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Rating respiratory disability: a report on behalf of a working group of the European Society for Clinical Respiratory Physiology*

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Rating respiratory disability: a report on behalf of a working group of the European Society for Clinical Respiratory Physiology. J.E. Cotes.
ABSTRACT: A rating procedure for respiratory disability has been developed; it entails measuring the symptom-limited maximal oxygen uptake or estimating the maximal uptake from the results of a submaximal exercise test and other relevant variables. The derivation assumes a linear scale of disability between the limits 0% and 100% which are defined. The percentage disability of 157 men with respiratory limitation of exercise has been used to delineate empirical grades of disability. These are of similar form to those used for grading respiratory impairment. More information is needed with a view to validation.
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Rating scales for mild, moderate and severe impairment of lung function (respiratory impairment) have been proposed by working groups of the American Thoracic Society (ATS) [1] and European Society for Clinical Respiratory Physiology (SEPCR) [2]. The proposals differ in their definition of the lower limit of normal which is taken to be, respectively, 20% and 1.64 SD below the reference value. The scales also differ in their interpretation of what is a normal ratio of forced expiratory volume in one second to forced vital capacity (FEV_1/FVC). In other respects the two sets of proposals are concordant including agreeing on the boundaries between slight-moderate and moderate-severe impairment: for FEV_1 and transfer factor these are, respectively, at 60% and 40% of the reference value (table 1).

The grade of respiratory impairment describes the loss of lung function but this is seldom of practical importance except to the extent that the impairment causes respiratory disability by reducing the capacity for exercise. Here the two rating scales differ fundamentally with the ATS [3] but not the SEPCR equating the grades of respiratory impairment with those for respiratory disability. Unfortunately, this simplistic view is in conflict with evidence which suggests that there is only a weak correlation between loss of lung function and the resulting loss of exercise capacity [4, 5]. Thus, an alternative approach is needed. The problem was addressed at a meeting held in Lausanne during the 1989 Annual Conference of the European Society for Clinical Respiratory Physiology.

Table 1. – SEPCR and ATS criteria for respiratory impairment using FEV_1, FVC, FEV_1% and/or T_L (absolute or with respect to reference value, exceptions to general criteria are in brackets)

Impairment	Criteria
None	SEPCR > (ref. -1.64 SD) ATS >80% ref. (FEV_1% ≥75% abs.)
Slight	Not normal but >60% ref.*
Moderate	In range 59–40% ref. (50% for FVC)
Severe	<40% ref. (50% for FVC)

*: for index which deviates most from normality; SEPCR: European Society for Clinical Respiratory Physiology; ATS: American Thoracic Society; FEV_1: forced expiratory volume in one second; FVC: forced vital capacity; T_L: transfer factor of the lungs.

Indications for an exercise test

Respiratory disability was defined according to the World Health Organization (WHO) classification of impairments, disabilities and hardships as a reduction in exercise capacity secondary to impaired lung function [6]. From this definition the assessment of respiratory disability requires both the existence of respiratory impairment as defined above and information about exercise performance. There was general agreement that the latter was best obtained by measurement of the cardio-respiratory response to symposium-limited progressive exercise, although an appropriately validated questionnaire or oxygen cost diagram [7] might sometimes be appropriate. A maximal work test interpreted without reference to the exercise ventilation [8, 9] was not an acceptable alternative. In addition the use of an exercise test was superfluous if the subject had gross respiratory impairment sufficient to preclude more than minimal activity.

Determination of maximal oxygen uptake

The exercise test should normally be progressive on a cycle ergometer or treadmill and be continued up to the symptom limited maximum. Ventilation, cardiac frequency, expired gas concentrations and oxygen saturation should be recorded and the electrocardiogram monitored throughout the test. For the result to be used as evidence for respiratory disability the exercise should be limited by breathlessness and not ischaemic pain, changes in the electrocardiogram, leg muscle fatigue or other non-respiratory symptoms. During exercise successive measurements of ventilation and consumption of oxygen should lie along a reasonably smooth curve, and the maximal tidal volume should be appropriate for the vital capacity [10]. At the point of stopping exercise the ventilation should be a maximal value dictated by the patient's FEV_1 [11]. Where the conditions were not met, or as a check on the measured maximal oxygen uptake, the uptake could be estimated from FEV_1, submaximal exercise ventilation and other appropriate variables as first suggested by WRIGHT [12], [13, 14]. For this purpose use could be made of a recent equation based on FEV_1 submaximal exercise ventilation, age and fat free mass. The equation was derived using results for 157 men selected as meeting all the above criteria for respiratory limitation of exercise [5].

Equation 1

$$\dot{n}O_2 \max = 13.4\ FEV_1 - 0.94\ \dot{V}_{E45} + 0.44\ FFM\ (Kg) - 0.31\ age + 66.4\ (SEE\ 11.6)$$

where $\dot{n}O_2$ max is maximal oxygen uptake in $mmol \cdot min^{-1}$, $\dot{V}_{E45}$ is ventilation at an oxygen uptake of 45 $mmol \cdot min^{-1}$, and FFM is fat free mass [5].

(To convert from $mmol \cdot min^{-1}$ to $l \cdot min^{-1}$ divide by 44.6).

Alternatively $\dot{n}O_2$ max could be estimated from the $\dot{V}_{E45}$, FEV_1 and transfer factor (TL) expressed as percentages of the reference values (designated %FEV, %TL).

Equation 2

$$\%\ \dot{n}O_2 \max\ (\%\ pred) = 0.44\ \%\ FEV_1 - 0.78\ \dot{V}_{E45} + 0.16\%\ T_L + 52.3$$

SEE 13% (7.3% in patients with asbestos-related lung disease). This form of the equation was appropriate for patients with asbestos-related lung disease [5].

However, the results for treadmill exercise and cycle ergometry are not completely interchangeable since maximal exercise ventilation and uptake of oxygen are greater on the treadmill [15] whilst perceived breathlessness and the extent of exercise desaturation are reported as greater on the bicycle [16, 17]. These differences need to be taken into account in evaluating the results of the exercise test.

Reference values for maximal oxygen uptake

For rating respiratory disability the observed or estimated maximal oxygen uptake should be related to an appropriate reference value. This should take into account age, sex, physique, customary activity (hence physical fitness) and possibly smoking habits. For this purpose customary activity could be expressed on a four point scale from inactive (grade 1) to participation in energetic sports (grade 4). Maximal oxygen uptake should be for the whole person and not per kg body mass; the latter mode introduces error because maximal oxygen uptake per kg body mass is not independent of body mass [18]. For cycle ergometry in men two independently derived sets of reference values meet these criteria (table 2) [19, 20]. They yield very similar results.

Table 2. – Reference equations for maximal oxygen uptake in healthy men using a cycle ergometer; these are due, respectively, to JONES *et al.* [19] and WELLER *et al.* [20]

Source		[19]	[20]
Coefficient terms			
Age	yr-	1.03	-0.95
Stature	cm	1.11	-
Body mass	kg	0.84	-
Fat free mass	kg	-	1.43
Activity grade	1–4	6.7	6.3
Smoking	yes/no	-	-8.1
Constant term		-103	70
Mean $\dot{n}O_2$max* $mmol \cdot min^{-1}$		129+	128+
Standard error		18.5	17.3

*: Age 35 yrs, height 1.73 m, weight. 70 kg, FFM 56 kg, activity score 2.5, 1/2 smoker. +: for $l \cdot min^{-1}$ divide by 44.6.

Percentage respiratory disability

The range of respiratory disability is from 0–100%. Zero disability is the lower limit of normal which, by analogy with SEPCR scores for respiratory impairment, includes results for all but the lowest 5% of healthy subjects and hence is set at 1.64 SD below the reference value. 100% disability should be compatible with sedentary activities for which the oxygen uptake is on average twice the resting metabolism [21]: this is approximately 22 $mmol \cdot min^{-1}$ (0.5 $l \cdot min^{-1}$). A person who is unable to increase the oxygen uptake beyond

Table 3. – Distribution of respiratory disability amongst 157 men with respiratory impairment and respiratory limitation of exercise (for details see text)

Percentage disability	Number of subjects	Proposed disability grade		Distribution of subjects %
0	44	0	none	28
01–19	31 }	1	slight	38
20–39	28 }			
40–59	40	2	moderate	25
60–79	11	3	severe	8
80–99	2 }			
100	1 }	4	100%	1

Table 4. – Example of rating respiratory disability in a lagger (MrCR)

Age yrs	55	58
Grade of breathlessness	1	2 to 3
FEV_1 l	2.65 (79%)	2.36 (72%)
TL mmol·min^{-1}·kPa^{-1}	6.69 (67%)	5.60 (58%)
$\dot{V}_{E45}$ l·min^{-1}	28	36
$\dot{n}O_2$ max obs* mmol·min^{-1}	87 (76%)	71 (65%)
$\dot{n}O_2$max ref+	114	109
% respiratory disability	-1	17
Grade of disability	0	1

Percentages of reference values are in brackets.*: estimated from equation 2; +: from table 2 [20]. Fat free mass was 57.5 kg at age 58 yrs and activity grade was 2 at age 55 yrs when patient was effectively a nonsmoker having not smoked for 18 yrs. These quantities were used for calculating the reference values.

this level has 100% disability. Within these limits and assuming a linear scale, the percentage disability is given by:

Equation 3:

$$\text{Disability} = \frac{[\dot{n}O_2 \text{ max (ref)} - 1.64 \text{ SD}] - \dot{n}O_2\text{max (obs)}}{10^{-2}\ ([\dot{n}O_2 \text{ max (ref)} - 1.64 \text{ SD}] - 22)}\ \%$$

Where "ref" and "obs" refer, respectively, to the reference and observed or estimated values for maximal oxygen uptake. For other items, see text.

Grade of respiratory disability

Grades of respiratory disability should reflect the percentage disability and exhibit a reasonably uniform distribution within the section of the population to whom the grading might be applied. Table 3 gives the distribution for the 157 subjects referred to above whose results formed the basis for equations 1 and 2. The distribution lends itself to grading on a scale having three intermediate points with the boundaries between slight to moderate disability and moderate to severe disability set, respectively, at 40% and 60%. This is consistent with the grading of respiratory impairment given above. An example of the grading procedure is given in table 4.

Validation of rating procedure

A scale for respiratory disability should have appropriate reproducibility; it should also exhibit acceptable levels of sensitivity and specificity with respect to disability assessed independently. One such measure is the grade of breathlessness of Fletcher assessed on an extended eight point scale [22]. For the present subjects the grade was correlated with the % disability but the correlation was poor (r=0.27). This may have been due in part to the grade having a large subjective component [23]. A higher correlation (r=0.54) was obtained with the rating for total cardio-respiratory disability made independently by an industrial tribunal (Cotes unpublished). Another source of variability could have been the use of symptoms as the criterion for limitation of exercise since the resulting $\dot{n}O_2$max might be expected to be more variable than one based on submaximal indices (equation 1). More information is needed on these aspects and on the use of the grading in practical situations.

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Evaluation d'handicap respiratoire: Un report par un groupe de travail de la Sociéte Europèene de Physiologie Clinique Respiratoire. J.E. Cotes.
RÉSUMÉ: Une methode d'evaluation d'handicap respiratoire a éré mis au point. Elle comporte la mesure de la consummation maximale d'oxygène symptome-limiteé ou l'estination de la consummation maximale à partir des resultats d'une test d'effort sous-maximale et d'autres variables partinantes. La deviation suppose une échelle lineare d'handicap entre les limites de 0% et 100% qui sont definies. Le pour centages d'handicap de 157 hommes avec une limitation respiratoire de l'effort à été utilisée pour délimiter de façon enperique des classes d'handicap Ces classes sont sem blamble à celles utilisées pour classer l'insulfisaue respiratoire. D'autres données reront necesaire afin de valider celte échelle.
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