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Comparison of Distance of 6-min Walk Test and the Incremental Shuttle Walk Test with Lung Function or Quality of Life in Patients with Chronic Obstructive Pulmonary Disease

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Background : Field walk tests such as the 6-min walk test (6MWT) and the incremental shuttle walk test (ISWT) are simple tests for assessing the degree of disability in individuals with chronic obstructive pulmonary disease (COPD). In the present study, the correlation between exercise performance and lung function or health-related quality of life (HRQoL) in both the 6MWT and the ISWT was examined in COPD patients.

Methods : A retrospective examination of 105 patients with COPD using the 6MWT or the ISWT and both lung function tests and assessment of HRQoL with the St George's Respiratory Questionnaire (SGRQ) was performed, and the correlation between walking distance and lung function parameters or SGRQ scores were assessed in each test.

Results : Walking distance was not correlated with lung function parameters, but was significantly correlated with the activity and impact domains, as well as the total score of the SGRQ in the 6MWT. In the ISWT, walking distance correlated significantly with inspiratory capacity, forced vital capacity, and forced expiratory volume in one second, but not with the total score of the SGRQ.

Conclusion : The 6MWT is reflective of health-related quality of life and the ISWT is reflective of lung function. *Shinshu Med J 61 : 57—64, 2013*

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Key words : chronic obstructive pulmonary disease, 6-min walk test, incremental shuttle walk test, St George's Respiratory Questionnaire

I Introduction

Exercise testing is useful for the assessment of the degree of disability, prognosis for survival, presence of exercise-induced hypoxemia, and response to treatment in patients with chronic obstructive pulmonary disease (COPD)[1]. Several modalities are available for the objective evaluation of functional exercise capacity. Of these modalities, field walk tests require less technical expertise and equipment, are simple to perform and are inexpensive[2]. Field walk tests are therefore extensively used for clinical or research purposes. A variety of walk tests exist, including time-based tests, fixed-distance tests, and controlled-pacing tests.

The 6-min walk test (6MWT) is currently the test of choice as a functional walk test for clinical or research purposes[3]. However the 6 min walking distance depends on the motivation of the patient because the 6MWT is a self-paced test.

The incremental shuttle walk test (ISWT) is a

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submaximal exercise test based on incremental increase in walking pace[4]. Consequently, maximal exercise capacity is probably better correlated with the ISWT than with the 6MWT. The ISWT is a reproducible measure of functional capacity in patients with chronic airflow limitation, and strong correlations between ISWT distance and maximal oxygen consumption have been reported, measured during treadmill testing[5].

Whether the walking distance in the 6MWT or that in the ISWT shows a better correlation with lung function or health-related quality of life (HRQoL) is still unclear, although both walking tests have been used for evaluation of exercise performance in patients with COPD. We hypothesized that the 6MWT is more reflective of HRQoL, because the 6MWT is a self-paced test and reflects activity of daily life, and the ISWT better reflects lung function because it is closer to a submaximal exercise test. In the present study, we examined the results of field walk tests (6MWT or ISWT), lung function tests, and HRQoL using St George's Respiratory Questionnaire (SGRQ), and analyzed the walking distance in each walking test in correlation with lung function parameters and SGRQ scores in patients with stable COPD.

II Subjects and Methods

A Subjects

This study was a retrospective study. One hundred and five consecutive symptomatic patients with stable COPD who had been seen at the outpatient clinic of Shinshu University Hospital from 2005 to 2008 were recruited and the results of field walk tests, lung function tests, and HRQoL using SGRQ were examined concurrently. COPD was diagnosed in accordance with the Global Initiative for Chronic Obstructive Lung Disease guidelines[6]. Patients with a history of long-term oxygen therapy, respiratory tract infection or exacerbation during the preceding 3 months, and ischemic heart disease or locomotive problems were excluded. Patients were divided into 2 groups according to the examination date : the 6MWT group (from 2005 to 2006) or the ISWT group (from 2007 to 2008). This study was approved by the institutional research ethics committee of Shinshu University School of Medicine and informed consent was obtained from each patient.

B Lung function tests

Spirometry, lung volume, and diffusion capacity for carbon monoxide (DLCO) were measured using Chestac-8800 (Chest Co. Ltd, Tokyo, Japan) in accordance with the American Thoracic Society protocol[7]. Functional residual capacity (FRC) was measured using a gas-dilution method, after which the subject immediately inspired to total lung capacity (TLC) and expired maximally to residual volume (RV), allowing calculation of lung volume and RV/TLC. DLCO was measured using the single-breath method. For the predicted values for forced expiratory volume in one second (FEV_1) and vital capacity (VC), Japanese local reference data[8] developed by the Japanese Respiratory Society were adopted, and the predicted values for DLCO and lung volumes (FRC, RV, and TLC) measured by body plethysmography were determined using the formulas of Nishida et al.[9] and Kory et al.[10], respectively.

C Health-related quality of life

HRQoL was assessed using a Japanese version of the SGRQ, which consists of 76 items and calculates a 3-component score (symptoms, activity, and impact) and a total score. The symptom component contains items related to symptomatology, including frequency of cough, sputum production, wheezing, and breathlessness. The activity component is concerned with physical activities that either cause or are limited by breathlessness. The impact component covers such factors as employment, being in control of health, panic, medication needs and side effects, and disturbance of daily life. Each of these scores ranges from 0 to 100, with a score of 100 indicating maximum disability[11]. The Japanese version of SGRQ is a valid and reliable measure of impaired health in COPD[12].

D Field walk test

1 The 6MWT

The 6MWT was performed according to the American Thoracic Society Guidelines[13]. In summary, the patients were instructed to walk at their fastest pace, attempting to cover the maximum possible distance within 6 min. Percutaneous oxygen saturation (SpO_2) and pulse rate (PR) were continuously monitored. An investigator timed the walk, and used the standard phrases of encouragement. The patients were allowed to stop anytime and anywhere until they had sufficiently rested to start walking again. Before and after the test, SpO_2, PR, and blood pressure were measured, and dyspnea was rated using the modified Borg breathlessness scale (BS).

2 The ISWT

The ISWT was performed according to a previously reported method[8]. In summary, the patient walked up and down a 10-m course. The speed at which the patient walked was dictated by an audio signal played on a compact disc. This compact disc emitted a single bleep at regular intervals, at which point the subject attempted to reach the opposite end of the course. Walking speed was increased every minute by a small increment, which meant that the patient was required to walk at a progressively faster pace. The end of the test was determined by either (a) the patient, when the patient was too breathless to maintain the required speed, or (b) the investigator, if the patient failed to complete a shuttle in the time allowed. SpO_2 and PR were continuously monitored. Before and after the test, SpO_2, PR, respiration rate, and blood pressure were measured, and dyspnea was rated using the modified BS.

E Statistical analysis

All results were expressed as mean±SD. Data distributions of variables in the various groups were first assessed using the goodness-of-fit test. When data for variables showed a normal distribution, the 2 groups were compared using the unpaired *t* test. When data for variables did not show a normal distribution, variables between the 2 groups were compared using the Mann-Whitney U test. Gender distribution difference between the 2 groups was compared using Fisher's exact test. Simple correlations between various parameters were examined using Pearson's correlation coefficient. A Pearson correlation coefficient of 0.40 or above was considered satisfactory. Multiple stepwise linear regression analysis was performed to identify which variables were significant determinants for the walking distance or HRQoL. A value of $p \leqq 0.15$ was used first to identify candidate variables, and then variables were removed from the regression model if the p value was more than 0.1. All statistical analyses were performed using a Windows-compatible software program (Stat Flex ver. 5.0, Artech Ltd., Osaka, Japan). A p value of < 0.05 was considered statistically significant.

Ⅲ Results

A Patient details

Patient characteristics and lung function values are shown in **Table 1**. Among the 105 patients, 52 patients (5 female patients) were classified into the 6MWT group, and 53 patients (3 female patients) into the ISWT group. There were no significant differences in patient characteristics between the 2 groups, except for the mean inspiratory capacity (IC)/TLC and DLCO, which were significantly lower in the 6MWT group than in the ISWT group, and the mean, which was significantly higher in the 6MWT group than in the ISWT group. The mean SGRQ symptom score, activity score, impact score, and total score in the 6MWT group were significantly higher than in the ISWT group (**Table 2**). The results of the walk tests are shown in **Table 3**. The mean post-SpO_2, delta SpO_2, and the mean pre- and post-modified BS did not significantly differ between the 2 groups. The mean pre-SpO_2, post-PR, and delta PR in the ISWT group were significantly higher than in the 6MWT group. The mean pre-PR in the 6MWT group was significantly higher than in the ISWT group.

B The relationship between walking distance and lung function or HRQoL (Table 4)

The 6MWT distance (6MWD) showed a significant correlation with the activity and impact

Table 1 Patient characteristics and lung function parameters

	6MWT group (n=52)	ISWT group (n=53)	p value
Age (yr)	72.6±7.1	70.0±7.3	p=0.065
Gender (male/female)	47/5	50/3	p=0.692
BH (cm)	162.9±7.5	163.5±6.4	p=0.662
BW (kg)	57.8±9.7	58.4±10.1	p=0.753
BMI (kg/m²)	21.7±2.9	21.8±3.1	p=0.929
VC, % of predicted (%)	98.0±16.9	105.0±20.4	p=0.091
FEV_1, % of predicted (%)	63.4±24.2	69.0±22.4	p=0.223
FEV_1/FVC (%)	52.2±14.3	56.5±13.1	p=0.110
IC/TLC (%)	35.6±8.6	39.8±8.4	p=0.012
FRC, % of predicted (%)	107.7±29.1	99.9±19.3	p=0.272
RV, % of predicted (%)	156.2±48.0	141.9±42.0	p=0.115
TLC, % of predicted (%)	114.0±18.7	112.4±18.4	p=0.684
RV/TLC (%)	47.0±8.7	42.1±10.0	p=0.009
DLCO, % of predicted (%)	48.2±19.3	56.1±21.1	p=0.048

Values are mean±SD

COPD : chronic obstructive pulmonary disease ; 6MWT : 6-min walk test ; ISWT : incremental shuttle walk test ; BH : body height ; BW : body weight ; BMI : body mass index ; VC : vital capacity ; FEV_1 : forced expiratory volume in one second ; FVC : forced vital capacity ; IC : inspiratory capacity ; TLC : total lung capacity ; FRC : functional residual capacity ; RV : residual volume ; DLCO : diffusion capacity for carbon monoxide

Table 2 SGRQ scores of patients with COPD

	6MWT group (n=52)	ISWT group (n=53)	p value
SGRQ symptom score	51.106±22.138	38.200±19.016	p=0.002
SGRQ activity score	58.492±30.273	35.688±25.735	p<0.001
SGRQ impact score	28.010±18.055	18.589±17.497	p=0.005
SGRQ total score	43.013±19.830	29.113±18.058	p<0.001

Values are mean±SD

COPD : chronic obstructive pulmonary disease ; 6MWT : 6-min walk test ; ISWT : incremental shuttle walk test ; SGRQ : St George's Respiratory Questionnaire

Table 3 Summary of walk test result of patients with COPD

	6MWT group (n=52)	ISWT group (n=53)	p value
pre SpO_2 (%)	94.9±1.8	95.7±1.5	p=0.014
post SpO_2 (%)	86.8±8.6	89.4±5.6	p=0.262
ΔSpO_2 (%)	-8.1±8.2	-6.3±5.1	p=0.685
pre PR (/min)	81.6±12.8	74.8±13.6	p=0.007
post PR (/min)	108.5±12.8	119.2±19.0	p=0.002
ΔPR (/min)	26.9±13.3	44.4±22.2	p<0.001
pre modified Borg breathlessness scale	0.22±0.50	0.21±0.55	p=0.422
post modified Borg breathlessness scale	3.88±2.41	3.19±2.20	p=0.082
walk test distance (m)	387±106	365±143	

All values represent mean±SD

Pre- and post-modified Borg scales represent median and ranges.

COPD : chronic obstructive pulmonary disease ; 6MWT : 6-min walk test ; ISWT : incremental shuttle walk test ; SpO_2 : Oxygen saturation ; ΔSpO_2 : post SpO_2-pre SpO_2 ; PR : pulse rate ; ΔPR : post PR-pre PR

Table 4 Simple regression analysis using Pearson's correlation coefficient

	6MWT distance		ISWT distance	
	Coefficient	p value	Coefficient	p value
FVC	0.33	p<0.016	0.52	p<0.001
FEV_1	0.34	p<0.013	0.50	p<0.001
FEV_1/FVC	0.17	p=0.239	0.35	p=0.011
FRC	0.19	p=0.168	-0.01	p=0.922
RV	0.21	p=0.135	-0.21	p=0.124
TLC	0.28	p=0.044	0.24	p=0.888
IC	0.27	p=0.049	0.46	p<0.001
RV/TLC	0.02	p=0.860	-0.35	p=0.009
DLCO	0.61	p<0.001	0.50	p<0.001
SGRQ symptom score	-0.28	p=0.041	-0.18	p=0.190
SGRQ activity score	-0.65	p<0.001	-0.44	p=0.001
SGRQ impact score	-0.63	p<0.001	-0.28	p=0.044
SGRQ total score	-0.60	p<0.001	-0.33	p=0.015
pre SpO_2	0.45	p<0.001	0.28	p=0.038
delta SpO_2	-0.26	p=0.061	-0.12	p=0.378
post modified Borg scale	-0.21	p=0.141	-0.02	p=0.845

COPD : chronic obstructive pulmonary disease ; 6MWT : 6-min walk test ; ISWT : incremental shuttle walk test ; FVC : forced vital capacity ; FEV_1 : forced expiratory volume in one second ; FRC : functional residual capacity ; RV : residual volume ; TLC : total lung capacity ; IC : inspiratory capacity ; DLCO : diffusion capacity for carbon monoxide ; SGRQ : St George's Respiratory Questionnaire ; delta SpO_2 : difference post SpO_2 from pre SpO_2

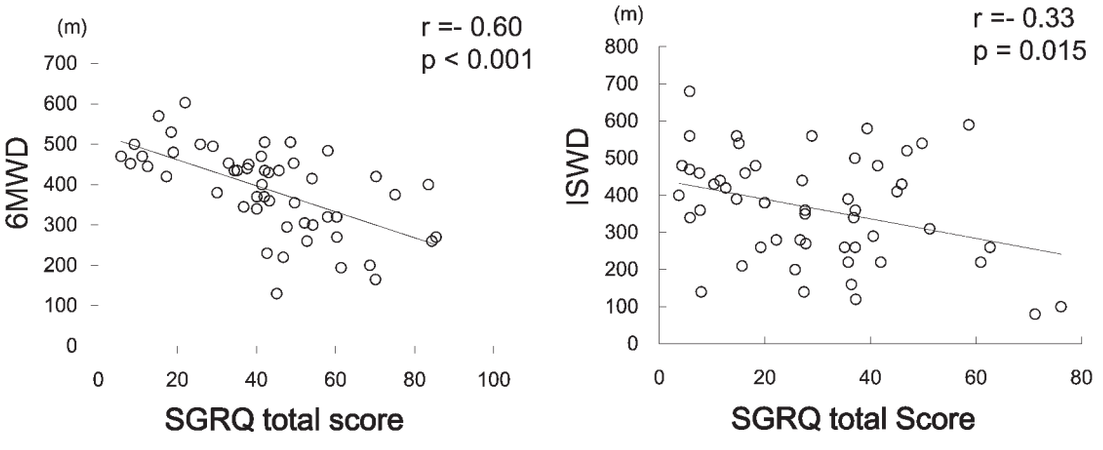

Fig. 1

The relation between St George's Respiratory Questionnaire (SGRQ) total score and the field walk tests. The correlation coefficient between the 6-min walk distance (6MWD) and SGRQ total score is -0.60. The correlation coefficient between the incremental shuttle walk test distance (ISWD) and SGRQ total score is -0.33.

domain scores, and the total score of SGRQ (**Fig. 1**) with a correlation coefficient over 0.4. With regard to lung functions, DLCO was significantly correlated with 6MWD, showing a coefficient of 0.61. The correlation coefficients between 6MWD and FVC, FEV_1, TLC and IC were less than 0.4. On the other hand, the ISWT distance (ISWD) was significantly correlated with FVC, FEV_1 (**Fig. 2**), IC, and DLCO, showing a high correlation coefficient of over 0.4. However, with respect to HRQoL, weak correlations between ISWD and the SGRQ scores were observed compared to the correlations between the 6MWD and the SGRQ scores.

The regression model for the 6MWD was

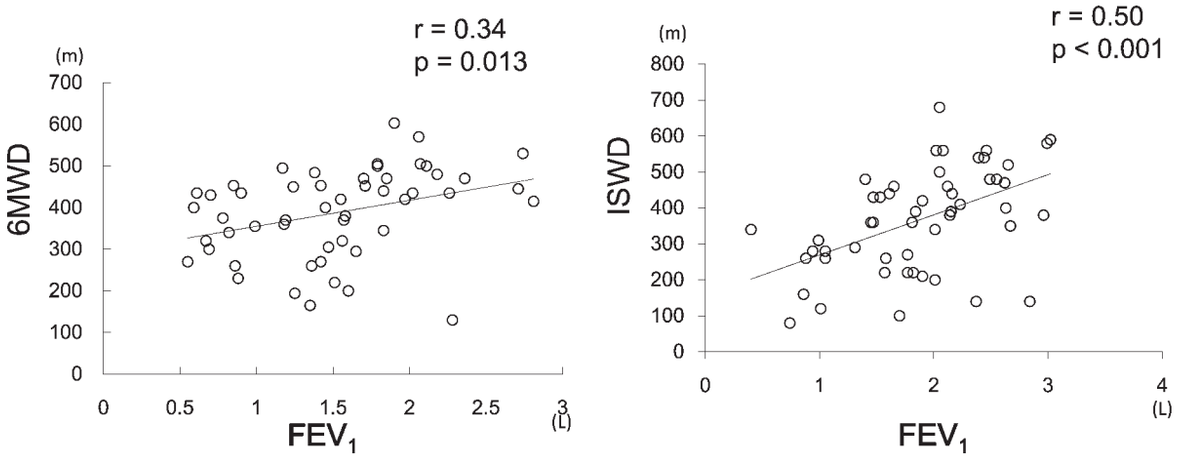

Fig. 2

The relationship between forced expiratory volume in one second (FEV_1) and the field walk test. The correlation coefficient between the incremental shuttle walk test distance (ISWD) and FEV_1 is 0.50. The correlation coefficient between the 6-min walk distance (6MWD) and FEV_1 is 0.34.

significant ($r=0.68$) and comprised DLCO ($R^2=0.376$, $p<0.001$), FEV_1 ($R^2=0.117$, $p=0.012$), and RV/TLC ($R^2<0.001$, $p=0.014$). This model accounted for 42.8 % of the walking distance in the 6MWT, and DLCO was the most significant determinant. The regression model for the total SGRQ score was significant ($r=0.70$) and included 6MWD ($R^2=0.359$, $p<0.001$) and FEV_1 ($R^2=0.291$, $p=0.001$). This model accounted for 46.5 % of the SGRQ, and 6MWD was the most significant determinant. The regression model for the ISWD was significant ($r=0.64$) and included DLCO ($R^2=0.249$, $p=0.007$), FVC ($R^2=0.270$, $p=0.011$), and FEV_1/FVC ($R^2=0.121$, $p=0.100$). This model accounted for 37.1 % of the ISWD, and DLCO was the most significant determinant. The regression model for the total SGRQ score was significant ($r=0.62$) and included post- and pre-modified BS ($R^2=0.272$ and <0.001, $p=0.008$ and 0.038, respectively), FVC ($R^2=0.132$, $p=0.036$), and FRC ($R^2=0.016$, $p=0.064$). This model accounted for 33.5 % of the SGRQ, and dyspnea during ISWT was the most significant determinant.

Ⅳ Discussion

The results of the present study indicate that exercise capacity evaluated by ISWD correlated better with lung function, but was poorly correlated with HRQoL. On the other hand, exercise capacity evaluated by 6MWD correlated better with HRQoL, but did not show a good correlation with parameters of airflow limitation. Multiple, stepwise, linear regression analysis also revealed that 6MWD was the most significant contributing factor for the evaluation of HRQoL among all the lung function parameters tested. Previous reports showed that maximum heart rate and BS rating were higher at the end of the ISWT than at the end of the 6MWT[4] and ISWD was strongly correlated with the maximum oxygen uptake, whereas 6MWD was correlated poorly with maximum oxygen uptake[5]. Furthermore, our present study showed a larger delta PR in the ISWT group than in the 6MWT group. This result suggests that the ISWT is closer to a submaximal exercise test than the 6MWT is, and may be a better indicator of lung function alterations such as airflow limitation and lung hyperinflation. Previous reports also showed a correlation between ISWD and lung function, such as VC and FEV_1[14] and no correlation between 6MWD and lung function including FVC, FEV_1, and TLC[15]. However, Mak VH et al and Wijkstra PJ et al reported that 6MWD was strongly correlated with FVC and FEV_1[16][17] and Vagaggini B et al reported that SWD was not correlated with FVC, FEV_1, and TLC[15]. In these studies, the severity of COPD estimated by air flow limitation with each mean FEV_1, % of the predicted

being 40.3 %[16], 44.3 %[17], and 48 %[15], was more severe than that of our study (63.4 %). These results suggest that the correlation between lung functions and walking distance depends on the severity of COPD. In our study, when restricted to patients with severe (30 %≤FEV_1<50 % predicted) and very severe (FEV_1<30 % predicted) COPD, 6MWD was significantly correlated with TLC, IC/TLC and DLCO, and SWD was not correlated with FEV_1. However, because the number of patients with severe and very severe COPD was small in our study, it is difficult to discuss each severity. Further studies which recruit each severity patients of every severity are needed.

In the present study, the SGRQ score showed a good correlation with 6MWD, as previously reported[11][16]. The SGRQ is one of the most widely used questionnaires for assessing HRQoL in COPD patients and is well known for its validity, repeatability, and sensitivity[11]. On the other hand, the 6MWT also reflects daily activity for most patients with severely impaired activities, and most patients do not achieve maximal exercise capacity during the 6MWT[13]. Because the 6MWT assesses the submaximal functional exercise capacity, and most of the activities of daily living are performed at submaximal levels of exertion, the 6MWD should correlate well with the SGRQ scores, especially with the scores of the activity domain.

The present study is the first to investigate the correlation between the ISWT and SGRQ. Some investigators reported a correlation between the ISWT and QoL that did not include the SGRQ[18][19]. Mean ISWD was only about 180 m and patients in these studies had less exercise capacity than patients in our study. In our study, when restricted to patients with severe and very severe COPD, mean ISWD was 240 m, and ISWD was significantly correlated with SGRQ activity, impact and total score in these patients. These results suggest that ISWD is correlated with HRQoL in patients with COPD showing decreased exercise capacity.

Ⅴ Limitation

The present study was a retrospective study and there was a different background in the 2 groups. The results showed that the patients in the 6MWT group showed more lung hyperinflation and disturbed gas exchange when compared with the patients in the ISWT group and reduction of HROoL estimated by the SGRQ. This is a limitation of the present study and it is difficult to compare each parameter in the two groups. Therefore, a further prospective study is needed to compare the 6MWT with the ISWT.

Ⅵ Conclusion

It was suggested that the 6MWT may be more reflective of QoL and the ISWT more reflective of lung function in patients with COPD. However, most of the patients were of mild or moderate severity. Furthermore, the background in the 6MWT group and that in the SWT group differed. Further prospective studies which recruit each severity patients of each severity are needed.

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