Mechanisms of Improvement in Exercise Capacity Using a Rollator in Patients With COPD*

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Study objective: We analyzed the effects of the use of a rollator on walking distance and physiologic variables: pulmonary gas exchange, heart rate, minute ventilation (Ve), oxygen saturation, and symptoms during the 6-min walk test (6MWT) in patients with COPD.

Setting: Outpatient clinic at university hospital.

Patients: Fourteen patients with COPD in stable clinical condition. One patient had mild COPD, five patients had moderate COPD, six patients had severe COPD, and two patients had very severe COPD.

Interventions: Two 6MWTs were performed with a portable metabolic system (VmaxST 1.0; Viasys Healthcare; MEDA; Aartselaar, Belgium) with a rollator and without a rollator, in random order. In addition, maximal voluntary ventilation (MVV) was measured with and without a rollator, randomly.

Results: The median 6MWT distance increased significantly with a rollator: 416 m without a rollator (interquartile range [IQR], 396 to 435 m), vs 462 m with a rollator (IQR, 424 to 477 m) [p = 0.04]. Significant increases were also seen in oxygen uptake (0.04 L/min [IQR, −0.002 to 0.09 L/min]); tidal volume (0.06 L/min [IQR, −0.001 to 0.11 L/min]); and Ve (0.95 L/min [IQR, −0.67 to 7.1 L/min]), recorded in the last minute of the 6MWT; as well as in MVV (3 L/min [IQR, 0 to 12 L/min]) [p < 0.05 for all]. Borg dyspnea scores tended to be lower with a rollator: 6 (IQR, 4 to 7) without a rollator, vs 5 (IQR, 4 to 7) with a rollator (p = 0.10). The variation in the 6MWT was explained by individual changes in walking efficiency (partial R² = 0.31) and changes in Ve (partial R² = 0.36) [p model < 0.04].

Conclusion: The use of a rollator improves walking distance of patients with COPD through an increased ventilatory capacity and/or better walking efficiency.

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Key words: COPD; exercise capacity; minute ventilation; rollator; walking aid; 6-min walk test

Abbreviations: HR = heart rate; IQR = interquartile range; MVV = maximal voluntary ventilation; PETCO₂ = end-tidal P₉O₂; RR = respiratory rate; SpO₂ = pulse oxygen saturation; Ti/Ttot = ratio between inspiratory time and total cycle time; DLCO = diffusing capacity of the lung for carbon monoxide; Ve = minute ventilation; VO₂ = oxygen uptake; VT = tidal volume; 6MWT = 6-min walking test

Walking is extremely important to be physically active, and is often encouraged as one of the most accessible ways to perform exercise.1 For many elderly and disabled patients, however, the ability to stand and walk without assistance can be compromised by cardiovascular, neurologic, metabolic, and/or musculoskeletal impairments.² In these conditions, walking aids are often prescribed to provide independent living and safe mobility.³ COPD is characterized by airflow obstruction and reduced exercise capacity, and these characteristics

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are associated with symptoms such as dyspnea and fatigue.4 Patients with COPD often report walking slower than people of the same age, having to stop walking to breathe, or not leaving the house because of breathlessness.5 Since patients with COPD experience such severe impairment, wheeled walking aids, especially rollators, are sometimes prescribed to improve functional exercise capacity.6

Studies6–8 investigating the use of wheeled walking aids in patients with COPD consistently showed improved walking distance, alleviated dyspnea, and improved oxygen saturation, especially in the more severely impaired patients. However, the mechanisms to explain these improvements have not been examined. Hence, it remains unclear why some patients benefit more from using a rollator than others. Therefore, the prescription of rollators continues to be empirically driven.

No study has investigated the impact on the cardiopulmonary response to exercise when these devices are used. This, however, may give insight in the mechanisms that explain the improved functional exercise capacity. Therefore, we analyzed the effects of the use of a rollator on walking distance and on physiologic variables: pulmonary gas exchange, heart rate (HR), minute ventilation (VE), pulse oxygen saturation (SpO2), and symptoms during the 6-min walk test (6MWT) in patients with COPD. We hypothesized that the potential mechanisms may be an improved ventilatory capacity, or a reduction in oxygen uptake (VO2) needed to cover a given distance, indicating an improvement in walking efficiency.

Materials and Methods

Patients and Design

Fifteen clinically stable patients with COPD who met the following criteria were studied: (1) no locomotory, neurologic condition, or disability limiting the ability to walk; (2) no need for oxygen supplementation during the 6MWT; (3) familiarity with the 6MWT; and (4) naïveté to the use of walking aids. After the explanation of all procedures, informed consent was obtained. Subjects performed three 6MWTs. The first 6MWT was a practice walk with the rollator (Rollnobil 540; Ortopedia; Kiel, Germany), followed by another two tests in which patients were wearing a portable metabolic system (VmaxST 1.0; Viasys Healthcare; MEDA; Aartselaar, Belgium). In the last two tests, patients walked with a rollator and without a rollator, in random order.

Procedures

6MWT. Patients were instructed how to use the rollator during walking, and performed a practice 6MWT using this device. The height of the handlebars was adjusted at the level of the ulnar styloid process. The arm position was assumed with the elbows flexed at approximately 30°.9 The practice test with the rollator was followed by two other 6MWTs in which patients were breathing through a mask from the portable metabolic system with a rollator and without a rollator. All walking tests were performed in a hospital corridor that was 53 m in length. Patients were asked to cover as much ground as possible within 6 min. The values obtained were referred to normal values by Troosters et al.10 Standardized encouragement11 was given by an experienced physiotherapist who followed patients during walking and also carried a pulse oximeter to assess SpO2. Both dyspnea and fatigue sensation were assessed with a Borg score12 at the end of the tests. The 6MWT is a standardized test,13 and its metabolic requirements in COPD have been described previously.14 In addition, the 6MWT is performed in a long corridor. Hence, frequent turning can be avoided, optimizing the use of the rollator. At least 30 min of rest was ensured between tests. After the calibration of the gas analyzer, a face mask with a dead space of < 30 mL (Hans Rudolph; Kansas City, MO) was placed over the patients’ nose and mouth, and tightly sealed with elastic straps around the head and neck. Patients were able to move freely without discomfort, as the device has a low weight (570 g). Online breath-by-breath calculations of VE, tidal volume (VT), VO2, carbon dioxide production, respiratory rate (RR), end-tidal PCO2 (PETCO2) and the ratio between inspiratory time and total cycle time (VT/TVTOT) were recorded by the portable metabolic system. A similar model of this device has been validated by Frieur et al.15 HR was assessed by a monitor (T31; Polar; Kempele, Finland). All variables were recorded at rest (2 min baseline), during the 6MWT and up to 2 min after each test. Signals from the metabolic system were transmitted during the tests by telemetry to a portable computer (Fujitsu C332 Lifebook; Fujitsu; Espoo, Finland) for on-line inspection of data quality. After the test, stored data were downloaded from the VmaxST 1.0 to ensure complete breath-by-breath data sets, and were analyzed by software (Metasoft Version 1.9.0; SensorMedics; Yorba Linda, CA; from 1998 to 2001). Because a steady state is generally established in the third to fourth minute of the 6MWT,14 VO2, RR, VT/TVTOT, VT, VE, PETCO2, SpO2 and HR recorded in the last minute of the 6MWT were used for further analysis. Walking efficiency was defined as the amount of VO2 needed to cover a given distance, and was calculated as the ratio between VO2 during the last minute of exercise and distance covered during the 6MWT. This variable can increase or decrease by the use of a rollator, and the individual responses in walking efficiency were addressed in the present study.

Pulmonary Function Tests: All patients underwent spirometry with determination of FEV1 and FVC. Spirometry was performed using the pneumotachograph of a constant volume plethysmograph (Vmax Autobox; SensorMedics; Bilthoven, The Netherlands) according to European Respiratory Society recommendations, using the tracing yielding the greatest sum of FVC and FEV1.16 Functional residual capacity and total lung capacity were measured with the constant volume plethysmograph above mentioned. In addition, the diffusing capacity of the lung for carbon monoxide (DLCO) was measured by the single-breath method (V6200 Autosorb; SensorMedics). The results were referred to the predicted values reported by Quanjer et al.16 Two sets of three maximal voluntary ventilation (MVV) maneuvers were performed (Vmax 29C; SensorMedics), one set with and another set without arm support on the rollator, in random order. During the MVV with the rollator, the device remained without brakes. Patients were told to perform the maneuver supporting their arms on the rollator exactly in the same way they did during the walking test. The best of three maneuvers in each MVV set was used for further analysis.
Statistical Analysis

Statistical analysis was performed on the data using the SAS package (SAS Institute; Cary, NC). Nonparametric statistical tests were used in the analysis due to the small sample size. Results are expressed as median (interquartile range [IQR]). A Wilcoxon signed-rank test was used to compare walking distance, VO₂, RR, Te/Ttot, VT, Ve, PETCO₂, MVV, Ve/MVV, Spo₂, HR, Borg scores, walking efficiency, and walking speed in the two testing conditions (without and with a rollator). Multiple stepwise regression analysis was performed with metabolic variables together with baseline lung function to establish the best predictor of the change in the 6MWT. For all comparisons, p < 0.05 was considered statistically significant.

Results

Fifteen patients were screened and tested. One patient was excluded from the analysis, as we failed to measure the physiologic variables during the walking tests due to technical problems. Baseline characteristics of the remaining 14 patients are shown in Table 1. On average, patients showed moderate-to-severe airflow obstruction, normal body mass index, and reduced DLCO. One patient had mild COPD, five patients had moderate COPD, six patients had severe COPD, and two patients had very severe COPD.¹⁷

Walking distance improved significantly with rollator: 416 m (IQR, 396 to 435 m) without a rollator, vs 462 m (IQR, 424 to 477 m) with a rollator (p = 0.04), especially in those patients with low baseline walking distance (Fig 1). As the test has a fixed time (6 min) and none of the patients interrupted it, the increase in distance was due to the higher average walking speed during walking with the rollator: 1.15 m/s (IQR, 1.1 to 1.2 m/s) without a rollator, vs 1.28 m/s (IQR, 1.17 to 1.32 m/s) with a rollator (p = 0.04).

VO₂ was higher in the test with the rollator (Table 2), and this increase was significantly related to the increased walking distance (r = 0.78, p = 0.001) [Fig 2]. The percentage increase in VO₂ was 4% (IQR, −0.3 to 10%) [Fig 3]. Both Ve and MVV increased slightly but consistently with support on the rollator (ΔVe, 0.95 L/min [IQR, −0.67 to 7.1 L/min] and ΔMVV, 3 L/min [IQR, 0 to 12 L/min]) [p < 0.02 for both]. MVV with arm support was significantly higher than MVV without arm support on the rollator (Fig 4). RR remained the same at the end of the 6MWT in the two test conditions (31 breaths/min [IQR, 27 to 34 breaths/min] without a rollator, vs 32 breaths/min [IQR, 25 to 35 breaths/min] with a rollator; p = 0.54), whereas VT at the end of the test with the rollator was significantly higher (0.92 L [IQR, 0.81 to 1.37 L]) without a rollator, vs 0.98 L [IQR, 0.92 to 1.43 L] with a rollator.

Table 1—Baseline Characteristics*  

<table>
<thead>
<tr>
<th>Characteristics</th>
<th>Data</th>
</tr>
</thead>
<tbody>
<tr>
<td>Male/female gender, No.</td>
<td>9/5</td>
</tr>
<tr>
<td>Age, yr</td>
<td>70 (65–76)</td>
</tr>
<tr>
<td>BMI</td>
<td>24.7 (22.5–27)</td>
</tr>
<tr>
<td>FEV₁, % predicted</td>
<td>45 (33–67)</td>
</tr>
<tr>
<td>FEV₁/FVC, %</td>
<td>41 (34–49)</td>
</tr>
<tr>
<td>TLC, % predicted</td>
<td>117 (103–130)</td>
</tr>
<tr>
<td>FRC, % predicted</td>
<td>164 (139–195)</td>
</tr>
<tr>
<td>DLCO, % predicted</td>
<td>54 (42–59)</td>
</tr>
</tbody>
</table>

*Data are presented as median (IQR) unless otherwise indicated. BMI = body mass index; TLC = total lung capacity; FRC = functional residual capacity.

Table 2—Variables With and Without a Rollator*  

<table>
<thead>
<tr>
<th>Variables</th>
<th>With Rollator</th>
<th>Without Rollator</th>
<th>p Value</th>
</tr>
</thead>
<tbody>
<tr>
<td>6MWT, m</td>
<td>416 (396–435)</td>
<td>462 (424–477)</td>
<td>0.04</td>
</tr>
<tr>
<td>VO₂, L/min</td>
<td>0.9 (0.65–1.2)</td>
<td>1.0 (0.85–1.25)</td>
<td>0.049</td>
</tr>
<tr>
<td>RR, breaths/min</td>
<td>31 (27–34)</td>
<td>32 (25–35)</td>
<td>0.54</td>
</tr>
<tr>
<td>Te/Ttot</td>
<td>0.36 (0.35–0.39)</td>
<td>0.38 (0.34–0.41)</td>
<td>0.09</td>
</tr>
<tr>
<td>VT, L</td>
<td>0.92 (0.81–1.37)</td>
<td>0.98 (0.92–1.43)</td>
<td>0.03</td>
</tr>
<tr>
<td>Ve, L/min</td>
<td>30 (28–42)</td>
<td>34 (28–42)</td>
<td>0.008</td>
</tr>
<tr>
<td>PETCO₂, mm Hg</td>
<td>34 (29–41)</td>
<td>33 (30–39)</td>
<td>0.71</td>
</tr>
<tr>
<td>MVV, L/min</td>
<td>55 (36–65)</td>
<td>60 (36–65)</td>
<td>0.001</td>
</tr>
<tr>
<td>Ve/MVV, %</td>
<td>67 (52–73)</td>
<td>68 (56–82)</td>
<td>0.62</td>
</tr>
<tr>
<td>ΔSpO₂, %</td>
<td>-3 (-6 to -1)</td>
<td>-2.5 (-6 to -1)</td>
<td>0.32</td>
</tr>
<tr>
<td>HR, beats/min</td>
<td>114 (101–131)</td>
<td>117 (108–130)</td>
<td>0.29</td>
</tr>
<tr>
<td>Borg dyspnea (0–10)</td>
<td>6 (4–7)</td>
<td>5 (4–7)</td>
<td>0.10</td>
</tr>
<tr>
<td>Borg fatigue (0–10)</td>
<td>5 (3–7)</td>
<td>4 (3–5)</td>
<td>0.061</td>
</tr>
<tr>
<td>Walking efficiency, L/min</td>
<td>12.70 (12.17–12.75)</td>
<td>12.75 (12.26–14.77)</td>
<td>1.0</td>
</tr>
</tbody>
</table>

*Data are presented as median (IQR). Metabolic measurements obtained during walking were those from the last minute of the 6MWT.
†Ratio between the VO₂ during the last minute of exercise and distance covered during the 6MWT.
Despite the increased walking distance and ventilation, patients tended to experience less dyspnea (Borg score) when walking with the rollator: 6 (IQR, 4 to 7) without rollator, vs 5 (IQR, 4 to 7) with rollator (p = 0.10) [Fig 5].

On average, walking efficiency remained the same in both tests. Seven patients showed improvement in their walking efficiency (V̇O₂/m) when using the rollator, while in the seven remaining patients walking efficiency deteriorated.

In a multiple stepwise regression analysis, the individual changes in walking efficiency were responsible for 31% of the change in the 6MWT, while 36% of the variation was determined by changes in V̇E (total R² = 0.67, p < 0.04). There was no relation between these last two variables (r = 0.28, p = 0.31).

**DISCUSSION**

This study confirms that the use of a rollator enables the most impaired patients to increase walking distance. In addition, this is the first study to show that the variation in walking distance was explained by changes in ventilatory capacity and/or walking efficiency.
The magnitude of the overall increase in walking distance is in accordance with previous findings.\textsuperscript{6–8} In our study, patients showed a median increase in the 6MWT of 27 m when using the rollator. This improvement slightly exceeds the weighted average of 19 m across the studies\textsuperscript{6–8} reported in the literature.

The ability to walk further or to experience less dyspnea when walking the same distance is considered an improvement in functional capacity.\textsuperscript{18} In our study, patients achieved such improvement as they walked further and, yet, tended to experience less dyspnea when using the rollator. These results are consistent with previous findings.\textsuperscript{6–8}

Ventilation increased when patients walked with the rollator. This increase is in contrast to the observations of Grant and Capel,\textsuperscript{19} who reported no difference in ventilation in five patients with COPD who walked with a wheeled walking aid. However, Grant and Capel\textsuperscript{19} used a nontimed walking test, allowing an increase in walking duration. In the latter study, patients had a lower walking speed with the walking aid, explaining why \( V_{\text{E}} \) did not increase. This finding is in contrast with our study, in which patients had a higher walking speed with the rollator during the timed (6 min) walking test, requiring higher values of \( V_{\text{O}_2} \). This is confirmed by the significant relation between changes in 6MWT and changes in \( V_{\text{O}_2} \) (Fig 2) and hence \( V_{\text{E}} \). The improvement in exercise endurance was not addressed in the current study.

Patients also increased the MVV when supporting their arms on the rollator. This increased ventilatory capacity when using the rollator allowed patients to walk faster with higher \( V_{\text{O}_2} \) levels without changing the \( V_{\text{E}}/\text{MVV} \) ratio. Indeed, patients showed an increase in \( V_{\text{O}_2} \), which was associated with the higher walking distance (Fig 2). The increase in both \( V_{\text{E}} \) and MVV may have occurred due to the position patients adopted when using the rollator. By bracing their arms on the rollator, patients can adopt the “forward-lean” position, commonly used by patients with COPD to relief dyspnea. This position has been reported to improve diaphragm function and, therefore, increase ventilatory capacity.\textsuperscript{20,21} Furthermore, Banzett et al\textsuperscript{22} showed that normal subjects are able to increase ventilatory capacity by bracing their arms. Likewise, patients with COPD may improve accessory muscle function by adopting the same position, allowing these muscles to be engaged in respiratory activities.

Despite the increased \( V_{\text{E}} \), patients tended to show a reduction in the dyspnea sensation when walking with the rollator. Dyspnea is influenced by different factors, and there are different possibilities that might have contributed to the tendency of reduction in dyspnea.

First, the forward-lean position could have been more favorable to respiratory muscles, increasing their maximal force generating capacity and, consequently, contributing to reduce the dyspnea sensation.\textsuperscript{22} O’Neill and McCarthy\textsuperscript{23} reported higher maximum inspiratory pressures when patients adopted the leaning-forward position and they associated this increase with the improved length-tension relationship of the diaphragm. Maximal respiratory pressures, however, were not assessed in our study. Second, a lower \( V_{\text{E}}/\text{MVV} \) ratio may have contributed to less dyspnea sensation. However, there was no difference in this ratio in the two testing conditions, as both \( V_{\text{E}} \) and MVV increased with the rollator. In addition, no correlation was observed between changes in \( V_{\text{E}}/\text{MVV} \) and changes in dyspnea.

Finally, emotional aspects could also have played a role, since it is known that anxious patients with COPD can experience more dyspnea than others when performing the same amount of work.\textsuperscript{8} Thus, the use of a rollator may have provided patients more confidence and security, resulting in lower dyspnea scores. Nevertheless, our relatively small sample size hinders the present study to address changes in dyspnea sensation when using a rollator. Although reduction and maintenance of the same Borg scores with higher walking distances were observed when patients used the rollator, this study did not have enough power to ascertain a difference in the Borg score.

When searching for the variables responsible for the variation in the 6MWT in individual patients, our regression model revealed that changes in \( V_{\text{E}} \) and changes in walking efficiency were the major contributors. Our data show that, besides the improvement in \( V_{\text{E}} \), the use of a rollator has also affected walking efficiency. Both deterioration and improvement in walking efficiency were observed in the present study. Walking efficiency may deteriorate, \( eg \), if a patient needs additional \( V_{\text{O}_2} \) to push the rollator. Alternatively, walking efficiency improves, \( eg \), if part of the body weight is “transferred” to the rollator. It has been shown that the use of a wheeled walker can increase stride length and walking speed in elderly subjects.\textsuperscript{24} Indeed, the rollator may have provided our patients with a feeling of security and stability, allowing increase in stride length and walking speed. This allows patients to walk faster with the same \( V_{\text{O}_2} \).

A potential limitation of the present study is that patients receiving oxygen supplementation did not participate in this trial. This is due to the limitation of the equipment to measure \( V_{\text{O}_2} \) while breathing high inspiratory oxygen fractions. Patients receiving oxygen supplementation are often severely physically impaired; according to Solway et al\textsuperscript{8} and our own results, the most disabled patients are the ones who benefit most from the use of a rollator. Thus, patients receiving oxygen
supplementation can also improve walking distance with the use of the rollator. The mechanisms of improvement in these patients are likely to be similar to the ones found in the present study.

Another point not investigated was the effect of the rollator on the time patients can continue to walk with the device without stopping. This kind of approach was not feasible in the present study, since we chose to use the 6MWT, a timed walking test, to assess exercise capacity. Rollators might allow patients to sustain walking for longer periods,8,19 providing additional benefit in daily life.

**Clinical Application**

The results of the present study show that patients with COPD do benefit from the use of a rollator, as they are able to increase ventilatory capacity and walk faster when using this device. As these patients often show impaired functional capacity,8 it can be ensured that a rollator, a device with a relatively low cost, could contribute to keep these patients more active and independent. The present study also supports the use of arm support in the context of pulmonary rehabilitation programs, especially in those in which walking is one of the exercise modalities applied. The use of arm support during walking allows patients to train at a higher walking speed, and may result in larger improvements in exercise capacity. Since patients, overall, do improve their ventilatory capacity when using a rollator, our data suggest that detailed analysis of walking efficiency should be done before prescribing these devices to patients in order to select the patients who can benefit most. Specific coaching should be provided in order to maximally increase walking efficiency when using the rollator. In conclusion, the use of a rollator improves walking distance of patients with COPD through an increased ventilatory capacity and/or better walking efficiency.

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