Reliability and Responsiveness of Gait Speed, Five Times Sit to Stand, and Hand Grip Strength for Patients in Cardiac Rehabilitation

Michael L. Puthoff PT, PhD, GCS;¹ Dan Saskowski MA²

¹St Ambrose University Physical Therapy Department, Davenport, IA

²Trinity Medical Center Cardiac Rehabilitation, Moline, IL

ABSTRACT

Purpose: Following a cardiac event patients are at risk for deficits in mobility and function. However, measures of physical performance are not commonly used and have not been extensively studied in patients enrolled in cardiac rehabilitation. The purpose of this study was to determine the reliability and the minimal detectable change (MDC) of gait speed, 5 times sit to stand (5 STS) and hand grip strength for individuals enrolled in cardiac rehabilitation.

Methods: Forty-nine individuals enrolled in phase II or III cardiac rehabilitation participated in the study. Gait speed, 5 STS, and hand grip strength were measured over two sessions held on the same day. Intraclass correlation coefficient was used to determine reliability and MDC₉₅ was calculated to measure responsiveness. **Results:** All 3 measures showed high reliability (ICC for gait speed = 0.96, 5 STS = 0.87, right hand grip strength = 0.97, left hand grip strength = 0.97). The MDC₉₅ for gait speed was 0.16 meters/second, 3.12 seconds for 5 STS, 5.2 kilograms for right and 5.1 kilograms for left hand grip strength. **Conclusion:** Gait speed, 5 STS, and hand grip strength are reliable and responsive measures for patients in cardiac rehabilitation. Findings support their use in clinical practice and future cardiac rehabilitation studies.

Key Words: cardiac rehabilitation, gait speed, sit to stand

INTRODUCTION AND PURPOSE

Cardiac rehabilitation is defined as a comprehensive, long-term program involving medical evaluation, prescribed exercise, cardiac risk factor modification, education, and counseling.¹ Patients who have experienced a major cardiac event such as a myocardial infarction or a percutaneous coronary intervention within the last year are eligible for cardiac rehabilitation services. Physical therapists serve as part of the multidisciplinary team that may interact with

patients enrolled in cardiac rehabilitation. The primary focus of cardiac rehabilitation is the management of symptoms, prevention of future coronary events, and improvement of patients' quality of life. There is strong evidence that cardiac rehabilitation programs reduce mortality, decrease symptoms, and improve exercise tolerance.³

Current guidelines for cardiac rehabilitation recommend the assessment of such areas as past medical history, cardiac disease risk factors, and exercise capacity.⁴ One area that is not commonly considered in cardiac rehabilitation is the functional status or abilities of the patient. There are no recommendations or guidelines to assess mobility or function in the *Core Components of Cardiac Rehabilitation/Secondary Prevention Programs*,⁴ the American Association of Cardiovascular and Pulmonary Rehabilitation (AACVPR) Consensus Statement *Outcomes Evaluation in Cardiac Rehabilitation/Secondary Prevention Programs*,⁵ or in a joint statement from the AACVPR/American College of Cardiology/American Heart Association⁶ on performance measures in cardiac rehabilitation. The typical patient in cardiac rehabilitation is over the age of 60, presents with multiple cardiovascular risk factors, such as inactivity and obesity, and is recovering from a recent cardiac event.^{7,8} All these factors can lead to deficits in balance, mobility, and function. With national initiatives to increase the number of individuals who enroll in cardiac rehabilitation programs, especially those who are older, female, and with multiple co-morbidities,^{15,16} there will likely be more patients presenting to cardiac rehabilitation programs with deficits in function. It will be essential that health care providers in cardiac rehabilitation programs, especially physical therapists, have physical performance measures that can capture mobility and balance in this population in order to provide the patient with the most appropriate interventions. As more investigators examine function for patients enrolled in cardiac rehabilitation, they will also need appropriate tools to capture physical performance.

In order for a measure to be effectively used in research studies and in clinical practice, establishing its reliability is essential. Reliability is the extent to which a measure is reproducible, consistent, and free from error.¹⁷ Without high reliability, the validity or meaning of the measure

Address correspondence to: Michael Puthoff at PuthoffMichaelL@sau.edu

is not useful. Even when the reliability of a measure has been established in one patient population, it should not be automatically applied to a different patient population.¹⁸ Differences such as overall health, medical conditions, and emotional status could alter the reliability between populations. If a measure is going to be used to assess changes over time, the responsiveness of the measure should be known. Responsiveness refers to a measure's ability to detect change over time when a patient has actually made an increase or decrease in performance.¹⁸ A common method to examine responsiveness is calculation of the minimal detectable change (MDC). Minimal detectable change is the smallest amount of change that is not likely to be due to chance variation in measurement.¹⁹ Changes found in the measure greater than MDC are considered true changes as opposed to measurement error.

Three physical performance measures that are potentially valuable in cardiac rehabilitation programs for measuring function are usual gait speed, 5 times sit to stand (5 STS) test, and hand grip strength. Gait speed is assessed by measuring the time it takes an individual to ambulate over a short distance at a comfortable pace.²⁰ In the field of gerontology, gait speed is referred to as the sixth vital sign due to its simplicity yet strong prognostic ability.^{21,22} Gait speed is related to strength, power, coordination, and balance and can predict older adults at risk for institutionalization, falls, loss of mobility, decline in cognition, and even death.²³⁻²⁵ The 5 STS test is completed by measuring the time it takes an individual to stand up from a chair 5 times in a row as quickly as possible.²⁶ Performance in the 5 STS test measures lower extremity muscle performance, assesses balance, and can predict falls in older adults.²⁷⁻²⁹ Hand grip strength is measured by having individuals apply a maximal force to a hand held dynamometer.³⁰ Low hand grip strength is a predictor of cognitive decline, functional limitations, disability, prolonged hospitalization, and mortality in older adults.³¹⁻³³ Gait speed, 5 STS, and hand grip strength can be completed in a few minutes making them ideal for clinical practice and clinically based research studies.

All 3 of these physical performance measures have been used in older adults and individuals with stable cardiovascular diseases.^{24,34-39} However, reliability and responsiveness of gait speed, 5 STS, and hand grip strength has not been established for patients enrolled in cardiac rehabilitation. Most patients enrolled in cardiac rehabilitation are community dwelling older adults and an argument could be made that the current literature should be applied to patients in cardiac rehabilitation. However these patients are in the recovery stage from a major medical event and have unique issues including recent surgeries, new medications, and the psychological issues associated with recovering from a cardiac event that may affect the reliability of physical performance measures. Reliability and responsiveness data in gait speed, 5 STS, and hand grip strength would provide guidance on their potential usefulness in cardiac rehabilitation programs in both research and clinical practice. The purpose of this study was to determine the reliability and the MDC of usual

gait speed, 5 STS, and hand grip strength for individuals enrolled in cardiac rehabilitation.

METHODS

Participants were recruited from Trinity Medical Center phase II and phase III cardiac rehabilitation programs through flyers and personal contact with the cardiac rehabilitation staff. Interested individuals were contacted by one of the investigators to describe the study and schedule a data collection session. This study was approved by the Trinity Medical Center and St. Ambrose University Institutional Review Board. Informed consent was obtained from participants prior to data collection and the rights of participants were protected throughout the study. During the informed consent process, participants were informed of the purpose of the study. For inclusion in the study, patients had to be currently enrolled in cardiac rehabilitation, able to ambulate 10 meters independently, with or without an assistive device, and be medically stable. Exclusion criteria included the following: acute or terminal illness, uncontrolled hypertension, uncontrolled metabolic disease, a bone fracture in the last 6 months, or neurological diseases that limit ability to ambulate or stand from a chair. Once enrolled in the study, gait speed, 5 STS, and hand grip strength were assessed over two sessions within the same day. The usual design of a reliability study is to allow multiple days to pass between data collection sessions. Because of the quantity of interventions provided in cardiac rehabilitation over a one week period combined with the progressive recovery process that takes place following a cardiac event, the investigators believed that a meaningful change in the measures may take place between sessions separated by a week. This could lead to a misrepresentation of the reliability and MDC for the physical performance measures. Because of this, both sessions were held on the same day with a rest period given between sessions.

To assess gait speed, participants walked across a straight, level 6-meter course at their comfortable speed with the time needed to traverse the middle 4 meters recorded with a standard stopwatch. Gait speed was measured twice with the fastest time used for analysis. Hand grip strength was assessed using a hand grip dynamometer with the handle at the second position. Strength was measured 3 times on each hand with the greatest value used for analysis. Finally, participants were asked to stand from a chair one time without using their arms. If participants were able to complete one time, they were then asked to stand up and sit down from a chair 5 times in a row as quickly as possible. The recording of time began on the command to start and ended at the completion of the 5th stand. After a 15 minute rest, gait speed, hand grip strength, and 5 STS were reassessed and the session was ended. Information about reason for participation in cardiac rehabilitation, medical history, surgical history, height, weight, and body mass index (BMI) were recorded from the participants' medical records and used during analysis. Both investigators participated in data collection with the same investigator

consistently measuring performance of both sessions for each participant. The investigators worked from a script during data collection and practiced the protocol prior to beginning the study to ensure consistency.

Independent sample t-test analysis was used to determine if there were significant differences between participants enrolled in phase II or III cardiac rehabilitation for age, BMI, and performance on the measures. Intraclass correlation coefficient (ICC) (2,1) was used to determine intrarater reliability. In order to determine MDC, standard error of the measurement, using the equation $SEM = \text{Standard Deviation} \times \sqrt{1 - ICC}$, was first calculated. Then MDC was determined at a 95% confidence interval (CI); $MDC_{95} = SEM \times 1.96 \times \sqrt{2}$.⁴⁰ The SEM was multiplied by 1.96 to provide a 95% CI and by the $\sqrt{2}$ to account for error introduced by using measures from two points in time.

RESULTS

In total 49 participants completed the study with no adverse outcomes. See Table 1 for descriptive data on the participants. There were no significant differences between those enrolled in Phase II and those in Phase III for age and BMI. Those in Phase III were more likely to be enrolled due to a coronary artery bypass graph (CABG) and those in Phase II because of a percutaneous coronary intervention (PCI). Table 2 lists the mean and standard deviation for the two trials, ICC, SEM, and MDC_{95} for gait speed, 5 STS, and hand grip strength. One participant was unable to complete

the full 5 STS during the second session and not included in the analysis for 5 STS. As listed in Table 2, all 3 measures showed high reliability. The ICC, SEM, and MDC_{95} were reasonable and similar to values found in community dwelling older adults and those recovering from a stroke or a hip fracture.^{28,41-46} Because of the high reliability of the measures, data from the first session was used to compare performance between participants enrolled in phase II and phase III cardiac rehabilitation (Table 3). A significant difference in gait speed and 5 STS was found, with those in phase III performing better than those in phase II.

DISCUSSION

In a representative sample of individuals enrolled in phase II and phase III cardiac rehabilitation, gait speed, 5 STS, and hand grip strength were shown to be reliable and responsive physical performance measures. Based on the ICC reported in Table 2, health care providers and researchers in cardiac rehabilitation programs should feel confident in the reproducibility of these 3 physical performance measures. The reported MDC_{95} values for gait speed, 5 STS, and hand grip strength can be very useful in cardiac rehabilitation. An increase or decrease in performance greater than MDC_{95} indicates a high likelihood of a meaningful change. Thus, these measures can be used to document real improvements in function through the course of cardiac rehabilitation. For example, if a patient enrolled in cardiac rehabilitation increases his

Table 1. Demographic Data

	All Participants (49)	Phase II (29)	Phase III (20)
Age	68.7 (8.8) years	67.2 (9.2) years	70.9 (7.8) years
BMI	30.0 (4.8) kg/m ²	30.7 (5.2) kg/m ²	29.0 (4.0) kg/m ²
Gender	Male = 29 (59.2%) Female = 20 (40.8%)	Male = 16 (55.2%) Female = 13 (44.8%)	Male = 13 (65.0%) Female = 7 (35.0%)
Reason for Cardiac Rehabilitation	PCI = 19 (38.8%) CABG = 16 (32.7%) MI = 7 (14.3%) Hypertension = 3 (6.1%) Valve Replacement = 2 (4.1%) Other = 2 (4.1%)	PCI = 16 (55.2%) CABG = 7 (24.1%) MI = 4 (13.8%) Valve Replacement = 1 (3.4%) Other = 1 (3.4%)	CABG = 9 (45.0%) PCI = 3 (15.0%) MI = 3 (15.0%) Hypertension = 3 (15.0%) Valve Replacement = 1 (5.0%) Other = 1 (5.0%)

BMI = body mass index, PCI = percutaneous coronary intervention, CABG = coronary artery bypass graph, MI = myocardial infarction
Mean (SD) for age and BMI
Number (percent of sample) for gender and reason for cardiac rehabilitation

Table 2. Mean, Standard Deviations, Reliability and Minimal Detectable Change Results

	Session 1 Mean (SD)	Session 2 Mean (SD)	ICC	SEM	MDC_{95}
Walking Speed (meters/second)	1.10 (0.27)	1.14 (0.29)	0.96	0.06	0.16
5 STS (seconds)	12.3 (3.12)	11.8 (2.92)	0.87	1.12	3.12
Right Hand Grip Strength (kilograms)	29.3 (10.8)	30.5 (11.1)	0.97	1.9	5.2
Left Hand Grip Strength (kilograms)	27.3 (11.1)	29.2 (11.4)	0.97	1.8	5.1

ICC = intraclass correlation coefficient, SEM = standard error of the measurement, MDC_{95} = 95% confidence interval for minimal detectable change, 5 STS = Five Time Sit to Stand Test

Table 3. Differences in Phase II and III Participants' Physical Performance Measures

	All Participants (49)	Phase II (29)	Phase III (20)
Walking Speed (meters/second)	1.10 (0.27)	1.00 (0.26)	1.23 (0.25)*
5 STS (seconds)	12.3 (3.12)	13.1 (3.2)	11.2 (2.7)*
Right Hand Grip Strength (kilograms)	29.3 (10.8)	28.1 (10.2)	31.1 (11.6)
Left Hand Grip Strength (kilograms)	27.3 (11.1)	25.6 (9.5)	29.7 (12.8)

*Significantly different from Phase II participants

gait speed from 0.85 m/s to 1.01 m/s, the physical therapist could feel confident that this is a meaningful change. The patient has improved his overall mobility and likely decreased his risk for a future adverse event. The MDC₉₅ can also help detect a true decline in function due to a recent change in medical status and health. If a patient returns for cardiac rehabilitation after a second myocardial infarction and his performance on the 5 STS increases from 10.0 seconds to 13.2 seconds, there should be concern about a decline in lower extremity muscle performance. This patient may benefit from a functionally based lower extremity strengthening program.

Results of this study have implications for physical therapists that work in cardiac rehabilitation or consult with cardiac rehabilitation programs. The results provide the justification of using these easy to perform and valuable measures in cardiac rehabilitation. Results of these measures can be used to guide individual care plans focused on function and mobility. While the number of physical therapists who routinely work in cardiac rehabilitation programs is small,⁴⁷ it is common for other health care providers in cardiac rehabilitation to ask physical therapists to consult on patients who present with mobility or balance problems. These physical performance measures could be used as a screening tool to determine if patients need therapy services to address mobility impairments or fall risk. In a recent report from the American Heart Association,⁴⁸ physical therapists were called upon to help identify individuals appropriate for cardiac rehabilitation and encourage referrals to cardiac rehabilitation. Gait speed, 5 STS, and hand grip strength could be part of the screening process that determines appropriateness for cardiac rehabilitation services.

The reliability and MDC for participants in this study are similar to published values for community dwelling older adults. Given that the average age of participants in this study was 69 years, this does not come as a surprise. However it is important that reliability and MDC were established specifically for patients in cardiac rehabilitation. Patients in cardiac rehabilitation are dealing with factors such as recent surgeries and hospitalizations, life threatening experiences, periods of inactivity, and new medications that may influence their mobility and physical performance. Data in this study may provide the support needed to encourage the use of these measures regularly in daily practice. Results of this study will also provide future

investigators with the justification they need to include these measures in their experimental design.

A previous study reported hand grip strength for 1960 patients enrolled in cardiac rehabilitation and found strong correlation to age, gender, and self-reported function.³⁹ The data presented in this paper complements this information by determining the MDC for hand grip strength. This will allow health care providers in cardiac rehabilitation to feel more confident when reassessing grip strength interpreting changes.

While a comparison of performance between participants in phase II and III was not a primary purpose of this study, the data presented in Table 3 provides some insight into different issues that may be present for patients in each phase. The participants in phase III showed better performance in gait speed and 5 STS. Possible explanations for this finding include those who are enrolled in phase III have benefited from long term structured exercise, they have a stronger commitment to their health, or individuals enrolled in phase III programs represent a sub-population of healthier individuals who are able to attend a phase III program. Other hypotheses include that those in phase II programs are still recovering from their cardiac event and have more factors limiting their mobility. While this is interesting data to compare, given the small sample in each group, no definitive conclusions should be drawn. More research with a specific intention to compare mobility between phase II and phase III patients should be considered.

There are limitations associated with this study. First, both sessions were completed on the same day. In some other reliability studies, investigators have allowed a week or more to pass between sessions. Because some of the participants in this study were only a couple of months after cardiac event, investigators were concerned that true change in mobility might take place over a one week period. Additionally while conducting both sessions on the same day is not the usual model, other investigators have used this experimental design out of similar concerns or as a matter of convenience.⁴⁹⁻⁵² It should also be pointed out that the ICC and MDC presented in this study are similar to values published for community dwelling older adults that separated sessions by multiple days. If this study's experimental design led to an inflation of ICC or MDC, one may expect a large difference between the results in this study and other published data, but this is not the case.

While this study assessed reliability and responsiveness, it did not address prognostic value of gait speed, 5 STS, and hand grip strength. It would be tempting to use published cut scores to predict fall risk and frailty from other populations when interpreting the performance of patients in cardiac rehabilitation. However future research will need to examine prognostic capabilities of these tools in cardiac rehabilitation.

Cardiac rehabilitation has been shown to reduce cardiac risk factors, improve aerobic capacity and strength, and decrease mortality.³ However, very few investigators have examined if deficits in function are present in this population^{38,53,54} and even fewer have studied if cardiac rehabilitation leads to meaningful improvements in physical performance measures. Future research should examine if cardiac rehabilitation improves function. Additionally future studies could examine if the addition of a functional based exercise program to cardiac rehabilitation leads to greater improvements in mobility or fall risk.

CONCLUSION

In summary, gait speed, 5 STS, and hand grip strength are reliable and responsive measures for patients in cardiac rehabilitation. This study provides data on responsiveness that can guide interpretation of changes in performance for patients in cardiac rehabilitation. Physical therapists and other health care providers in cardiac rehabilitation should feel confident in using these physical performance measures for patients enrolled in phase II and phase III programs. This study also provides the needed support for gait speed, 5 STS, and hand grip strength to be used in future cardiac rehabilitation studies.

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