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Short title: Timed up and go test in heart failure

Title: Timed up and go test: A reliable and valid test in patients with chronic heart failure.

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ABSTRACT

Background: The timed up and go test (TUGT) is a short-duration functional test, frequently used in rehabilitation settings as a measure of balance and mobility. Reliability and validity for patients with chronic heart failure (CHF) has yet to be determined. This prospective cohort study aimed to determine: test-retest reliability of the TUGT in patients with CHF; relationships between the TUGT and other variables including functional tests; and predictors of the TUGT.

Methods: Secondary analysis of data collected in a multicenter randomized controlled trial of exercise training in recently hospitalized patients with heart failure (EJECTION-HF). The TUGT was conducted twice at baseline to determine reliability. Assessments were compared to six minute walk distance (6MWD), 10m walk test time, and other clinical variables. Intra-class correlation coefficient (ICC) was used to determine test-retest reliability and correlations for relationships with other variables. A multiple regression was used to identify predictors of the TUGT.

Results: In 278 participants (mean age 62 years), the TUGT demonstrated excellent within-day test-retest reliability (ICC = 0.93). A shorter (better) TUGT time was associated with longer 6MWD ($r = -0.81$, $P < .001$) and shorter 10m walk test time ($r_s = 0.80$, $P < .001$). Best predictors of the TUGT were 6MWD and age, which accounted for 66% of the variance.

Conclusions: The TUGT appears to be a reliable and valid functional measurement in patients with CHF.

Key words: exercise test, functional capacity, cardiac failure, outcome assessment.

List of abbreviations:

Abbreviations	Details
AQoL-4D	Assessment of quality of life – 4 dimensions
CHF	Chronic heart failure
COPD	Chronic obstructive pulmonary disease
EJECTION-HF	Exercise joins education: combined therapy to improve outcomes in newly-discharged heart failure
ICC	Intra-class correlation coefficient
IQR	Inter-quartile range
MDC_{95}	Minimal detectable change at 95% confidence interval
NYHA	New York Heart Association functional classification
r, r_s	Pearson's correlation coefficient, Spearman's correlation coefficient
SEM	Standard error of measurement
TUGT	Timed up and go test
6MWD	Distance on the six minute walk test
6MWT	Six minute walk test

Highlights:

- The timed up and go test (TUGT) is a quick and easy-to-administer functional test.
- The TUGT demonstrated excellent test-retest reliability in patients with heart failure and was strongly associated with other functional exercise tests.
- Best predictors of the TUGT were age and 6-minute walk distance.
- The TUGT appears to be a reliable tool, and may be appropriate for evaluating effects of interventions such as heart failure exercise programs.

MANUSCRIPT – CLEAN VERSION

INTRODUCTION

Exercise is an effective intervention for people with chronic heart failure (CHF).[1] An outcome measure frequently used in heart failure exercise programs is the six minute walk test (6MWT), a sub-maximal measure of functional exercise capacity.[2] Although the 6MWT may be suitable for younger patients with fair exercise capacity, it may not be the best measure for some patients with CHF, as this patient group often have multiple co-morbidities, frailty[3] and tend to fall.[4] Additionally, as centre-based programs are inaccessible to many, approaches that can be administered in alternative environments including the home should be considered.

The timed up and go test (TUGT) is a functional test which may be suitable in the home-setting. This test assesses mobility and balance; requires minimal equipment; is quick and easy to administer;[5] and has been shown to be valid and reliable in the elderly[5,6] and other patient groups.[7,8]

The aims of this study were to: determine the test-retest reliability of the TUGT in patients with CHF; assess concurrent validity of the TUGT through comparison with other variables including the 6MWT and 10m walk test; and report the best predictors of the TUGT. We hypothesized that the TUGT would be reliable and valid in patients with CHF.

MATERIALS AND METHODS

Settings and participants: This investigation is a secondary analysis of baseline data

collected from participants enrolled in the *Exercise Joins Education: Combined Therapy to Improve Outcomes in Newly-discharged Heart Failure* (EJECTION-HF) trial, with methods reported in detail previously.[9] In brief, the study recruited patients from cardiology and general medical wards with CHF who had a recent hospital admission and were enrolled in a 12-week comprehensive heart failure disease management program including either twice-weekly supervised center-based exercise training (intervention), or recommendations for unsupervised home exercise (control). Participants were enrolled from five hospitals in south-east Queensland, Australia, from 2008-2013. The study was approved by hospital ethics committees and included in the Australian Clinical Trials Registry (ACTR12608000263392).

Outcome measurements: All tests were administered by a single trained independent assessor. The TUGT was measured using a standard stopwatch to record time taken to stand from a 45cm high chair with arm rests, walk 3m at a comfortable pace, turn 180 degrees, return to the starting point, and again sit.[5] The test was conducted using regular footwear and usual mobility aid, and performed twice (TUGT1 and TUGT2), with adequate rest time (until symptom resolution) between the two tests.

Participants performed the 6MWT in accordance with recommended guidelines[2] on a modified 25m walk track. The 6MWT was performed twice at baseline and the longest six minute walk distance (6MWD) was used in the analysis. The 10m walk test (at both comfortable and fast pace) was also undertaken on a straight walk track from a static start[10] in a subset of participants (n = 110). The time taken to walk 10m was recorded in seconds. Each test was measured twice, with the quicker of two tests recorded.

Quality of life was measured with the Assessment of Quality of Life (AQoL-4D). This validated generic utility measure encompasses four dimensions including independent living, relationships, senses and mental health.[11]

Demographic and clinical information were obtained from a patient interview and the medical record, and included the New York Heart Association (NYHA) functional classification; self-reported falls in the previous 12 months; and left ventricular ejection fraction reported from echocardiography performed in the previous six months.

Data analysis: Statistical analysis was performed using SPSS Statistics 22 (SPSS Inc., Chicago, IL). Baseline data for all participants contributed to the analysis. Data were checked for missing values, distribution and outliers. The TUGT data was logarithmically transformed to achieve normality.

Test-retest reliability was examined using the intra-class correlation coefficient (ICC), two-way mixed effects model with single measures and absolute agreement. The strength of reliability was interpreted where excellent was > 0.9. Standard error of measurement (SEM) and minimal detectable change at 95% confidence interval (MDC_{95}) were calculated on the transformed data, using previously described formulas.[12] A Bland and Altman's plot was presented to visually examine the trends and agreements between the two tests.[13]

Relationships between the TUGT and other continuous variables were examined using scatter plots, and Pearson's (r) or Spearman's (r_s) correlations as appropriate. Mann-Whitney's test was used to determine differences in dichotomous variables.

A stepwise multiple linear regression was undertaken to investigate best predictors of the TUGT (with transformation) from variables including the 6MWD; 10m walk test at comfortable and fast paces; age; gender; left ventricular ejection fraction; disease severity on the NYHA; falls; and AQoL. $P < .05$ was considered to be significant.

RESULTS

The study included 278 participants (Figure 1). Participant characteristics are summarized in Table 1.

TUGT reliability

Test-retest reliability of the TUGT in patients with CHF was excellent (ICC = 0.93, $P < .001$) at baseline. Mean TUGT1 time was slower than TUGT2, with a back-transformed mean difference (95% CI) of 1.04 (1.03-1.06) seconds ($P < .001$). The SEM and MDC_{95} values on the transformed data were 0.04 and 0.11 seconds respectively. The Bland-Altman plot shows the mean difference in the TUGT between the two tests (Figure 2).

Relationship between the TUGT and other variables

As illustrated in Figure 2, the TUGT was associated with functional tests in patients with CHF. A shorter (faster) time on the TUGT was associated with longer 6MWD ($r = -0.81$, $P < .001$); and shorter time on the 10m walk tests at both comfortable ($r_s =$

0.80, P < .001) and fast paces (r_s = 0.88, P < .001).

A faster TUGT was also weakly associated with better quality of life (r_s = -0.31, P < .001); younger age (r_s = 0.44, P < .001); lower NYHA class (r_s = 0.45, P < .001), and no falls history (median 8.62 seconds [inter-quartile range 3.64] vs 10.38 [7.53], P < .001).

The best predictors of the TUGT in multivariate modeling were 6MWD and age, with $F_{(2, 247)}$ of 243, P < .001 and R^2 of 0.66. The model equation for the transformed best TUGT was 1.258 − (0.001×6MWD) + (0.001×age).

DISCUSSION

This study demonstrates that the TUGT was both reliable and valid in patients recently discharged from hospital with CHF, with excellent test-retest reliability when the test was performed on the same day and strong association with other functional exercise tests (6MWD and 10m walk test). Slower TUGT time was associated with poorer quality of life, older age, worsening disease severity and recent falls history. The best predictors of the TUGT were 6MWD and age, accounting for 66% of the variance.

The median TUGT time of 8.9 seconds reported in our study is similar to the mean TUGT time of 9.4 seconds reported in individuals over the age of 60 years.[14] Reliability of the TUGT seen in our study is consistent with other studies.[6,7] Despite excellent reliability, we found a learning effect of this test, similar to previous findings in the cardiac rehabilitation setting.[8] These results support the practice of

performing two tests and using the best performance in the analysis.[7,8]

The TUGT may be an appropriate functional test to use across hospital clinics, community settings and during home visits for patients with CHF. It may be particularly relevant to patients with CHF, as this group of patients often have frailty[3] and falls.[4] The strong concurrent validity with the 6MWD suggests that it may be a useful measure of response to exercise in settings where the 6MWT is not practical. The advantage of the TUGT is that it requires only a small amount of space, making it suitable within home and clinic environments with space constraints. The TUGT reflects important daily physical functions, such as the ability to rise from a chair and walk around the house, and predicts development of disability in older people.[15] Given many patients with CHF are elderly and frail,[3] practical measures such as the TUGT may provide useful information about an individual's function and measure changes in performance.

Study strengths and limitations

The current study has strengths, including single assessor; consistent method; multiple sites; and a large spread of age and disease severity which may increase generalizability of the study results. Limitations include that this was a selected study population, and hence may not apply to all patients with CHF. The 10m walk test was only undertaken in 110 participants, which limited the correlation analysis. The current study demonstrated excellent test-retest reliability and concurrent validity of the TUGT in patients with CHF, but further research is required to determine predictive validity and the minimal clinically important difference for the TUGT.

CONCLUSION

This study showed that the TUGT had excellent within-day test-retest reliability and was strongly correlated with other functional tests in this group of patients. TUGT time was slower with poorer quality of life, older age, worsening disease severity and fallers. The TUGT appears to be a reliable tool, and may prove a practical outcome measure for patients with CHF.

CONTRIBUTIONS OF AUTHORS

RH conceived and designed the study and drafted the manuscript. All authors were consulted on the study design, edited and approved the manuscript. AMudge, JS and JA contributed and cleaned the data.

DECLARATION OF CONFLICTING INTERESTS:

The authors declare that there was no conflict of interest.

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Table 1. Baseline characteristics

Characteristics	**Total (n = 278)**
Age (years), mean (SD)	62.4 (13.9)
Men, n (%)	207 (75)
BMI (kg/m^2), mean (SD)	31 (8)
Ethnicity, n (%)	
Caucasian	229 (82)
Aboriginal and Torres Strait Islanders	41 (15)
Other	8 (3)
Etiology, n (%)	
Ischemic cardiomyopathy	109 (39)
Valvular	13 (5)
Hypertensive	50 (18)
Idiopathic dilated cardiomyopathy	70 (25)
Other	36 (13)
Heart failure with preserved ejection fraction, n (%)	39 (14)
LVEF (%), mean (SD)	31 (14)
Cardiac devices including pacemakers, implantable cardiac defibrillators and cardiac resynchronization therapy devices (%)	52 (19)
Co-morbidities, n (%)	
Atrial arrhythmia in past 5 years	114 (41)
Diabetes mellitus	101 (36)
Asthma	44 (16)

COPD	31 (11)
Cerebrovascular disease or transient ischemic attack	28 (10)
Medications, n (%)	
ACE-I or ARB	254 (91)
B-Blockers	261 (94)
Furosemide	226 (81)
NYHA, n (%)	
I	53 (19)
II	147 (53)
III	47 (17)
IV	31 (11)
Walking aid, n (%)	
None	237 (85)
Stick	25 (9)
4 wheeled walker	14 (5)
Other walking aids	2 (1)
Experienced at least one fall in last 12 months, n (%)	39 (14)
Functional capacity	
Best 6MWD (m), mean (SD)	363 (120)
Best TUGT (seconds), median (IQR)	8.9 (3.9)
Best 10m comfortable walk (seconds), median (IQR)	8.53 (3.02)
Best 10m fast walk (seconds), median (IQR)	6.56 (2.36)
AQoL-4D utility score	0.57 (0.27)

Abbreviations: ACE-I, angiotensin-converting enzyme inhibitor; ARB, angiotensin receptor blocker; AQoL-4D, Assessment of Quality of Life – 4 dimensions; B-

blockers, beta-blockers; BMI, body mass index; COPD, chronic obstructive pulmonary disease; DBP, diastolic blood pressure; HR, heart rate; IQR, inter-quartile range; kg, kilogram; LVEF, left ventricular ejection fraction; n, number; NYHA, New York Heart Association scale; SBP, systolic blood pressure; SD, standard deviation; TUGT, timed up and go test; 6MWD, six minute walk test distance.

Figure 1. Study flowchart

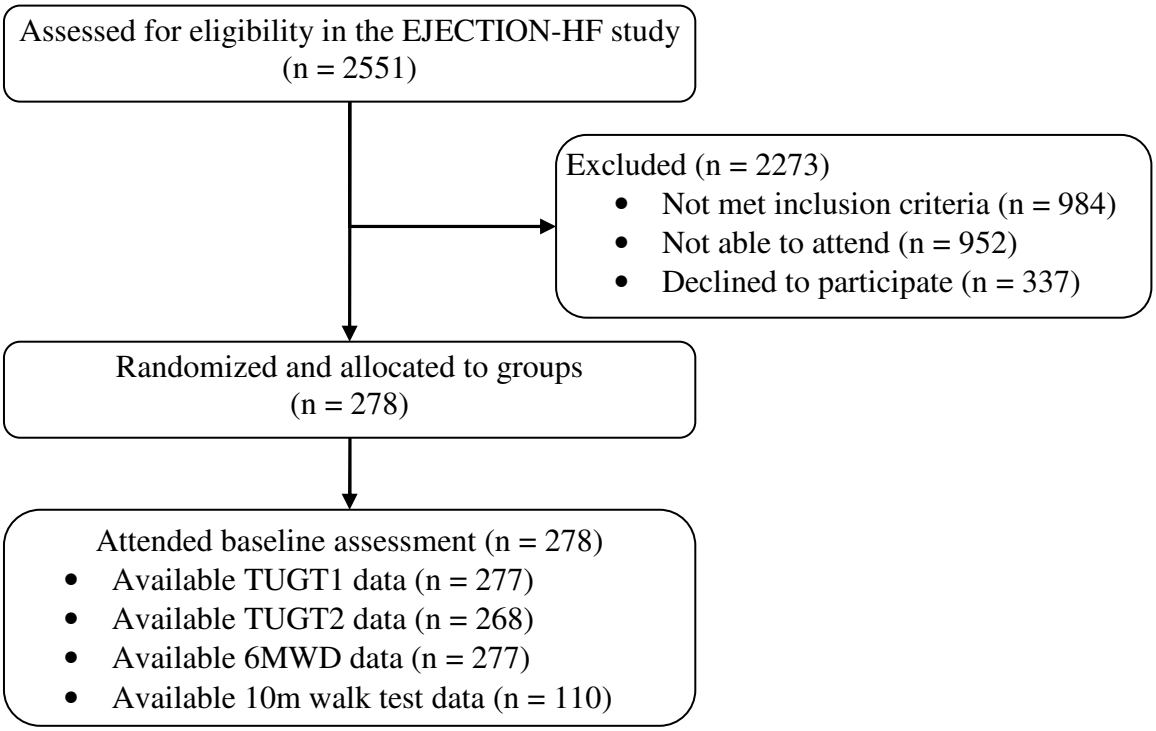
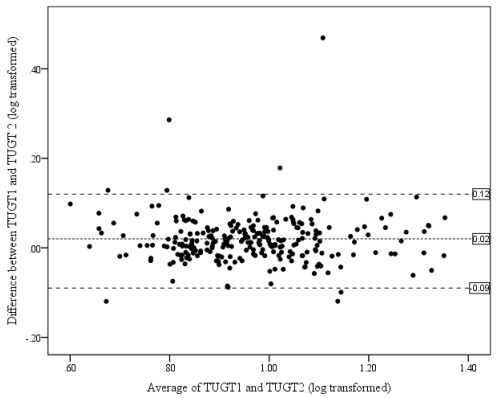
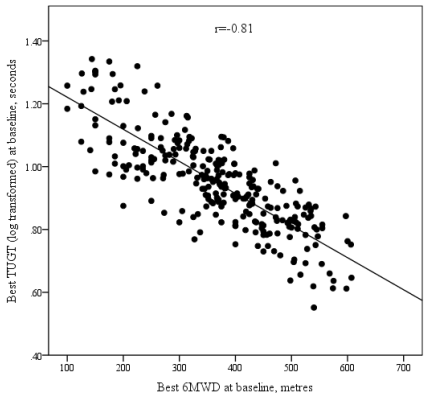


Figure 2. Bland and Altman plot of the TUGT; and relationship with other variables

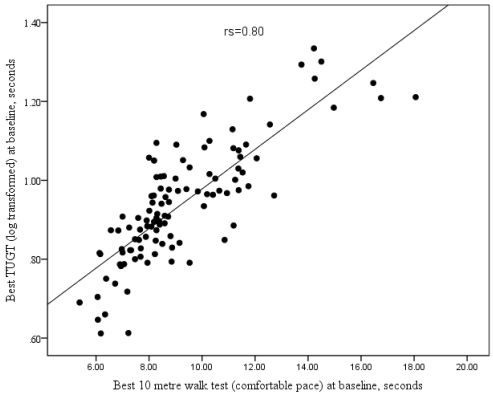
Bland and Altman plot of the difference against the mean of first and second TUGT (with transformation)



Relationship between the TUGT and 6MWD



Relationship between the TUGT and 10m walk test (comfortable pace)



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