Prim Care Respir J 2011; **20**(4): 434-440

Primary Care RESPIRATORY JOURNAL
www.thepcrj.org

RESEARCH PAPER

Measuring walking speed in COPD: test-retest reliability of the 30-metre walk test and comparison with the 6-minute walk test

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Received 25th March 2011; revised 8th June 2011; accepted 27th June 2011; online 21st September 2011

Abstract

Aims: To examine test-retest reliability of the 30-metre walk test (30mWT) in patients with chronic obstructive pulmonary disease (COPD) and to compare the 30mWT with the 6-minute walk test (6MWT).

Methods: Forty-nine subjects with stable COPD were included. The 30mWT consists of walking at different walking intensities over a distance of 30 metres – self-selected speed (ss-30mWT) and maximal speed (ms-30mWT). The test was conducted twice and the time to walk 30 metres was recorded. The 6MWT was performed in duplicate on the same day.

Results: Test-retest reliability was high: intraclass correlation coefficient ($ICC_{2.1}$) = 0.93 (95% CI 0.87 to 0.97) for maximal walking speed and 0.87 (95% CI 0.78 to 0.93) for self-selected walking speed. Both maximal and self-selected speed had a standard error of measurement (SEM) of 0.07 m/s and SEM% was 4.4 for maximal speed and 5.9 for self-selected speed. The correlation, criterion validity, between ms-30mWT and the 6MWT was r=0.78 ($p<0.001$). Heart rate, dyspnoea, exertion and oxygen saturation were more affected after the 6MWT than after the 30mWT ($p<0.001$).

Conclusions: The 30mWT is a reliable submaximal test that is easy to perform and can be used to measure physical function (walking ability) in patients with COPD. It may be well suited for primary care settings.

M Andersson, *et al*. *Prim Care Respir J* 2011; **20**(4): 434-440
http://dx.doi.org/10.4104/pcrj.2011.00082

Keywords COPD, primary care, rehabilitation, 30-metre walk test, 6-minute walk test, reliability

Introduction

Chronic obstructive pulmonary disease (COPD) is primarily a lung disease, but it has extrapulmonary effects that contribute to the severity of the disease.[1] In addition to airflow limitation, extrapulmonary effects such as systemic inflammation, muscle deconditioning and malnutrition contribute to reduced exercise capacity.[2] In patients with severe COPD, a decline in walking distance is a stronger predictor of mortality than lung function and occurs independently of change in lung function.[3,4]

Cardiopulmonary exercise testing (CPET), conducted on a bicycle or treadmill, is considered the gold standard for investigating a person's exercise intolerance and determining exercise capacity.[5] Although this form of testing is accurate in determining physiological components, it is less reliable for emulating the patient's function in everyday life. Furthermore, CPET is expensive and complex, and only available in specialised clinics. The results from ventilatory and metabolic responses during cycling and walking[6] indicate that the information obtained during cycling may not reflect daily activities. The capacity for undertaking physically demanding activities in daily life might therefore be better reflected by a walk test.[7-9]

To overcome the need for expensive and sophisticated equipment, several field tests have been developed. The 6-minute walk test (6MWT),[8,9] incremental shuttle walk test (ISWT),[10] and endurance shuttle walk test (ESWT)[11] are common tests for measuring functional capacity in patients with COPD.

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Although field tests are easy to perform, there is still resistance in clinical implementation probably due to lack of time or hesitation to subject patients to physically demanding tests. The time needed to perform the 6MWT is calculated to be 90 mins (15 mins for test 1, 60 mins rest, 15 mins for test 2).[9]

The 30-metre walk test (30mWT) is used to assess muscle performance of the lower extremities and walking ability in older subjects,[12] in patients with hemiparesis after stroke,[13] and in those with multiple sclerosis.[14] The outcome measure is walking speed derived from the time patients take to cover a distance of 30 metres. The ability to walk short distances and to increase walking speed from a self-selected speed is a skill needed in everyday life situations such as crossing a street intersection safely. The 30mWT takes approximately 15 mins to perform, is not as physically demanding, and could therefore be easier to implement in clinical practice. Although the 30mWT has been used as an outcome measure in patients with COPD,[15] there is limited information regarding its use in this group.

The aim of this study was to examine test-retest reliability of the 30mWT in patients with COPD and to compare the 30mWT with the 6MWT.

Methods

Subjects

Fifty-five patients with stable COPD (forced expiratory volume in 1 second/forced vital capacity (FEV_1/FVC) <0.70) who were able to perform the walk tests were invited to participate in the study. They were recruited from a register of patients who had had previous contact with the research unit or pulmonary unit at the Uppsala University hospital in Uppsala, Sweden (n=27) and from Sahlgrenska University Hospital in Gothenburg, Sweden (n=28). Four declined due to health reasons and two due to change of residence. The study was approved by the regional ethical board, Gothenburg, Sweden and informed consent was obtained from the subjects.

Background data

Data on age, gender, number of years with diagnoses of COPD, and smoking history were collected by interview and checked in the medical records. Height (cm) and body weight (kg) were measured and body mass index (kg/m^2) was calculated.

Spirometry

Post-bronchodilator lung function was assessed by dynamic spirometry (Jaeger MasterScope, Viasys Healthcare, Hoechberg, Germany). FEV_1 and FVC were measured according to guidelines.[16] Predicted values according to European Community for Coal and Steel were used.[17]

30mWT

The subjects walked 30 metres in a quiet corridor wearing comfortable shoes. The test consisted of two parts. First, subjects walked at a self-selected (i.e. preferred) walking speed (ss-30mWT) then, after 2 mins of rest, they walked the 30 metres at maximum walking speed (ms-30mWT). The main outcome was walking speed (metres/second, m/s) at self-selected and maximal walking intensities.

6MWT

The 6MWT test was performed according to ATS guidelines[9] and conducted along a quiet 30-metre corridor. The outcome was distance (metres) covered in 6 mins. The test was performed in duplicate the same day. Twelve subjects from Gothenburg did not perform the 6MWT as the study originally started as a test-retest study of the 30mWT but later expanded to a comparison with the 6MWT. There were no significant differences between patients who did or did not perform the 6MWT.

Procedures

At the first visit, subjects performed the ss-30mWT and, after 2 mins rest, the ms-30mWT. The start and finish point for the 30-metre distance was marked with tape stripes and cones on the floor and was visible to both test leader and subject. To assure timing was accurate, the subject was instructed to start by countdown from the test leader and the recording started when the subject's foot passed the starting line and ended when the foot touched the floor after crossing the 30-metre line. Self-selected speed was explained as the walking speed that was normally used and preferred, and the maximal speed was the fastest walking speed subjects could manage without running. After 10 mins rest the first 6MWT was conducted, followed by 45-60 mins of rest and then the second 6MWT.

At the second visit, after 7–14 days and at the same time of the day, the 30mWT was retested.

Before the start and immediately after all tests, subjects rated their breathlessness according to the Borg CR-10[18] and exertion according to the Borg-RPE.[18] Oxygen saturation and heart rate were measured by hand-held pulsoximetry (TuffSat, GE Healthcare, Chalfont St Giles, UK).

Statistical analysis

Data were analysed with IBM SPSS statistics Version 18.0. The correlation between the test and retest was calculated by intraclass correlation coefficient (ICC) with 95% confidence intervals (95% CI). The ICC chosen was of single measures and absolute agreement with random effect ($ICC_{2.1}$).[19] Measurement variability was investigated by calculating the standard error of measurement (SEM) and corresponding 95% CI. SEM is presented in the same unit as the original measurement (i.e. m/s) whereas percentage SEM (SEM%) is independent of the unit of measurement and allows comparison with other tests. To examine if a significant ($p<0.05$) systematic bias existed between the test and retest, paired t tests were used and Bland-Altman plots with limits of agreement were constructed. The upper and lower limits of agreement were calculated by taking the standard deviation (SD) of the mean difference between tests (d) ± 1.96, respectively. The correlation between walking speed in the 30mWT and the distance walked in the best 6MWT was

Table 1. Demographic data, lung function and smoking history

	Total (n=47)	Male (n=16)	Female (n=31)	p-value
Age (years)	67±8	68±8	67±7	0.60
BMI (kg/m²)	25±6	30±6	23±5	0.001
FEV_1 (L)	1.20±0.49	1.50±0.50	1.05±0.41	0.005
FEV_1 (% predicted)	46±17	46±14	46±19	0.84
FVC (L)	2.77±0.85	3.55±0.95	2.42±0.55	0.0001
FVC (% predicted)	83±22	80±21	85±23	0.45
Pack years (years)	36±20	46±26	31±13	0.06

Values shown are mean±SD.

BMI=body mass index; FEV_1=forced expiratory volume in 1 second; FEV_1 (% predicted)=predicted FEV_1 in percent; FVC=forced expiratory volume; pack years=(number of cigarettes/day x years smoking)/number of cigarettes/pack

Table 2. Reliability of the 30-metre walk test (30mWT) and the 6-minute walk test (6MWT)

Test	$ICC_{2.1}$ (95%CI)	d (95% CI)	SEM	SEM%
ss-30mWT (m/s)	0.87 (0.78 to 0.93)	0.01 (–0.40 to 0.43)	0.07	5.9
ms-30mWT (m/s)	0.93 (0.87 to 0.97)	0.04 (–0.40 to 0.49)	0.07	4.4
6MWT (m)	0.94 (0.75 to 0.98)	22 (14.0 to 30.6)	20.01	4.7

ss-30mWT=self-selected walking speed over 30 metres; ms-30mWT=maximal walking speed over 30 metres; 6MWT=6 minute walking test; $ICC_{2.1}$=intraclass correlation coefficient; CI=confidence interval; d=mean difference between occasions; SEM=standard error of measurement; SEM%=standard error of measurement expressed as a percentage.

Table 3. Walking speeds and distances in the tests

Test	Test 1 Mean ± SD	Min–max	Test 2 Mean ± SD	Min–max
ss-30mWT (m/s)	1.14±0.20	0.76–1.54	1.15±0.18	0.79–1.50
ms-30mWT (m/s)	1.55±0.28	1.07–2.14	1.60±0.30	1.02–2.31
6MWT (m)	413±99	215–608	435±104	186–634

ss-30mWT=self-selected walking speed in 30-metre walk test; ms-30mWT=maximal walking speed in 30-metre walk test; 6MWT=6-minute walk test.

Table 4. Correlation between the two 30mWT intensities and the best 6MWD

Subjects	ss-30mWT to best 6MWT		ms-30mWT to best 6MWT	
	Test 1	Test 2	Test 1	Test 2
Total (n=35)	0.73	0.73	0.79	0.78
Women (n=23)	0.72	0.70	0.79	0.78
Men (n=12)	0.82	0.82	0.81	0.81

ss-30mWT=self-selected walking speed 30-metre walk test; ms-30mWT=maximal walking speed 30-metre walk test; 6MWT=6-minute walk test.
All coefficients are significant (p<0.001).

calculated by Pearson's r. The Mann-Whitney test and Wilcoxon test were used to analyse non-parametric data. The impact of gender on walking speed was calculated by repeated measures ANOVA. To maintain a significance level of 0.05 given multiple analyses, the Bonferroni method was used. All presented significant p values remained significant after correction.

Results

Demographic data are presented in Table 1. Two subjects were excluded as they did not attend the retests. The mean age was 67 years and mean FEV_1 percent predicted was 46%. The mean time since COPD diagnosis was 8 years (range 0.5–24.0).

Test-retest

The test-retest reliability for the 30mWT had excellent agreement with narrow CIs: $ICC_{2.1}$ 0.93 (95% CI 0.87 to 0.97) for maximal speed and 0.87 (95% CI 0.78 to 0.93) for self-selected speed (Table 2). SEM was 0.07 m/s for both maximal and self-selected speeds, and percentage measurement variability (SEM%) was <6 at both speeds. In the 6MWT, the $ICC_{2.1}$ was 0.94 (95% CI 0.75 to 0.98) and SEM% 4.7 (Table 2).

An improvement between the test and retest for 30mWT was seen only at maximal speed (p=0.004) with a mean increase of 0.05 m/s (2.9%) (Table 3). The mean difference between the test occasions at the self-selected speed was 0.01 m/s with limits of agreement of –0.20 to 0.17 (Figure 1A), and at maximal speed was 0.04 m/s with limits of agreement of –0.24 to 0.15 m/s (Figure 1B). The increased speed was not explained by gender (p=0.29).

In the 6MWT, the mean improvement in walking distance between tests was 22 m (5.8%; p<0.001) with no gender differences (p=0.53; Table 3). The mean walking distance in the best 6MWT was 438±99 metres (77% of predicted 6-minute walk distance, 6MWD)[20] with no difference between men and women (p=0.09).

Comparison between 30mWT and 6MWT

A high correlation was found between distance walked in the 6MWT and walking speed in the 30mWT (r= 0.78 (maximal speed) and r= 0.73 (self-selected), Table 4). A linear regression model of ms-30mWT (independent variable) and walking distance (dependent variable) was used to form an equation for estimating walking distance based on speed in the ms-30mWT; $6MWD_{predicted}$ = –30.9 + (294.9 x walking speed in ms-30mWT) (Figure 2).

Test response

The self-selected and maximal 30mWTs resulted in only a

Figure 1. Bland-Altman plots for (A) self-selected 30-metre walk test (ss-30mWT) and (B) maximal speed 30-metre walk test (ms-30mWT). The difference between the first test and retest are plotted against the mean between the first test and retest. Mean difference (unbroken line) and 95% CI (dotted lines) and upper and lower limits of agreement (dashed lines) are shown

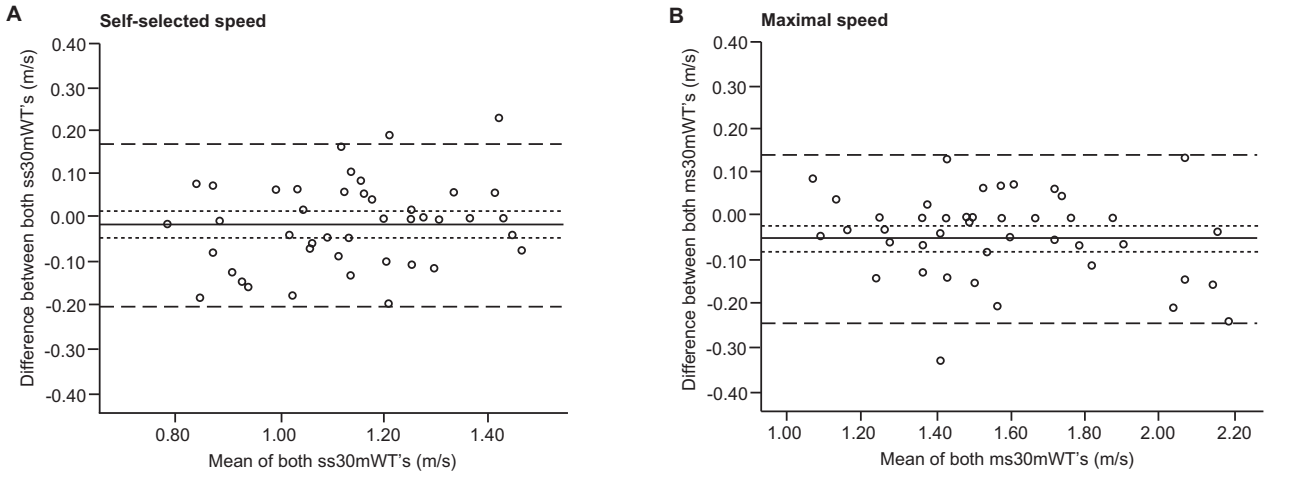

Figure 2. Best 6-minute walk test (6MWT) plotted against the maximal walking speed in the first 30-metre walk test (30mWT). r represents the Pearson correlation coefficient

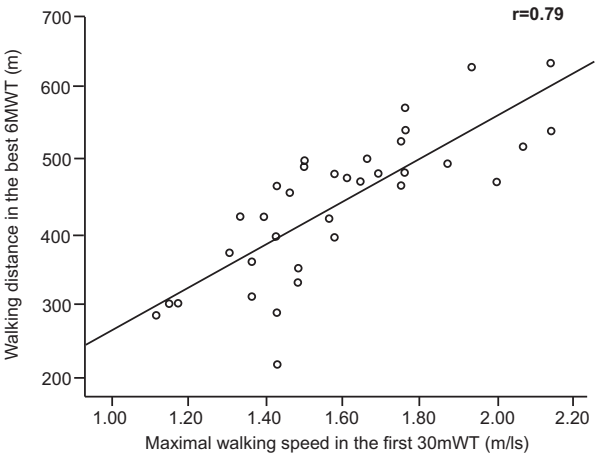

Table 5. Test responses for the second ms-30mWT and the best of two 6MWTs, median (minimum-maximum)

	ms-30mWT (n=47)		6MWT (n=35)	
	Before	After	Before	After
Heart rate (bpm)	83 (57–120)	96 (68–130)	84 (55–107)	109 (77–148)**
Oxygen saturation (%)	95 (85–98)	94 (85–98)	95 (87–98)	88 (65–96)**
Breathlessness (0–10)	0 (0–6)	2 (0–6)	0.5 (0–4)	5 (0–10)**
Perceived exertion (6–20)	6 (0–14)	9 (6–15)	7 (6–13)	14 (6–19)**

Breathlessness determined according to the Borg CR-10 scale.
Perceived exertion determined according to the Borg RPE scale.
**p<0.001 for 'after' values between tests.
ms-30mWT=maximal speed 30-metre walk test; 6MWT=6-minute walk test.

small increase in heart rate and marginally increased exertion and breathlessness (Table 5), whereas the 6MWT resulted in significantly higher heart rates, exertion, breathlessness, and a significant decrease in oxygen saturation.

Discussion

The 30mWT is reliable at both self-selected and maximal speeds and was well tolerated by the subjects. Walking speed over 30 metres correlated well with the distance walked in 6 mins, but is less time-consuming and less strenuous to perform for COPD patients than the 6MWT.

The mean walking speed in the self-selected 30mWT was 1.15 m/s and the mean maximal walking speed was 1.60 m/s. These values are in accordance with results from a pilot study of resistance training in a group of patients with COPD where the corresponding mean values were 1.18 m/s for ss-30mWT and 1.55 m/s for ms-30mWT.[15] Reference values for healthy Swedish people aged 40–79 years are 1.16–1.47 m/s for ss-30mWT and 1.64–2.51 m/s for ms-30mWT.[21] Thus, both self-selected and maximal speeds were lower in our COPD patients. A decreased walking speed was reported by Pitta *et al*.[7] who quantified locomotion in daily life with an accelerometer and found a 25% lower walking speed in patients with COPD than in healthy controls.

In the externally-paced ISWT, walking distance is the main outcome but walking speed can be calculated.[10] The maximal

walking speed at the end of the ISWT varied between 1.01 and 1.52 m/s in different studies.[22-34] These values are lower than ours, probably because of the longer distance walked during the test.

A reduced walking speed predicts mortality and identifies elderly people at risk of adverse health outcomes.[35,36] Although walking speed is seldom measured in COPD, clinicians often ask about walking speed when using the Modified Medical Research Council (MMRC) scale.[37] Both the second and third levels (0–4 levels) deal with walking speed: "Troubled by shortness of breath when hurrying on the level or walking up a slight hill" or "walks slower than people of the same age on the level because of breathlessness or has to stop for breath when walking at own pace on the level". Asking patients about their physical function is not as reliable as measuring it.

Walking ability – as measured by walking distance in a fixed time or externally paced tests – is an important and widely used means of evaluating prognosis, interventions, or to follow the impact of disease in patients with COPD.[38] A walking distance of <350 metres predicts mortality,[39] which would be equivalent to a walking speed of 1.0 m/s. One reason for the interest in measuring walking ability is that walking is a common physical activity that is shared by both patients and healthy individuals and reference values are available.[20,21,40] Walking is a complex activity requiring strength, balance, and timing. If any of these parameters is reduced there is potential for decreased walking speed. In patients with COPD, irrespective of disease severity or level of dyspnoea, muscle wasting and reduction in quadriceps strength are documented.[41,42] Furthermore, balance is impaired and falling is common in patients with moderate and severe COPD.[43] This is unfortunate as osteoporosis is a common co-morbidity in COPD. It has also been shown that there is an increased risk of hip fractures, loss of independence, and mortality in COPD patients with osteoporosis.[44]

The walking speed of the 30mWT correlated well with the distance walked in the 6MWT, both at self-selected (r=0.73) and maximal speed (r=0.79), indicating good criterion validity. A criterion validity >0.70 is desirable.[45] The 6MWT is regarded as a good measure of physical function in daily life and, in the light of our results, the 30mWT might be used as a measure of physical function in patients with COPD. One benefit of the 30mWT, other than the time to perform the test, is the low demand on the patient. There were small changes in heart rate, dyspnoea, exertion, and oxygen saturation during the tests, so all patients might be able to perform it. From the reference equation we propose, the walking speed from the ms-30mWT can be used to calculate the 6MWD which, for most clinicians, is a well-known unit. On the other hand, the 30mWT did not identify patients who desaturate during physical activity and, if this is to be evaluated, the 6MWT would be preferable.[46] The decision as to the type of test to use should be based on the clinical question in hand – to screen for impaired physical function or to investigate possible reasons for it. In the first scenario the 30mWT would be an adequate option while, in the latter, the 6MWT might be more appropriate since it provokes the cardiopulmonary systems to a higher degree. The best test to identify physiological limitations is still CPET.

In this study the mean walking speed increased by 0.01 m/s (1.9%, p=0.338) for self-selected speed and by 0.05 m/s (2.9%, p=0.004) for maximal speed. Although statistically significant for the maximal speed, the increase is probably not clinically significant and/or even perceptible to the patient. The mean distance walked in the 6MWT increased by 22 metres (5.8%, p<0.001) in accordance with results from other studies,[47-49] and the improvement between tests has been explained as a learning effect and/or due to motivational aspects in subjects.[47-49] Since walking 30 metres is probably a more familiar task for patients than walking for 6 mins, the learning effect might be smaller.

Reliability is a concept comprised of different properties – agreement between ratings, systematic changes in the mean, and measurement error, are recognised as important aspects of a reliability study[50] – and ICC values >0.75 indicate excellent reliability.[19] The ICC results of 0.93 (maximal speed) and 0.87 (self-selected speed) were similar to those in a study evaluating gait performance tests in post-stroke patients.[51] Our SEM% values of 5.9 (self-selected speed) and 4.4 (maximal speed) are also in accordance with previous results with regard to comfortable walking (SEM% = 7.9) and fast walking (SEM% = 5.7), indicating that the measurement error in short walking tests is low. The 6MWT displayed similar values in the present study ($ICC_{2.1}$ of 0.94 and SEM% of 4.7), indicating that the measurement error of the two tests is of similar magnitude. The high test-retest correlation (ICC) with narrow CIs, small SEM and SEM%, small mean difference between tests (d) and narrow limits of agreement all indicate that the 30mWT is a reliable test for patients with COPD.

Limitations of our study are the relatively small number of participants, a skewed gender distribution, and a possible bias in the selection process as our patients were recruited from specialist pulmonary clinics. The manual timing in the walking tests might have been inaccurate despite the use of a standardised test protocol, and different testers could also be a possible source of inaccuracy. In the present study only two tests were performed but, as a systematic increase in maximal speed was observed, a third investigation may have determined if a plateau had been reached. An inter-day variability in performance is also a factor that is hard to control, but efforts were made to minimise this variability by conducting the 30mWT retest at approximately the same time of day.

In conclusion, this study shows that the 30mWT is reliable and safe for patients with COPD, and walking speeds over 30 metres correlate well with the distance walked in 6 mins. The ability to walk a short distance and to be able to increase walking

speed may be more useful for patients in everyday life than the ability to walk for 6 mins. The 30mWT might be a suitable test for measuring physical function in patients with COPD in primary care. Further studies investigating the effect of an intervention on walking speed are desirable. Studies investigating the degree to which morbidity and mortality can be predicted from the 30mWT are also needed.

Handling editor
Anthony D'Urzo

Statistical review
Gopal Netuveli

Acknowledgements
We would like to acknowledge the assistance of Professor Christer Janson at Uppsala University and Professor Sven Larsson at University of Gothenburg, Sweden for their valuable comments in the process of revising the manuscript, and physiotherapy students Eva Jansson, Jennie Persson, Karin Vemhäll and Mari Troeng for their assistance in data collection in Uppsala.

Conflicts of interest
The authors declare that they have no conflicts of interest in relation to this article.

Contributorship
MA recruited participants in Uppsala, wrote the manuscript, and together with US and ME was responsible for data analysis strategies. LM recruited subjects and collected data in Gothenburg. US designed and initiated the study in collaboration with ME. AS and HJ participated in designing the experiment and collecting data in Uppsala. Furthermore, all authors contributed in revising the manuscript.

Funding
This work was supported by the Swedish Heart and Lung Association, Stockholm, and the Swedish Heart Lung Foundation, Stockholm.

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