

## Analysis and correlation of the Six-Minute Walk Test and Two-Minute Step Test in an elderly population participating in a cardiac rehabilitation program

### Teste de Caminhada de Seis Minutos e Teste de Marcha Estacionária de Dois Minutos em uma população idosa participante de um programa de reabilitação cardíaca

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#### ABSTRACT

The six-minute walk test (6MWT) and two-minute step test (2MST) are submaximal tests widely used in the elderly population functional capacity evaluation. **Objective:** To investigate whether the cardiac rehabilitation (CR) program was able to promote an increase in these tests and if there was an association between them; and to compare the hemodynamic stress caused by each of the tests. **Methods:** Retrospective, observational study in elderly participants in CR program. 24 elderly people were evaluated and classified according to the Fried frailty phenotype. The 6MWT and the 2MST were applied, observing the mean distance walked and the number of steps performed, respectively, as well as the double cardiac product (DP) at the beginning and after 4 months of the CR program. **Results:** There was an increase of 57 meters in the mean distance covered by the 6MWT ( $364.31 \pm 108.01$  vs.  $421.65 \pm 108.73$ ,  $P < 0.001$ ) and 14 steps performed in the 2MST ( $62.17 \pm 22.50$  vs.  $76.17 \pm 25.56$ ,  $P = 0.011$ ) after 4 months of CR and we found a significant correlation between the tests and their results ( $P < 0.001$ ). When comparing the DP, both tests had a significant reduction ( $14469.92 \pm 2497.91$  vs.  $13348.21 \pm 2839.36$ ,  $P = 0.022$  and  $15744.17 \pm 3591.87$  vs.  $13222.29 \pm 2505.39$ ,  $P < 0.001$ ; respectively). **Conclusion:** A relationship between the number of steps performed in the 2MST with the mean distance covered of 6MWT suggest the use of them as an effective indicator in CR program and the association between them offers greater possibilities for treatment and evaluation of an elderly population.

**Keywords:** Heart Injuries/rehabilitation, Walk Test, Aged

#### RESUMO

O teste de caminhada de seis minutos (TC6m) e o teste de marcha estacionária de dois minutos (TME2min) são testes submáximos amplamente utilizados na avaliação da capacidade funcional da população idosa. **Objetivo:** Investigar se o programa de reabilitação cardíaca (RC) foi capaz de promover melhora nesses testes e se houve associação entre eles; além de comparar o estresse hemodinâmico causado por cada um dos testes nessa população. **Métodos:** Estudo retrospectivo e observacional em idosos participantes do programa de RC. Foram avaliados 24 idosos e classificados de acordo com o fenótipo de fragilidade de Fried. Foram aplicados o TC6m e o TME2min, observando-se a distância média percorrida e o número de passos realizados, respectivamente, bem como o duplo produto cardíaco (DP) no início e após 4 meses do programa de RC. **Resultados:** Houve aumento de 57 metros na distância média percorrida no TC6m ( $364,31 \pm 108,01$  vs.  $421,65 \pm 108,73$ ,  $P < 0,001$ ) e 14 passos realizados no TME2min ( $62,17 \pm 22,50$  vs.  $76,17 \pm 25,56$ ,  $P = 0,011$ ) após 4 meses de RC e encontramos correlação significativa entre os testes e seus resultados ( $P < 0,001$ ). Ao comparar o DP, ambos os testes tiveram redução significativa ( $14.469,92 \pm 2.497,91$  vs.  $13.348,21 \pm 2.839,36$ ,  $P = 0,022$  e  $15.744,17 \pm 3.591,87$  vs.  $13.222,29 \pm 2.505,39$ ,  $P < 0,001$ ; respectivamente). **Conclusão:** A relação entre o número de passos realizados no TME2min com a distância média percorrida no TC6m sugere a utilização deles como um indicador eficaz em programa de RC e a associação entre eles oferece maiores possibilidades de tratamento e avaliação de uma população idosa.

**Palavras-chaves:** Traumatismos Cardíacos/reabilitação, Teste de Caminhada, Idoso

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#### Conflict of Interests

Nothing to declare

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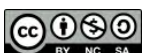
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## INTRODUCTION

Cardiac Rehabilitation (CR) is already known as essential care in patients with cardiovascular diseases and, therefore, it is considered as Class I recommendation by the American Heart Association, the European Society of Cardiology and the Brazilian Society of Cardiology.<sup>1-4</sup> One of the main outcomes that confirm the effectiveness of a CR program is the improvement of patient's functional capacity. The gold standard test to measure this functional improvement is the cardiopulmonary exercise test, however the high cost and its scarce availability limit its use.

Simpler submaximal tests are good alternatives for this assessment, with the six-minute walk test (6MWT) being the most used in clinical practice, in several populations.<sup>1-5</sup> However, its performance may be compromised in the frail elderly population, or in patients with some degree of gait impairment. Also, the required space to reproduce this test (30 m) may be an additional limitation for using this tool.<sup>4-7</sup>

Recently, the 2-minute step test (2MST) has been proposed for the elderly and other populations as a low-cost, less stressful and easier to apply alternative because requires less time and space to be performed.<sup>6-9</sup> Since the first publication by Rikli and Jones<sup>7</sup>, some studies have used the 2MST, but, there is still a gap in the literature regarding its standardization, as well as a minimum value that could be used as a cut to guarantee the effectiveness of a rehabilitation program, like is known for 6MWT.<sup>7,9</sup> The relationship between these tests has already been proven and one study with heart failure patients demonstrated a greater perception of general and lower limb fatigue with 2MST compared to 6MWT, which can make it a challenge for elderly, especially for those with prefrailty or frailty syndrome.<sup>8,10</sup> Frailty syndrome is characterized by weakness, slowness, exhaustion, low activity, non-intentional weight lost, and it can lead to worse clinical outcomes such as mortality and highest rate of hospital readmission.<sup>4,11</sup> Currently, the number of elderly people with prefrailty and frailty has increased in CR, what demand specific tools both to assess this population and to demonstrate the effect of the rehabilitation program carried out.

Although very promising, 2MST feasibility and correlation with more established tests, such as the 6MWT, needs to be better studied, in this population. In addition, it's important to understand whether a CR program is able to improve functional outcomes of the frail elderly population.

## OBJECTIVE

The aims of this study were: 1. to assess the correlation between 6MWT and 2MST in an elderly population, before and after a CR program, 2. to compare the hemodynamic stress caused by each of them and, 3. to assess whether CR was able to modify the frailty in those elderly people classified by the Fried phenotype.

## METHODS

This was a retrospective, observational study conducted with data of elderly participants of cardiac rehabilitation program carried out at a private hospital between April 2014 and May 2017. The study was approved by the hospital ethics and research committee (CAAE: 25659119.5.0000.0071). Consent was given for not applying the informed consent form in accordance with the 466/12 resolution of CONEP. The investigations were carried out in accordance with the Declaration of Helsinki.

## Inclusion Criteria

Frailty, evaluated by Fried classification<sup>11</sup> and non-frailty patients between 60-95 years old who completed at least 85% of the proposed exercise sessions during 4 months of cardiac rehabilitation program.

## Exclusion Criteria

Elderly who did not have the 6MWT or 2MST in two moments of evaluation and patients who had clinical conditions (cardiopulmonary, orthopedic and neurological) that preclude the performance of the proposed exercises

## 6MWT

The 6MWT was carried out in a 30 m corridor, where the patient was guided to travel the longest tolerable distance for 6 minutes, being allowed to stop walking in case of extreme fatigue or symptoms limiting. Variables analyzed were: walking distance, heart rate and blood pressure.<sup>12-15</sup>

## 2MST

The 2MST measures the maximum number of knees raises that the individual can perform in 2 minutes. At the signal, the subject began the stationary gait (without running), performing as many knees raises as possible in two minutes. The knee height taken at each step was established at a midpoint between the patella and the anterior superior iliac crest.<sup>7,9,16</sup> In our study, we choose to assess the number of steps performed by each patient and their cardiovascular effect based on the analysis of the double product (DP).<sup>1</sup>

## Frailty patient classification

The frailty classification used was the phenotype described by Fried, being the gold standard in the diagnosis for such syndrome.<sup>11</sup> The frailty index proposed by Fried was performed on all elderly in the program as part of their initial assessment. There were analyzed five health domains: inactivity status, muscle strength, mobility, weight loss and physical exhaustion. The presence or absence of each of the domains was scored, giving a potential score ranging from 0 to 5, where the one that has three or more domains was considered frail, one or two were pre-frail and those that did not score were considered robust.

## Cardiac Rehabilitation Program

The CR program consisted of 36 sessions, where the minimum frequency required was twice a week. The rehabilitation protocol included aerobic training on a treadmill or exercise bike at 50-60% of the maximum heart rate, initially for 10 minutes and progressing until 30 minutes. Muscle strengthening exercises performed with free weights or equipment, functional exercises, balance and the training resistance exercises loads were based on the one repetition maximum test, individually established in the beginning of CR and during the 4 months program when functional evaluation allowed. Patient's reassessment was carried out after the conclusion of all sessions, which occurred in a period of 4 months.

Quantitative variables were described as mean and standard deviation and qualitative variables as absolute and relative frequencies. The comparison of variables between moments was performed using the paired Student's t-test or the paired Wilcoxon test, according to the probability distribution. Delta of the distance covered in the 6MWT and delta of the number of steps performed on the 2MST were created and Pearson's correlations between them were performed. Linear regression analysis was performed to estimate the delta of the distance covered in relation to the steps delta and the ratio obtained between them. The SPSS® version 22 statistical package was used. The threshold of statistical significance for all the tests was set at  $p < 0.05$ .

## RESULTS

Thirty-four elderly met the eligibility criteria and were screened for the study. Ten elderly did not complete the 4 months program, as they did not complete the 85% of the program, therefore, twenty-four were included in the study. Clinical patients' characteristics and comorbidities are shown in Table 1. Mean patient age was 79.5±8.4 years, 71% male, 37.5% had coronary insufficiency, 17.5% valvopathy and arrhythmia, 33.3% hypertension and 8.3% had metabolic syndrome. At the beginning of the CR, the sample contained 4.2% robust patients, 70.8% prefrailty and 25.0% frailty elderly.

**Table 1.** General clinical characteristics of the sample

Variables	N	%
Age (Years), mean ± (SDs)	79.5±8.4	
<b>Gender</b>		
Men	17	70.8
Women	7	29.2
<b>Fried Frailty Phenotype</b>		
Robust	1	4.2
Prefrailty	17	70.8
Frailty	6	25
<b>Clinical Diagnosis</b>		
Corony Artery Disease	9	37.5
Valvular Heart Disease	4	16.7
Cardiac Arrhythmia	4	16.7
Hypertension	8	33.3
Metabolic Syndrome	2	8.3

SDs: standard deviations

The functional capacity and hemodynamic parameters are show in Table 2. The CR increased the number of steps performed during 2MST (62.17±22.50 vs. 76.17±25.56, P= 0.011) and the 6-minute walking distance (364.31±108.01 vs. 421.65±108.73, P<0.001). The double product on exercise peak of 2MST (15744.17±3591.87 vs. 13222.29±2505.39, P<0.001) and 6MWT (14469.92±2497.91 vs. 13348.21±2839.36, P= 0.022) decreased after four months of rehabilitation program (Table 2).

Further analysis showed a strong and significant correlation between 6MWT and 2MST (r= 0.730, P<0.001) (Table 3) and that there was a relationship between the number of steps performed in the 2MST with the mean distance covered of 6MWT (Figure 1).

The Table 4 shows the change in Fried frailty phenotype classification after 4 months of CR. We observed that the rehabilitation protocol significantly modified the classification of the frailty level of the elderly, with 58.3% of them becoming robust (P<0.001).

**Table 2.** Results obtained with the tests before and after Cardiac rehabilitation (CR)

Variable	Initial Evaluation		4 months		p
	Mean	SDs	Mean	SDs	
2MST (steps numbers)	62.17	22.50	76.17	25.56	0.011*
6MWT (meters)	364.31	108.01	421.65	108.73	<0.001
Double product 2MST	15744.17	3591.87	13222.29	2505.39	<0.001*
Double product 6MWT	14969.92	2497.91	13348.21	2839.36	0.022*

SDs: standard deviations; 2MST: two-minute step test; 6MWT: six-minute step test; Student's t-test; \*Wilcoxon paired

**Table 3.** Results of Cardiac rehabilitation in changing variables; Pearson's correlation between 2MST and 6MWT

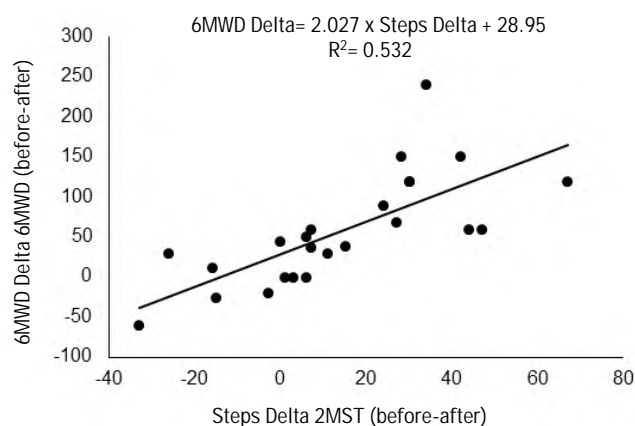
Variable	Mean	SDs	Pearson's	p
Change of 2MST (steps)	14.0	24.2	0.730*	<0.001
Change of 6MWT (meters)	57.3	67.4		

2MST: two-minute step test; 6MWT: six-minute walk test; SDs: standard deviation; \*Pearson correlation

**Table 4.** Classification of Fried Frailty Phenotype during Cardiac Rehabilitation (CR)

	Initial Evaluation		4 months		p
	N	%	N	%	
Robust	1	4.2	14	58.3	<0,001
Prefrailty	17	70.8	9	37.5	
Frailty	6	25	1	4.2	

Wilcoxon paired test



**Figure 1.** The relationship between the numbers of steps performed in the two-minutes step test (2MST) with the distance covered in meters from the six-minute walk test (6MWT) after cardiac rehabilitation (CR)

## DISCUSSION

The study demonstrated a strong association between the 6MWT and 2MST tests and suggested that the increase of 14 steps in 2MST was correlated with improve of 57 meters in 6MWT after CR program applied to the studied population. The study also showed that CR after 4 months modified Fried Classification in our population. These results suggest the possibility of using 2MST as a useful substitute for 6MWT as an indicator of CR effectiveness.<sup>7,8,10</sup> Pedrosa et al.<sup>8</sup> observed an association between these two tests applied to hypertensive elderly women. The 6MWT was originally developed to meet the assessment of functional capacity and monitoring the effectiveness of treatments and prognosis of patients with cardiorespiratory diseases.<sup>12,13,17</sup>

It is currently the most used in outpatient clinical practice as it is easily applied, well tolerated and reflects accurately, daily living activity.<sup>12,17,18</sup> Enright et al.<sup>14</sup> observed that the 6-min walking distance (6MWD) proved to be effective in assessing morbidity and mortality in patients with cardiovascular and/or pulmonary diseases. They showed higher risk for patients who performed less than 300m in the test. Boxer et al.<sup>15</sup> assessed frail elderly people using the 6MWT and observed a lower performance than the other non-frail groups, indicating the usefulness of the test to identify

risk for frailty, emphasizing that walking distances less than 400m could be criteria to identify sarcopenia and decreased mobility.

In our study, the initial distance covered in 6MWT was 354.31m. Our population was composed of a large majority of prefrailty elderly, but with great age variability, between 61 and 94 years old.

These facts, may explain, in part, the intermediary performance observed. However, considering previous studies, such as that of Saad et al.<sup>18</sup> our initial 6MWT distance was below the mean expected for the Brazilian population in this age group. This study points out that for the 3 main equations that determine this prediction, proposed by Enright and Sherrill,<sup>14</sup> Troosters et al.<sup>19</sup> and Iwana et al.<sup>20</sup> the latter being specific for the Brazilian population, higher values could be expected for this age group, respectively being 434.8m, 555.2m and 514.8m. After 4 months of training, the mean distance reached increased to 421.65m, with a mean increase of 57.3m. Increases over 30m in COPD patients already demonstrate training effectiveness and change in outcomes.<sup>13,21,22</sup> In a study of 112 patients with chronic obstructive pulmonary disease (COPD), the smallest noticeable clinical difference in the test was 54m for the group mean.<sup>13</sup> Regarding the studied population, there are no conclusive studies evaluating the value considered significant as functional improvement after CR program.

Considering the 2MST, despite the studies showing a correlation with the 6MWT, its values are less studied in an attempt to establish the proper increase in mean steps after CR program that represents treatment improvement.<sup>7,8,9,10,16</sup> Thus, we emphasize that, there is no consensus for the reference values for the Brazilian population, regarding the number of steps predicted by age as well as the necessary improvement to reflect clinical impact.<sup>8,9,16</sup>

A 2MST validation study for the Brazilian population showed 83% sensitivity and moderate specificity (67%) to assess the functional capacity of hypertensive elderly people, with a cutoff point between 65 and 69 steps for this group.<sup>16</sup> The reference values described and used largely by the literature correspond to the original research of Rikli and Jones,<sup>7</sup> in which they stipulate 78 steps for the same age group of our population. In our study, initially, the mean number of steps performed was 62, which is below the cutoff point proposed for hypertensive elderly people or those with associated comorbidities which was suggested by Rikli.<sup>7,16</sup> After 4 months, the mean achieved was 76 steps, representing an increase of 14 steps. This was an important improvement and were highly associated with the 57m increase in 6MWT. We can assume that this number of steps is significant for clinical outcomes, but studies with a larger number of participants are needed to confirm these findings.

In view of the hemodynamic findings evaluated during the execution of these tests in our population, both tests showed reduced values of DP after 4 months of CR. With a lower DP in the 2MST, we can favor its performance in patients with low reserve or exercise capacity or even for those with some degree of disability that prevents them from performing 6MWT.<sup>8,9,10</sup> The 2MST could also be an alternative as it's a faster test and use less space to be performed.<sup>6,7,8,9,10,16</sup> Therefore, it is ideal for clinical practice, especially for critically ill patients, in which 6MWT can represent a test close to the maximum, due to the metabolic energy expenditure limited by the symptoms of these patients.<sup>8,9,10</sup>

Our results indicate that the 2MST can be considered a reliable assessment of functional capacity and could, therefore, represent a valuable addition to the arsenal of functional tests for the frail

elderly population.<sup>8,9,10,13,18</sup>

Regarding clinical aspects, our study also showed a significant change in the classification of the frailty level with 58.3% of them becoming robust after 4 months of CR program. The improvement in performance for both tests is of great importance as activities such as walking and climbing stairs are both very challengeable for patients with frailty.<sup>3,4,11,15</sup> The rehabilitation process, whenever possible, should prioritize the functional activities like gait in order to improve them and make it less energy expendable and adequate cardiac effort.<sup>3,8,13,22</sup>

The limitations of the present study should be highlighted, as being a retrospective study based on the analysis of data available in evaluation forms where there was no information about anthropometric measures and evaluation of subjective feeling of effort (Borg scale). Studies with a larger number of participants diagnosed with frailty could allow the analysis of correspondence between the values obtained in the tests.

## CONCLUSION

The 2MST enables a reliable assessment of functional capacity in frailty patients and may thus be considered as an effective alternative for the 6MWT for elderly people in a CR program. Furthermore, the CR program was able to reverse the frailty in most patients.

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