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LETTER TO THE EDITOR

Use of the Borg dyspnea scale to identify dynamic hyperinflation during the 6-minute walking test in individuals with moderate-severe COPD: A pilot study

In individuals with chronic obstructive pulmonary disease (COPD), dynamic hyperinflation (DH) may be a determinant of the worsening in dyspnea discomfort during exertion.[1] DH is the temporary increase of the end-expiratory lung volume above baseline values, with consecutive reduction of the inspiratory capacity (IC), which occurs when ventilatory demand is acutely increased.[2] The assessment of DH during exertion can be limited in clinical settings when there is need for expensive and specific equipment and trained assessors.[2] Therefore, this study aimed to determine whether the Borg dyspnea scale[3] (BORG-D), an easy and affordable tool to assess dyspnea, may have a cutoff point capable of identifying individuals with stable COPD who develop DH during the 6-minute walk test (6MWT). Also, it investigated if other clinical outcomes are similarly associated with dyspnea complaints in women and men with COPD.

This cross-sectional analysis was developed with data previously collected in a convenience sample of consecutive individuals with COPD at the Laboratory of Research in Respiratory Physiotherapy of the Universidade Estadual de Londrina, Brazil. Inclusion and exclusion criteria may be found in the original publication.[4] The protocol was approved by the institution's ethics committee (#151/2013) and all participants signed an informed consent form.

The 6MWT was performed according to international standardization.[5] Dyspnea was quantified using the BORG-D ranging from 0 (no dyspnea) to 10 (maximum dyspnea) and patients were properly instructed before the application of the scale. The main outcome used for analysis was dyspnea self-reported immediately after the 6MWT minus that reported immediately before the test (Δ_BORG-D). Additionally, ΔSpO_2/distance index was determined as post minus pre SpO_2 divided by the 6MWT distance x 100.

DH during the 6MWT was quantified by serial assessments of IC using a portable spirometer (Spiropalm, Cosmed, Italy). The device's original face mask model was used for all patients. There were no complaints concerning the mask's use as tested in the original study.[4] Measures were done at rest, 2 and 4 min after the beginning of the test, 15 s before completion, and immediately at the end of the test. DH was defined by a reduction in IC over the test (delta IC nadir minus pre-test, or ΔIC) according to two criteria: at least 150 ml (ΔIC>150 ml)[2] or at least 4.5%predicted (ΔIC>4.5%pred)[6] relative to the resting value.

Data were described as mean±standard deviation or median [interquartile range 25–75%] according to normality in data distribution (Shapiro-Wilk test). The cutoff points for Δ_BORG-D were verified by the area under the curve (AUC) of the receiver operating characteristics. Differences between sexes were analyzed through parametric, non-parametric and Chi-square tests, as indicated. The software used was SPSS 22.0 (IBM, USA) with a statistical significance level set as $P<0.05$.

Twenty-four individuals with moderate-severe COPD (13men; 67±6years) were studied. Table 1 shows all sample characteristics and sex comparisons. Out of the 24 patients, 75% (11 male and 7 female) developed DH according to the ΔIC>150 ml criterium, whereas 79% (11 male and 8 female) developed DH according to the ΔIC>4.5%pred criterium. In addition, in comparison to men, women were younger, had less severe disease, less static hyperinflation and lower ΔSpO_2.

Table 2 shows that a cutoff point for Δ_BORG-D (increase > 2.75 points in BORG_D after the 6MWT) satisfactorily identified ΔIC>4.5%pred for the whole (general) group and especially for men. When using ΔIC>150 ml, the same cutoff point was satisfactory only for men. Regarding women, a satisfactory cutoff point could not be found with any DH criterium (Table 2).

The present results corroborate with previous literature[1] showing an association between DH and BORG-D during the 6MWT. However, it takes it further by proposing a cutoff point of an increase ≥2.75 (or 3) points in BORG-D after the 6MWT as able to identify individuals with moderate-severe stable COPD who develop DH defined as a decrease in IC >4.5%pred during exertion.[6] Thus, individuals who showed an increase in BORG-*D* > 3 points after the 6MWT are

Abbreviation: COPD, Chronic obstructive pulmonary disease; DH, Dynamic hyperinflation; EELV, End-expiratory lung volume; IC, Inspiratory capacity; BORG-D, Borg dyspnea scale; 6MWT, 6-minute walk test; AUC, area under the curve; FEV_1, Forced expiratory volume in the first second; BMI, Body mass index; RV/TLC, Residual volume/total lung capacity.

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Table 1 Sample characteristics and comparison according to sex.

Variable	Overall (*n* = 24)	Men (*n* = 13)	Women (*n* = 11)	*P* value (men *vs* women)
Age (years)	67.00 ± 5.85	69.15 ± 5.14	64.45 ± 5.6.2	0.039
BMI (kg/m^2)	28.90 ± 4.3	28.74 ± 5.56	28.42 ± 5.73	0.800
FEV_1 (L)	1.48 ± 0.38	1.52 ± 0.46	1.45 ± 0.30	0.706
FEV_1 (% predicted)	55.52 ± 17.58	47.45 ± 14.11	6.27 ± 17.31	0.018
FVC (L)	2.84 ± 0.49	3.09 ± 0.48	2.59 ± 0.37	0.019
FVC (% predicted)	83.96 ± 16.51	77.85 ± 12.86	91.18 ± 17.96	0.046
FEV1/FVC (%)	52.29 ± 9.99	48.83 ± 11.11	55.75 ± 7.71	0.139
IC pre 6MWT (L)	2.22 ± 0.54	2.79 ± 0.73	2.51 ± 0.66	0.341
IC 2min_6MWT (L)	1.93 ± 0.51	2.11 ± 0.57	1.71 ± 0.34	0.076
IC 4 min_6MWT (L)	1.90 ± 0.48	2.06 ± 0.47	1.71 ± 0.43	0.086
IC 5:45_6MWT (L)	1.88 ± 0.51	2.13 ± 0.48	1.60 ± 0.38	0.011
IC post 6MWT (L)	1.97 ± 0.50	2.21 ± 0.49	1.69 ± 0.36	0.017
ΔIC nadir-pre 6MWT (L)	−0.48 ± 0.40	−0.61 ± 0.42	−0.35 ± 0.35	0.107
ΔIC nadir-pre 6MWT >150 ml, Yes/No (n[%])	18[75] / 6[25]	11[85] / 2[15]	7[64] / 4[36]	0.478
ΔIC nadir-pre 6MWT >4.5%pred, Yes/No (n[%])	19[79] / 5[21]	11[85] / 2[15]	8[73] / 3[27]	0.475
RV/TLC ratio (%)	49.58 ± 7.56	52.69 ± 6.44	45.91 ± 7.38	0.025
6MWT (m)	458.67 ± 46.44	466.69 ± 59.92	449.18 ± 21.65	0.342
6MWT (% predicted)	88.33 ± 10.54	87.08 ± 12.16	89.82 ± 8.47	0.538
SpO_2 post-6MWT (%)	90.58 ± 5.03	89.38 ± 5.37	92.00 ± 4.42	0.212
ΔSpO_2 post-pre 6MWT(%)	−4.13 ± 3.34	−5.54 ± 3.17	−2.45 ± 2.80	0.021
ΔSpO_2/distance index	0.60 ± 0.83	0.90 ± 0.85	0.25 ± 0.69	0.054
ΔBORG D (points)	3.37 ± 2.14	3.88 ± 2.22	2.77 ± 1.97	0.179
ΔBORG F (points)	2.12 ± 2.23	2.61 ± 2.42	1.53 ± 1.90	0.275
Literate Yes/No (*n*[%])	23[96] / 1[4]	13[100] / 0[0]	10[91] / 1[9]	0.458

Data presented in absolute frequency, mean ± standard deviation or median [interquartile rage 25% −75%]. BMI: body mass index; FEV_1: forced expiratory volume in the first second; FVC: forced vital capacity; IC: Inspiratory capacity; 6MWT: 6-minute walking test; L: liters; RV: residual volume; TLC: total lung capacity; DH: Dynamic Hyperinflation; SpO_2: Pulse oxygen saturation; Index Δ SpO_2/distance: ratio of SpO_2 pre-post to 6MWD x 100. BORG D: Borg dyspnea; BORG F: Borg fatigue.

possible hyperinflators, whereas this applies especially for men but not necessarily for women. Previous literature described that hyperinflation may be related to various clinical outcomes in addition to dyspnea. Abdelwahab et al.[7] found that severe hyperinflation can be predicted by the index between ΔSpO_2 and the 6MWT distance presenting value ≥0.6. In the present study, only the general sample and the male group had values above this cutoff. This corroborates the finding of higher DH in men, although comparable increase in DH during exertion between men and women have been previously described.[8] The non-feasibility of finding a cutoff point for women is probably due to the fact that the female participants in this sample were younger, had less severe disease, less static hyperinflation and lower ΔSpO_2 than male participants. A study with a sample of slightly older women with more severe disease and more

Table 2 Results of different criteria to detect dynamic hyperinflation (delta inspiratory capacity nadir-pre test) in individuals with COPD performing the 6MWT.

Criterium	AUC	Sensibility	Specificity
ΔIC nadir-pre 6MWT >150 ml, general	0.60	72%	67%
ΔIC nadir-pre 6MWT >4.5%pred, general	0.72	74%	80%
ΔIC nadir-pre 6MWT >150 ml, men	0.84	81%	100%
ΔIC nadir-pre 6MWT >4.5%pred, men	0.84	82%	100%
ΔIC nadir-pre 6MWT >150 ml, women	0.43	86%	50%
ΔIC nadir-pre 6MWT >4.5%pred, women	0.60	88%	67%

Receiver operating characteristic (ROC) curve of the delta cutoff point of the Borg dyspnea scale (Δ _BORG-D nadir-pre 6MWT) to identify dynamic hyperinflation (DH) in individuals with COPD performing the 6-minute walk test (6MWT). Criterium ΔIC>150ml: reduction of inspiratory capacity of at least 150 ml during or after the 6MWT; Criterium ΔIC>4.5%pred: reduction of inspiratory capacity of at least 4.5% predicted during or after the 6MWT. The cutoff point for men and general sample was an increase >2.75 points in the BORG dyspnea scale after the 6MWT, whereas for women was >1.75 points.

pronounced static hyperinflation may be necessary to identify such a cutoff for female patients. Further, previous literature describes that it is common for women with COPD to be more symptomatic than men, even with milder disease severity, and this can be justified by the reduced ventilatory reserve that contributes to women reaching total lung capacity limit faster.[9] Therefore, a female-specific cutoff may be necessary.

Another difference found was that women showed less hyperinflation compared to men. Perhaps static hyperinflation is better related to dyspnea in women than in men; previous studies with mixed samples have shown that there is an association between these outcomes.[10] Further studies may advance understanding of the mechanisms of dyspnea in women.

Despite its novelties, the present study has limitations such as the small sample size, lack of testing of the cutoff on a larger sample and absence of the BORG-D measurements at the minutes 2, 4 and 5:45 of the 6MWT. Furthermore, a convenience sample of consecutive individuals with COPD was used in which women had different characteristics than men, and perhaps the design could have encompassed matched groups of male and female patients with similar characteristics. New studies with larger samples, similar characteristics between the sexes (including disease severity and static hyperinflation), a wider range of disease severity and with other relevant outcomes could be useful to expand the understanding of the present results.

In conclusion, when defining DH as a reduction in IC of at least 4.5%predicted, an increase $\geq$2.75 (or 3) points in the Borg dyspnea scale after the 6MWT was able to satisfactorily identify individuals with moderate/severe COPD who hyperinflate during the test. In specific analyses according to sex, it was also possible to establish the same satisfactory cutoff point for men using the same definition of DH, as well as defining DH based on a reduction in IC of at least 150 ml. However, no satisfactory cutoff point was found for women using any DH criterium.

Authors' contribution

A.P.V.M.F. conceptualization, formal analysis, methodology, investigation, writing — original draft and writing — review & editing. L.F.B. conceptualization, formal analysis, methodology, investigation, writing — original draft and writing — review & editing. F.P. conceptualization, formal analysis, methodology, investigation, writing — original draft and writing — review & editing. L.M. conceptualization and writing — review & editing. N.A.H. conceptualization and writing — review & editing.

Declaration of Competing Interest

None.

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