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Test-retest reliability and validity of the timed up and go test and 30-second sit to stand test in patients with pulmonary hypertension☆

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ABSTRACT

Background: Timed up and go (TUG) and sit to stand (STS) tests that required less space and easier to be performed in respiratory and cardiac diseases for assessing functionality. Aim was to test the reliability of TUG and 30-second STS (30STS) tests and determine the validity of TUG and 30STS tests in patients with Pulmonary Hypertension (PH).

Methods: Thirty-eight patients with diagnosed PH were included. We collected TUG, 30STS, quadriceps muscle strength, physical activity level, and 6MWT. Intra-class correlation coefficient (ICC) was used to determine test-retest reliability and correlations with quadriceps muscle strength, physical activity level and 6MWT for validity of the TUG and 30STS tests.

Results: The TUG and 30STS tests were associated with age, functional class, muscle strength, physical activity and functional exercise capacity in patients with PAH ($p < 0.05$). 6MWT was associated with age, functional class, muscle strength, physical activity and functional exercise capacity ($p < 0.05$). ICC (95%) for TUG test and 30STS were 0.96 (0.93–0.98) and 0.95 (0.90–0.97), respectively.

Conclusions: The TUG and 30STS tests were reliable and valid tests for measuring physical performance in PH. This study supports using the TUG and 30STS tests as practical assessment tools in patients with PH.

1. Introduction

Pulmonary hypertension (PH) is a disease that increases in mean pulmonary artery pressure ≥ 25 mmHg which measures with right heart catheterization [1]. Patients with PH present impairments in muscle strength, exercise capacity, and balance [2–4]. Outcome measurements are an important component of pulmonary and cardiac rehabilitation programs [5]. Six-Minute Walk Test (6MWT) is one of the most common tests for measuring exercise capacity in PH [6]. Because of comorbidities in PH and needing for a long corridor and more time for performing 6MWT that it may not be suitable using 6MWT for all times [7]. Besides, a study showed that 16% of patients attending cardiac rehabilitation were unable to complete a duplicate 6MWT [8]. Therefore, alternative tests may be useful for daily clinical practice for measuring physical performance.

Besides the 6MWT, other tests such as timed up and go (TUG) and sit to stand (STS) requiring less space and time and easier to be performed in home settings have been shown to use in patients with chronic obstructive pulmonary disease (COPD) and heart failure (HF) for assessing to functionality and lower extremity capacity of the patients [9–14]. Bisca et al. has been showed that TUG and STS tests can be used to evaluate lower limbs' functional capacity and they can be well tolerated by patients in COPD in clinical practice [9]. Also, it was reported that the TUG test is a reliable outcome measure in cardiac rehabilitation, and it is providing similar relative changes after rehabilitation [15].

As the 6MWT involves a similar amount of exercise during activities of daily living, it can directly reflect the exercise abilities of patients while carrying out activities of daily living [16]. However, considering the significant impact of PH on patients' physical capacity, patients are commonly withdrawal from such long activities of daily living and even relative easy activities such as short walking and sit to stand could be affected. Therefore, the TUG and STS tests can be more relevant to the activities of daily living, especially with the progression of the disease. In addition, there is novel evidence that patients with cardiopulmonary disease can have impaired balance [4] and the TUG and STS tests are also commonly using to assess balance and fall risk [17]. In recent years, the TUG and STS tests have been started to be used

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commonly as outcome measures in the cardiopulmonary rehabilitation [9–15]. On the other hand, the psychometric properties of these tests in PH have not been investigated yet. Therefore, the aim of this study was to investigate the psychometric properties (including test-retest reliability, convergent validity, and know-groups validity) of the TUG and 30-second STS (30STS) tests in patients with PH.

2. Method

Thirty-eight patients with a diagnosis of PH from the PH Outpatient Clinic in the Department of Cardiology, Dokuz Eylül University Hospital were recruited to the study. Written informed consent was obtained from all participants in accordance with the Declaration of Helsinki. The study was approved by the Noninvasive Research Ethics Board of Dokuz Eylül University (Protocol No: 3326-GOA). Pulmonary hypertension was defined by right-sided heart catheterization as an increase in mean pulmonary arterial pressure of ≥25 mmHg at rest. Patients were eligible if they were 18 years older above, clinically stable, and able to walk independently. Patients with orthopedic disease which may affect tests, acute cor pulmonale, left heart failure or severe ischemic heart disease were not included in the study.

For a test-retest reliability study, when alpha and power are fixed at 0.05 and 80% respectively, a minimum sample size of 22 is sufficient to detect the value of 0.50 for the intraclass correlation coefficient (ICC) [18]. With an additional 20% of a possible drop-out rate, the sample size was calculated as 28 participants.

Demographic, physical, and physiologic characteristics (age, height, weight, body mass index, PH classification, New York Heart Association classification, and pulmonary arterial pressure) of the patients with PAH were recorded. Comorbid conditions were gathered from the medical records of the patients. The seven most common comorbid conditions in patients with PAH (hypertension, clinical depression, type 2 diabetes mellitus, obesity, COPD, sleep apnea, and thyroid disease) were recorded [7].

2.1. Outcome measurements

The TUG was performed from a standard chair (height = 43 cm) according to the instructions [19]. Participants were stand up from the chair, walked 3 m at a comfortable pace, turn and walk back to the starting point, and sit down again [19]. Participants wore their regular footwear. The ordinary stopwatches were used for recording test time in seconds. The time was started with “go” word and stopped when the participant sat down. The test time was used as the main outcome of the analysis.

The 30STS was applied according to the protocol described by Gill and McBurney [20]. The test was administered using a chair (height = 43 cm) without arms. Participants were asked to rise from a seated position and sit as quickly and safely as possible in 30 s. The completed number of chair stands within 30 s is counted and recorded for this test. Arms are crossed at the wrists and held against the chest. Feet placed on the floor at an angle slightly back from the knees. The participant started with “go” word and rose to a full stand and then returned to the initial seated position. The participants were encouraged to complete as many full stands as possible within a 30-second time limit.

Knee extensor muscle strength was evaluated bilaterally using a digital dynamometer (Manual Muscle Tester™, Lafayette Instrument Company, Lafayette, Indiana) [21]. The test was performed with participants sitting in a chair with an assistant helping to stabilize. Each knee extensor muscle group was tested 3 times, and the highest value was recorded.

The standard 6MWT protocol recommended by the American Thoracic Society guideline was used. 30-m straight indoor track was used to perform test [22]. Participants were allowed to stop and rest if needed.

International Physical Activity Questionnaire Short Form (IPAQ-SF) was used to determine physical activity level [23,24]. It is a 7-item questionnaire which asks the frequency and duration of many activities doing in during the previous 7 days. Moderate activities, vigorous activities, and walking scores were calculated as durations multiplied by known metabolic equivalents (MET) per activity.

2.2. Protocol

After the demographic data and IPAQ-SF were collected, and the muscle strength assessment was conducted. First, the 6MWT was performed. After a resting period of 3 h, patients were performed the TUG and 30STS tests. Adequate resting period was provided between the TUG and 30STS. To examine the test-retest reliability, the patients were performed the TUG and 30STS tests again after a resting period of 1 h. Before each performance-based test, level of tiredness and dyspnea were determined according to the Borg scale, and heart rate was recorded to ensure that the patients were stable. All tests were administered by a single physiotherapist.

2.3. Statistical analysis

The statistical analysis was performed using IBM SPSS software (Version 25.0, IBM Corp., Armonk, NY). Descriptive statistics were used to describe patients' demographic characteristics and assessment results. Continuous variables were expressed by mean (standard deviation), while categorical variables were reported as number (%). The Shapiro-Wilk test and investigation of histogram graphics were used for the determination of the normal distribution.

The test-retest reliability was assessed using the ICC using the two-way random effects and absolute agreement methods [25]. The data measured by one rater across two trials for the TUG and 30STS were used to assess the test-retest reliability. The strength of reliability was interpreted as excellent when >0.9. Measurement variability was investigated by calculating the standard error of measurement (SEM) and corresponding 95% Confidence Interval (CI). The smallest real difference (SRD) (i.e., $1.96 \times SEM \times \sqrt{2}$) was used to determine whether the change score of an individual patient was real at the 95% confidence level [26]. The SRD percentage can be used because the SRD percentage is independent of the units of measurement. Acceptable SRD was settled as the SRD percentage < 30% of the mean score [27]. Construct validity was assessed in terms of convergent and known-groups validity. To assess the convergent validity of the TUG and 30STS, we hypothesized that there would be moderate to strong correlations between these tests and age, NHYA classes, knee extensor strength, IPAQ-SF, and 6MWT. Correlations between the variables were examined using Pearson's correlation coefficients. A correlation coefficient > 0.5 was considered to be a strong correlation, 0.3 to 0.5 to be a moderate correlation, and 0.2 to 0.3 to be a weak correlation [28]. For investigating known-groups validity, the comparison of the TUG and 30STS test scores between the patients with NYHA Class II and III were conducted using the Mann-Whitney *U* test. We hypothesized that the patients with NYHA Class II would have better test scores compared to those with Class III. Statistical significance was defined at $p < 0.05$.

3. Results

Thirty-eight patients with PH participated and completed the tests in the study. The characteristics of the patients are summarized in Table 1. The majority of patients New York Heart Association class II (n = 22) and all subjects performed the TUG test without using any gait aid. Some patients had comorbid conditions not associated with PH including hypertension (39.5%), type 2 diabetes mellitus (13.2%), obesity (21.1%), sleep apnea (13.2%), and thyroid disease (10.5%).

In this study, TUG and 30STS tests showed excellent reliability. ICC values for the TUG and 30STS tests were 0.96 and 0.95, respectively.

Table 1
Characteristics of the participants with pulmonary hypertension (n = 38).

Variables	Mean ± SD
Age (years)	50.26 ± 18.03
Gender, n (%)	
Female	31 (81.6)
Male	7 (18.4)
Body mass index (kg/m^2)	25.53 ± 5.32
NYHA classification, n (%)	
Class II	22 (57.9)
Class III	16 (42.1)
mPAP (mmHg)	62.91 ± 23.64
Cardiac index (L/dk/m^2)	2.82 ± 1.17
BNP level (pg/ml)	436.36 ± 835.71
Clinical classification of pulmonary hypertension, n (%)	
PAH	36 (94.7)
CTEPH	2 (5.3)
Muscle strength of right knee extensors (kg)	14.14 ± 6.19
6MWD (m)	372.76 ± 121.57
IPAQ-SF	303.81 ± 377.40

SD, standard deviation; NYHA, New York Heart Association; mPAP, mean pulmonary arterial pressure; BNP, brain natriuretic peptide; PAH, pulmonary arterial hypertension; CTEPH, chronic thromboembolic pulmonary hypertension; 6MWD, six-minute walk distance; IPAQ-SF, International Physical Activity Questionnaire Short Form.

Table 3
Correlations between the TUG and 30STS tests with other study variables.

		Age	NYHA	Knee extensor muscle strength	IPAQ-SF	6MWD
TUG	r	0.533	0.480	−0.384	−0.343	−0.776
	p	0.001	0.002	0.017	0.038	<0.001
30STS	r	−0.612	−0.455	0.544	0.376	0.660
	p	<0.001	0.004	<0.001	0.022	<0.001
6MWD	r	−0.402	−0.635	0.490	0.537	–
	p	0.012	<0.001	0.002	0.001	

All correlations are statistically significant.
TUG, timed up and go; 30STS, 30-second sit to stand; NYHA, New York Heart Association; 6MWD, six-minute walk distance; IPAQ-SF, International Physical Activity Questionnaire-Short Form.

The SRD95 was 1.82 for the TUG test. The SRD95 was 2.31 for 30STS. The reliability results of the tests were shown in Table 2.

As showed in Table 3, the TUG and 30STS tests were significantly correlated with age, functional class, muscle strength, physical activity and functional exercise capacity in patients with PAH ($p < 0.05$). The TUG test score was strongly correlated with the 6MWT ($r = -0.77$, $p < 0.001$) and age ($r = 0.533$, $p = 0.001$), moderately correlated with knee extensor muscle strength ($r = 0.384$, $p = 0.017$), IPAQ-SF ($r = 0.343$, $p = 0.038$), and NYHA class ($r = 0.480$, $p = 0.002$). The 30STS test score was strongly correlated with the 6MWT ($r = -0.660$, $p < 0.001$), knee extensor strength ($r = 0.544$, $p < 0.001$), and age ($r = -0.612$, $p < 0.001$), moderately correlated with IPAQ-SF ($r = 0.376$, $p = 0.022$) and NYHA class ($r = -0.455$, $p = 0.004$).

6MWT was strongly correlated with NYHA class ($r = -0.635$, $p = 0.002$) and IPAQ-SF ($r = 0.537$, $p = 0.001$), and moderately correlated with age ($r = 0.402$, $p = 0.012$) and knee extensor muscle strength ($r = 0.490$, $p = 0.002$). The patients with NYHA Class II had significantly lower TUG score and higher 30STS score compared to those with Class III ($p < 0.05$) (Table 4).

4. Discussion

This study showed that the TUG and 30STS tests were reliable, simple and valid measures to assess physical performance in patients with PH with excellent test-retest reliability when the tests were performed on the same day. The results also showed that the TUG and 30STS tests had low standard error and SRD95 (percentage). In addition, faster TUG time and higher 30STS test number time were associated with better disease severity and exercise capacity, younger age, higher knee extensor muscle strength, and physical activity. The TUG and 30STS tests also had know-group validity.

The mean TUG test time was shown as 9.64 s in this study which is lower than the median test time of 8.9 s reported in patients with heart failure and COPD [10,13], but these results were lower than the reported as an abnormal test time (11 s) in COPD [11]. We showed a strong correlation between TUG test time and 6MWD which is consistent with other studies [11,13]. 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. Besides 6MWD, we showed a correlation between TUG test time and knee extensor muscle strength and physical activity for validity as similar to the first research [29]. The reliability of the TUG test has been reported in people with and without comorbid conditions [12,13,15,30]. Mesquita et al. found that within-day test-retest reliability of the TUG test is reliable in patients with advanced COPD, HF, and chronic renal failure for both the total sample and subgroups, with ICC values ranging from 0.85 to 0.98 [12]. They also have been shown that the TUG test as a valid test for the assessment of functional performance in COPD, and TUG was responsive to pulmonary rehabilitation [11]. Excellent within-day test-retest reliability (ICC = 0.93) has been reported for the TUG test in patients with chronic HF [13]. We found excellent within-day test-retest reliability (ICC = 0.96) in this study. The reliability of the TUG test seen in this study was consistent with other studies. The TUG test is requiring a small amount of space as an advantage, and so it could be suitable to use this test within home and clinic environments and hospital clinics with space constraints.

The mean 30STS score was 12.23 times in this study which is similar in a study that reported score 13 times [31] and higher than the mean score of 8.9 times [32] reported in patients with COPD. Although patients with COPD older than our patients, these results were thought that lower knee extensor muscle strength in our patients may affect the 30sec-STS score, and because of that, there was no difference between scores. A strong correlation between 30STS score and 6MWD was reported in this study. We also showed correlation between 30STS score and knee extensor muscle strength and physical activity for validity which was similar to the other study that they found a correlation between 30STS score and with lower limb strength in older adults with COPD [32]. Zanini et al. also found a significant relationship between 30STS and 6MWD and peripheral muscle performance of lower limbs and suggested the 30STS test as a valid and reliable tool to assess peripheral muscle performance of lower limbs in patients with COPD [31]. They showed that 30STS test had a better relationship with one-repetition maximum strength than 1-minute STS test. These results support the using 30STS test for functionality and lower extremity capacity assessment. We found an excellent 30STS test within-day test-retest reliability (ICC = 0.95) in this study, similar to other studies

Table 2
The test results and test-retest reliability of the TUG and 30STS tests in patients with PAH.

	First trial Mean ± SD	Second trial Mean ± SD	Difference Mean ± SD	ICC (95% CI)	SEM	SRD95 (percentage)
TUG (seconds)	9.64 ± 3.58	9.32 ± 3.19	0.32 ± 0.84	0.96 (0.93–0.98)	0.71	2.05 (21)
30STS (number)	12.23 ± 3.77	12.07 ± 3.87	0.15 ± 1.19	0.95 (0.90–0.97)	0.84	2.32 (18)

TUG, timed up and go; 30STS, 30-second sit to stand; CI, confidence interval; SRD, smallest real difference.

Table 4
Comparison of the TUG and 30STS test scores between the patients with NYHA Class II and III.

	Patients with NYHA Class II (n = 22)	Patients with NYHA Class III (n = 16)	p
TUG (seconds)	8.20 (2.93)	11.64 (3.53)	<0.001*
30STS (number)	13.68 (3.34)	10.25 (3.49)	0.004*

TUG, timed up and go; 30STS, 30-s sit to stand.
Values are reported as mean (standard deviation).
NYHA, New York Heart Association; TUG, timed up and go; STS, sit to stand.
* Statistically significant difference.

[31,33]. Also, Jones et al. showed a good test-retest intraclass correlation and a highly significant correlation between chair-stand and one-repetition maximum strength leg-press performance in older adults [33]. Both two tests may be performed to evaluate functionality and lower extremity capacity in patients with PAH, but they cannot be used to prescribe an exercise training program. So, clinicians should think carefully about what they need to measure and then decide which test is the most appropriate.

There are some limitations of this study. First, all patients had NYHA Class II and III and were from a single university hospital center. Therefore, our results cannot be generalized to all patients with pulmonary hypertension. Second, we only investigated the test-retest reliability, concurrent validity, and known-group validity. Further research is required to determine the minimal clinically important difference for these tests. Future studies should also investigate the predicting values of these tests in survival which is an important issue in this population. Third, since it was not one of the aims of this study, our sample size was inadequate to calculate a cut-off value for the tests. Future larger studies should also be conducted to determine cut-off values specific to this population. Last, it is known that some comorbid conditions can influence the administration of the 6MWT as a long test. Although the TUG and 30STS tests are shorter, such comorbid conditions might also effect of their administration. Therefore, future studies aiming to investigate the effects of comorbid conditions on these tests are highly warranted.

5. Conclusion

The TUG and 30STS tests are reliable, valid, simple, and practical outcome measure tests to assess physical performance in patients with PH. Also, TUG and 30STS tests were associated with age, disease severity, physical activity, and exercise capacity. This study supports using the TUG and 30STS tests as practical assessment tools in patients with PH.

CRediT authorship contribution statement

Buse Ozcan Kahraman: Conceptualization, Writing - original draft, Data curation, Formal analysis, Writing - review & editing.**Ismail Ozsoy:**Conceptualization, Formal analysis, Writing - review & editing. **Bahri Akdeniz:**Formal analysis, Resources, Writing - review & editing. **Ebru Ozpelit:**Formal analysis, Resources, Writing - review & editing. **Can Sevinc:**Formal analysis, Resources, Writing - review & editing. **Serap Acar:**Formal analysis, Writing - review & editing.**Sema Savci:**Conceptualization, Writing - original draft, Project administration, Writing - review & editing.

Declaration of competing interest

None.

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