare the results of functional capacity evaluation indices obtained in the 6MWT' with CPET, in patients with chronic heart failure not advanced.

Methods

The patients included in this study were selected from the sample of a project previously conducted in our Institution, whose main objective was to assess the contractile reserve in patients with heart failure of nonischemic etiology. That original study prospectively investigated 30 patients with HF functional class I - III (NYHA). The patients were clinically stable, using medication properly optimized and followed up in the outpatient HF clinic of our institution. Among these patients, we identified those whose existing CPET and 6MWT data could be recovered from the relevant processing and analysis systems. Thus, we identified 16 patients (12 men and 4 women) with mean age (\pm SD) 57.5 (\pm 10.1) years, diagnosed with HF functional class I-II (NYHA). All of them had participated voluntarily in the study, whose main anthropometric, clinical and laboratory characteristics are summarized in Table 1.

At the time of testing, all of them signed an informed consent and the study was approved by the Research Ethics Committee of HCFMRP - USP.

Walk test and cardiopulmonary exercise test

After a careful clinical evaluation and inclusion in the study, patients undergone the 6MWT', and within a week, were submitted to CPET. This narrow time window aims to limit the potential influence of changes in the clinical status and severity of symptoms on the results of functional capacity tests. All tests were performed in the morning to standardize the influence of circadian variations in heart rate (HR) and other cardiorespiratory variables.

The 6MWT' were applied by the same investigators in a corridor of 30 meters, with markings every 5 meters for accurately determining the distance walked¹³. Patients were monitored by Polar™ S810 frequency meter, with instantaneous recording and storage of HR values; the blood pressure values were obtained by auscultation (aneroid sphygmomanometer) before the test, immediately after the end, in the second and fourth minutes of recovery, and the index of perception of Borg exercise intensity (CR10) was obtained at the beginning and at the end of the test. Peak HR was obtained on further analysis of the data stored by the software POLAR™ Precision Performance SW.

Patients were instructed to walk at a maximum speed during six minutes (6MWT'1); if necessary, they could stop to rest and then resume the test. The observers used stimulation sentences for patients to maintain the same walking pace through the end of the test, and after six minutes, the distance walked (DW) was measured. After an interval of 30 minutes and a maximum of 45 minutes, the patients repeated the walk test (6MWT'2), following the same method.

The calculation of estimated oxygen consumption (VO_2) for the walk test was performed using a formula previously published¹⁰.

Table 1 - Anthropometric, laboratory and clinical characteristics of the sample investigated (n = 16)

Parameters	Values
Age (mean \pm SD)	57.5 \pm 10.1 (years)
BMI (mean \pm SD)	27.63 \pm 4.71 (kg/m ²)
Baseline HR (mean \pm SD)	69 \pm 8 (bpm)
Baseline BP (mean \pm SD)	106 \pm 14 x 70 x 10 (mmHg)
LVEF (mean \pm SD)	31.4 \pm 7.96 (%)
Gender	
Male No. (%)	12 (75)
Female No. (%)	4 (25)
Functional class	No.
I No. (%)	9 (56.25)
II No. (%)	7 (43.75)
Etiology	No.
Idiopathic disease No. (%)	6 (3.5)
Chagas disease No. (%)	4 (25)
Hypertension No. (%)	3 (18.75)
Alcoholic No. (%)	2 (12.5)
Diabetes, No. (%)	1 (6.25)
Medication	No.
B-blocker No. (%)	16 (100)
Diuretics, No. (%)	16 (100)
ACEI No. (%)	12 (75)
Digital No. (%)	9 (56.25)
Hypoglycemic No. (%)	5 (31.25)
ARBs No. (%)	4 (25)
Antiarrhythmics No. (%)	3 (18.75)
Vasodilator No. (%)	1 (6.25)
Anticoagulant No. (%)	1 (6.25)

BMI - body mass index; Baseline HR - heart rate at rest; Baseline BP - blood pressure at rest; LVEF - left ventricular ejection fraction; ACEI - angiotensin-converting enzyme inhibitor; ARBs - aldosterone receptor antagonist.

All volunteers were submitted to a maximal exercise test. The protocol consisted of dynamic physical exercise in a seated position on an electronically-braked cycle ergometer (Corival 400, Quinton). The power applied in the cycle ergometer was ramp type with intensity determined by the formula developed by Wasserman et al¹⁴ based on anthropometric characteristics, age and gender. Patients were encouraged to make the effort applied to the power at which they reached cardiorespiratory exhaustion. In all patients studied, the onset of the ramp was preceded by an effort at minimum load (3-4 Watts) at a constant speed of 60 revolutions per minute, with the aim of obtaining a preheating of the physiological systems involved in carrying the oxygen. The ventilatory variables were obtained in this protocol using an ergospirometer (CPX/D MedGraphics), which allows the acquisition, processing and storage of data from breath to breath. Peak VO_2 and HR

values were expressed as an average over the last 30 seconds of record, and were chosen to be compared with the distance walked and the VO_2 inferred in the 6MWT'.

To analyze the correlation between the 6MWT' and CPET, we chose to use the 6MWT'2, since, in the second test, it is expected that patients are better acquainted with the methodology and can perform it with greater control over the technique.

Statistical analysis

Data were expressed as mean \pm standard deviation. The statistical analysis was performed using Spearman's nonparametric correlation test. The level of statistical significance was 5%.

Results

Correlation data between 6MWT'1 and 6MWT'2 are shown in Figure 1. The DW showed a high correlation coefficient, statistically significant between 6MWT'1 and 6MWT'2 (545.47 ± 74.49 m and 550.31 ± 66.40 m, respectively) ($r = 0.93$; $p < 0.0001$, Figure 1A). Peak HR response was measured by

the cardiofrequencymeter at the end of the sixth minute of each test (128 ± 24 bpm for 6MWT'1 and 129 ± 25 bpm for 6MWT'2) also showed significant correlation ($r = 0.89$; $p < 0.0001$, figure 1B). Similarly, peak VO_2 estimated in 6MWT'1 and 6MWT'2 (20.34 ± 2.23 ml/kg/min; 20.49 ± 1.99 ml/kg/min, respectively) showed high and significant correlation value ($r = 0.93$, $p < 0.0001$, figure 1C). Finally, the intensity of perceived exertion at the end of each test (4.5 ± 1.7 and 4.8 ± 1.7 for 6MWT'1 and 6MWT'2, respectively), as assessed by the Borg scale, also showed a highly significant correlation ($r = 0.85$, $p < 0.0001$, figure 1D).

Figure 2 illustrates the correlated parameters between 6MWT'2 and CPET. The ratio of peak HR in the 6MWT'2 and CPET (129 ± 25 bpm and 122 ± 24 bpm, respectively) shows a moderate but significant correlation coefficient ($r = 0.66$, $p = 0.005$, figure 2A). The ratio of estimated VO_2 peak in 6MWT'2 through a formula set forth in the literature¹⁰ and in the CPET, through direct analysis of expired gases (20.49 ± 1.99 ml/kg/min for 6MWT'2 and 14.12 ± 4.11 ml/kg/min for CPET), shows a moderate correlation value, but still significant ($r = 0.57$; $p = 0.02$, figure 2B). Finally, the analysis of the relationship between DW in the 6MWT'2 and the peak

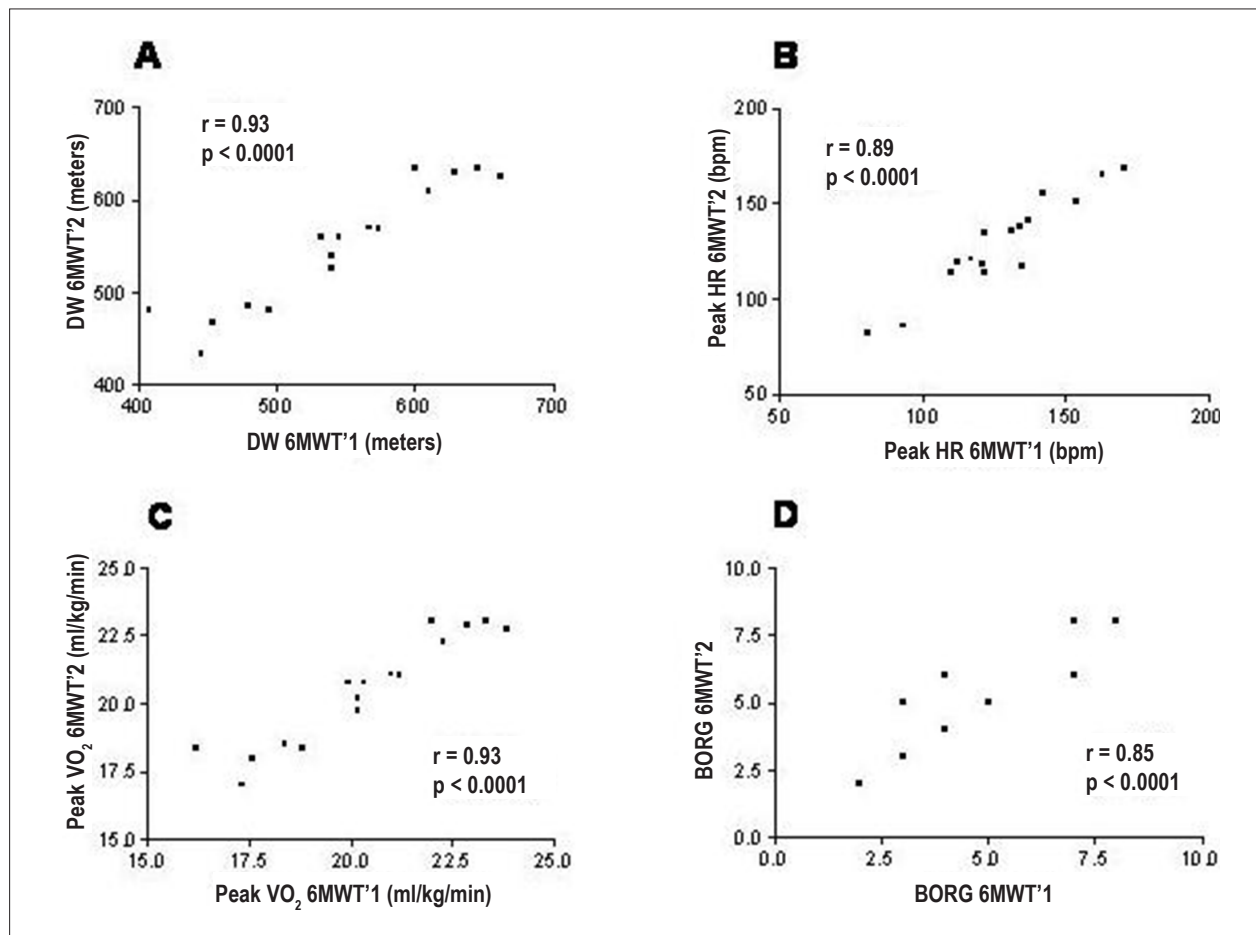


Figure 1 - A - correlation of DW (in meters) between 6MWT'1 and 6MWT'2; B - correlation of peak HR (bpm) reached in 6MWT'1 and 6MWT'2; C - correlation of estimated peak VO_2 (ml/kg/min) between 6MWT'1 and 6MWT'2; D - correlation of perceived exertion intensity (Borg CR 10) in 6MWT'1 and 6MWT'2. Where: DW - distance walked; 6MWT'1 - six-minute walk test; 6MWT'2 - six-minute walk test 2; VO_2 - oxygen consumption.

VO₂ obtained in the CPET (550.31 ± 66.40 and 1025.25 ± 332.13 ml/min) shows a moderate and significant correlation coefficient ($r = 0.70$; $p = 0.002$, figure 2C).

Discussion

Assessment of submaximal effort through the 6MWT' has been incorporated into clinical practice for patients with HF due to easy application, low cost and safety. This test has proven useful and reliable in the assessment of functional capacity, prognosis and therapeutic effectiveness in patients with this syndrome^{5,8,9,15}.

One objective of this study was to analyze the reproducibility of the application of the 6MWT' in HF, by conducting two sequential tests for the same patient. In this respect, our data show that the analysis of the variables DW, HR, VO₂, and perceived exertion measured in the two six-minute walk tests had a strong correlation, showing its reproducibility. As a consensus, most studies found in the literature have used the application of more than one test to determine the distance walked, since this procedure can improve patients' familiarity with the technique^{5,8,12}. Corroborating our findings, Cahalin et al¹⁰ tested the

reproducibility of the 6MWT' in 20 patients, and found an estimated intraclass correlation coefficient of 0.96.

The cardiopulmonary stress test has been widely used in the objective measurement of the VO₂, and is currently considered the reference standard in assessing the functional capacity functional^{16,17}. It has long been used as a predictor of morbidity and mortality in HF patients, as demonstrated by Gitt et al¹⁸ in a study involving 223 patients with HF that showed that the group of patients with peak VO₂ ≤ 14 ml/kg/min or VO₂ at anaerobic threshold < 11 ml/kg/min had a greater risk of death. However, this technique has a high cost, requires sophisticated equipment, skilled labor and is only found in certain centers⁵; besides, it requires greater patient cooperation.

In this sample, average peak VO₂ obtained by direct measurement in CPET was 14.12 ± 4.11 ml/kg/min. When this average was correlated with the average obtained by indirect measurement in the 6MWT' (20.49 ± 1.99 ml/kg/min), we observed that although the formula used to calculate the VO₂ in the 6MWT' overestimates the actual peak VO₂, there was a moderate correlation between them. Using the same formula, Cahalin et al¹⁰ also demonstrated in patients with HF a linear correlation between peak VO₂ in 6MWT and CPET.

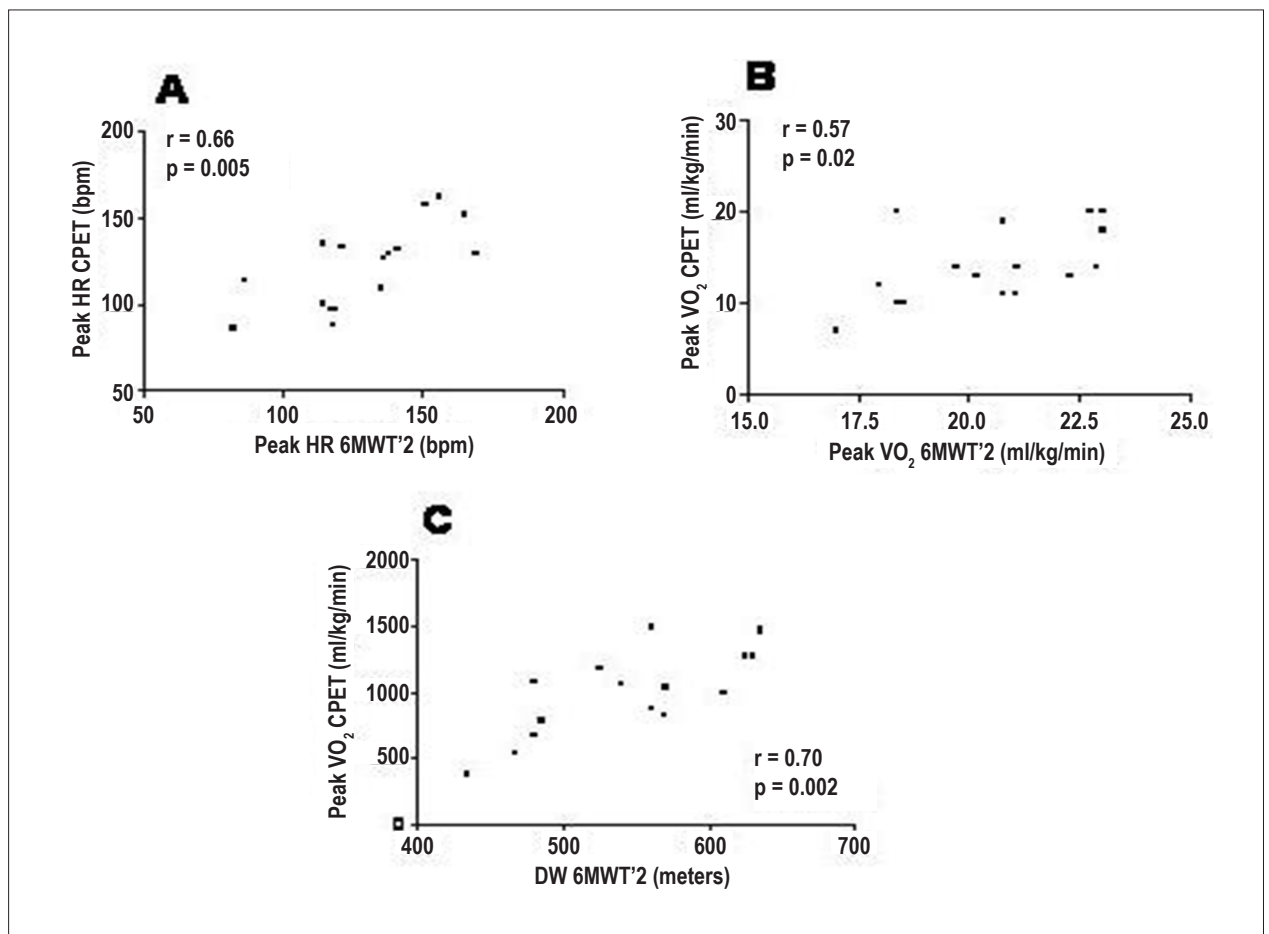


Figure 2 - A - correlation of peak HR (bpm) between 6MWT'2 and CPET; B - correlation of peak VO₂ (ml/kg/min) between 6MWT'2 and CPET; C - correlation of peak VO₂ (ml/min) of CPET with DW (m) of 6MWT'2. Where: HR - heart rate; 6MWT'2 - six-minute walk test 2; CPET - cardiopulmonary exercise testing; VO₂ - oxygen consumption; DW - distance walked.

A variable of great importance in the prognostic evaluation of 6MWT in patients with HF is the maximum DW. Some studies have shown that a value smaller than or equal to 300 meters in six minutes indicates a worse prognosis compared with patients walking more than 300 meters^{10,19}. Our study was able to show that two critical variables, the DW in 6MWT' and peak VO_2 in the CPET have a correlation at a moderate level and statistically significant at peak exertion in patients with HF functional class I - II ($r = 0.70$; $p = 0.002$). Previous studies^{10,17} confirm our results showing a good correlation between the results of the 6MWT' and CPET^{12,20,21}. Faggiano et al²⁰ in a sample of 26 patients with HF (NYHA II - IV), found a significant correlation between the DW in the 6MWT' and peak VO_2 reached in the CPET ($r = 0.63$).

The results reported in the literature, however, are not homogeneous. In the study by Lucas et al¹² conducted with 307 patients with advanced HF (ejection fraction $< 35\%$), peak VO_2 reached in symptom-limited CPET, applied in a subgroup of 213 patients with a peak VO_2 between 10 to 20 ml/kg/min showed a low correlation with the DW in the 6MWT' ($r = 0.28$). In another study, Roul et al¹⁹, also conducted in 121 patients with HF (functional classes NYHA-II-III, ejection fraction $29.6\% \pm 13\%$) demonstrated a low correlation between the peak VO_2 in symptom-limited CEPT, and DW in the 6MWT' ($r = 0.24$).

The main factor responsible for the apparent discrepancy between our results and those of other researchers, in contrast to the results obtained in the studies cited above, may lie in the characteristics of the population in each study, particularly the severity of HF. Thus, it is plausible that, in populations with advanced HF (FC III-IV), the correlation between CPET and 6MWT' is smaller. Reinforcing this hypothesis, in the study by Lucas et al¹², the application of correlation analysis not restricted to the most severely ill patients resulted in better levels of correlation ($r = 0.52$).

The occurrence of the linear relationship between HR responses and VO_2 ²¹ during dynamic exercise has provided the basis for application of indirect methods for assessing functional reserve for exercise prescription and its use in stress tests that do not have direct measurement of oxygen consumption. Comparing the peak HR achieved in the CPET and 6MWT', we observed a moderate but significant correlation ($r = 0.66$, $p = 0.005$). Considering that the chronotropic response was similar in both tests, this finding

becomes relevant, since the 6MWT' is a very simple and accessible evaluation method. It is noteworthy that, according to the 1st National Cardiovascular Rehabilitation Consensus²², so that the prescription of physical activity is performed safely and appropriately, the best way would be using peak HR obtained in a symptom-limited stress test.

We believe that from the present results, the prescription of exercise by use of 6MWT' can be a safe, effective and affordable option for patients with less severe HF in functional class I-II.

In a recent publication, Guazzi et al²³ studied 253 patients diagnosed with HF, targeting the clinical and prognostic comparison between cardiopulmonary and six-minute walk tests. The authors confirmed the 6MWT' to be a simple and reliable tool for quantification of exercise intolerance in HF patients, however, they consider that more evidence is needed to recommend the use of the 6MWT' as an alternative prognostic marker in isolation or in combination with other variables derived from the CPET.

Conclusion

Our results lead us to conclude that, when applied to patients with heart failure in non-advanced functional class (NYHA FC I-II), the 6MWT' is a method of high reproducibility, and exhibits good correlation with the variables measured in the cardiopulmonary exercise testing.

Thus, our results suggest that the 6MWT' is a suitable, safe and affordable alternative for the prescription of aerobic exercise in patients with heart failure in non-advanced functional class.

Potential Conflict of Interest

No potential conflict of interest relevant to this article was reported.

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Study Association

This study is not associated with any post-graduation program.

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