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Sit-to-Stand Test: A Practical Tool for Evaluating Exercise Capacity in Children with Chronic Respiratory Disease

Otur-Kalk Testi: Kronik Solunum Hastalığı Olan Çocuklarda Egzersiz Kapasitesini Değerlendirmek için Pratik Bir Araç

Meltem KAYA [1] **Hikmet UCGUN** [1] **Aysenur TEMİZEL TOMBUL** [1]
Erkan CAKİR [2] **Hilal DENİZOGLU KULLİ** [1]

[1] *PT PhD., Department of Physiotherapy and Rehabilitation, Faculty of Health Sciences, Istanbul Atlas University, Istanbul,*

[2] *MD., Division of Pediatric Pulmonology, Faculty of Medicine, Istinye University, Istanbul,*

Sorumlu yazar / Corresponding author

Meltem KAYA

meltem_rmglu@hotmail.com

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ABSTRACT

Aim: *Chronic respiratory disease (CRD) is frequently associated with a reduced exercise capacity. Exercise capacity is routinely assessed through six-minute walk test (6MWT), but the sit-to-stand test (STST) is commonly explored as an alternative test method in various conditions. The present study aimed to investigate the correlation between the 6MWT and the 1-minute STST (1min-STST) and 30-second STST (30s-STST) in children with CRD.*

Material and Method: *A total of 159 children (mean age: 11.74 ± 3.41 years) with CRD (asthma, primary ciliary dyskinesia, cystic fibrosis, Kartagener's Syndrome, and postinfectious bronchiectasis) were included in the study. All participants performed 1min-STST, 30s-STST, and 6MWT. Test results and cardiorespiratory responses to tests were recorded.*

Results: *6MWT was strongly correlated with the 1min-STST and 30s-STST (r=0.769, r=0.758, respectively) (p<0.001). Levels of dyspnea and fatigue after the 1min-STST and 30s-STST were significant but weakly correlated with levels of dyspnea and fatigue after the 6MWT (dyspnea r=0.245, r=0.248, respectively; fatigue r=0.239, r=0.241, respectively) (p<0.05). There were statistically significant differences among the tests regarding cardiorespiratory responses (p<0.05). There were statistically significant differences among the disease groups in terms of 6MWT, 30s-STST, and 1min-STST (p=0.028, p=0.038, and p=0.035, respectively) (p<0.05).*

Conclusion: *30s-STST and 1min-STST may serve as practical, efficient, and time-saving alternatives for assessing exercise capacity in children with CRD.*

Keywords*: Chronic respiratory disease, Children, exercise capacity, Six-minute walk test, Sit-to-stand test*

ÖZET

Amaç: *Kronik solunum hastalığı, azalmış egzersiz kapasitesi ile sıklıkla ilişkilendirilmektedir. Egzersiz kapasitesi genellikle altı dakika yürüme testi (6DYT) ile değerlendirilir, ancak otur-kalk testi (OKT), çeşitli durumlarda alternatif bir test yöntemi olarak araştırılmaktadır. Bu çalışmada, kronik solunum hastalığı olan çocuklarda 6DYT ile 1 dakika OKT (1dk-OKT) ve 30 saniye OKT (30sn-OKT) arasındaki korelasyonunun araştırması amaçlandı.*

Gereç ve Yöntem*: Çalışmaya kronik solunum hastalığı olan (astım, primer siliyer diskinezi, kistik fibrozis, Kartagener Sendromu ve post-enfeksiyöz bronşektazi) 159 çocuk (ortalama yaş: 11.74 ± 3.41 yıl) dahil edildi. Tüm katılımcılara 1dk-OKT, 30sn-OKT ve 6DYT uygulandı. Test sonuçları ve testlere verilen kardiyorespiratuar yanıtlar kaydedildi.*

Bulgular: *6DYT mesafesi ile 1dk-OKT ve 30sn-OKT arasında güçlü bir korelasyon saptandı (sırasıyla r=0.769, r=0.758; p<0.001). 1dk-OKT ve 30sn-OKT sonrası ölçülen dispne ve yorgunluk seviyeleri, istatistiksel olarak anlamlı olmakla birlikte, 6DYT sonrası dispne ve yorgunluk seviyeleri ile zayıf bir korelasyon gösterdi. (dispne r=0.245 ve r=0.248; yorgunluk r=0.239 ve r=0.241; p<0.05). Kardiyorespiratuar yanıtlar açısından testler arasında istatistiksel olarak anlamlı fark tespit edildi (p<0.05). Hastalık grupları arasında 6DYT, 30sn-OKT ve 1dk-OKT sonuçları açısından istatistiksel olarak anlamlı farklılık saptandı (sırasıyla p = 0.028, p = 0.038 ve p = 0.035; p<0.05).*

Sonuç: *30sn-OKT ve 1dk-OKT, kronik solunum hastalığı olan çocuklarda egzersiz kapasitesini değerlendirmek için geçerli, etkili ve zaman tasarrufu sağlayan alternatif yöntemlerdir.*

Anahtar kelimeler: *Kronik solunum hastalığı, Çocuklar, egzersiz kapasitesi, Altı dakika yürüme testi, Otur-kalk testi*

INTRODUCTION

Chronic diseases are a major global public health issue and are encompassed as a long-term condition that persistently affects overall health. Respiratory diseases are one of the primary categories of chronic diseases with a high burden of morbidity and mortality affecting children and adolescents (Grover & Joshi, 2015; Soriano et al., 2020). Chronic respiratory diseases (CRDs) in children refer to a group of diseases that affect the lung and respiratory system including cystic fibrosis (CF), bronchiectasis (BE), asthma, chronic neonatal lung disease, and interstitial lung diseases (Zar & Ferkol, 2014).

Purulent sputum expectoration, cough, and dyspnea are the most common symptoms, though children may also exhibit non-specific respiratory symptoms such as fatigue, chest pain, and reduced exercise capacity (Bar-Yoseph et al., 2019; Cakmak et al., 2020). Potential mechanisms contributing to the decline in exercise capacity in CRD include altered ventilatory and respiratory mechanics, gas exchange impairments, peripheral and respiratory muscle dysfunction, the effects of medications, and physical inactivity, among others (Vogiatzis & Zakynthinos, 2012). As resting physiological evaluation methods like pulmonary function test (PFT), pulmonary diffusion capacity, or high-resolution computed tomography scans may not accurately predict exercise capacity in individuals with CRD, incorporating exercise capacity assessments into managing CRD is strongly recommended (Chetta & Olivieri, 2009). Thus, since exercise testing is an important part of pulmonary rehabilitation programs, several laboratory-based and field-based tests reflecting maximal and sub-maximal exercise capacity are currently used for these patients (Chetta & Olivieri, 2009; Pasteur, Bilton, & Hill, 2010).

The 6-minute walk test (6MWT) is commonly used to provide information regarding sub-maximal exercise capacity, response to rehabilitation, and prognosis for a range of cardiopulmonary diseases (Rasekaba, Lee, Naughton, Williams, & Holland, 2009). Moreover, since most daily activities are performed at submaximal levels of exertion, it has been proposed that sub-maximal tests are a superior indicator of physical capability compared to laboratory-based tests (de Groot & Takken, 2011). The 6MWT not only requires adequate space and time to perform but is also sensitive to changes in test conditions, such as verbal instructions or supplemental oxygen (Singh et al., 2014).

Numerous studies have indicated that the sit-to-stand test (STST) is a time-efficient and easily applicable alternative to assess exercise capacity in various pulmonary conditions, such as chronic obstructive pulmonary disease (COPD) (Vaidya, Chambellan, & De Bisschop, 2017), adults with CF (Radtke, Puhan, Hebestreit, & Kriemler, 2016), lung transplantation (Kohlbrenner, Benden, & Radtke, 2020), and post COVID-19 (Nunez-Cortes et al., 2021). Although the STS movement is often performed in daily living activities and is thought to measure lower limb strength both 6MWT, and STST are self-paced and elicit submaximal effort (Reychler et al., 2018). The strong convergent validity of the STST with key outcomes like maximal and submaximal exercise capacity and measures of patient well-being may explain why it is proposed as an alternative to the 6MWT in the literature (Gruet, Peyré-Tartaruga, Mely, & Vallier, 2016). Most studies utilize the 30-second STST (30s-STST) or the 1-minute STST (1min-STST), both of which have demonstrated significant correlations with the 6MWT (Vaidya et al., 2017). However, the research to date has tended to focus on adult patients. To the best of our knowledge, one study has demonstrated that the STST is a valid and alternative method for evaluating exercise capacity in children with BE. (Zeren, Gurses, Kulli, Ucgun, & Cakir, 2020).

To date, the STST has not been compared to the 6MWT in the heterogeneous CRD population in children with different clinical presentations and progression. The present study aimed to examine the correlation between the 6MWT and both the 1min-STST and the 30s-STST in children with CRD.

MATERIALS AND METHODS

Research Type

A prospective and observational study was conducted.

Study Population and Sample

A total of 164 patients, aged 6 to 17 years, with CRD, were included in the study. These patients were referred from a university hospital and comprised the following groups: asthma (n=42), primary ciliary dyskinesia (PCD, n=28),

Kartagener syndrome (KS, n=23), cystic fibrosis (CF, n=32), and postinfectious bronchiectasis (BE, n=39). The participants' inclusion criteria were as follows: a clinical diagnosis of asthma, BE or CF, being the ages of 6 and 17 years, able to understand spoken language, and willing to participate in the study. The participants were excluded if they had any mental, or physical disability or cardiac abnormalities that could perform the tests or had an acute exacerbation in the last 4 weeks or a history or candidate for lung transplantation.

The sample size was calculated using the G*Power 3.1 software (University of Düsseldorf, Germany). Reported correlation coefficients for the relationship between STST and 6MWT in COPD patients vary between 0.470 and 0.750, indicating a moderate to strong correlation (Vaidya et al., 2017). Based on this, we hypothesized that a significant correlation between STST and 6MWT would be observed, with a correlation coefficient of at least 0.590 (moderate) in children with CRD. To confirm this with 95% confidence and 95% statistical power, the required sample size was determined to be 110 participants.

Study Design

Each participant performed 30s-STST, 1min-STST, and 6MWT on the same day with the same assessor. The sequence of tests (30s-STST, 1min-STST, and 6MWT) was randomized using a computer-generated random number list (www.randomizer.org), and the assessor conducting the analysis was blinded to the test order. At least a 30-minute rest period was provided between tests to prevent muscle fatigue.

Data Collection Tools

The demographic characteristics of the participants were recorded. The information regarding gender, age, height, weight, the age at diagnosis, and the presence of chronic disease were collected.

Pulmonary Function: Pulmonary function tests (PFT) were conducted using a spirometer (COSMED Pony FX) by the guidelines set by the American Thoracic Society (ATS) and European Respiratory Society (ERS) (Miller et al., 2005). The PFT parameters, expressed as percentages of the predicted values, included forced vital capacity (FVC), forced expiratory volume in one second (FEV1), the FEV1/FVC ratio, and peak expiratory flow (PEF).

Sit-to-stand Test: The STST was performed using a standard chair 46 cm in height without armrests. The chair was positioned against a wall to minimize movement during the test. Participants were instructed to sit on a chair, position themselves so their feet were flat on the floor, and cross their arms over their chest. They were then asked to stand up fully, ensuring their legs were completely straight, and return to a seated position until their bottom made clear contact with the chair. This motion was repeated as quickly as possible for 30 seconds during the 30s-STST and for 60 seconds during the 1min-STST. Standardized instruction without encouragement was used during the tests. A demonstration test was previously performed. The number of completed STS repetitions in 30 and 60 seconds was recorded (Morita et al., 2018).

Six-minute Walk Test: The 6MWT was conducted following the ATS guidelines ("ATS statement: guidelines for the six-minute walk test," 2002) in a 30-meter corridor. Participants were instructed to rest for at least 5 minutes on a chair before the test. All participants received pre-test instructions, and during the test, verbal encouragement with standardized phrases was provided every minute, along with updates on the remaining time. Participants were permitted to rest during the test but were encouraged to walk as fast as possible at their own walking pace without running. The total distance walked within six minutes was measured in meters.

Cardiorespiratory Responses: Heart rate (HR), pulse oxygen saturation (SpO2), level of dyspnea, and fatigue were measured and recorded both before and immediately after each test. HR and SpO2 were continuously monitored during the tests using a pulse oximeter. Participants were asked to rate their level of dyspnea, and fatigue using the Modified Borg Scale (Borg, 1982).

Ethical Considerations

This study was approved by the Ethics Committee of Istanbul Atlas University (Date: 23.12.2024 and Approval Number: 10/08) and conducted in accordance with the principles outlined in the Helsinki Declaration. Written informed consent was obtained from both the children and their parents or legal guardians before participation.

Data Analysis

Data were analyzed using the statistical software package IBM SPSS v.26 (SPSS Inc., USA). Descriptive analysis was conducted for

demographic and PFT parameters, as well as for the results of the best tests. Data were reported as mean ± standard deviation or as median with interquartile range, based on the normality of the distribution. The Kolmogorov-Smirnov test was used to assess data normality. For between-group comparisons, one-way analysis of variance (ANOVA) was applied to normally distributed variables, while Kruskal-Wallis tests were used for non-normally distributed variables. Pearson's correlation analysis was conducted to examine the relationships between performance in the 6MWT, 30s-STST, 1min-STST, and other cardiorespiratory responses. Correlation coefficients (r) were classified as follows: 0–0.19 (very weak), 0.20–0.39 (weak), 0.40–0.59 (moderate), 0.60–0.79 (strong), and 0.80–1.0 (very strong) (Cohen, 1992). The statistical significance was accepted as p<0,05 for all analyses.

RESULTS

A total of 164 patients (mean age: 11.74 ± 3.41 years) with CRD (asthma n=40, PCD n=28, KS n=21, CF n=31, and postinfectious BE n=39) were assessed for eligibility. Five patients were excluded from the study either because they did not meet the inclusion criteria or chose not to participate (Figure 1). The demographics and clinical characteristics of the participants are shown in Table 1. All groups had similar characteristics regarding demographic and clinical characteristics except for age at diagnosis (Table1).

The correlation of 6MWT with 1min-STST and 30s-STST is shown in Table 2. 6MWT distance was strongly correlated with the 1min-STST and 30s-STST in children with CRD (r=0.769, r=0.758, respectively) (p<0.001). Levels of dyspnea and fatigue after the 1min-STST and 30s-STST were significant but weakly correlated with levels of dyspnea and fatigue after the 6MWT in children with CRD (dyspnea r=0.245, r=0.248, respectively; fatigue r=0.239, r=0.241, respectively) (p<0.05).

Comparison of cardiorespiratory responses of 6MWT, 1min-STST, and 30s-STST are shown in Table 3. There were statistically significant differences among the tests regarding heart rate, oxygen saturation, dyspnea, and fatigue (p<0.05).

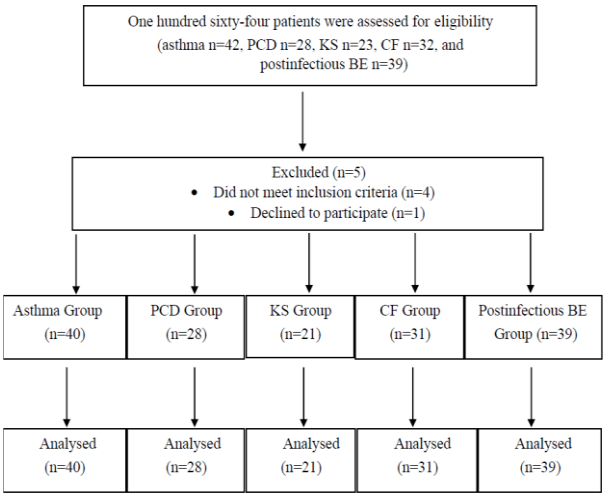

Figure 1: Flow diagram of study design.

Abbreviations: BE: bronchiectasis, CF: cystic fibrosis, KS: Kartagener's Syndrome; PCD: primary ciliary dyskinesia.

Table 1. The Demographic and Clinical Characteristics of the Patients

	Asthma (n=40)	PCD (n=28)	KS (n=21)	CF (n=31)	Postinfectious BE (n=39)	p
Age (years)	13.4 ± 2.4	12.5 ± 3.1	12.4 ± 2.60	11.8 ± 2.22	11.7 ± 3.01	0.242
Gender (n; %)						
Girl	16 (40%)	13 (46.4%)	9 (42.8%)	17 (54.8%)	19 (48.7%)	
Boy	24 (60%)	15 (53.5%)	12 (57.1%)	14 (45.1%)	20 (51.2%)	0.806
BMI (kg/m^2)	18.2 ± 4.2	18.6 ± 2.62	19.0 ± 4.5	17.9 ± 3.1	18.4 ± 3.4	0.452
Age at diagnosis (month)	92.8 ± 24.5	60.1 ± 22.5	58.8 ± 14.3	4.5 ± 2.3	85.8 ± 40.7	<0.001*
Pulmonary Function Test						
FVC (pred%)	93.2 ± 16.4	90.2 ± 16.7	89.2 ± 15.8	88.2 ± 18.6	92 ± 13.8	0.393
FEV_1 (pred%)	90.5 ± 12.4	87.35 ± 16.4	87.35 ± 16.4	84.1 ± 15.7	84.9 ± 16.2	0.245
FEV_1/FVC (%)	91.8 ± 14.7	87.2 ± 12.2	89.2 ± 13.4	88.6 ± 15.5	88 ± 14.8	0.380
PEF (pred%)	87.1 ± 15.9	82.9 ± 15.5	85.9 ± 16.5	84.9 ± 13.5	86.2 ± 15.4	0.268

Note: Data are presented as mean ± SD or n; %.
Abbreviations: BE: bronchiectasis, BMI: body mass index, CF: cystic fibrosis, FEV1: forced expiratory volume in 1s; FVC: forced vital capacity; KS: Kartagener's Syndrome, PCD: primary ciliary dyskinesia; PEF: peak expiratory flow; pred: predicted.
*:p<0.05.

Table 2. Correlation of 6MWT with 1min-STST and 30s-STST in Children with CRD

	6MWT (m)	
Variables	**r**	**p**
1min-STST repetitions (n)	0.769	<0.001*
30s-STST repetitions (n)	0.758	<0.001*
6MWT level of dyspnea		
1min-STST level of dyspnea	0.245	0.039*
30s-STST level of dyspnea	0.248	0.031*
6MWT level of fatigue		
1min-STST level of fatigue	0.239	0.042*
30s-STST level of fatigue	0.241	0.040*

Abbreviations: 6MWT: 6-minute walk test, 1min-STST: 1-minute sit-to-stand test, 30s-STST: 30-seconds sit-to-stand test. *:p<0.05.

Table 3. Comparison of Cardiorespiratory Responses of 6MWT, 1min-STST, and 30s-STST

	6MWT	1min-STST	30s-STST	p
Δ Heart rate (beats/min)	45.3 ± 10.2	29.3 ± 8.4	17.6 ± 9.5	<0.001*
Δ Oxygen saturation	-3 ± 1.4	-1 ± 1.1	-0.95 ± 0.8	<0.001*
Δ Level of dyspnea	4.1 ± 2.4	2 ± 1.8	1.4 ± 0.9	0.025*
Δ Level of fatigue	5.2 ± 2.1	2.2 ± 1.3	1.9 ± 0.8	<0.001*

Abbreviations: min: minute; 6MWT: 6-minute walk test, 1min-STST: 1-minute sit-to-stand test, 30s-STST: 30-seconds sit-to-stand. *:p<0.05.

The correlation of 6MWT between 1min-STST and 30s-STST in different disease groups is presented in Table 4. The 1min-STST and 30s-STST were strongly correlated with 6MWT in children with asthma (r=0.637, r=0.601 respectively) and PCD (r=0.682, r=0.680, respectively); and very strongly correlated with 6MWT in children with KS (r=0.823, r=0.811, respectively), CF (r=0.865, r=0.847, respectively), and postinfectious BE (r=0.851, r=0.828, respectively) (p<0.001).

Results of 6MWT, 1min-STST, and 30s-STST in different disease groups are shown in Table 5. Statistically significant differences were observed among the groups in terms of 6MWT distance, repetitions of 30s-STST, and 1min-STST (p=0.028, p=0.038, and p =0.035, respectively). The post-hoc analysis revealed that the asthma group consistently demonstrated statistically higher performance in all test results compared to the other groups.

Table 4. Correlation of 6MWT with 1min-STST and 30s-STST in Different Disease Groups

	6MWT distance (m)	
	r	**p**
Asthma (n=40)		
1min-STST repetitions (n)	0.637	<0.001*
30s-STST repetitions (n)	0.601	<0.001*
PCD (n=28)		
1min-STST repetitions (n)	0.682	<0.001*
30s-STST repetitions (n)	0.680	<0.001*
KS (n=21)		
1min-STST repetitions (n)	0.823	<0.001*
30s-STST repetitions (n)	0.811	<0.001*
CF (n=31)		
1min-STST repetitions (n)	0.865	<0.001*
30s-STST repetitions (n)	0.847	<0.001*
Postinfectious BE (n=39)		
1min-STST repetitions (n)	0.851	<0.001*
30s-STST repetitions (n)	0.828	<0.001*

Table 5. Comparison of Test Results of 6MWT, 1min-STST, and 30s-STST in Different Disease Groups

	Asthma (n=40)	PCD (n=28)	KS (n=21)	CF (n=31)	Postinfectious BE (n=39)	p
6MWT distance (m)	596.4 ± 52.3	568 ± 42.1	574.1 ± 78.9	538 ± 59.1	572.8 ± 52.4	0.028*
1min-STST repetitions (n)	46.2 ± 9.5	41.7 ± 5.1	42.0 ± 3.4	38.0 ± 3.4	41.9 ± 4.6	0.035*
30s-STST repetitions (n)	26.5 ± 3.5	20.6 ± 5.2	21.5 ± 4.7	19.2 ± 5.4	20.7 ± 4.9	0.038*

Abbreviations: BE: bronchiectasis, CF: cystic fibrosis, KS: Kartagener's Syndrome, m: meter; PCD: primary ciliary dyskinesia; 6MWT: 6-minute walk test, 1min-STST: 1-minute sit-to-stand test, 30s-STST: 30-seconds sit-to-stand. *:p<0.05.

DISCUSSION

The present study demonstrates that a significant relationship was observed between the 6MWT with the 30s-STST and 1min-STST in children with CRD, supporting the convergent validity of the STST as an alternative measure of exercise capacity in this population. Levels of dyspnea and fatigue after the 1min-STST and 30s-STST were weakly correlated with levels of dyspnea and fatigue after the 6MWT. The 1min-STST and 30s-STST elicited lower HR, oxygen saturation, dyspnea, and fatigue responses than the 6MWT. These findings indicate that the STST could be a safer alternative for assessing exercise capacity in children with CRD due to its cardiorespiratory responses. Furthermore, when the relationship between the tests was analyzed separately within each disease group, a significant and strong association was also present.

Field-based tests were developed as alternatives to estimate maximal oxygen consumption, which continues to be the gold standard for determining exercise capacity (Takken, Bongers, Van Brussel, Haapala, & Hulzebos, 2017). The 6MWT, the most used test in clinical settings, is reliable for assessing exercise capacity. There is increasing evidence supporting its application in healthy populations and various diseases (de Groot & Takken, 2011; Li et al., 2005; Rasekaba et al., 2009). However, despite its established utility, the 6MWT has several limitations that can restrict its feasibility and applicability in certain clinical and research settings. Several researchers have highlighted that the 6MWT non-standardized tracks with varying lengths influence the number of turns, and the absence of strict environmental controls may result in inaccurate outcomes (Beekman et al., 2013; Ng, Yu, To, Chung, & Cheung, 2013). Furthermore, the 6MWT can be physically demanding for patients with severe mobility issues or those who experience significant dyspnea during walking. These factors make the test less suitable for individuals with advanced disease stages or functional limitations. Additionally, the time and space required for the test can pose logistical challenges, particularly in outpatient settings and pediatric populations (Zeren et al., 2020). Alternative and timal tests, such as the STST, have emerged to overcome some of the barriers to participation in pulmonary rehabilitation and as well as the limitations imposed by the proposed requirements for 6MWT in various clinical settings, particularly in the rapidly expanding novel telehealth services (Milner, Boruff, Beaurepaire, Ahmed, & Janaudis-Ferreira, 2018; Vaidya et al., 2017).

The STSTs have been revealed as a practical and reliable alternative to the 6MWT for evaluating exercise capacity in adult populations, particularly those with CRD such as COPD (Vaidya et al., 2017). Numerous studies have demonstrated significant correlations between STSTs and 6MWT in adults, emphasizing their validity. For instance, the 1min-STST has shown strong correlations with 6MWT distance in COPD patients, with correlation coefficients ranging from r=0.590 to r=0.670 depending on the timing of the assessment during rehabilitation programs (Crook et al., 2017). Similarly, the 30s-STST has been validated in COPD populations, demonstrating a moderate correlation with the 6MWT distance (r=0.466) (Zhang et al., 2018). In contrast, while the use of STSTs in adults is well-documented, their application in pediatric populations, especially those with CRD, remains relatively underexplored. Some recent studies have been presented to evaluate the utility of STSTs in children. For example, in children with BE, the 30s-STST demonstrated a strong correlation with the 6MWT (r=0.718), suggesting its potential as an alternative tool for assessing functional capacity (Zeren et al., 2020). Similarly, in children and adolescents with CF, the 1min-STST exhibited a moderate correlation with the 6MWT distance (r=0.480) (Combret et al., 2021). In healthy children, the STST has also been explored as a quick and reliable method for assessing exercise capacity. A study conducted by Gurses et al. also reported a significant correlation between the 30s-STST and the 6MWT in healthy young adults, with a correlation coefficient of 0.611 as well (Gurses, Zeren, Kulli, & Durgut, 2018). Our study further corroborates the role of STSTs as an alternative to the 6MWT in pediatric populations. Specifically, we found that 6MWT distance was strongly correlated with the 1min-STST (r=0.769) and 30s-STST (r=0.758) in children with CRD. Furthermore, another important finding was that when we analyzed different CRD groups separately in children, we also detected a strong correlation between the STSTs and 6MWT. These findings indicate that STSTs, which are simpler, less time-consuming, and require minimal equipment, can serve as effective tools for assessing exercise capacity in children with CRD, particularly in settings where conducting the 6MWT is not feasible. Besides,

the combination of data from children with CRD, individuals with COPD, and healthy children indicates that the relationship between the STSTs and 6MWT is not dependent age of the individual or the presence of an underlying disease.

Although the STSTs and 6MWT may effectively assess exercise capacity, our findings indicated statistically significant differences between the tests in terms of cardiopulmonary responses, such as heart rate, oxygen saturation, dyspnea level, and fatigue. Specifically, the 6MWT elicited more pronounced changes in these parameters compared to the STSTs, which is consistent with previous research highlighting the different physiological demands of these tests. Several studies have explored the cardiopulmonary responses to these tests. Crook et al. demonstrated that the 1min-STST produced lower peak HR and oxygen consumption compared to the 6MWT in patients with COPD, indicating that the STST imposes a lower cardiovascular load (Crook et al., 2017). Similarly, another study demonstrated that the 6MWT evokes greater changes in dyspnea, HR, and oxygen saturation in patients with COPD than the STST (Ozalevli, Ozden, Itil, & Akkoclu, 2007). In a study conducted by Meriem et al., it was demonstrated that the 6MWT resulted in a greater degree of desaturation than STST. This was attributed to the continuous walking effort required in the 6MWT (Meriem et al., 2015). Zeren et al. reported that the 6MWT resulted in greater increases in HR and dyspnea levels compared to the 30s-STST in children with BE, reflecting the higher intensity and endurance demands of the 6MWT (Zeren et al., 2020). The highest cardiorespiratory responses could be speculated due to the longer duration of the 6MWT. In contrast to earlier findings, Aguilaniu et al. demonstrated that the three-minute sit-to-stand test (3min-STST) produced cardiorespiratory responses comparable to those of the 6MWT in patients with COPD (Aguilaniu et al., 2014). However, it was observed that fatigue levels were significantly higher after the 3min-STST compared to the 6MWT. This finding may be attributed to the fact that extending the duration of the STST to align with the cardiorespiratory demands of the 6MWT might not be suitable, as leg fatigue and the nature of the movement could hinder performance and compromise its reliability in evaluating exercise capacity. Nevertheless, considering all STSTs had lower cardiorespiratory responses than the 6MWT, it can be conjectured that the STSTs may be used as a safer method to assess exercise capacity in children with CRD as well.

The STST was initially developed as a practical and time-efficient method to assess lower limb muscle strength, functional mobility, and endurance (Csuka, 1993). Over time, different protocols, including the 5-repetition sit-to-stand test (5STS), 30s-STST, and 1min-STST have been introduced to evaluate exercise capacity across various clinical populations. Among these, researchers have sought to identify the most effective protocol, particularly for CRD such as COPD, to better reflect aerobic capacity, functional endurance, and exercise performance (Morita et al., 2018). The present study investigated the correlation between the 6MWT and the 1min-STST and, the 30s-STST in children with CRD. Our findings demonstrated that while both protocols yielded statistically significant results, the 1min-STST consistently exhibited stronger correlation coefficients. This suggests that the prolonged duration of the 1min-STST imposes greater hemodynamic and aerobic demands, making it better suited to assess real-life physical performance and endurance. The literature indicates that shorter versions of the STST, such as the 5-repetition and 10-second primarily rely on anaerobic metabolism, making them more suitable for assessing muscle strength and speed. However, as the duration of the test increases, aerobic metabolism begins to play a larger role, shifting the focus toward exercise tolerance (Vaidya et al., 2017). Previous studies support this assumption, demonstrating stronger correlations for the 1min-STST with exercise capacity and clinical outcomes compared to shorter protocols. For instance, Morita et al. compared the 5STS, 1min-STST and, the 30s-STST in patients with COPD (Morita et al., 2018). They reported that the 1min-STST showed significant correlations with key measures, including the 6MWT ($r = 0.47$). The correlation was notably higher compared to shorter tests, highlighting the 1min-STST stronger association with exercise capacity. Similarly, Crook et al. validated the 1min-STST in COPD patients and reported strong correlations with the 6MWT ($r = 0.59$) at admission and ($r= 0.67$) at discharge (Crook et al., 2017). These findings underscore the robustness of the 1min-STST as a measure of exercise capacity, like the widely used 6MWT. Further supporting this, Gephine et al. demonstrated that the 1min-STST elicited cardiorespiratory stress comparable to a cycling

cardiopulmonary exercise test (CPET), with peak VO2 values reaching 113% of CPET values (Gephine et al., 2020). The study also reported correlations between the 1min-STST and quadriceps muscle fatigue and longer recovery times, emphasizing the 1min-STST as a clinically relevant tool for assessing exercise capacity. Additionally, Vaidya et al. noted that longer STST protocols, such as the 1min-STST, showed stronger correlations with aerobic capacity and functional exercise measures compared to shorter tests. Specifically, the 1min-STST demonstrated correlations with the 6MWT (r = 0.64–0.68), highlighting its ability to better capture exercise capacity and overall functional status (Vaidya et al., 2017). In summary, while both the 1-min STST and 30-s STST are effective for assessing exercise capacity in children with CRD, the choice of test should be based on the patient's condition, physical capacity, and assessment goals to ensure optimal evaluation and management.

Finally, a number of important limitations need to be considered. Firstly, although numerous studies have shown that STST performance is dependent on lower limb strength (Bisca, Morita, Hernandes, Probst, & Pitta, 2015), we were unable to measure peripheral muscle strength. Furthermore, the literature indicates that reduced physical activity is common both in children and adults with CRD and is an important determinant of exercise capacity (Vaes et al., 2024). We did not gather any data on physical activity levels using either objective or subjective methods. Although it is widely recognized that chair height can influence STS performance, this study did not ensure that participants were seated with precisely 90° of hip and knee flexion. However, we standardized the chair height at 46 cm by using the same chair for all participants, consistent with the approach adopted in most previous studies (Csuka, 1993; Morita et al., 2018).

CONCLUSIONS

A significant relationship was observed between the 6MWT with the 30s-STST and 1min-STST in children with CRD. Furthermore, the 30s-STST and 1min-STST impose a lower cardiorespiratory burden compared to the 6MWT, indicating that both tests are relatively safer than the 6MWT. In conclusion, the 30s-STST and 1min-STST may serve as practical, efficient, and time-saving alternatives for assessing exercise capacity in children with CRD.

Ethics Committe Approval

The study was approved by the Ethics Committee İstanbul Atlas University (Date: 23.12.2024 and Approval Number: 10/08)

Author Contributions

Idea/Concept: M.K., H.U., E.C., H.D.K.; Design: M.K., H.U., A.T.T., H.D.K.; Supervision/Consulting: E.C., H.D.K.; Analysis and/or Interpretation: M.K., H.U.; Literature Search: M.K., A.T.T.; Writing the Article: M.K., H.U.; Critical Review: E.C., H.D.K.

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Conflict of Interest

The authors have no conflict of interest to declare.

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REFERENCES

Aguilaniu, B., Roth, H., Gonzalez-Bermejo, J., Jondot, M., Maitre, J., Denis, F., & Similowski, T. (2014). A simple semipaced 3-minute chair rise test for routine exercise tolerance testing in COPD. *International journal of chronic obstructive pulmonary disease*, 1009-1019.

ATS statement: guidelines for the six-minute walk test. (2002). *Am J Respir Crit Care Med, 166*(1), 111-117. doi:10.1164/ajrccm.166.1.at1102

Bar-Yoseph, R., Ilivitzki, A., Cooper, D. M., Gur, M., Mainzer, G., Hakim, F., . . . Zucker-Toledano, M. (2019). Exercise capacity in patients with cystic fibrosis vs. non-cystic fibrosis bronchiectasis. *PloS one, 14*(6), e0217491.

Beekman, E., Mesters, I., Hendriks, E. J., Klaassen, M. P., Gosselink, R., van Schayck, O. C., & de Bie, R. A. (2013). Course length of 30 metres versus 10 metres has a significant influence on six-minute walk distance in patients with COPD: an experimental crossover study. *J Physiother, 59*(3), 169-176. doi:10.1016/s1836-9553(13)70181-4

Bisca, G. W., Morita, A. A., Hernandes, N. A., Probst, V. S., & Pitta, F. (2015). Simple lower limb functional tests in patients with chronic obstructive pulmonary disease: a systematic review. *Archives of physical medicine and rehabilitation, 96*(12), 2221-2230.

Borg, G. A. (1982). Psychophysical bases of perceived exertion. *Medicine and science in sports and exercise, 14*(5), 377-381.

Cakmak, A., Inal-Ince, D., Sonbahar-Ulu, H., Bozdemir-Ozel, C., Ozalp, O., Calik-Kutukcu,

E., . . . Selcuk, Z. T. (2020). Physical activity of patients with bronchiectasis compared with healthy counterparts: A cross-sectional study. *Heart & Lung, 49*(1), 99-104.

Chetta, A., & Olivieri, D. (2009). The Clinical Relevance of Exercise Capacity Assessment in Respiratory Diseases: Introduction. *Respiration, 77*(1), 2-2. doi:10.1159/000178797

Cohen, J. (1992). A power primer. *Psychol Bull, 112*(1), 155-159. doi:10.1037//0033-2909.112.1.155

Combret, Y., Boujibar, F., Gennari, C., Medrinal, C., Sicinski, S., Bonnevie, T., . . . Le Roux, P. (2021). Measurement properties of the one-minute sit-to-stand test in children and adolescents with cystic fibrosis: a multicenter randomized cross-over trial. *PloS one, 16*(2), e0246781.

Crook, S., Büsching, G., Schultz, K., Lehbert, N., Jelusic, D., Keusch, S., . . . Frey, M. (2017). A multicentre validation of the 1-min sit-to-stand test in patients with COPD. *European Respiratory Journal, 49*(3).

Csuka, M. (1993). Simple method for measurement of lower extremity muscle strength. *Am J Med, 78*, 21-27.

de Groot, J. F., & Takken, T. (2011). The six-minute walk test in paediatric populations. *J Physiother, 57*(2), 128. doi:10.1016/s1836-9553(11)70026-1

Gephine, S., Bergeron, S., PF, T. L., Mucci, P., Saey, D., & Maltais, F. (2020). Cardiorespiratory Response during the 1-min Sit-to-Stand Test in Chronic Obstructive Pulmonary Disease. *Medicine and science in sports and exercise, 52*(7), 1441-1448.

Grover, A., & Joshi, A. (2015). An overview of chronic disease models: a systematic literature review. *Global journal of health science, 7*(2), 210.

Gruet, M., Peyré-Tartaruga, L. A., Mely, L., & Vallier, J.-M. (2016). The 1-minute sit-to-stand test in adults with cystic fibrosis: correlations with cardiopulmonary exercise test, 6-minute walk test, and quadriceps strength. *Respiratory care, 61*(12), 1620-1628.

Gurses, H. N., Zeren, M., Kulli, H. D., & Durgut, E. (2018). The relationship of sit-to-stand tests with 6-minute walk test in healthy young adults. *Medicine, 97*(1), e9489.

Kohlbrenner, D., Benden, C., & Radtke, T. (2020). The 1-minute sit-to-stand test in lung transplant candidates: an alternative to the 6-minute walk test. *Respiratory care, 65*(4), 437-443.

Li, A. M., Yin, J., Yu, C., Tsang, T., So, H., Wong, E., . . . Sung, R. (2005). The six-minute walk test in healthy children: reliability and validity. *European Respiratory Journal, 25*(6), 1057-1060.

Meriem, M., Cherif, J., Toujani, S., Ouahchi, Y., Hmida, A. B., & Beji, M. (2015). Sit-to-stand test and 6-min walking test correlation in patients with chronic obstructive pulmonary disease. *Annals of thoracic medicine, 10*(4), 269-273.

Miller, M. R., Hankinson, J., Brusasco, V., Burgos, F., Casaburi, R., Coates, A., . . . Wanger, J. (2005). Standardisation of spirometry. *Eur Respir J, 26*(2), 319-338. doi:10.1183/09031936.05.00034805

Milner, S. C., Boruff, J. T., Beaurepaire, C., Ahmed, S., & Janaudis-Ferreira, T. (2018). Rate of, and barriers and enablers to, pulmonary rehabilitation referral in COPD: a systematic scoping review. *Respiratory medicine, 137*, 103-114.

Morita, A. A., Bisca, G. W., Machado, F. V., Hernandes, N. A., Pitta, F., & Probst, V. S. (2018). Best protocol for the sit-to-stand test in subjects with COPD. *Respiratory care, 63*(8), 1040-1049.

Ng, S. S., Yu, P. C., To, F. P., Chung, J. S., & Cheung, T. H. (2013). Effect of walkway length and turning direction on the distance covered in the 6-minute walk test among adults over 50 years of age: a cross-sectional study. *Physiotherapy, 99*(1), 63-70. doi:10.1016/j.physio.2011.11.005

Nunez-Cortes, R., Rivera-Lillo, G., Arias-Campoverde, M., Soto-Garcia, D., Garcia-Palomera, R., & Torres-Castro, R. (2021). Use of sit-to-stand test to assess the physical capacity and exertional desaturation in patients post COVID-19. *Chronic respiratory disease, 18*, 1479973121999205.

Ozalevli, S., Ozden, A., Itil, O., & Akkoclu, A. (2007). Comparison of the Sit-to-Stand Test with 6 min walk test in patients with chronic obstructive pulmonary disease. *Respiratory medicine, 101*(2), 286-293.

Pasteur, M. C., Bilton, D., & Hill, A. T. (2010). British thoracic Society guideline for non-CFbronchiectasis. *Thorax, 65*(Suppl 1), i1-i58.

Radtke, T., Puhan, M. A., Hebestreit, H., & Kriemler, S. (2016). The 1-min sit-to-stand test—A simple functional capacity test in cystic fibrosis? *Journal of Cystic Fibrosis, 15*(2), 223-226.

Rasekaba, T., Lee, A. L., Naughton, M. T., Williams, T. J., & Holland, A. E. (2009). The six-minute walk test: a useful metric for the cardiopulmonary patient. *Internal Medicine Journal, 39*(8), 495-501. doi:https://doi.org/10.1111/j.1445-5994.2008.01880.x

Reychler, G., Boucard, E., Peran, L., Pichon, R., Le Ber-Moy, C., Ouksel, H., . . . Beaumont, M. (2018). One minute sit-to-stand test is an alternative to 6MWT to measure functional exercise performance in COPD patients. *The clinical respiratory journal, 12*(3), 1247-1256.

Singh, S. J., Puhan, M. A., Andrianopoulos, V., Hernandes, N. A., Mitchell, K. E., Hill, C. J., . . . Spruit, M. A. (2014). An official systematic review of the European Respiratory Society/American Thoracic Society: measurement properties of field walking tests in chronic respiratory disease. *European Respiratory Journal, 44*(6), 1447-1478.

Soriano, J. B., Kendrick, P. J., Paulson, K. R., Gupta, V., Abrams, E. M., Adedoyin, R. A., . . . Ahmadian, E. (2020). Prevalence and attributable health burden of chronic respiratory diseases, 1990–2017: a systematic analysis for the Global Burden of Disease Study 2017. *The Lancet Respiratory Medicine, 8*(6), 585-596.

Takken, T., Bongers, B. C., Van Brussel, M., Haapala, E. A., & Hulzebos, E. H. (2017). Cardiopulmonary exercise testing in pediatrics. *Annals of the American Thoracic Society, 14*(Supplement 1), S123-S128.

Vaes, A. W., Burtin, C., Casaburi, R., Celli, B. R., Evans, R. A., Lareau, S. C., . . . Troosters, T. (2024). Prevalence and prognostic importance of exercise limitation and physical inactivity in COPD. *Breathe, 20*(2).

Vaidya, T., Chambellan, A., & De Bisschop, C. (2017). Sit-to-stand tests for COPD: a literature review. *Respiratory medicine, 128*, 70-77.

Vogiatzis, I., & Zakynthinos, S. (2012). Factors limiting exercise tolerance in chronic lung diseases. *Comprehensive Physiology, 2*(3), 1779-1817.

Zar, H. J., & Ferkol, T. W. (2014). The global burden of respiratory disease—impact on child health. In (Vol. 49, pp. 430-434): Wiley Online Library.

Zeren, M., Gurses, H. N., Kulli, H. D., Ucgun, H., & Cakir, E. (2020). Sit-to-stand test in children with bronchiectasis: Does it measure functional exercise capacity? *Heart & Lung, 49*(6), 796-802.

Zhang, Q., Li, Y.-x., Li, X.-l., Yin, Y., Li, R.-l., Qiao, X., . . . Han, Y.-f. (2018). A comparative study of the five-repetition sit-to-stand test and the 30-second sit-to-stand test to assess exercise tolerance in COPD patients. *International journal of chronic obstructive pulmonary disease*, 2833-2839.