Original Article

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Reliability and agreement in the evaluation of gait speed in cardiac surgery

Confiabilidade e concordância na avaliação da velocidade da marcha em cirurgia cardíaca

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ABSTRACT

Objective: To evaluate the reliability and agreement of the test-retest in assessing walking speed in patients undergoing cardiac surgery (CS), as well as to quantify the learning effect between the tests. **Method:** A prospective longitudinal study that assessed walking speed using the Six-Meter Walking Speed Test (6mWST) in the preoperative period, postoperative period (PO), and after hospital discharge. Data were analyzed using the intraclass correlation coefficient (ICC) and the minimum detectable alteration (MDC_{95}). **Results:** The sample (n = 82; 62.51 ± 8.88 years) showed excellent test-retest reliability of the 6MWT in the preoperative period (ICC= 0.98; 95% CI: 0.97–0.99) (p< 0.001), in the PO (ICC = 0.97; 95% CI: 0.94–0.99) (p< 0.001), and after hospital discharge (ICC= 0.97; 95% CI: 0.94–0.99) (p< 0.001). There was an increase in walking speed between the test and retest in the PO and after hospital discharge, with a mean learning effect of 0.06 m/s (95% CI: 0.17–0.29 m/s) (p < 0.001). The MDC95 indicates that walking speed in 95% of the sample will vary by less than 0.014 m/s in the preoperative period and less than 0.016 m/s in the PO and after hospital discharge. **Conclusion:** The test-retest of the 6MWT demonstrated adequate reliability and agreement in patients undergoing CS at the different time points evaluated. A significant learning effect was also observed, indicating that repeating the test is necessary to obtain accurate walking speed measurements.

Keywords: Reproducibility of Results, Walking Speed, Thoracic Surgery, Physical Functional Performance

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Conflict of Interests
Nothing to declare

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RESUMO

Objetivo: Avaliar confiabilidade e concordância do teste-reteste na avaliação da velocidade de marcha em pacientes submetidos à cirurgia cardíaca (CC), bem como quantificar o efeito de aprendizagem entre os testes. **Método:** Estudo longitudinal prospectivo que avaliou a velocidade de marcha utilizando o Teste de Caminhada de 6 Minutos (TC6m) no pré-operatório, pós-operatório (PO) e após alta hospitalar. Dados analisados por meio do coeficiente de correlação intraclasse (ICC) e a alteração mínima detectável (MDC_{95}). **Resultados:** Amostra (n= 82; 62,51±8,88 anos). O ICC demonstrou excelente confiabilidade entre teste-reteste de TC6m no pré-operatório (ICC= 0,98; IC 95%: 0,97-0,99) (p<0,001), no PO (ICC= 0,97; IC 95%: 0,94-0,99) (p<0,001), e após alta hospitalar (ICC= 0,97; IC 95%: 0,94-0,99) (p<0,001). Houve aumento da velocidade de marcha entre o teste-reteste no PO e após a alta hospitalar, com efeito médio de aprendizagem de 0,06 m/s (IC95% 0,17-0,29 m/s) (p<0,001). O MDC_{95} indica que a velocidade de marcha de 95% da amostra variará em <0,014 m/s no pré-operatório e <0,016 m/s no PO e após alta hospitalar. **Conclusão:** O teste-reteste do TC6m demonstrou confiabilidade e concordância adequadas em pacientes submetidos à CC nos diferentes momentos avaliados. Foi observado um efeito de aprendizagem significativo, indicando que a repetição do teste é necessária para obter medições precisas da velocidade de marcha.

Palavras-chaves: Reprodutibilidade dos Testes, Velocidade de Caminhada, Cirurgia Torácica, Desempenho Funcional Físico

INTRODUCTION

Walking speed, considered the sixth vital sign, is an important indicator of general health status and has been used to screen and detect frail individuals.[1,2] The walking speed test (WST) is widely applied in cardiac surgery due to its predictive ability and ease of execution.[3] Such a test is commonly used in the preoperative period to identify patients with high surgical risk and assist in decision-making about the best procedure.[2] In addition, it can be used in the postoperative period to minimize unfavorable events and assist in safe cardiac rehabilitation.[4]

There are different ways of applying the WST, with distances of 4, 5, 6, and 10 meters being the most used for the short-distance walking test.[1,5,6] Another test used is the 6-minute walk test (6MWT), which assesses gait with a focus on endurance.[7,8] Consistent studies in patients undergoing transcatheter aortic valve implantation showed that there is no difference in gait speed between studies that used the limited distance walking test (4MWT/5MWST/15fWT) and those that applied the time-limited walking test (6MWT).[9] Studies in the elderly recommend repeating the test due to the learning effect, possibly associated with optimizing stride length and decreased anxiety.[8,10,11]

However, it is still unclear whether it is necessary to submit a patient with cardiovascular impairment to more than one measure of WST, considering that repeated tests may not be feasible due to the low exercise capacity in this population.

OBJECTIVE

This study aims to evaluate the reliability and agreement of the test-retest in evaluating gait speed in patients submitted to cardiac surgery at different operative time points, and quantifying the learning effect between the tests.

METHOD

This is a longitudinal and prospective study that analyzed patients undergoing coronary artery bypass grafting (CABG) surgery and/or valve replacement aged between 30 and 80 years, were recruited consecutively from admission to the intensive care unit of the teaching hospital in southern Brazil, following an invitation made by the researcher in charge. The study was developed in the period from September 2018 to October 2019. In front of the recruiting, each subject needed to talk to understand the purpose of the study, and we provided formal consent for each subject. We had obtained approval for the study from the hospital's ethics committee (protocol number 2.877.022). The procedure of written informed consent was also given for retrieving socio-demographic and clinical data and for using personal data (name, address) for follow-up assessment. The Guidelines for Reliability and Agreement Study Reports (GRRAS) were followed.[11]

The sample calculation was performed after evaluating five individuals, considering an alpha of 0.05 and power of 95%, respectively, using Spearman's correlation coefficient and based on the gait speed obtained through the 6mWST preoperatively and in the PO (r= 0.70). A total of 62 individuals were estimated to ensure a correlation coefficient with half the intensity estimated by the pilot study (r= 0.35).[12]

Participants and examiner

Patients with CABG and valve replacement scheduled during the study period were invited to participate. The inclusion criteria were: patients of both genders, able to communicate effectively, and walking without auxiliary walking devices. Those who underwent urgent cardiac surgery or who presented orthopedic deficits that prevented ambulation were excluded.

The evaluations were performed by the same physiotherapist who had 3 years of experience. The examiner received 20 hours of training to administer the WST. In addition, two assistant researchers followed the data collection and assisted in the care of the patient and the researcher.

Clinical and demographic evaluation

Clinical and demographic information was extracted from the electronic medical records in the preoperative period. Clinical severity was quantified using the Simplified Acute Physiology Score (SAPS III),[13] and the sample was evaluated for gender, age, and anthropometric characteristics such as body mass index (BMI), obtained through the ratio between body mass (in kilograms) and height (in meters) squared, and waist-hip ratio (WHR), calculated as the ratio of abdominal circumference to hip circumference.

Procedures

Gait speed was evaluated at three different moments: preoperatively, in the PO, and after hospital discharge (outpatient clinic), when the patient returned for medical evaluation. The patient was accompanied by the evaluator to the place prepared for performing the test, and the 6MWST was carried out in a flat corridor, in which two meters were marked for acceleration, six meters for the effective test, and two meters for deceleration.

The patients performed the 6MWST according to the standardized instructions, with their feet positioned behind the zero-meter start line, walking as fast as possible, but without running, towards the finish line. The stopwatch was triggered from the moment one of the lower limbs crossed the second meter, and the test was immediately stopped when one of the lower limbs crossed the eighth meter. Each patient was submitted twice to 6MWST, covering the test-retest, and five minutes of resting time was allowed in the sitting position between both tests. The velocity was obtained through the ratio between the distance of six meters by the time traveled in seconds, and a speed of ≤ 0.8 m/s was considered poor physical performance.[14,15]

Statistical analysis

The Shapiro-Wilk test was used to verify the normality of data distribution, and the data were presented in absolute numbers, mean, and standard deviation. The test-retest reliability was evaluated using the bidirectional random intraclass correlation coefficient with single measurements (ICC), with 95% confidence intervals (CI). The paired Student's t-test was used to compare the test-retest preoperatively, in the PO, and the outpatient clinic after discharge ($p \leq 0.05$). The standard measurement error (SEM = SD $\sqrt{1}$ - ICC) was calculated for the test-retest, and the standard deviation (SD) indicated that the standard deviation and the minimum detectable change (MDC = SEM × 1.96 × $\sqrt{2}$) were associated with a 95% CI.[16]

A Bland-Altman graph was used to analyze the agreement between the test-retest in the preoperative period. The Statistical Package for Social Science (SPSS 23.0, IBM, Armonk, NY, USA) software program was used for all analyses.

RESULTS

The initial sample consisted of 82 individuals evaluated in the preoperative period. The PO evaluation occurred at 5.06±1.70 days after cardiac surgery, and outpatient evaluation was performed at 17.66±5.89 days after hospital discharge. The total sample size differed between the moments evaluated due to adverse outcomes, mortality risk (SAPS III), constituted as the chance of the patient presenting an unfavorable clinical stage, death, and follow-up loss (Figure 1).

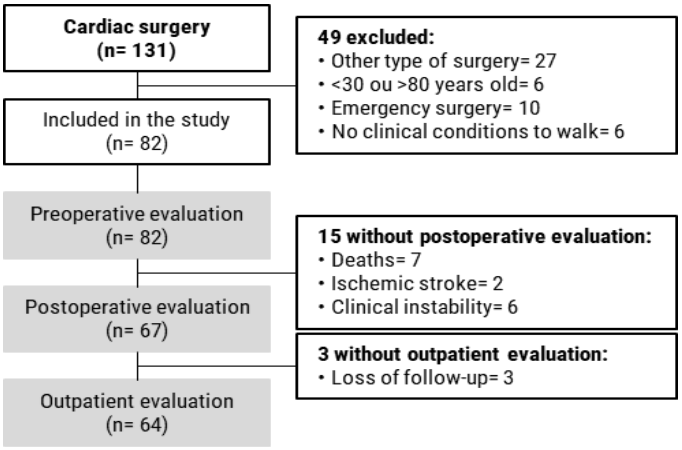

Figure 1. Study flowchart

A total of 65 (79.3%) of the evaluated patients were male and had a mean age of 62.51±8.88 years. The most relevant dysfunction was cardiac atherosclerotic disease (37.8%), followed by aortic stenosis (25.6%). The clinical and anthropometric characteristics of the analyzed sample are described in Table 1.

Table 1. Sample characterization

	(n= 82)
BMI (Kg/m^2)	27.72 ± 4.02
WHR (cm)	0.97 ± 0.05
EF (%)	58.30 ± 8.76
Smoking (packs/year)	33.85 ± 21.80
Comorbidities, n (%)	
SAH	68 (82.9)
Diabetes	24 (29.3)
Dyslipidemia	17 (20.7)
Type of surgery, n (%)	
CABG	46 (56.1)
Valve replacement	31 (37.8)
Both	5 (6.1)
CPB (min)	62.56 ± 15.93
Clamping time (min)	51.07 ± 14.84
SAPS III	31.41 ± 9.75
ICU length of stay (days)	2.97 ± 1.46
Length of hospital stay (days)	8.92 ± 4.02

Data expressed in frequencies and percentages, mean, and standard deviation. BMI: body mass index; WHR: waist-hip ratio; EF: ejection fraction; SAH: systemic arterial hypertension; CABG: coronary artery bypass graft; CPB: cardiopulmonary bypass; SAPS III: Simplified Acute Physiology Score III; ICU: intensive care unit

The patients presented a good performance on the 6mWST in the three moments evaluated. The results of the mean gait speed, ICC, SEM, and MDC95 for the operative moments evaluated are described in Table 2.

Table 2. Reliability results between test-retest

	Test (m/s)	Retest (m/s)	ICC (95% CI)	SEM (m/s)	MDS$_{95}$ (m/s)
Preoperative	1.48 ± 0.42	1.48 ± 0.46	0.98 (0.97-0.99)	0.017	0.014
Postoperative	0.98 ± 0.40	1.04 ± 0.42	0.97 (0.94-0.99)	0.020	0.016
Outpatient	1.41 ± 0.39	1.46 ± 0.40	0.97 (0.94-0.99)	0.020	0.016

Data expressed in mean and standard deviation. ICC (95% CI): intraclass correlation coefficient with 95% confidence interval; SEM: standard measurement error; MDC95: minimum detectable change at 95% confidence level

The patients showed a significant increase in the speed in the test for retest in the PO of 0.98 m/s (95% CI: 0.19-1.76 m/s) versus 1.04 m/s (95% CI: 0.22-1.87 m/s) and 1.41 m/s (95% CI: 0.64-2.18 m/s) versus 1.46 m/s (95% CI: 0.68-2.25 m/s) in the outpatient clinic after discharge (Figure 2). The average learning effect in the PO and after discharge was 0.06 m/s (95% CI 0.17-0.29 m/s) (p<0.001).

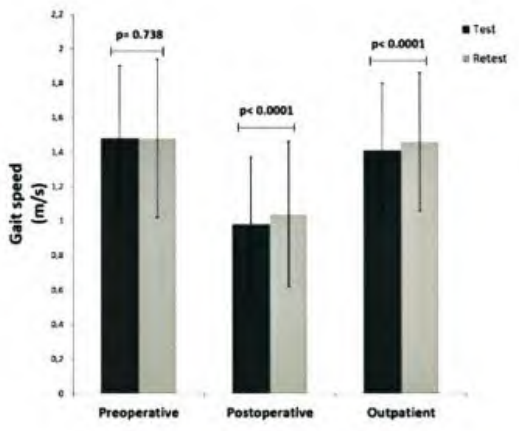

Figure 2. Figure 2. Comparison between test-retest in the moments evaluated

There was an increase in gait speed between the tests in the preoperative period; the average bias value among the measurements was considered low (Figure 3).

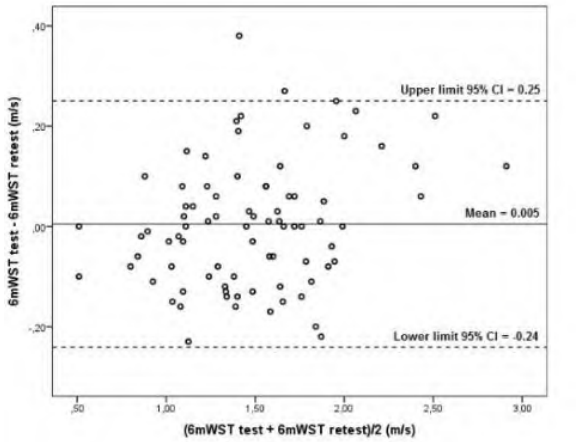

Figure 3. Analysis of agreement through the Bland-Altman graphic arrangement (means versus differences) between the preoperative measurements of the six-meter walking speed test

DISCUSSION

The present study evaluated the reliability and agreement of the test-retest in the evaluation of gait speed in patients submitted to cardiac surgery. The reliability of the test-retest in the operative time points evaluated was considered excellent; however, a learning effect of 0.06 m/s (95% CI 0.17-0.29 m/s) was observed in the evaluation performed in the PO and after discharge. The MDC95 indicates that the gait speed of 95% of the individuals submitted to cardiac surgery will vary <0.014 m/s preoperatively and <0.016 m/s in the PO and after discharge, implying that a change of ≥0.014 and ≥0.016 m/s is necessary to obtain 95% certainty that the change is not due to the variability of the test-retest.

According to the American Thoracic Society Guidelines for the 6MWT7, a practical test is not required in most clinical contexts. However, there is an increase of 20 meters (6%) in the distance covered in the 6MWT in the retest in patients with severe chronic obstructive pulmonary disease (COPD). It is recommended to repeat the 6MWT approximately at the same time of day to minimize intraday variability or wait at least 1 hour before the second test.[7]

When analyzing the reliability of the 6MWT in patients with chronic heart failure, Uszko-Lencer et al.[17] observed a learning effect of 31 meters (95% CI 27-35 m) between the practice test and the retest. However, Adsett et al.[10] did not observe a learning effect in patients with a distance covered < 300 meters in the first test.[10]

In our study, adequate agreement was observed through the Bland-Altman graph between the tests in the preoperative period. However, the patients significantly increased gait speed in the PO and after discharge, and there was an average learning effect of 0.06 m/s. Martinez et al.[15] applied the 6mWST in hospitalized older adults and showed that its practice is feasible and safe, and there was a progressive increase between the first and third measurements in the analysis of the three gait speed measurements, with the third being more reliable due to its greater correlation with the highest and lowest value of mean bias and limits of agreement. Furthermore, Kon et al.[18] verified excellent test-retest reliability when evaluating gait speed in patients with COPD.

Although we observed a minimal learning effect in the PO and after discharge, the MDC95 in the evaluated operative time points provides an evaluation of relative improvement or deterioration in a parameter value, and it would be beneficial to the clinician to determine whether the performance has changed. Thus, a real change in the parameter of interest can not only be reasonably determined by evaluating statistical significance but also by incorporating the MDC into decision-making.[16]

Anxiety on the part of patients in reestablishing their activities of daily living, as well as the fear of performing certain movements safely, can cause limitations and insecurity after cardiac surgery. Such patients may also present weakness, pain, and physical deconditioning, even before the surgical procedure, due to the previous cardiac condition, in which this condition is further accentuated after cardiac surgery.[19]

In our study, this condition was evidenced by decreasing gait speed in the PO and after discharge. Patients are initially afraid when needing to walk without assistance, which we infer that the patients establish greater confidence in the retest and thereby present a better performance in gait speed. The present study presents some limitations, such as the fact that it did not compare gait speed with another physical test considered the gold standard in the hospital environment. Another important factor to be considered was the follow-up losses due to mortality risk, which made it impossible to evaluate part of the sample. As far as we know, this study is the first to evaluate the reliability and agreement of gait speed in cardiac surgery. We can highlight that the reliability of the test-retest in the operative time points evaluated was considered excellent. The second measurement during the test-retest was configured to measure the best performance in the PO and after discharge, without deferral in the preoperative evaluation.

The measurement error and variability associated with gait speed were only 0.014 m/s preoperatively and 0.016 m/s in the PO and after discharge. This information is useful for a clinician who tries to interpret gait velocity measurements in patients submitted to cardiac surgery at different operative time points.

CONCLUSION

The test-retest of the 6mWST demonstrated adequate reliability and agreement in patients undergoing cardiac surgery at the different assessed time points (preoperative, postoperative, and post-discharge). A significant learning effect was also observed, indicating that repeating the test is necessary to obtain more accurate measurements of gait speed.

AUTHOR CONTRIBUTIONS

Research conception and design: Abentroth LRL, Paiva DN; Data collection: Abentroth LRL, Schwantes MA, Lopes EE; Data analysis and interpretation: Abentroth LRL, Paiva DN, Schwantes MA, Lopes EE; Statistical analysis: Abentroth LRL, Cardoso DM, Paiva DN; Manuscript writing: Abentroth LRL, Paiva DN, Moura GP, Souza de MM, Bellini LL, Cardoso DM, Schwantes MA, Lopes EE; Critical review of the manuscript regarding intellectual content: Abentroth LRL, Cardoso DM, Paiva DN.

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