Assessment of Functional Capacity in Chagas Heart Disease by Incremental Shuttle Walk Test and its Relation to Quality-of-Life

Henrique Silveira Costa, Rafael Leite Alves, Stela Alves da Silva, Maria Clara Noman Alencar, Maria do Carmo Pereira Nunes, Márcia Maria Oliveria Lima[1], Manoel Otávio da Costa Rocha

School of Medicine, Federal University of Minas Gerais, Belo Horizonte, Minas Gerais, Brazil, [1]Federal University of Jequitinhonha and Mucuri Valleys, Diamantina, Minas Gerais, Brazil

Correspondence to:
Dr. Henrique Silveira Costa,
R. dos Guajajaras, Centro, 1172/407 Belo Horizonte, Minas Gerais, Brazil.
E-mail: henriquesilveira@yahoo.com.br

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Original Article

ABSTRACT

Background: The cardiopulmonary exercise test (CPET) is considered to be the gold standard to evaluate functional capacity (FC) in patients with heart failure. However, field tests such as the 6-min walk test (6MWT) and the incremental shuttle walk test (ISWT) are simple and effective in evaluating the same. Despite the increasing use of ISWT, no studies that used the test in patients with Chagas heart disease (CHD) were found and only few studies have evaluated the health-related quality-of-life (HRQoL) in this population. The objective of this study was to correlate the distance walked in the ISWT with distance walked by 6MWT and peak oxygen uptake (VO_{2peak}) by CPET and HRQoL in patients with CHD.

Methods: A total of 35 patients with CHD were evaluated according to the FC and HRQoL. The FC was assessed by CPET, 6MWT and ISWT. HRQoL was assessed by the generic short-form health survey (SF-36) and Minnesota Living with Heart Failure Questionnaire (MLHFQ). Descriptive data were shown as mean and standard deviation or median and interquartile range. The correlation was carried out with Pearson or Spearman correlation test. A receiver operating characteristic (ROC) curve was constructed to investigate the accuracy of ISWT for predicting low values of VO_{2peak}.

Results: The distance walked in ISWT correlated with VO_{2peak} ($r = 0.587$; $P < 0.001$), distance walked in 6MWT ($r = 0.484$; $P = 0.003$), MLWHFQ scores ($r = -0.460$; $P = 0.006$) and physical functioning and role physical domains of the SF-36 scores ($r = 0.435$, $P = 0.009$; $r = 0.477$, $P = 0.008$, respectively). There was no significant difference between the distances walked in field tests ($P = 0.694$). The area under the ROC curve was 0.871 for ISWT in predicts a VO_{2peak} value of, at least, 25 mL/kg/min.

Conclusions: The ISWT showed to be effective in evaluating the FC in CHD and in demonstrate the impact of disease on some aspects of the HRQoL of these patients.

Keywords: 6-min walk test, cardiopulmonary exercise test, chagas heart disease, functional capacity, health-related quality-of-life, incremental shuttle walk test

INTRODUCTION

Chagas disease, a major cause of heart failure (HF) in Latin America, affects approximately eight million people[1]

and represents a significant public health and socio-economic problem in these countries.[2] Chagas heart disease (CHD) is associated with worse prognosis[3] and symptoms such as fatigue and dyspnea, which contribute to a progressive reduction in functional capacity (FC),[4,5] reflecting a negative impact on the perception of health-related quality-of-life (HRQoL) in these individuals.[6]

The FC can be assessed by laboratory stress tests with direct or estimated measurements of maximal oxygen consumption ($VO_{2\ max}$) and field tests by the distance walked.[7] The cardiopulmonary exercise test (CPET), the gold standard in the analysis of FC in HF, is expensive and not well-tolerated by some patients.[8,9] On the other hand, field tests are simple, easy to administer, inexpensive and more tolerated by patients.[8]

Among field tests, the 6-min walk test (6MWT), widely used in cardiac[10] and chagasic patients,[11-13] has shown moderate correlation between FC evaluated by distance walked with VO_{2max}.[14] One of the factors cited for the moderate correlation between these measures is the methodological differences between the tests. Although in 6MWT load is self-controlled and the patient determines their walking pace,[15] the CPET has standardized load increments protocols.[16]

In an attempt to minimize these methodological discrepancies, an alternative proposal for the field tests has been used the incremental shuttle walk test (ISWT), which has more similar procedures to those of maximum stress tests.[17] It is also a symptom-limited test and load (speed) has stages with standardized increments.[18] Previous studies have shown better correlation between the distance walked by the ISWT with peak oxygen uptake (VO_{2peak}) in heart disease;[19,20] although, its value and significance in CHD patients remains to be established.

On the other hand, in recent decades, there has been increased interest in the assessment of HRQoL and patient's perception about the impact of the disease and the benefits of treatment.[21] The assessment of HRQoL in CHD is a complex process by the interrelation of biological, historical, political and socio-economic factors with a strong labor impact and stigmatizing character. Despite growing interest in HRQoL assessment and the importance of it in CHD patients, very few studies exist in research databases involving HRQoL profiles of the CHD group.[22-24]

This study aims to verify the applicability of ISWT in evaluate FC in CHD patients by correlating the distance walked with VO2peak by CPET and the relationship of these measures with HRQoL questionnaires.

METHODS

Study design

This cross-sectional study was conducted at the Chagas disease outpatient clinic and the Cardiology Service of the Hospital of the Federal University of Minas Gerais, Brazil, a tertiary Chagas disease referral center. The research was carried out in accordance with the declaration of Helsinki (2000) and was approved by the Ethics Committee of the Federal University of Minas Gerais. All the patients gave their written informed consent before participating in the study.

Criteria for inclusion were the presence of two or more positive serological tests for *Trypanosoma cruzi*; to be in stable clinical condition (no acute exacerbation of heart disease in the last 3 months), both sexes, age between 30 and 60 years. Criteria for exclusion were: Having participated in the last 6 months of any program of regular physical activity for at least 30 min on most days of the week; presence of heart disease for any other cause, use of a cardiac pacemaker; presence of hypertension Stage II or III, depending on the classification of Joint National Committee VII[25] and presence of lung, pleural or renal disease, musculoskeletal limitations, diabetes mellitus or any other condition that affects the ability to perform functional tests.

The previously selected subjects underwent clinical evaluation, echocardiography, CPET, 6MWT, ISWT and HRQoL questionnaires short-form health survey (SF-36) and Minnesota Living with Heart Failure Questionnaire (MLHFQ).

Each test was conducted by one researcher. Stress tests were performed with an interval of 1 week between them and at the same time of day to avoid circadian changes.

Echocardiogram

Images were acquired using Philips HDI 5000-ATL echo machine (Bothell, Washington, USA). The echocardiography techniques and calculations of different cardiac dimension and volumes were performed according to the recommendations of

the American Society of Echocardiography.[26] Left ventricular ejection fraction (LVEF) was calculated according to the modified Simpson's rule.

CPET

The CPET was carried out in an air-conditioned laboratory on a treadmill with the metabolic analysis system Ergo PC Elite Micromed-Brasilia/DF. The gas analyzer was expired MetaLyzer® 3B Cortex-Leipzig, Germany, 1998. The CPX was conducted from ramp protocol, treadmill Centurion 200 of Micromed Biotechnology Ltda. Oxygen consumption (VO_2) was measured breath-by-breath and is considered as the biggest value of VO_2 obtained in the test (VO_{2peak}).

An 11-lead electrocardiographic monitoring was obtained at rest in the supine position and during exertion, continuously (Eletocardiografo/Elite-Micromed Biotecnologia Ltda). Blood pressure was measured by Tycos® sphygmomanometer and stethoscope Littmann® at rest and in the effort every 3 min.

6MWT

The 6MWT was guided by international guidelines.[7,27] Patients were instructed about the right to interrupt the test in case of discomfort or other complications. Briefly, the subjects were instructed to walk as fast as possible without running in a corridor of 30 m. We used standardized words of encouragement every minute. Two tests were applied to each subject, with 15-min interval between them and the longest distance walked was considered for analysis.

ISWT

Tests were guided by the pioneering study by Singh *et al.*[18] and undertaken in a course of 10 m, identified by two cones located 0.5 m from the end of the path to avoid abrupt changes of direction. The speed reached by the patient was controlled by an audio signal in 12 levels of intensity. Patient should finish the course determined by the number of laps (10 m each) corresponding to each stage before the beep. The test was finished when patient completed the 12 levels of intensity or when he could not complete the distance target for each level within the time for 3 times.

HRQoL

HRQoL was assessed by the SF-36 and MLHFQ. The SF-36 is a generic questionnaire containing 36 items in 8 domains (physical functioning [PF], role physical [RP], bodily pain, general health [GH], vitality, social functioning [SF], role emotional and mental health [MH]), previously validated for Brazilian Portuguese by Ciconelli *et al.*[28] Furthermore, the MLHFQ is a specific questionnaire for patients with HF. The questionnaire consists of 21 questions about functionality and disabilities related to HF and is also validated for Brazilian Portuguese language by Carvalho *et al.*[29]

Statistical analysis

The sample size calculation has been done to assess the correlation between VO_{2peak} by CPET and distance walked in ISWT. The coefficient of determination was based on a previous article,[19] where the correlation between VO_{2peak} and distance walked in ISWT was 0.51. Using G Power software, version 3.1.0 (Heinrich Heine. University, Dusseldorf, Germany) and considering an alpha error of 0.05, beta error of 0.10 (statistical power of 90%) and coefficient of determination of 30% (r = 0.5), there was obtained a sample of 30 patients.

Data were analyzed with Statistical Package for the Social Sciences version 17.0 (SPSS Inc., Chicago, IL, USA). The normal distribution of data was verified by Kolmogorov-Smirnov test. The descriptive analysis was shown as mean and standard deviation in data with normal distribution or median and interquartile range (MD/25-75%) in non-normal distribution. Pearson and Spearman correlation was carried out to evaluate correlations between distance walked in field tests and VO_{2peak} when appropriate. To compare the distance between field tests, was used the Wilcoxon signed rank test.

A receiver-operator curve was used to verify the accuracy of the ISWT in predicting a reduced VO_{2peak} (25 mL/kg/min or lower) and to identify the cut-off value with the best combination of sensitivity and specificity for that prediction. The value of 25 mL/kg/min was adopted in accordance with the classifications of American College of Sports Medicine[30] for the age group of patients recruited into the study. The level of significance was α <5%.

RESULTS

Characteristics of the sample and correlation between stress tests

A total of 53 subjects with CHD were selected

and 35 were considered as eligible for the study. Then, 28 subjects were excluded and nine of these had non-cardiac forms of Chagas disease, four were physically active, three had cardiac pacemaker, two were diabetic, two had orthopedic impairments (arthritis and sequelae of stroke), two were transplanted. Sample characteristics are summarized in Table 1.

The graphs of correlation are shown in Figure 1. The distance walked by ISWT was significantly correlated with VO_{2peak} obtained by CPET ($r = 0.587$; $P < 0.001$) [Figure 1a] and with distance walked by 6MWT ($r = 0.484$; $P = 0.003$) [Figure 1b]. We also found a significant correlation between the VO_{2peak} and the distance walked in 6MWT ($r = 0.577$, $P < 0.001$). There was no significant difference between the distance walked in both field tests ($P = 0.694$).

Accuracy of ISWT to predict a VO_{2peak} ≤25 mL/kg/min

According to Figure 2, the distance walked in ISWT was predictive of a VO_{2peak} ≤25 mL/kg/min. The area under the receiver operating characteristic curve was 0.871 (confidence interval 95%: 0.749-0.994). The most optimal cut point was a distance <407.55 m. The sensitivity and specificity for that cut point were 80% and 85.7%, respectively.

Correlation between HRQoL and FC

Table 2 shows a significant correlation between ISWT with MLHFQ and some scores of SF-36 (PF, RP and MH) while VO_{2peak} correlated only with PF domain of the SF-36.

DISCUSSION

Peak VO_2 directly measured by expired gas analysis is the best way to assess FC in patients with HF.

Table 1: Anthropometric characteristics, clinical variables and functional capacity of the sample (n=35)

Characteristics	Mean±SD; MD (25-75%)
Age (years)	47.1±8.2
Sex (male/female)	23/12
BMI (kg/m^2)	26.5±4.6
SBP (mmHg)	100 (90-110)
DBP (mmHg)	70 (60-70)
HR (bpm)	68.6±9.6
LVEF (%)	59 (41-64)
NYHA (n)	I (20)/II (9)/III (6)
VO_{2peak} (mL/kg/min)	26.3±8.1
6MWT distance (m)	571±81.7
ISWT distance (m)	437.9 (329-658.2)

Data presented as mean and standard deviation (mean±SD) or median (MD) and interquartile range (25-75%). BMI=Body mass index, SBP=Systolic blood pressure, DBP=Diastolic blood pressure, mmHg=Millimeters of mercury, HR=Heart rate, bpm=Beats per minute, LVEF=Left ventricular ejection, NYHA=New York heart association; VO2peak=Peak oxygen consumption, 6MWT distance=Distance walked in 6 min walk test; ISWT distance=Distance walked in incremental shuttle walk test, SD=Standard deviation

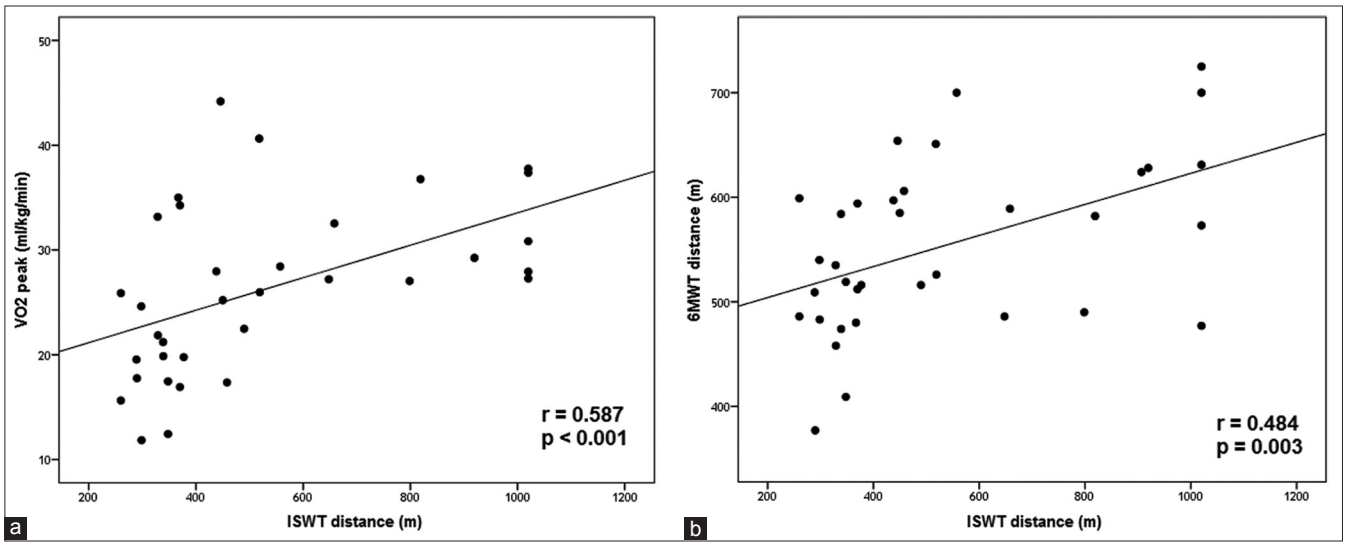

Figure 1: (a) Correlations between peak oxygen uptake and distance walked in incremental shuttle walk test (ISWT); (b) Correlations between the distance walked in 6-min walk test and ISWT

Table 2: Correlation between HRQoL assessed by SF-36 and MLHFQ and FC measured by VO_{2peak} and distance walked in ISWT

HRQoL	Score	FC			
		VO_{2peak}		ISWT distance	
		R	*P*	*R*	*P*
MLHFQ	14 (5.5-32)	−0.337	0.055	−0.460	0.006*
SF-36 domains					
PF	85 (70-95)	0.383	0.025*	0.435	0.009*
RP	75 (25-100)	0.192	0.285	0.447	0.008*
BP	62 (51.7-100)	0.128	0.447	0.125	0.480
GH	64.9±20.9	0.209	0.244	0.304	0.080
V	70 (50-90)	0.173	0.335	0.277	0.112
SF	100 (59.8-100)	0.085	0.638	0.267	0.128
RE	100 (33-100)	−0.024	0.893	0.232	0.186
MH	71.1±26.5	0.041	0.822	0.430	0.011*

Data presented as mean and standard deviation (mean±SD) or medians and interquartile range (MD/25-75%). HRQoL=Health-related quality-of-life, MLHFQ=Minnesota living with heart failure questionnaire, VO2peak=Peak oxygen consumption, ISWT distance=Distance walked in incremental shuttle-walk test, SF-36=Short-form health survey, PF=Physical functioning, RP=Role physical, BP=Bodily pain, GH=General health, V=Vitality, SF=Social functioning, RE=Role emotional, MH=Mental health, FC=Functional capacity, SD=Standard deviation, *P<0.05

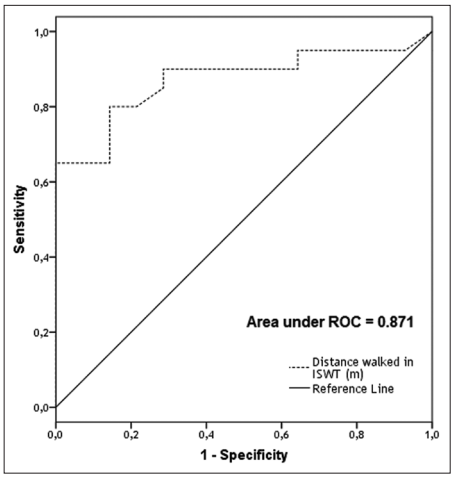

Figure 2: Receiver-operating characteristic curve representing the ability of distance walked in incremental shuttle walk test to predict a peak oxygen uptake of, at least, 25 mL/kg/min

However, the equipment is expensive and not available in many centers. Hence, the use of alternative tools for assessment of FC, in the context of Chagas disease, is extremely important, because endemic areas are generally poor and have few resources. Thus, the present study correlated the distance walked in ISWT with VO_{2peak} measured by the CPET, the gold standard in the assessment of FC and distance walked in 6MWT, the most widely used field test in patients with heart diseases.

This study is the first to demonstrate a significant correlation between the FC by distance walked in Incremental Shuttle Walk Test (ISWT) and direct measurement of VO_{2peak} in patients exclusively with CHD. In addition, we describe the accuracy of ISWT to predict a VO_{2peak} ≤25 mL/kg/min and its relationship with HRQoL assessment tools in this population.

Studies evaluating the relationship between the distance walked in ISWT with VO_{2peak} found a strong correlation between these measures.[9,19,20] Lewis *et al.*[20] observed in 25 patients with HF (53 ± 8 years, New York Heart Association [NYHA] II-III) a strong correlation between the distance walked in ISWT and VO_{2peak} (r = 0.730, P < 0.001). Similar results (r = 0.830, P < 0.001) were reported by Morales *et al.*[19] between the same measures applied to 46 patients with HF (53.0 ± 10.0 years, NYHA II-IV). Using a larger sample, Pulz *et al.*[9] also found a strong correlation between the distance walked in ISWT and the CPET VO_{2peak} (r = 0.79, P < 0.001).

Among field tests, Pulz *et al.*[9] studied 63 patients with HF (51.3 ± 10.2 years, 16 chagasic) and compared the responses in FC analyzed by the two field tests (6MWT and ISWT) and found a significant difference between them (P < 0.001), with greater distance walked during the 6MWT. In contrast, in our study, the distance walked in both testes was similar. This discrepancy may be due, at least, to the difference in samples studies. Although Pulz *et al.*[9] evaluated only patients with more compromised cardiac function (LVEF 24 ± 5.6%; NYHA II-IV), our sample was consisted, on average, by individuals with more preserved cardiac function.

Our results indicate that ISWT correlates with the direct measurement of VO_2 and 6MWT. Walking tests are less expensive and could be used in the early detection of changes in FC in poor and endemic areas and increase effectiveness in the prevention and treatment of heart disease. Studies with direct measurements of VO_2 during the walking tests should be explored to clarify the relationship of each of these tests with cardiac performance.

The present study also demonstrated a good sensibility and specificity of distance walked in ISWT to predict a VO_{2peak} of, at least, 25 mL/kg/min. This accuracy in the prediction can be useful in screening and risk stratification of patients with CHD.

Our study also evaluate the relationship of FC, assessed by the CPET and the ISWT, with HRQoL in these patients, since a major goal of treatment for HF is to maximize the functionality and independence of these individuals, reflecting better HRQoL.[31] Currently, there are two main ways of measuring HRQoL: Generic and specific instruments. As the two instruments provide different information, they can be used concomitantly.

By comparing the HRQoL generic questionnaire SF-36 and VO_{2peak} assessed by CPET of 27 patients (54.6 ± 9.2 years) with HF, Quittan *et al.*[32] found a significant correlation between VO_{2peak} and SF ($r = 0.5$, $P = 0.01$) and GH ($r = 0.55$, $P = 0.007$) domains of SF-36. However, Nogueira *et al*.[33] showed a mild and no significant correlation between VO_{2peak} and all the domains of SF-36 in 46 patients with HF (52.26 ± 9.09 years) and the higher commitment in the physical aspect. The results in our study are similar and showed a correlation only between VO_{2peak} and PF domain of the SF-36, suggesting that functional limitation imposed by the disease is associated to the worsening of HRQoL.

The same study[33] showed a negative correlation ($r = -0.5$, $P < 0.05$) between VO_{2peak} and the score obtained by MLHFQ specific questionnaire, remembering that higher scores in MLHFQ reflect worse HRQoL. In contrast, we found a no significant correlation between these variables, however, our sample consisted of patients with lower cardiac impairment and highest score of HRQoL assessed by MLHFQ compared to them (14 vs. 41.86, respectively).

In the present study, when HRQoL was compared to the distance walked in ISWT, we observed a negative correlation between the distance walked in ISWT and MLHFQ and positive correlation between the distance walked in ISWT and PF, RP and MH domains of the SF-36. No studies that verify the correlation between HRQoL and ISWT in patients with heart disease were found.

CONCLUSIONS

Considering the results obtained, we suggest that the ISWT, because it has good correlation with VO_{2peak} and better relationship with HRQoL instruments, can be used as an alternative test in the evaluation of FC by the distance walked in patients with CHD.

The present study not intended to be representative of all patients with CHD considering its pleomorphism. Thus, further studies with this approach should be conducted in different stages of this disease.

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