

Comparison of the Sit-to-Stand Test with the 6-Minute Walk Test in Post-Coronary Artery Bypass Graft Patients

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ABSTRACT

Objectives: To compare the sit-to-stand test and the 6-minute walk test in cardiac rehabilitation patients who had undergone coronary artery bypass graft (CABG) surgery

Study design: Cross-sectional study

Setting: Department of Physical Medicine and Rehabilitation, Phramongkutklao Hospital, Ratchathewi District, Bangkok

Subjects: Thai adults aged between 20 and 79 years who had undergone CABG and came to the hospital to receive cardiac rehabilitation as an outpatient

Methods: Participants started with the 6-minute walk test. After adequate rest, the participants then performed the sit-to-stand test. The 6-minute walk distance and sit-to-stand test results were recorded, along with blood pressure, heart rate and the rating of the perceived exertion scale before and after the tests.

Results: There were a total of 43 participants. The correlation coefficient (r) between the 6-minute walk test and the sit-to-stand test was 0.58 ($p < 0.001$), indicating a moderately significant correlation. The exercise intensities from both the sit-to-stand and 6-minute walk tests were light were considered safe.

Conclusions: A moderately significant correlation was demonstrated between the sit-to-stand test and the 6-minute walk test in post-CABG patients. The intensity of both tests was light and safe. The sit-to-stand test should be considered an alternative submaximal exercise test in outpatient cardiac rehabilitation services.

Keywords: sit-to-stand test (STST), 6-minute walk test (6MWT), coronary artery bypass graft (CABG), cardiac rehabilitation

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improve their quality of life, and reduce the recurrence of events, morbidity, and mortality.¹ The American College of Cardiology (ACC) and the European Society of Cardiology (ESC) both recommended that all cardiovascular patients participate in a cardiac rehabilitation program (class I recommendation).^{2,3} Exercise training is an essential part of the program and is begun during the first phase of cardiac rehabilitation. It is further recommended that all patients complete an exercise test before starting the exercise program.⁴ Both the cardiopulmonary exercise test (CPET) and the electrocardiogram exercise stress test (EST) provide comprehensive information. However, those methods require expensive equipment and an experienced technician. As a result, they are not widely applied.

A walk test is an indicator for assessing the efficiency and effectiveness of overall treatment and a patient's hospital discharge readiness.⁵ The 6-minute walk test (6MWT) is a submaximal functional test which is widely used in cardiac rehabilitation clinics because it is easy to conduct, requires less time, and produces results that are associated with basic activities in daily life.^{5,6} However, 6MWT results can be affected by a variety of factors unrelated to cardiopulmonary status, including age, sex, height, and weight.^{7,8} The sit-to-stand test (STST), which counts how many times a participant can stand up from and sit down on a chair in one minute, is used to measure lower body muscular strength and endurance and has been accepted as an indicator for functional testing.⁹ The STST has been found to be moderately correlated with the 6MWT in healthy young adults.¹⁰ It has been used with patients with a chronic obstructive pulmonary disease (COPD) and has shown a good correlation with the 6MWT.^{11,12} The STST is less hemodynamically stressful, so it can be used to estimate exercise capacity in patients who have low functional capacity or gait impairment.¹³⁻¹⁵ Furthermore, the test can be performed in a limited space and in a short period of time. This study aims to evaluate the relationship between the STST and 6MWT among post-coronary artery bypass graft (CABG) patients in a cardiac rehabilitation clinic.

Introduction

Cardiac rehabilitation is an integrated rehabilitation program for patients with cardiovascular problems that provides recommendations for safe exercise programs and lifestyle modification. The primary purpose of a cardiac rehabilitation program is to increase the functional capacity of individual patients in order to allow them to return to their vocation,

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Methods

Study design and participants

The present cross-sectional study was conducted between January and November 2022. The eligibility criteria were Thai adults age between 20 and 79 who had undergone CABG and had come to the hospital receive cardiac rehabilitation as an outpatient. All participants were given an explanation of the study's procedure and provided written informed consent prior to participating in the study. Participants who had contraindications for the 6MWT and submaximal exercise testing according to the American Thoracic Society (ATS) guidelines were excluded.

Ethical considerations

Ethical approval for this study was obtained from the Institutional Review Board, Royal Thai Army Medical Department (IRB number: R084h/64), and all the subjects provided informed consent for their participation.

6-Minute walk test

The participants were instructed to walk as far as possible in six minutes, going back and forth along a straight line 15-meter route. Before the actual test, the participants practiced walking the route one time to reduce the learning effect. If they became exhausted, participants were allowed to stop or reduce their walking speed without stopping the counting of the time. The examiner announced the time remaining every minute following the ATS guidelines. The distance covered during the test was recorded in meters.

Sit-to-stand test

The sit-to-stand test (STST) used a 46-cm high chair with no armrests which was placed against a wall to prevent movement of the chair. The participants sat upright on the chair with both hands at their waist. Their feet were flat on the floor, spaced at the same width as their shoulders. Before the test began, the participants were instructed to do two practice repetitions. During the test they stood up and sat on the chair as many times as possible in one minute, moving at a speed they felt safe. If they became too exhausted, participants could stop, although the counting down of the time continued. The examiner announced when 15 seconds was left, and when the examiner said, "Time is up," the participants had to stop. Only the repetitions in which participants were able to stand upright without support were counted. The participants did not practice before this test because no learning effects have been found and the practice could cause lower limb fatigue.¹⁵

Physiological responses to the tests

The patients' heart rate, oxygen saturation, blood pressure, any abnormal signs or symptoms, and the modified Borg Rating of Perceived Exertion Scale (CR10 RPE scale)

results before and after the test were recorded. Exercise intensity was calculated using the Karvonen method, with the estimated maximum age-related heart rate calculated using Tanaka's formula ($208 - 0.7 \times \text{age}$). All participants performed the 6MWT first, followed by the STST. There was a rest period between the two tests and all parameters were allowed to return to baseline values before the next test was started.

Statistical analysis

The calculated sample size was 43, assuming alpha (α) 0.05, (β) 0.10, and a correlation coefficient of 6MWT with STST in COPD patients of 0.75.¹¹ The baseline and clinical characteristics of the patients were recorded as mean and standard deviation (SD) for continuous data, and as frequency and percentage for categorical data. The 6MWT and the STST correlation was evaluated using Pearson's correlation coefficient.

Results

Of the 43 participants who had undergone CABG within the previous six months, the majority were male (90.7%) with a mean age of 62.8 (8.5) years and a range of 45-78 years. The mean left ventricular ejection fraction (LVEF) was 56.2% and the mean body mass index was 23.2 (2.2) kg/m². Of the participants, 69.8% were categorized in the minimal risk group for cardiac rehabilitation, and 86.5% had triple vessel disease, as shown in Table 1. Physiological responses, including peak heart rate, oxygen saturation, blood pressure, and the modified Rating of Perceived Exertion Scale, are shown in Table 2. The mean 6MWT and STST exercise intensities were 33.9 (14.7) and 26.9 (11.3), respectively, indicating the light intensity of both tests. The scatter plot between the 6MWT and the STST is displayed in Figure 1. A moderate positive correlation between the 6MWT and STST was found ($r=0.58$, p

Table 1. Demographic data and clinical characteristics of the participants (n = 43)

Variables	
Age (years) ¹	62.8 (8.5)
Body mass index (kg/m ²) ¹	23.2 (2.2)
Left ventricular ejection fraction (%) ¹	56.2 (15.6)
Male ²	39 (90.7)
Risk ² (AACVPR stratification)	
Minimal	30 (69.8)
Moderate	8 (18.6)
High	5 (11.6)
Type of coronary diseases ²	
Single vessel	3 (7.0)
Double vessel	3 (7.0)
Triple vessel	37 (86.0)
6-minute walk test (m) ¹	404.6 (76.5)
Sit-to-stand test (repetitions) ³	22 (19-25)

¹Mean (SD), ²Number (%), ³median (IQR)

AACVPR, American Association of Cardiovascular and Pulmonary Rehabilitation

Table 2. Physiological parameters of the tests

Parameters	6MWT	STST
Peak heart rate	102.7 (15.3)	98.3 (14.2)
Oxygen saturation (%)	97.5 (1.1)	97.6 (0.9)
RPE	2.2 (1.2)	2.1 (1.0)
Systolic blood pressure (mmHg)	158.5 (24.3)	148.9 (19.4)
Diastolic blood pressure (mmHg)	84.0 (13.8)	81.3 (14.7)
Intensity	33.9 (14.7)	26.9 (11.3)

Values are presented as mean (SD),

6MWT, 6-minute walk test; STST, sit-to-stand test, RPE, rating of perceived exertion

< 0.001). Importantly, no adverse events related to either of the two tests were found in this study.

Discussion

The primary aim of the present study is to evaluate the relationship between the 6MWT and the STST among post-CABG patients who received treatment in an outpatient cardiac rehabilitation program. The results indicate that the STST has a moderate positive correlation with the 6MWT ($r=0.58$), which is in concordance with previous studies.^{12,14} However, some studies conducted in an COPD population by Ozalevli et al. and Reychler et al. have reported a higher correlation ($r=0.75$ and 0.71 , respectively) than the present study.^{11,15} A possible explanation for this difference is that all participants in the present study performed the 6MWT before the STST, so some participants may have felt tired after the long walk and completed the STST at a slower speed than they otherwise could.^{11,15} Regarding cardiorespiratory parameters during the STST and 6MWT (Table 2), there were no significant differences in peak heart rate, oxygen saturation, RPE, blood pressure, or level of intensity between two tests in the post-CABG patients. This differs from previous studies by Meriem et al. and Reychler et al.^{14,15}, which reported variations in heart rate and pulsed oxygen saturation were significantly different between the two tests and that the STST was found to be less hemodynamically stressful than the 6MWT in COPD patients.

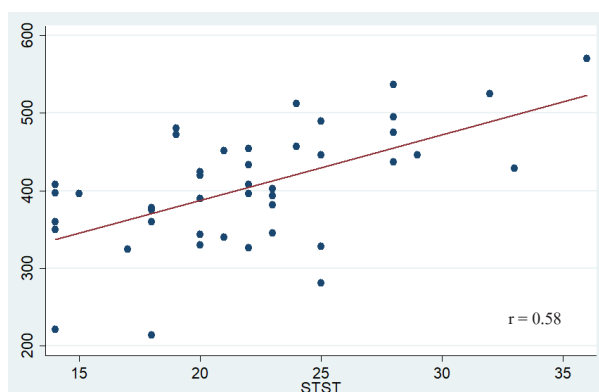


Figure 1. Scatter plot between 6-minute walk test (Y axis) and sit-to-stand test (X-axis)

The most critical significant potential barrier to using 6MWT is that it requires more space and takes more time than the 6MWT, which is only commonly available requiring physical and staff resources which may be limited in some clinical settings. The present study found that the STST required less time and space than the 6MWT, so the STST could be considered a more suitable alternative functional test in some clinical settings. Based on the linear regression model, the estimated distance covered during the 6MWT can be calculated using the formula $D = 7.71[\text{STST}] + 1.75[\text{LVEF}] + 136.3$, where D is the estimated walking distance. STST is the number of Sit-To-Stand repetitions, and LVEF is the left ventricular ejection fraction. In the present study, the correlation coefficient (r) between the estimated 6MWT distance and the actual distance was 0.68 (Figure 2).

Several limitations of this study should be considered. All participants performed the 6MWT first, followed by the STST which may have caused the results from STST to be lower than they would otherwise have been. The 6MWT in this study was performed along a 15-meter-long corridor, which is shorter than the standard distance of 30 meters, so participants had to reverse direction twice as often. Additionally, participants in this study were post-CABG patients in an outpatient cardiac rehabilitation program, so the results cannot be directly applied to other patient groups. Additionally, almost all participants were male (90.7%), so the results might not be generalizable to females. Finally, the sample size was relatively small.

Conclusions

The STST demonstrated a moderately significant correlation with the 6MWT in post-CABG patients. The test is of light intensity and is regarded as safe. Thus, it should be considered an alternative submaximal exercise test in outpatient cardiac rehabilitation services.

Acknowledgments

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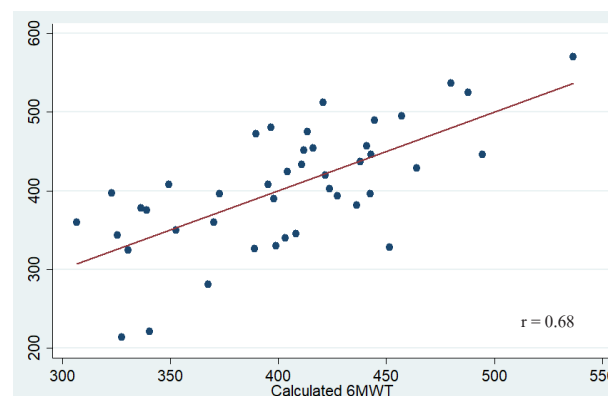


Figure 2. Scatter plot between 6-minute walk test (6MWT) (Y axis) and calculated 6MWT (X-axis)

Conflicts of interest

The authors report no conflicts of interest.

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