# A pragmatic assessment of the placement of oxygen when given for exercise induced dyspnoea

J W W Killen, P A Corris

**Abstract**

*Background*—It is uncertain whether patients with chronic obstructive pulmonary disease (COPD) given oxygen for symptom relief should be advised to use it before or after exertion.

*Methods*—Eighteen patients with smoking related COPD who desaturated on exercise were given oxygen or air from a cylinder in a single blind manner and in an order determined by Latin square randomisation, before and after ascending stairs. The time of ascent, desaturation, and dyspnoea associated with the ascent was compared across the treatment groups.

*Results*—Oxygen given before or after the ascent reduced maximal dyspnoea from 49.1 mm (95% CI 35.5 to 62.7) to 41.7 mm (95% CI 34.3 to 49.1) of a 100 mm visual analogue scale, reduced desaturation (oxygen before 4.9% (95% CI 3.6 to 6.2), oxygen after 6.4% (5.3 to 7.5), air before and after 8.2% (6.7 to 9.7%)), but did not affect time of ascent (air before: 5.1 s (95% CI 3.4 to 6.9) reduction from training ascent; oxygen before: 6.1 s (95% CI 2.9 to 9.2) reduction).

*Conclusions*—Oxygen prescribed for symptomatic relief of dyspnoea benefits selected patients with COPD, but it seems not to matter whether it is taken before or after exertion.

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**Department of Respiratory Medicine, Freeman Hospital, High Heaton, Newcastle upon Tyne NE7 7DN, UK**
J W W Killen
P A Corris

Correspondence to:
Dr J W W Killen,
Department of Medicine,
Queen Elizabeth Hospital,
Gateshead, Tyne and Wear
NE9 6SX, UK
email:
jeremy.killen@exchange.
gatesh-tr.northy.nhs.uk

'*Half way up the stairs*
*Isn't up,*
*And isn't down*.'[1]

Whilst the provision of long term oxygen therapy in patients who are hypoxic at rest has been shown to alter prognosis,[2 3] the place of oxygen therapy as a symptom reliever in patients with chronic airflow obstruction remains a matter for debate. Oxygen delivery systems for use during exercise have been extensively evaluated[4 5] but still have the reputation of being heavy and inconvenient.[6] Oxygen cylinders are prescribed for the relief of episodic short lived dyspnoea in patients with chronic obstructive pulmonary disease (COPD), but there is little evidence to support or refute this practice.[7] There is no evidence to guide doctors as to which patients might benefit, nor to guide patients how to best use the oxygen prescribed.

We therefore designed a pragmatic assessment of benefit from oxygen for exercise induced dyspnoea. Dyspnoea was induced by the ascent of stairs, a common problem for our patients, and the intervention was air or oxygen delivered from a cylinder at 2 l/min before and after ascending stairs. Our aims were to assess whether our patients benefited from oxygen when blinded to what they were receiving, and therefore whether they should be advised to take oxygen before or after exertion.

## Methods

Subjects were selected from hospital attenders at a teaching hospital who had COPD predominantly related to cigarette smoking and who were being considered for symptomatic oxygen therapy. They all had stairs at home and found ascending these produced severe dyspnoea. We excluded subjects with a history of ischaemic heart disease, left ventricular failure, or other cause of reduced mobility such as severe arthritis. Subjects who were on long term oxygen therapy or who fulfilled the criteria for provision of long term oxygen therapy were also excluded. All subjects desaturated on exertion.

The assessment took place on a set of stairs at the hospital comprising 22 steps. Each step was 16.5 cm high, giving a total ascent of 3.6 m. There was a banister rail on each side of the stairs but subjects could not hold both rails simultaneously. Each subject rested for five minutes on a chair at the bottom of the stairs, ascended the stairs with one of us (JK), and rested for five minutes on a chair at the top after their ascent. Each ascent was preceded by the instructions "Go up the stairs, just as you would do at home", and further encouragement was not given. Pulse and oxygen saturation were continuously monitored (Ohmeda Biox 3740 Pulse Oximeter with finger probe) and recorded before the ascent, immediately after the ascent, and at one minute intervals thereafter. The nadir saturation was also recorded. Dyspnoea was assessed by a visual analogue scale before the ascent, immediately after the ascent, and at one minute intervals thereafter. The visual analogue scale was 100 mm long and ranged from "not at all breathless" at one end to "extremely breathless" at the other end. Subjects could not see their previous responses. The time taken for the ascent was also recorded on a digital stopwatch and rounded to the nearest second.

The first ascent of these stairs was a "screening ascent", before and after which the subjects were breathing room air. Only subjects who desaturated to below 90% were included in the

*Table 1  Physiological characteristics of subjects*

| Baseline characteristics | Median (quartiles) |
| --- | --- |
| Age (years) | 67.5 (60.5, 74.3) |
| M:F | 8:10 |
| Smoking history (pack years) | 35 (30, 55) |
| FEV$_1$ (l) | 0.53 (0.45, 0.76) |
| FEV$_1$ (% predicted) | 26 (18.5, 35) |
| TLCO (mmol/min/kPa) | 2.49 (1.48, 3.54) |
| TLCO (% predicted) | 44 (29, 64) |
| BMI (kg/m$^2$) | 23.3 (17.6, 26.9) |
| Oximetry at rest (%) | 94 (91, 95) |

FEV$_1$ = forced expiratory volume in one second; TLCO = carbon monoxide transfer factor; BMI = body mass index.

next stage in which they made three more ascents with at least 30 minutes between each ascent. During the five minutes before and after these ascents they breathed from a cylinder of either compressed air or oxygen, delivered at 2 l/min via a face mask, in a single blind manner. Thus, one ascent was made with compressed air at the top and bottom ("air/air"), one ascent was made with oxygen at the top ("air/oxygen"), and one was made with oxygen at the bottom ("oxygen/air"). The order of the ascents was determined by randomisation within a Latin square. The time of the ascent, pulse rate, oxygen saturation, and dyspnoea were assessed in the same manner as for the screening ascent. At the end of the five minute rest period after the ascent subjects were asked for their comments and were asked how the last ascent compared with previous ascents.

Statistical analysis was by the general linear method of analysis of variance (Minitab v9). Data were analysed using the Shapiro-Wilk test for normality and confidence intervals were calculated by Arcus Quickstat. The sample size was fixed at 18 to allow adequate randomisation within a Latin square.

**Results**
Eighteen subjects were found who matched our inclusion criteria and desaturated on the screening ascent. The characteristics of the subjects are given in table 1.

The timing of peak dyspnoea varied between subjects, occurring at the top of the stairs in 10 subjects but up to three minutes after finishing the ascent in the other eight subjects. Similarly, the nadir of oxygen saturation was usually within the first minute but occurred later in a number of patients. There was no correlation between the timing of peak dyspnoea and the timing of nadir saturation ($r = 0.04$, p = 0.87). Outcome data are summarised in table 2.

DYSPNOEA
Analysis of variance across all treatment groups showed a trend for difference that was not sig-

nificant (p = 0.078). However, if the oxygen treatment groups are combined, the effect of oxygen treatment is shown to be significant (p = 0.027) with a reduction in mean maximum dyspnoea from 49.1 mm to 41.7 mm on the visual analogue scale. There was no significant order effect across the treatment ascents.

TIME OF ASCENT
There was no significant difference (p = 0.364) between treatment groups in the time of ascent, with a reduction in mean time of ascent of only 0.9 seconds after breathing oxygen. There was no significant order effect across the treatment ascents.

OXIMETRY
The maximum change in saturation was derived by subtracting the nadir saturation for each ascent from the oximetry saturation after five minutes breathing room air at rest. There was a highly significant difference between groups (p<0.001) in the extent of desaturation on or after exertion.

SUBJECT PREFERENCE
Seven subjects preferred oxygen at the top of the stairs, five preferred oxygen at the bottom of the stairs, three expressed a preference for a non-oxygen ascent, and three did not express a preference. As a group, therefore, there was no significant preference for oxygen treatment (p = 0.119 by binomial theory). Preference was influenced by the order of ascent (p = 0.049) with only one subject preferring the second ascent (which happened to be "air/oxygen"), six preferring the penultimate ascent, and eight subjects preferring the last ascent.

**Discussion**
There was a reduction in mean maximum dyspnoea with oxygen therapy that is likely to be biologically significant. The reduction in dyspnoea on the "air/air" ascent compared with the screening ascent is likely to be a learning effect, although a placebo effect is also possible. The design of the study does not allow this to be inferred wholly as a placebo effect. There was no evidence of a further learning effect in subsequent ascents, nor evidence of a fatigue effect acting in an opposite way.

However, our original objective of finding whether the oxygen cylinder should be delivered before or after exercise remains unattained (except on an individual basis). Although there is a trend for patients to express a preference for oxygen treatment, this did not achieve statistical significance. Oxygen treatment significantly reduced the extent of desaturation, particularly when given before climbing the stairs.

There are few published data on symptomatic oxygen therapy. Rhind *et al*[8] suggested that oxygen did not affect the six minute walking distance or "time taken for recovery" in 12 subjects. Similarly, McKeon *et al*[9] found no benefit from pretest oxygen on a progressive maximal exercise test (20 subjects, mean exercise duration 5.5 minutes) in terms of intratest dyspnoea. This was in contrast to Woodcock *et*

*Table 2  Summary of outcome data for 18 subjects who completed the study*

| | Cylinder before/after | | |
| --- | --- | --- | --- |
| | Air/air | Oxygen/air | Air/oxygen |
| Maximum dyspnoea on VAS (mm) | 49.1 (27.3) | 42.8 (23.2) | 40.6 (21.0) |
| Δ Maximum dyspnoea from 1st ascent (mm) | 12.6 (19.5) | 18.9 (22.2) | 21.1 (18.7) |
| Δ Time of ascent from 1st ascent (s) | 5.6 (5.8) | 6.1 (6.4) | 4.7 (4.9) |
| Maximum Δ saturation (%) | 8.2 (3.0) | 4.9 (2.7) | 6.4 (2.2) |

Values are mean (SD).

al[10] who found a statistically significant difference in distance walked and intratest dyspnoea after pretest oxygen (10 subjects, mean exercise duration 4.5 minutes) on a progressive maximal exercise test. However, our test has a very different exercise paradigm, comprising a short burst of exertion where pretest oxygen has a more plausible biological role. Longer exercise times, particularly if incremental in intensity, would militate against finding an effect of pretreatment with oxygen. Evans *et al*[11] found that post-test oxygen hastened recovery from maximal exertion in terms of time taken for dyspnoea to return to normal, but found no effect on respiratory rate or heart rate. Our patients were not asked to exert themselves maximally and we have not analysed the data on time to recovery.

Our study was designed pragmatically to assess whether our patients would benefit from oxygen in their homes. As this was a clinical assessment we are unable, from our own data, to comment on the mechanisms by which oxygen might have relieved dyspnoea. However, Swinburn *et al*[12] showed additional benefit from oxygen in patients with hypoxia at rest, over and above an effect of a cool stream of gas on the nasal mucosa and face, which also reduced dyspnoea in some patients. Lane *et al*[13] have shown that preventing desaturation by administering oxygen during exercise reduces dyspnoea, and that this is related to a decrease in ventilation, and Swinburn *et al*[14] suggest that there is also a central component to the reduction in dyspnoea independent of a decrease in ventilation. Further evaluation of the physiology is available elsewhere.

In summary, oxygen treatment reduces dyspnoea associated with short bursts of exertion if this exertion is associated with hypoxia, but it is unimportant whether oxygen is given before or after exertion. Our protocol screened out those subjects who did not desaturate and guided those subjects who did desaturate as to how they could most effectively use short burst intermittent oxygen therapy.

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