Gait speed as a functional capacity indicator in patients with chronic obstructive pulmonary disease

Duygu Ilgin, Sevgi Ozalevli, Oguz Kilinci, Can Sevinc1, Arif H Cimrin1, Eyup S Ucan1

Abstract:
AIM: Walking distance is generally accepted as a functional capacity determinant in chronic obstructive pulmonary disease (COPD). However, the use of gait speed in COPD patients has not been directly investigated. Thus, the aim of our study was to assess the use of gait speed as a functional capacity indicator in COPD patients.

METHODS: A total 511 patients with mild-to-very severe COPD and 113 healthy controls were included. The lung functions (pulmonary function test), general health- and disease-related quality of life (Medical Outcomes Study 36-Item Short-Form of Health Survey, St George’s Respiratory Questionnaire), and gait speed (6-minute walk test) were assessed.

RESULTS: The mean gait speed values were slower in moderate (75.7 ± 14.0 m/min), severe (64.3 ± 16.5 m/min), and very severe (60.2 ± 15.5 m/min) COPD patients than controls (81.3 ± 14.3 m/min). There were significant correlations between gait speed and age, dyspnea-leg fatigue severities, pulmonary function test results (FEV1, FVC, FVC%, FEV1/FVC ratio, PEF, PEF%), and all subscores of Medical Outcomes Study 36-Item Short-Form of Health Survey and activity, impact and total subscores of St George’s Respiratory Questionnaire in patients with moderate, severe, and very severe COPD. However, these correlations were higher especially in patients with severe and very severe COPD.

CONCLUSIONS: As a conclusion, according to our results gait speed slows down with increasing COPD severity. Also, gait speed has correlations with age, clinical symptoms, pulmonary functions, and quality of life scores in COPD patients. Thus, we consider that gait speed might be used as a functional capacity indicator, especially for patients with severe and very severe COPD.

Key words:
Chronic obstructive pulmonary disease, gait speed, functional capacity

Chronic obstructive pulmonary disease (COPD) is a major cause of reduced functional status among elderly people.[1] Therefore, evaluation of functional status is an important cornerstone of COPD treatment.[1,2] The determination of walking distance holds great importance among the functional status assessment methods in patients with COPD.[3] Although reduced gait speed has been accepted as a main determinant of disability, age-related subclinical conditions, institutionalization, and mortality in the healthy elderly,[4,5] the importance of gait speed assessment as an outcome measure of functional status in the elderly with chronic lung diseases has been emphasised in only few studies and has not been directly investigated.[7,8] The studies on gait speed have shown that there were apparent deficiencies in comfortable and fast gait speeds in patients with COPD.[9-13] Although the impacts of COPD on functional status occur at different severities according to the disease stage, only patients with severe lung disease have been recruited for these studies.[10-13] Also, the relationship between gait speed and main functional indicators of the disease has not been determined yet. With respect to these studies, the aim of our study was to assess the use of gait speed as a functional outcome parameter in patients with COPD.

Methods
This study assessed the files of 511 patients, who were diagnosed with COPD according to Global Initiative for Obstructive Lung Disease Guideline (GOLD)[17] and met the study inclusion criteria, as a study group and 113 healthy age-matched subjects as a control group. The inclusion criteria included having clinically stable condition in the last 6 weeks (having a standard medical treatment, no supplemental oxygen treatment, and no exacerbation), no participation in any exercise program in the last 1 year, having no neurological, inner ear, cardiac, metabolic or orthopedic disease, having no cognitive problems, being able to ambulate without assistance and/or assistive devices. The files that did not meet inclusion criteria were excluded from the study. The control group subjects were chosen among the relatives of patients, consisted of 113 healthy individuals who had normal pulmonary function, and no history of any medical condition that might affect gait speed.
The study protocol was approved by our university Clinical and Laboratory Research Ethics Committee. The methods to be applied were explained to the control group participants whose written consents and permissions to screen study group patients' files were obtained.

**Study design**

Age, sex, height, body weight, body mass index (BMI), educational status, smoking history, exercise habits, and medication for COPD and control group were recorded. The medical history, respiratory symptoms, pulmonary function test, 6-minute walk test (6MWT), and scores of the St George's Respiratory Questionnaire (SGRQ) and Medical Outcomes Study 36-Item Short-Form of Health Survey (SF-36) were determined from the files of COPD group.

Subjects underwent pulmonary function tests according to the American Thoracic Society (ATS) recommendations (Sensor Medics Vmax 22 spirometer, SensorMedics, Inc, Anaheim, CA, USA) while being on their usual bronchodilator regimen. Forced vital capacity (FVC), forced expiratory volume in one second (FEV1), FEV1/FVC ratio, peak expiratory flow (PEF) values, and their percentages according to the predicted values were recorded.

General health-related quality of life (QoL) was assessed using the SF-36. The SF-36 comprises eight multi-item subscales, which are physical functioning, role limitations due to physical problems, vitality, social functioning, role limitations due to emotional problems, bodily pain, general health, and mental health. Each of the dimensions is scored from 0 to 100, with higher scores indicating better health-related QoL.

The SGRQ was used to assess disease-related quality of life. It contains three sections: Investigating symptoms, activity, and impacts. For each subscale and for the overall questionnaire, scores range from zero (no impairment) to 100 (maximum impairment).

The 6MWT was applied according to ATS criteria. After the test, the distance walked in 6 minutes (6MWD) was recorded for each patient.

### Results

Before and after the 6MWT, peripheral oxygen saturation (SpO2), severity of dyspnea, and leg fatigue were assessed. The severity of dyspnea and leg fatigue were recorded using the Modified Borg Scale (MBS). This is a 10-point scale with a non-linear scaling scheme using descriptive terms to anchor responses from the participants. The SpO2 was recorded for patients in a sitting position using the Pulse Oximeter (Model: MD 300 2 × 1.5V AAA).

Gait speed was determined as m/min and m/sec by dividing distance walked during 6MWT by 6MWT time.

**Statistical analysis**

All analyses were performed using SPSS (version 15.0). It was checked whether data were normally distributed. One-way ANOVA, X2, and Pearson’s correlation analyses were used for determination of group differences and relationship between gait speed and functional outcome parameters, respectively. Post-hoc test (Boferroni) was used to locate differences between groups. *P* < 0.05 value was considered significant.

**Table 1: Demographic and clinical characteristics**

|          | COPD groups (n = 511) | Control group (n = 113) | P      |
|----------|-----------------------|------------------------|--------|
|          | I (n = 67)            | II (n = 246)           | III (n = 153) | IV (n = 45) |        |
| Age (year) | 63.7 ± 10.6           | 67.1 ± 9.5            | 66.0 ± 9.8    | 62.7 ± 8.6  | 61.7 ± 9.9 | <0.001* |
| Height (m)  | 1.7 ± 1.0             | 1.7 ± 0.8             | 1.7 ± 0.8     | 1.7 ± 0.7  | 1.7 ± 0.9  | 0.89    |
| Weight (kg) | 72.2 ± 12.8           | 71.2 ± 11.8           | 70.9 ± 13.6   | 69.0 ± 13.4 | 75.3 ± 12.6 | 0.016*  |
| BMI (Kg/m²) | 25.7 ± 3.8            | 25.6 ± 3.9            | 25.4 ± 4.6    | 25.3 ± 5.0 | 27.2 ± 4.2 | 0.006*  |
| FEV1 (Liter) | 2.5 ± 1.7             | 1.7 ± 0.4             | 1.1 ± 0.3     | 0.7 ± 0.2  | 2.7 ± 0.8  | <0.001* |
| FEV1 (%)    | 90.0 ± 8.4            | 64.0 ± 8.3            | 39.5 ± 5.8    | 25.0 ± 3.2 | 99.3 ± 16.9 | <0.001* |
| FVC (Liter) | 3.9 ± 1.0             | 2.9 ± 0.7             | 2.2 ± 0.6     | 1.6 ± 0.5  | 3.5 ± 1.0  | <0.001* |
| FVC (%)     | 106.8 ± 16.6          | 84.2 ± 11.4           | 61.8 ± 11.5   | 45.0 ± 9.3 | 101.1 ± 15.6 | <0.001* |
| FEV1/FVC (%) | 65.6 ± 3.0            | 59.6 ± 6.4            | 51.2 ± 8.4    | 44.6 ± 8.1 | 78.6 ± 5.1  | <0.001* |
| PEF (Liter/sec) | 6.51 ± 1.83         | 4.96 ± 1.48           | 3.28 ± 1.07   | 2.54 ± 1.35 | 7.13 ± 2.14 | <0.001* |
| PEF (%)     | 86.0 ± 18.4           | 67.6 ± 16.3           | 44.3 ± 12.3   | 32.7 ± 10.8 | 97.8 ± 22.1 | <0.001* |
| Smoking history (packet × years) | 44.0 ± 26.0 | 55.2 ± 31.3 | 57.3 ± 37.0 | 57.8 ± 32.6 | 32.5 ± 17.5 | <0.001* |

Data are presented as mean ± SD. *P* < 0.05; COPD = Chronic obstructive pulmonary disease, BMI = Body mass index, FVC = Forced vital capacity, FEV1 = Forced expiratory volume in one second, PEF = Peak expiratory flow.
and very severe COPD patients had higher dyspnea, leg fatigue severities, and peripheral oxygen desaturation level as compared to mild and moderate COPD patients. Very severe patients had higher dyspnea severity and peripheral oxygen desaturation level than severe COPD patients ($P < 0.001$, [Table 2]).

The values of SF-36 and SGRQ scores tended to be lower in patients with severe and very severe COPD than controls as well as mild and moderate COPD patients [Table 3].

There were significant correlations between gait speed and age, dyspnea, leg fatigue severities, $SpO_2$ value, pulmonary function test results ($FEV_1$, $FVC$, $FVC\%$, $FEV_1/FVC$ ratio, $PEF$, $PEF\%$), all subscores of SF-36, activity, impact, and total subscores of SGRQ in COPD patients. These correlations were particularly higher in severe and very severe COPD patients [Tables 4 and 5].

### Table 2: Results of 6-minute walk test

| COPD groups | Control group | $P$  |
|-------------|---------------|------|
| 6MWD (m)    | 505.2 ± 85.3  | 487.9 ± 85.5 | <0.001* |
| Gait speed (m/min) | 84.2 ± 14.2 | 81.3 ± 14.3 | <0.001* |
| Gait speed (m/sec) | 1.4 ± 0.2 | 1.3 ± 0.2 | <0.001* |
| Dyspnea severity MBS (0-10) | 0.8 ± 1.6 | 0.4 ± 0.1 | <0.001* |
| Leg fatigue severity MBS (0-10) | 0.8 ± 1.6 | 1.3 ± 1.8 | <0.001* |
| $SpO_2$ (%) | −0.1 ± 1.9 | −0.3 ± 2.8 | −0.3 ± 2.2 | <0.001* |

Data are presented as mean ± SD. * = $P < 0.05$; 6MWD = Distance walked in 6 minutes; $SpO_2$ = Peripheral oxygen saturation. Dyspnea, leg fatigue severities, and $SpO_2$ values were given as differences between after and before 6-minute walk test values.

### Table 3: Scores of health-related quality of life questionnaires

| COPD groups | Control group | $P$  |
|-------------|---------------|------|
| The Medical outcomes study 36-item short-form of health survey | | |
| Physical functioning | 24.8 ± 4.5 | 24.9 ± 4.9 | <0.001* |
| Role limitations (physical) | 7.0 ± 1.5 | 6.6 ± 1.7 | <0.001* |
| Bodily pain | 8.7 ± 2.2 | 8.4 ± 2.3 | 0.038* |
| General health | 19.3 ± 4.7 | 19.5 ± 4.3 | <0.001* |
| Vitality | 16.6 ± 4.2 | 16.0 ± 4.4 | <0.001* |
| Social functioning | 8.4 ± 1.8 | 8.2 ± 2.2 | <0.001* |
| Role limitations (emotional) | 5.1 ± 1.2 | 4.8 ± 1.3 | 0.001* |
| Mental health | 21.0 ± 5.0 | 21.4 ± 5.3 | <0.001* |
| The St. George’s respiratory questionnaire | | |
| Symptoms | 34.2 ± 19.4 | 31.0 ± 21.9 | <0.001* |
| Activity | 33.0 ± 24.0 | 37.6 ± 21.1 | <0.001* |
| Impacts | 26.9 ± 18.2 | 19.8 ± 17.8 | 0.014* |
| Total score | 31.2 ± 18.6 | 25.3 ± 18.7 | <0.001* |

Data are presented as mean ± SD. * = $P < 0.05$; COPD = Chronic obstructive pulmonary disease.

### Table 4: Relationship between gait speed and functional outcome parameters

| COPD groups | Control group |
|-------------|---------------|
| Age (years) | $−0.28^*$ | $−0.26^*$ | $−0.57^{***}$ |
| $FEV_1$ (Liter) | 0.34** | 0.31*** | 0.45** | 0.53*** |
| $FVC$ (Liter) | 0.36** | 0.31*** | 0.46*** | 0.53*** |
| $FVC$ (%) | NS | 0.17* | 0.34* | NS |
| $FEV_1/FVC$ (%) | NS | 0.26** | NS | NS |
| $PEF$ (Liter/sec) | 0.31* | 0.32*** | 0.33*** | NS | 0.46*** |
| $PEF$ (%) | NS | 0.18** | 0.17* | 0.45** | 0.34*** |
| Dyspnea severity MBS (0-10) | NS | $−0.37^{***}$ | $−0.41^{***}$ | $−0.34^{***}$ |
| Leg fatigue severity MBS (0-10) | NS | $−0.34^{***}$ | NS | NS |
| $SpO_2$ (%) | NS | $−0.21^{**}$ | $−0.23^{**}$ | NS |

Data are presented as Pearson’s correlation coefficient ($r$). * = $0.05 \geq P > 0.01$; ** = $0.01 \geq P > 0.001$; *** = $P \leq 0.001$; NS = Non-significant; COPD = Chronic obstructive pulmonary disease, BMI = Body mass index, FVC = Forced vital capacity, $FEV_1$ = Forced expiratory volume in one second, $PEF$ = Peak expiratory flow, $SpO_2$ = Peripheral oxygen saturation.
the community.

6MWT might be accepted as a time-based long distance walk if a short distance-based walk test is indicative of functional gait speed test in short physical performance battery, and of survival in COPD patients. Furthermore, 6MWT is well correlated with mortality, and shown to be a better predictor of severe and very severe COPD patients.

In previous studies on gait speed, different gait speed assessment methods, such as 10-m gait speed test, gait speed calculated from 6-minute walk test distance (6MWD), 4-m gait speed test in short physical performance battery, and timed up and go test have been performed. The effect of COPD on gait speed has been also asked using Medical Research Council dyspnea scale and St George’s quality of life questionnaire. In these gait speed assessment methods, short and long walks and comfortable and fast speeds have been used and their effects asked. However, it is not yet known which test provides enough information on functional status.

In our study, we calculated gait speed from 6MWT distance. Because 6MWD is accepted as a surrogate marker of functional capacity in COPD. It is a simple field test, which has also been correlated with mortality, and shown to be a better predictor of survival in COPD patients. Furthermore, 6MWT is well correlated with maximal oxygen consumption and is accepted an indicator of functional capacity in COPD. Also, while a short distance-based walk test is indicative of functional independence within the home, gait speed calculated from 6MWT might be accepted as a time-based long distance walk test showing endurance capacity and independence within the community.

In this study, we aimed to assess the use of gait speed as a functional outcome parameter in COPD patients. We found that gait speed was slower in COPD patients than healthy controls and tended to slow down with increasing COPD severity. Also, gait speed was well correlated with major outcomes in COPD patients, such as age, clinical symptoms, dyspnea and leg fatigue, pulmonary function test results, and health-related QoL scores. These correlations were found to be particularly higher in severe and very severe COPD patients. Therefore, we consider that gait speed might be used as a functional capacity indicator for severe and very severe COPD patients.

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In our study, gait speed values were higher compared to the Menard-Rothe et al.’s study reporting the gait speed in very severe COPD patients. We considered that this difference could be related to the their patients’ supplemental oxygen usage related to their worst clinical status. On the other hand, gait speed in our patients was lower than in Butcher et al.’s study. This could be related to the use of different gait speed assessment methodology. They used 10-m gait speed test as a fast gait speed assessment method. Also, this difference could be related to the their patients’ exercise habits because their study group had been enrolled in the exercise program for at least three times per week during 3 weeks. Moreover, our mean data tended to be slower according to COPD severity. Gait speed values for moderate, severe, and very severe COPD patients decreased 10%, 23.6%, and 28.6%, respectively, of mild COPD patients’ gait speed. For severe and very severe COPD groups, gait speed values were slower than healthy controls and gait speed values reported for healthy subjects over 60 years of age. Studenski et al. reported that individuals who walked less than 67 m/s may be most likely to be limited in the energy needed for self-care and household activities. Thus, we consider that slowing down gait speed values for severe and very severe COPD patients in our study reflects that these patients were limited in self-care and household activities as most important independent functional capacity indicators for the elderly. Thus, we prove that gait speed slows down with increasing disease severity and severe and very severe COPD patients have slower gait speed values than mild-to-moderate COPD patients and healthy controls.

Gait speed has been found to be correlated with major outcomes such as disability, age-related subclinical conditions, institutionalization, and mortality in healthy elderly subjects.[]

### Table 5: The relationship between gait speed and quality of life scores

| COPD groups | Control group |
|-------------|---------------|
| I           | II            | III           | IV            |
| Physical functioning | NS 0.41*** | 0.60*** | 0.72*** | 0.42*** |
| Role limitations (physical) | NS 0.30*** | 0.31*** | 0.50*** | NS |
| Bodily pain | NS 0.23*** | NS 0.33* | 0.40*** |
| General health | NS 0.31*** | 0.36*** | 0.58*** | 0.23* |
| Vitality | NS 0.30*** | 0.41*** | 0.49*** | 0.32*** |
| Social functioning | NS NS 0.49*** | 0.40** |
| Role limitations (emotional) | NS NS 0.25*** | 0.45** |
| Mental Health | NS 0.20** | 0.32*** | 0.38* |
| The St. George’s respiratory questionnaire | |
| Activity | NS −0.40*** | −0.45*** | −0.50* | NS |
| Impact | NS −0.38*** | −0.44*** | −0.56*** |
| Total | NS 0.42*** | −0.49*** | −0.56** |

Data are presented as Pearson’s correlation coefficient (r). * = 0.05 ≥ P > 0.01; ** = 0.01 ≥ P > 0.001; ***P ≤ 0.001; NS = Non-significant

### Discussion

In this study, we aimed to assess the use of gait speed as a functional outcome parameter in COPD patients. We found that gait speed was slower in COPD patients than healthy controls and tended to slow down with increasing COPD severity. Also, gait speed was well correlated with major outcomes in COPD patients, such as age, clinical symptoms, dyspnea and leg fatigue, pulmonary function test results, and health-related QoL scores. These correlations were found to be particularly higher in severe and very severe COPD patients. Therefore, we consider that gait speed might be used as a functional capacity indicator for severe and very severe COPD patients.

In previous studies on gait speed, different gait speed assessment methods, such as 10-m gait speed test, gait speed calculated from 6-minute walk test distance (6MWD), 4-m gait speed test in short physical performance battery, and timed up and go test have been performed. The effect of COPD on gait speed has been also asked using Medical Research Council dyspnea scale and St George’s quality of life questionnaire. In these gait speed assessment methods, short and long walks and comfortable and fast speeds have been used and their effects asked. However, it is not yet known which test provides enough information on functional status.

In our study, we calculated gait speed from 6MWT distance. Because 6MWD is accepted as a surrogate marker of functional capacity in COPD. It is a simple field test, which has also been correlated with mortality, and shown to be a better predictor of survival in COPD patients. Furthermore, 6MWT is well correlated with maximal oxygen consumption and is accepted an indicator of functional capacity in COPD. Also, while a short distance-based walk test is indicative of functional independence within the home, gait speed calculated from 6MWT might be accepted as a time-based long distance walk test showing endurance capacity and independence within the community. Menard-Rothe et al. studied self-selected gait speed in patients with end-stage COPD referred for lung volume reduction surgery or lung transplantation. Gait speed during 6MWT was found to be lower than the speed required for independent community ambulation. Butcher et al. showed a lower fast gait speed in COPD patients treated with supplemental oxygen therapy than healthy controls and COPD patients not requiring supplemental oxygen therapy. Also, Beauchamp et al. reported that standard clinical measure of functional mobility, assessing gait speed with timed up and go test, in patients with COPD were lower in fallers than non-fallers.

In our study, gait speed values were higher compared to the Menard-Rothe et al.’s study reporting the gait speed in very severe COPD patients. We considered that this difference could be related to the their patients’ supplemental oxygen usage related to their worst clinical status. On the other hand, gait speed in our patients was lower than in Butcher et al.’s study. This could be related to the use of different gait speed assessment methodology. They used 10-m gait speed test as a fast gait speed assessment method. Also, this difference could be related to the their patients’ exercise habits because their study group had been enrolled in the exercise program for at least three times per week during 3 weeks. Moreover, our mean data tended to be slower according to COPD severity. Gait speed values for moderate, severe, and very severe COPD patients decreased 10%, 23.6%, and 28.6%, respectively, of mild COPD patients’ gait speed. For severe and very severe COPD groups, gait speed values were slower than healthy controls and gait speed values reported for healthy subjects over 60 years of age. Studenski et al. reported that individuals who walked less than 67 m/s may be most likely to be limited in the energy needed for self-care and household activities.

Thus, we consider that slowing down gait speed values for severe and very severe COPD patients in our study reflects that these patients were limited in self-care and household activities as most important independent functional capacity indicators for the elderly. Thus, we prove that gait speed slows down with increasing disease severity and severe and very severe COPD patients have slower gait speed values than mild-to-moderate COPD patients and healthy controls.

Gait speed has been found to be correlated with major outcomes such as disability, age-related subclinical conditions, institutionalization, and mortality in healthy elderly subjects.
Similarly, we found that gait speed values were correlated with age, clinical symptoms, dyspnea and leg fatigue, pulmonary function test results, and health-related QoL scores in COPD patients.

Cook *et al.* showed that PEF in nonsymptomatic, healthy older adults was significantly correlated with physical performance as measured by fast walking speed.[20] Eisner *et al.* showed that there was an association between pulmonary function impairment (FEV$_1$) and physical functional limitations in COPD patients.[21] Butcher *et al.* found that there were correlations between fast walking speed and FEV$_{1}$, FVC, and PEF values in patients with COPD.[11] In our study, we found correlations between gait speed values and FEV$_{1}$, FVC, FEV$_{1}$/FVC, and PEF values in COPD patients. Also, these correlations were higher in patients with severe and very severe COPD. These results suggest that gait speed may be an important assessment parameter showing alterations in lung functions, which are used to measure disease severity and predict mortality.

Dyspnea is the most common activity-limiting symptom, the primary reason for patients to seek medical attention, and an independent predictor of mortality, in COPD.[20] During clinical assessment process, clinicians ask COPD patients with MRC dyspnea scale “whether they have slower walking speed than healthy age-matched subjects” for determining the effects of dyspnea on walking activity as a simple and main functional activity.[20] However, there are no studies analyzing the potential impact of dyspnea on gait speed. In our study, we determined correlations between gait speed and perceived dyspnea severity in patients with moderate, severe, and very severe COPD. These results proved that gait speed may be a determinant of dyspnea as a most important disease-specific clinical symptom limiting functional status.

Lower limb muscle strength has been determined as a predictor of gait speed test performance in the healthy elderly.[23] Although, it is known that COPD patients have reduced lower limb muscle mass, strength and endurance, its relation with gait speed has not been shown yet. However, for COPD patients it has been reported that perceived leg fatigue levels after the 6MWT could reflect reduced leg muscle performance.[26] According to our results, higher leg fatigue severities in severe and very severe COPD groups and negative correlation between gait speed and leg fatigue severity in moderate COPD group could be related to slower gait speed values in these groups in our study. Thus, we consider that gait speed may represent lower limb muscle dysfunction related to COPD.

In the healthy elderly, physical performance and self-rated health status have been determined as the strongest predictors of mortality.[27] For COPD patients, it has been shown that a relationship between reduced physical capacity and disease-related quality of life assessed by SGRQ.[28] Ketelears *et al.* showed that COPD patients with higher walking distance had less restriction during activities and that the disease had less impact on their daily life.[29] Although walking speed has been assessed indirectly using some questions of functional outcome measures such as MRC dyspnea scale and SGRQ, there were no study directly showing a relationship between walking speed and quality of life for COPD patients. In our study, we found correlations between gait speed and all subscores of SF-36 scale in patients with moderate, severe, and very severe COPD. Also, we determined correlations between activity, impact, and total scores of SGRQ in patients with moderate, severe, and very severe COPD. The relationship between gait speed and quality of life subscores of severe and very severe COPD patients were higher. We suggest that slower gait speed related to increasing disease severity may be an indicator of general health and disease-related QoL in patients with severe, and very severe COPD.

Our study has several limitations. First, in this study, groups were not optimally matched for BMI, age, and gender. These factors might affect gait speed.[19-23] If individuals with and without COPD have to be included, it is very difficult, almost impossible, to match participants for BMI, age, and gender. On an average, controls with the same body length have larger body mass than patients with moderate-to-severe COPD. This implies that it cannot be confirmed that group differences represent different COPD status; group differences might as well be related to differences in relative body mass. Second, subjects in the moderate and severe COPD groups were on the average 3 years younger than participants in other groups. Although effects of age differences between subgroups will theoretically exist, we expect them to be small, and have only a minor effect on the outcome of the study. Lusardi *et al.* and Bohannon *et al.* compared gait speed in different age groups (according to decades). They found differences in gait speed between these different age groups comparable to the differences we found between COPD patients. Also, healthy controls and all COPD groups had negative correlations between age and gait speed. These support our idea that differences between subgroups will not be large enough to affect the results of our study. Third, in our study, there were gender differences between COPD and control groups. Previous studies have reported that men tend to walk farther than women. Although the number of women in our study was higher among controls, and they walked faster than patients with COPD. Therefore, we expect gender may have only a minor affect on the outcome of the study. Fourth, we did not assess the effects of physical activity level on gait speed. The relatively shorter walking distance values for controls according to their health status could be related to lower physical activity level. Finally, we assessed COPD patients, who did not use supplemental oxygen treatment. Thus, our results cannot represent supplemental oxygen treatment effects on gait speed. In addition, we did not assess the effects of corticosteroid treatment, respiratory and peripheral muscle strength, which are considered to be important determinants of disease symptoms and 6MWT results in COPD.[9]

As a conclusion, our results show that gait speed is lower in patients with moderate, severe and very severe COPD than healthy controls, decreases according to increasing disease severity, and has correlations with disease-related main outcome parameters, especially in patients with severe and very severe COPD. Thus, we suggest that gait speed might be used as a functional capacity indicator, especially for patients with severe and very severe COPD. In addition, there is great variation in the methodology of gait speed measurement. This variability makes comparison of gait speed across studies difficult. We used a time-based long walk test to assess
gait speed. However, there were no studies comparing the advantages and disadvantages of the time-based long walk and short distance-based tests to assess gait speed in COPD patients. Further researches, including standardized gait speed assessment methodology, should focus on the determination of normative gait speed data and its relationship between morbidity and mortality rates, and effects of physical activity level and different treatment modalities such as pulmonary rehabilitation programs, exercise training programs, and the use of supplemental oxygen and corticosteroid treatments in COPD.

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