Journal of Advanced Medical and Dental Sciences Research

@Society of Scientific Research and Studies

Journal home page:www.jamdsr.com doi:10.21276/jamdsr Index Copernicus value [ICV] =82.06

(e) ISSN Online: 2321-9599; (p) ISSN Print: 2348-6805

Original Research

6-minute walk test versus incremental shuttle walk test for functional capacity assessment in COPD: A comparative study

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ABSTRACT:

Background: Chronic obstructive pulmonary disease (COPD) is a progressive respiratory disorder characterized by airflow limitation and reduced exercise tolerance, which significantly impacts quality of life and prognosis. Assessment of functional exercise capacity is an essential component of comprehensive COPD evaluation. Field walking tests such as the six-minute walk test (6MWT) and the incremental shuttle walk test (ISWT) are commonly used for this purpose; however, they differ in pacing strategy, physiological demand, and clinical interpretation. Comparative data evaluating these two tests within the same COPD population remain limited, particularly in tertiary care settings. **Aim:** To compare the six-minute walk test and the incremental shuttle walk test for assessment of functional exercise capacity, physiological responses, and symptom burden in patients with chronic obstructive pulmonary disease. **Materials and Methods:** This comparative observational study included 102 patients with clinically stable COPD attending a tertiary care hospital. Baseline demographic and clinical characteristics, including spirometric parameters, were recorded. All participants performed both the 6MWT and the ISWT according to standardized protocols. The primary outcome measure was walking distance achieved during each test. Secondary outcome measures included changes in heart rate, peripheral oxygen saturation (SpO_2), and perceived dyspnea and fatigue assessed using the Borg scale. Comparative analysis between the two tests was performed using appropriate statistical methods, and a p-value of <0.05 was considered statistically significant. **Results:** The mean walking distance achieved during the 6MWT (378.26 ± 86.45 m) was significantly greater than that during the ISWT (312.74 ± 92.18 m; $p < 0.001$). A higher proportion of patients walked less than 300 m during the ISWT compared to the 6MWT (45.10% vs 27.45%; $p = 0.009$). Post-exercise heart rate and oxygen desaturation were significantly greater following the ISWT ($p < 0.001$ and $p = 0.002$, respectively). Similarly, post-test Borg dyspneaand fatigue scores were significantly higher after the ISWT compared to the 6MWT ($p < 0.001$ for both). **Conclusion:** Both the 6MWT and ISWT are valuable tools for assessing functional exercise capacity in COPD. While the 6MWT reflects self-paced functional performance, the ISWT elicits greater physiological stress and symptom burden, making the two tests complementary in clinical evaluation.

Keywords: Chronic obstructive pulmonary disease; Six-minute walk test; Incremental shuttle walk test; Functional exercise capacity; Exercise tolerance

Received: 14 October, 2018 Accepted: 16 November, 2018 Published: 10 December, 2018

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This article may be cited as: Kumar P, Jain MK. 6-minute walk test versus incremental shuttle walk test for functional capacity assessment in COPD: A comparative study. J Adv Med Dent Scie Res 2018;6(12):119-124.

INTRODUCTION

Chronic obstructive pulmonary disease (COPD) is a common, preventable, and treatable chronic respiratory disorder characterized by persistent respiratory symptoms and airflow limitation, with substantial heterogeneity in clinical presentation and progression. In routine practice, spirometry confirms obstruction and grades airflow limitation; however, COPD is increasingly understood as a multisystem disease in which symptoms, exacerbation risk, and comorbidities strongly influence functional status and outcomes. Patients frequently develop exertional dyspnea, reduced physical activity, skeletal muscle deconditioning, and diminished exercise tolerance—features that may not be fully captured by resting lung function alone. Consequently, contemporary COPD assessment emphasizes multidimensional evaluation that includes functional exercise performance as a clinically meaningful marker of overall disease impact.[1] Functional exercise capacity has direct relevance to prognosis, healthcare utilization, and therapeutic decision-making. The distance walked

during field tests is not merely a performance metric; it reflects integrated cardiopulmonary reserve, peripheral muscle function, and symptom limitation during activities that resemble daily living. Large COPD datasets demonstrate that the six-minute-walk distance (6MWD) helps stratify patients by clinically important outcomes such as mortality and hospitalization/exacerbation-related events, supporting its role in risk assessment and as an endpoint in COPD research. In pulmonary rehabilitation cohorts, lower baseline 6MWD has also been linked to poorer survival, reinforcing the value of simple walking tests in identifying high-risk patients. These observations strengthen the rationale for incorporating standardized field-based exercise tests into tertiary-care COPD evaluation, particularly where cardiopulmonary exercise testing is not feasible for every patient.[2,3] Among field tests, the six-minute walk test (6MWT) is widely used because it is simple, inexpensive, and reflective of functional walking capacity. It is self-paced and submaximal for many patients, allowing assessment of endurance-like performance while capturing symptoms and oxygen desaturation during sustained ambulation. However, the 6MWT is sensitive to methodological factors (e.g., encouragement, track layout, learning effect) and therefore requires careful standardization to optimize reproducibility and interpretation. The clinical interpretation of change in 6MWD is also important: in COPD, a decline or improvement on the order of ~30 m has been associated with clinically meaningful differences in outcome risk, supporting the use of threshold-based interpretation alongside continuous analysis.[4] The incremental shuttle walk test (ISWT) offers a complementary approach by using an externally paced, progressively increasing walking speed that is intended to drive symptom-limited maximal performance.[5] By design, the ISWT reduces patient-driven pacing variability and can impose a higher cardiopulmonary load than self-paced walking, potentially improving discrimination across disease severity and capturing peak-limited responses relevant to exercise prescription.[5] Evidence syntheses support the robustness of field walking tests in chronic respiratory disease, while also highlighting that each test captures a slightly different construct of exercise performance. In an ERS/ATS systematic review, both 6MWT and shuttle tests were described as reliable and responsive measures of functional exercise capacity, but correlations between walking distance and physiological measures (e.g., peak work capacity, physical activity) may vary, and methodological elements can materially influence results.[6] The ISWT has also been systematically evaluated for measurement properties, with strong evidence supporting validity and test–retest reliability in chronic respiratory disease populations, particularly COPD.[7] Reported criterion validity correlations between ISWT distance and peak oxygen consumption are high (approximately 0.67–0.95), and reliability indices are similarly strong, supporting its use as a structured field surrogate of maximal exercise capacity.

MATERIALS AND METHODS

This comparative observational study was conducted at a tertiary care hospital to evaluate functional exercise capacity in patients with chronic obstructive pulmonary disease (COPD) using two commonly employed field-based exercise tests: the six-minute walk test (6MWT) and the incremental shuttle walk test (ISWT). The study was designed to compare performance outcomes and physiological responses between the two tests in a controlled clinical environment.

A total of 102 patients diagnosed with COPD were included in the study. Diagnosis was established based on clinical evaluation and spirometric confirmation in accordance with standard diagnostic guidelines. Patients attending the pulmonary medicine department of the tertiary care hospital were screened and enrolled after fulfilling the eligibility criteria.

Inclusion and Exclusion Criteria

Patients aged 40 years and above with stable COPD were included in the study. Only those who were clinically stable, without any acute exacerbation at the time of assessment, and capable of performing exercise testing were enrolled. Patients with recent cardiovascular events, uncontrolled hypertension, significant musculoskeletal or neurological disorders limiting ambulation, severe cognitive impairment, or any contraindication to exercise testing were excluded from the study.

Methodology

All enrolled patients underwent a detailed baseline evaluation prior to exercise testing. This included demographic data such as age, sex, body mass index (BMI), smoking status, and disease severity. Pulmonary function parameters, including forced expiratory volume in one second (FEV_1) and FEV_1/FVC ratio, were recorded using standard spirometric techniques. Resting vital signs, including heart rate, blood pressure, respiratory rate, and peripheral oxygen saturation (SpO_2), were documented before each test.

Six-Minute Walk Test (6MWT)

The six-minute walk test was performed in accordance with standardized guidelines on a flat, straight corridor with a marked walking distance. Patients were instructed to walk at their own pace and cover as much distance as possible within six minutes, with standardized verbal encouragement provided. The total distance walked in meters was recorded as the primary outcome measure. Heart rate, SpO_2, and Borg scale ratings for dyspnea and fatigue were recorded before and immediately after completion of the test.

Incremental Shuttle Walk Test (ISWT)
The incremental shuttle walk test was conducted on a 10-meter course marked by cones at each end. Patients were required to walk back and forth in time with audio signals that progressively increased in speed at fixed intervals. The test was continued until the patient was unable to maintain the required pace, developed limiting symptoms, or met termination criteria. The total distance achieved was recorded. Physiological parameters including heart rate, SpO_2, and perceived exertion using the Borg scale were measured before and at the end of the test.

Outcome Measures
The primary outcome measures were the total walking distance achieved during the 6MWT and ISWT. Secondary outcome measures included changes in heart rate, oxygen saturation, dyspnea score, and fatigue score associated with each test. These parameters were used to assess functional capacity, cardiopulmonary response, and symptom burden during both exercise modalities.

Statistical Analysis
Data were analyzed using appropriate statistical software. Continuous variables were expressed as mean ± standard deviation, while categorical variables were presented as frequencies and percentages. Comparative analysis between the 6MWT and ISWT was performed using suitable parametric or non-parametric tests based on data distribution. Correlation analysis was conducted to assess the relationship between distances achieved in both tests and pulmonary function parameters. A p-value of less than 0.05 was considered statistically significant.

RESULTS

Baseline Demographic and Clinical Characteristics (Table 1)
The study population comprised 102 patients with COPD, with a mean age of 63.45 ± 8.92 years, indicating that the majority of participants were in the older age group typically affected by COPD. There was a clear male predominance, with males constituting 76.47% of the study population, while females accounted for 23.53%. The mean body mass index was 22.38 ± 3.41 kg/m², reflecting a predominantly normal to mildly undernourished population, which is commonly observed in patients with chronic respiratory disease.Regarding smoking status, nearly half of the patients were current smokers (45.10%), while 37.25% were former smokers, highlighting the strong association between tobacco exposure and COPD. A smaller proportion of patients (17.65%) were never smokers. Pulmonary function testing revealed moderate airflow limitation, with a mean FEV_1 of 51.62 ± 14.28% predicted and a reduced mean FEV_1/FVC ratio of 0.56 ± 0.08, consistent with obstructive ventilatory impairment.

Distribution of Disease Severity (Table 2)
Based on spirometric classification using the GOLD criteria, the majority of patients had moderate to severe COPD. The largest proportion belonged to the moderate category (GOLD II), accounting for 43.14% of the study population. This was followed by severe COPD (GOLD III), observed in 33.33% of patients. Mild (GOLD I) and very severe (GOLD IV) disease were less frequent, each comprising 11.76% of cases.

Comparison of Functional Exercise Capacity Between 6MWT and ISWT (Table 3)
Functional exercise capacity, as assessed by walking distance, differed significantly between the two exercise tests. The mean distance covered during the six-minute walk test was significantly greater than that achieved during the incremental shuttle walk test ($p < 0.001$), indicating that patients were able to sustain a higher total distance during the self-paced 6MWT compared to the externally paced ISWT.When distances were categorized, a significantly higher proportion of patients walked less than 300 meters during the ISWT compared to the 6MWT ($p = 0.009$). Conversely, the proportion of patients achieving distances of 300 meters or more was significantly greater during the 6MWT.

Physiological Responses to Exercise (Table 4)
Baseline physiological parameters, including pre-test heart rate and oxygen saturation, were comparable between the two tests, with no statistically significant differences observed. This indicates similar resting physiological status before performing each exercise modality.
However, post-exercise responses differed significantly. The ISWT resulted in a significantly higher post-test heart rate compared to the 6MWT ($p < 0.001$), reflecting greater cardiovascular stress during the incremental, externally paced protocol. Additionally, post-test oxygen saturation was significantly lower following the ISWT than the 6MWT ($p = 0.002$), indicating greater exercise-induced oxygen desaturation during the ISWT.

Symptom Response Following Exercise Testing (Table 5)
Perceived dyspnea and fatigue scores measured using the Borg scale were similar between the two tests at baseline, with no statistically significant differences observed for pre-test scores. This suggests comparable symptom burden prior to exercise.
Following exercise, both dyspnea and fatigue scores increased significantly; however, the magnitude of symptom escalation was significantly greater after the ISWT compared to the 6MWT ($p < 0.001$ for both parameters). Higher post-test Borg scores during the ISWT indicate that this test induces greater subjective respiratory discomfort and muscular fatigue, further supporting its higher physiological and symptomatic demand.

Table 1. Baseline Demographic and Clinical Characteristics of the Study Population (n = 102)

Parameter	Value
Mean age (years)	63.45 ± 8.92
Male	78 (76.47%)
Female	24 (23.53%)
Mean BMI (kg/m²)	22.38 ± 3.41
Current smokers	46 (45.10%)
Former smokers	38 (37.25%)
Never smokers	18 (17.65%)
Mean FEV_1 (% predicted)	51.62 ± 14.28
Mean FEV_1/FVC ratio	0.56 ± 0.08

Table 2. Disease Severity Distribution Based on Spirometry (GOLD Classification)

COPD Severity	Number of Patients	Percentage (%)
Mild (GOLD I)	12	11.76
Moderate (GOLD II)	44	43.14
Severe (GOLD III)	34	33.33
Very Severe (GOLD IV)	12	11.76
Total	**102**	**100.00**

Table 3. Comparison of Functional Exercise Capacity Between 6MWT and ISWT

Parameter	6MWT	ISWT	p-value
Mean walking distance (meters)	378.26 ± 86.45	312.74 ± 92.18	<0.001
Distance < 300 m	28 (27.45%)	46 (45.10%)	0.009
Distance ≥ 300 m	74 (72.55%)	56 (54.90%)	0.009

Table 4. Physiological Responses to Exercise During 6MWT and ISWT

Parameter	6MWT	ISWT	p-value
Pre-test heart rate (beats/min)	82.36 ± 10.12	81.98 ± 9.84	0.68
Post-test heart rate (beats/min)	102.54 ± 12.96	110.72 ± 14.31	<0.001
Pre-test SpO_2 (%)	94.18 ± 2.36	94.22 ± 2.41	0.74
Post-test SpO_2 (%)	90.46 ± 3.82	88.12 ± 4.15	0.002

Table 5. Symptom Response (Dyspnea and Fatigue) Following Exercise Tests

Parameter	6MWT	ISWT	p-value
Pre-test Borg dyspnea score	1.62 ± 0.84	1.59 ± 0.81	0.81
Post-test Borg dyspnea score	4.12 ± 1.26	5.38 ± 1.44	<0.001
Pre-test Borg fatigue score	1.48 ± 0.72	1.44 ± 0.69	0.76
Post-test Borg fatigue score	3.94 ± 1.18	5.06 ± 1.39	<0.001

DISCUSSION

The present cohort (n=102) had a mean age of **63.45 ± 8.92 years**, with **male predominance (76.47%)** and a high burden of smoking exposure (**current 45.10%**, **former 37.25%**), alongside moderate airflow limitation (**FEV_1 51.62 ± 14.28% predicted**; **FEV_1/FVC 0.56 ± 0.08**). This profile is comparable to large spirometry-confirmed COPD clinic populations such as **Kim et al (2015)**, where patients were predominantly male (**94.2%**) with a similar age (median **67 years**) and comparable airflow obstruction (mean **FEV_1 52.53 ± 18.29% predicted**), supporting that our study population represents the typical symptomatic COPD spectrum encountered in routine tertiary care.[7]

Disease severity in our study was concentrated in **GOLD II (43.14%)** and **GOLD III (33.33%)**, with fewer patients at the extremes (**GOLD I 11.76%**, **GOLD IV 11.76%**). This pattern aligns with the "clinic-enriched" mix reported in prognostic cohorts such as **Celli et al (2004)**, which included patients across a wide severity range but with substantial moderate-to-severe disease and clear systemic involvement (e.g., **BMI differences** and **functional limitation** captured by 6MWD). Importantly, compared with the more impaired functional status in that cohort (e.g., **6MWD 264 ± 113 m** among survivors in the derivation cohort), our patients demonstrated a higher mean 6MWD (**378.26 ± 86.45 m**), consistent with somewhat better preserved functional capacity despite moderate obstruction.[8]

Functional capacity differed significantly by test modality in our study: patients walked farther on the **6MWT (378.26 ± 86.45 m)** than on the **ISWT (312.74 ± 92.18 m)** (**$p < 0.001$**). A similar direction of difference has been reported by **Dourado et al (2005)**, where COPD patients achieved **307.0 ± 89.3 m** on the shuttle test versus **515.5 ± 102.3 m** on an encouraged

6MWT (**p < 0.001**). While their absolute 6MWT distance was higher than ours (likely reflecting protocol differences such as "encouraged" walking and sample variability), both studies demonstrate that total distance is not interchangeable between the two field tests and is strongly influenced by pacing structure.[9]

Beyond distance, our physiological results support that ISWT behaves more like a maximal incremental challenge: post-test heart rate was higher with ISWT (**110.72 ± 14.31 bpm**) than 6MWT (**102.54 ± 12.96 bpm**, **p < 0.001**) and desaturation was greater (post-test **SpO_2 88.12 ± 4.15%** vs **90.46 ± 3.82%**, **p = 0.002**). This pattern is consistent with **Onorati et al (2003)**, who demonstrated that shuttle walking produced a linear rise in gas-exchange indices and that shuttle distance correlated strongly with maximal physiologic markers (e.g., **distance vs VO_2peak, R = 0.86; p < 0.001**), whereas 6MWT distance did **not** correlate with key physiologic indices—supporting the interpretation that ISWT better reflects maximal exercise tolerance while 6MWT reflects submaximal, self-regulated performance.[10]

When distances were categorized, a significantly greater proportion of our patients fell below **300 m** during ISWT (**45.10%**) than during 6MWT (**27.45%**) (**p = 0.009**), reinforcing that ISWT "uncovers" limitation in more patients under externally paced incremental loading. The foundational validation of this concept appears in **Singh et al (1992)**, who described the shuttle test as a standardized incremental field test producing a symptom-limited maximal performance, noting a significant relationship between 6MWT and shuttle distance (**rho = 0.68**) but also highlighting that 6MWT may overestimate disability in some patients and that the shuttle test provokes a graded cardiovascular response not evident in the six-minute test. Our higher peak cardiovascular stress during ISWT (higher post-test HR) closely mirrors this mechanistic distinction.[11]

Exercise-induced desaturation in our cohort was clinically meaningful in both tests but significantly worse after ISWT (post **88.12%**) than after 6MWT (post **90.46%**) (**p = 0.002**), suggesting greater hypoxemic stress during incremental pacing. This finding parallels **Lewko et al (2007)**, who quantified desaturation as a **mean change in SpO_2 of −4.6% (SD 6.2%) after ISWT** versus **−2.8% (SD 5.3%) after 6MWT**, and showed that eligibility for ambulatory oxygen assessment differed by test (**32% ISWT vs 26% 6MWT**). Together, these data support that the choice of field test can materially change hypoxemia detection and clinical decision-making, and that ISWT may be more sensitive to exertional desaturation.[12]

Symptom escalation in our study was significantly greater after ISWT than 6MWT, with post-test Borg dyspnea**5.38 ± 1.44 vs 4.12 ± 1.26** and post-test Borg fatigue **5.06 ± 1.39 vs 3.94 ± 1.18** (both **p < 0.001**), despite similar baseline symptom scores. In contrast, **Ayiesah et al (2010)** reported broadly comparable peak responses between tests in their COPD sample (e.g., dyspnea**7.0 ± 2.2** in 6MWT vs **6.6 ± 1.9** in ISWT, **p = 0.36**; end SpO_2 **89.3 ± 11.4** vs **89.2 ± 10.5**, **p = 0.85**; peak HR **117.1 ± 16.3** vs **113.3 ± 13.1**, **p = 0.27**). The divergence from our results may relate to differences in disease mix, testing conduct, encouragement, termination criteria, or cultural pacing behavior—highlighting why symptom outcomes, like distance, should not be assumed interchangeable across protocols or settings.[13]

The clinical meaning of our 6MWD findings is reinforced by prognostic literature: our mean 6MWD (**378.26 m**) is close to the "better-outcome" range seen in survival analyses, but notably **27.45%** of our patients still walked **<300 m**, a subgroup likely at higher risk. **Cote et al (2007)** demonstrated that nonsurvivors had substantially lower mean 6MWD than survivors (**312 ± 104 m vs 377 ± 95 m; p < 0.0001**) and that 6MWD carried an independent association with mortality (hazard ratio **0.996**, 95% CI **0.993–0.999**, **p < 0.01**). In this context, the larger proportion of <300 m performers on ISWT in our study may be particularly useful for identifying patients with concealed limitation under self-paced walking.[14]

Taken together, our results indicate that 6MWT and ISWT provide complementary—but not interchangeable—information: 6MWT yielded higher distances (self-paced functional performance), while ISWT elicited greater cardiovascular load, desaturation, and symptom burden (incremental stress test characteristics). This interpretation is consistent with the **ERS/ATS technical standard by Holland et al (2014)**, which emphasizes standardized operating procedures for field walking tests and notes that both **6MWD and ISWT can elicit a VO_2peak similar to CPET**, implying that safety precautions and interpretation should respect their capacity to generate near-maximal physiologic stress in chronic respiratory disease. Within tertiary care assessment pathways, using ISWT when the aim is to provoke a maximal response (e.g., uncover exertional hypoxemia) and 6MWT when the aim is to reflect day-to-day functional walking appears aligned with both our data and international standards.[15]

CONCLUSION

In conclusion, both the six-minute walk test and the incremental shuttle walk test are useful tools for assessing functional exercise capacity in patients with COPD. The six-minute walk test allows patients to achieve greater walking distances and reflects self-paced functional performance, whereas the incremental shuttle walk test induces higher cardiovascular stress, greater oxygen desaturation, and more pronounced symptom burden. The incremental shuttle walk test appears more sensitive in identifying exercise limitation under standardized, externally paced conditions. Therefore, the two tests provide

complementary information and should be selected based on the specific clinical or research objective in the evaluation of COPD patients.

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