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# Characteristics and Predictors of Postural Control Impairment in Patients With COPD Participating in a Pulmonary Rehabilitation Program

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13 All authors meet the 4 ICMJE criteria for authorship, have read and approved the manuscript.

14

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## 1 **Structured ABSTRACT**

2 Purpose: Postural control impairment has been identified as a potential extra-respiratory  
3 manifestation in patients with COPD. The aims of this study were to identify clinical factors  
4 that characterize patients with reduced postural control, to examine the correlation between  
5 clinical factors and postural control and to determine predictors of an impaired postural control  
6 among COPD participants enrolled in a pulmonary rehabilitation program.

7 Methods: This study is a secondary analysis of an observational study (PARACHUTE). The  
8 baseline assessment of the pulmonary rehabilitation program was used for the analysis. The  
9 postural control impairment was defined using the Brief-BESTest score (BBT).

10 Results: 73 participants were included in the analysis, 43 of them were classified in the reduced-  
11 postural control group. The between-group comparison (non-reduced versus reduced postural  
12 control) identified differences for partial pressure in oxygen ( $\text{PaO}_2$ ), Saint-George respiratory  
13 questionnaire (SGRQ) total score and sub-scores (SGRQ-Symptoms, SGRQ-Activities and  
14 SGRQ-Impact), COPD assessment test (CAT) and anxiety score of Hospital Anxiety and  
15 Depression scale. BBT score was significantly correlated with maximal inspiratory pressure  
16 (MIP), SGRQ, SRGQ-Symptoms, SGRQ-Impact, Falls Efficacy Scale, modified Medical  
17 Research Council scale, six-minute walk test and  $\text{PaO}_2$ . Logistic regression identified SGRQ-  
18 Symptoms,  $\text{PaO}_2$ , MIP and body mass index (BMI) as predictors of the presence of a reduced  
19 postural control.

20 Conclusion: Low quality-of-life (QoL) and  $\text{PaO}_2$  and high anxiety seem to be discriminative  
21 characteristics of COPD patients with reduced postural control. Furthermore, QoL,  $\text{PaO}_2$ ,  
22 inspiratory muscle strength and BMI seem to be acceptable predictors of the presence of a  
23 postural control impairment.

24

## 1 **Condensed Abstract**

2 COPD patients with impaired postural control had a poorer QoL, lower PaO<sub>2</sub> and higher anxiety  
3 scores compared to patients with normal postural control. Predictors of impaired postural  
4 control in COPD patients were symptom-related QoL, PaO<sub>2</sub>, inspiratory muscle strength and  
5 body mass index.

6

| <b>Key perspective</b>  |
|---|
| - The identification of discriminative and predictive parameters among classically assessed factors in pulmonary rehabilitation could help the detection of postural control impairment in COPD participants. |
| - Clinicians could use identified discriminative characteristics and / or clinical factors predictors to guide their clinical reasoning on postural control impairment in COPD patients.                      |
| - Future research is needed to investigate the effect of specific interventions aiming to modify identified predictors on postural control in COPD patients.  |

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1 Chronic Obstructive Pulmonary Disease (COPD) is a common, preventable and treatable  
2 pathology that is characterized by persistent respiratory symptoms and airflow limitation.<sup>1</sup>  
3 According to the World Health Organization, COPD is the third highest cause of mortality  
4 worldwide in 2019.<sup>2</sup> The evolution of COPD is not limited to respiratory symptoms:  
5 comorbidities are extremely frequent during the evolution of the disease<sup>3</sup>, and increase the  
6 impact on the quality of life of COPD patients.<sup>4</sup> Among these comorbidities, the impairment of  
7 postural control has been described as one important extra-respiratory manifestation for these  
8 patients.<sup>5</sup>

9 Postural control is a complex system, which manages the body's position in space for the dual  
10 purposes of stability and orientation.<sup>6</sup> The postural control of COPD patients has been  
11 documented by numerous experimental studies and three systematic reviews have highlighted  
12 the impairment of postural control of people with COPD compared to control participants.<sup>7-9</sup>  
13 However, the mechanisms behind and the potential consequences of postural control alteration  
14 are only partially known.<sup>8,9</sup>

15 Pulmonary rehabilitation is one of the major treatments for people with COPD<sup>10</sup> and consists  
16 of a comprehensive, individualised intervention based on thorough assessment of identifiable  
17 treatable traits.<sup>11,12</sup> Exercise training and therapeutic education are considered as cornerstones  
18 of pulmonary rehabilitation and various interventions are delivered in addition to fit patient  
19 needs.<sup>12</sup> The initial evaluation of a pulmonary rehabilitation program must be holistic to realize  
20 an overview of patient's strengths, impairments, and project. To this purpose, a wide range of  
21 areas are assessed during this evaluation (e.g. pulmonary function, symptoms, exercise  
22 capacity, muscular function, quality of life, etc.).<sup>11</sup>

23 The latest American Thoracic Society/European Respiratory Society statement on pulmonary  
24 rehabilitation recommended to include the evaluation of postural control in the initial  
25 assessment.<sup>13</sup> However, no specific tests are recommended in the guidelines and a

1 comprehensive assessment of postural control can be complex, time-consuming, and is not  
2 usually performed as a first-line procedure in patients with COPD.<sup>14</sup> Although not all people  
3 with COPD have impaired postural control (an estimated 40-45% have reduced postural  
4 control<sup>15,16</sup>), identifying the characteristics and predictors of a reduced postural control could  
5 facilitate the detection and the classification of at risk-patients and thus individuals who require  
6 a comprehensive postural control assessment. In addition, exploring the correlation between  
7 postural control in COPD patients and various clinical factors could be of interest to clarify or  
8 support hypotheses about the underlying mechanisms (e.g. muscle function or dyspnea<sup>9</sup>) and  
9 impacts of postural control impairment (e.g. on activities of daily living or quality of life<sup>15</sup>).

10 The aims of this study were 1) to identify clinical factors that characterize patients with reduced  
11 postural control, 2) to identify predictors of a reduced postural control in these patients and 3)  
12 to investigate any correlation between postural control and clinical factors in patients with  
13 COPD.

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## 15 **METHODS**

16

### 17 ***STUDY DESIGN AND SETTINGS***

18 This study is a secondary cross-sectional analysis of the PARACHUTE study<sup>17</sup>, conducted in  
19 the pulmonary rehabilitation unit of the Centre Hospitalier des Pays de Morlaix, from January  
20 2019 to December 2019. This study's purpose was to determine the effect of a pulmonary  
21 rehabilitation program on fear of falling of COPD patients. This research was approved by the  
22 ethics committee of the Centre Hospitalier Universitaire de Brest (number 29BRC18.0246) and  
23 was registered on Clinical Trials (number NCT03793452).

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## ***PARTICIPANTS***

Inclusion criteria were as follows: patients older than 18 years old with a confirmed diagnostic of COPD stage 2 to 4 (A-D) according to the GOLD criteria.<sup>1</sup>

Exclusion criteria were: (1) Patients with a diagnosed pathology impairing his balance, (2) Previous pneumonectomy or lobectomy in the past 6 months, (3) Refusal of participation, (4) Patients with an incapacity to follow a standard rehabilitation program, (5) Pregnant or breast-feeding woman, (6) Patients under tutorship or curatorship.

Participants participated on a four-week program in the pulmonary rehabilitation unit of the Centre Hospitalier des Pays de Morlaix. Patients were assessed at the beginning and at the end of the program. The study of the association between postural control and clinical factors was performed on baseline data.

## ***ASSESSMENTS***

The postural control was assessed using the Brief BESTest (BBT) which is a composite functional tool<sup>18</sup>. The BBT is a derivative of the BESTest, an assessment aiming to investigate every sub-components of postural control.<sup>19,20</sup> The BBT explores a significant number of sub-components of postural control (seven out of nine according to Sibley et al. operational definition of postural control<sup>21</sup>). The BBT is valid<sup>22</sup> and reliable<sup>22,23</sup> in the COPD population. Normative values were reported by O'Hoski et al.<sup>24</sup> for people from 50 to 90 years old.

Every participant realized a spirometry with Forced Expiratory Volume in 1 second and Forced Vital Capacity maneuvers after bronchodilators, in accordance to international recommendations.<sup>25</sup>

1 An arterial puncture was performed for arterial blood gases analysis to obtain the resting partial  
2 pressure of oxygen in blood (PaO<sub>2</sub>) and the partial pressure of carbon dioxide in blood.

3 Inspiratory muscle strength was obtained by assessing the maximal inspiratory pressure (MIP)  
4 measured using a Micro RPM (Micro Medical), following the European Respiratory Society  
5 statement on respiratory muscle testing.<sup>26</sup> Isometric maximal voluntary quadriceps strength and  
6 quadriceps endurance were measured using a hand-held dynamometer (MicroFET 2, Hoggan),  
7 following a standardized, validated and reliable procedure.<sup>27,28</sup>

8 Exercise capacity was measured using the six-minute walk test and the one-minute Sit to Stand  
9 test. The six-minute walk test is a self-paced walking test, which measures the distance covered  
10 by an individual over the course of six minutes. This is a valid and reliable tool for assessing  
11 exercise capacity in people with COPD.<sup>29</sup> The one-minute Sit to Stand test assessed the ability  
12 to change from a sitting to a standing position repeatedly, for one minute. The one-minute Sit  
13 to Stand test is a relevant and reliable tool for assessing functional status of patients with  
14 COPD.<sup>30</sup>

15 Dyspnea was evaluated in a multi-dimensional way with the Dyspnea-12 questionnaire, the  
16 Modified Medical Research Council dyspnea Scale, the London Chest Activity of Daily Living  
17 and the Multidimensional Dyspnea Profile (conducted at the end of the six-minute walk test).  
18 The Dyspnea-12 is a questionnaire investigating the affective and sensory dimensions of the  
19 dyspnea.<sup>31</sup> The Modified Medical Research Council is a zero-to-four scale, assessing the global  
20 impact of dyspnea in the life of patients.<sup>32</sup> The London Chest Activity of Daily Living is a tool  
21 designed to assess the impact of dyspnea in fifteen different activities of daily living.<sup>33</sup> The  
22 Multidimensional Dyspnea Profile is a composite tool that assessed the affective and sensory  
23 dimension of dyspnea related to an activity.<sup>34</sup> The Multidimensional Dyspnea Profile is  
24 separated into three different scales (“A1” and “A2” regarding affective dimension of dyspnea

1 and “QS” regarding the sensory dimension of dyspnea). These questionnaires were validated in  
2 the COPD population and translated into French.<sup>35,36</sup>

3 Quality of life (QoL) was measured with both the Saint George Respiratory questionnaire  
4 (SGRQ) and the COPD Assessment Test (CAT). The SGRQ is a questionnaire designed to  
5 measure the impact on overall health, daily life, and perceived well-being in patients with  
6 obstructive airways disease.<sup>35</sup> The SGRQ gives three sub-scores (symptoms, activities, and  
7 impacts) and a total score. Each score is given on a 0-to-100-point scale (a higher score indicates  
8 a higher impact of the disease in the QoL of patients). The CAT is a questionnaire assessing the  
9 impact of COPD on health status.<sup>38</sup> The CAT totals eight items, each item is scored on a 1 to 5  
10 point scale. Range of CAT scores from 0–40 where higher scores denote a more severe impact  
11 of COPD on patient life.

12 Anxiety and depression were evaluated using the Hospital Anxiety and Depression Scale .<sup>39</sup> It  
13 consists of 14 items, 7 for anxiety disorders and 7 for depressive disorders. Each item is scored  
14 between 0 and 3 and a score out of 21 is given for each dimension. A higher score indicates a  
15 higher risk of anxiety or depressive symptoms.

16 Patients were asked to report falls on the twelve-month period before the inclusion in the  
17 program. Fear of falling was evaluated using the Fall Efficacy Scale-International.<sup>40</sup> , a self-  
18 administered questionnaire designed to assess the fear of falling that has been widely used in  
19 previous research in the COPD population.<sup>41,42</sup> It consists of 16 items, scored from 1 to 4 by the  
20 patient. The total score is therefore between 16 and 64 points. A high score indicates a high fear  
21 of falling.

22

23 ***STATISTICAL ANALYSIS***

1 Descriptive data were presented as mean ( $\pm$  standard deviation) or as median (interquartile  
2 range) according to the nature of the variable and the distribution. The normality of the  
3 distribution was tested using the Shapiro-Wilk test.

4 Using the normative values of the BBT <sup>24</sup>, a reduction of postural control was defined by a BBT  
5 score below the lower limit of the 95% confidence interval to the mean BBT score for the  
6 decade. Thus, the participants were classified into the reduced postural control group or the  
7 non-reduced postural control group. The analysis of the differences between these two groups  
8 was performed using the independent Student t-test, the Mann-Whitney U test or the  $\chi^2$ . The  
9 effect size for between-group differences was calculated using the Cohen's *d* or the rank biserial  
10 correlation.

11 The correlation analysis between the postural control score (BBT) and the clinical factors was  
12 performed using the Pearson correlation coefficient or the Spearman's rank correlation  
13 coefficient.

14 A binomial logistic regression was performed with the presence or not of a reduced postural  
15 control as the dependent variable. A forward stepwise approach was used to determine the best  
16 regression model. Independent variables were selected from the between-groups analysis and  
17 the correlation analysis. The number of independent variables selected was adapted to the  
18 sample size, using the rule of thumb of a minimum of ten participants per predictor.<sup>43</sup> Selected  
19 independent variables were successively incorporated into the model to obtain the lowest  
20 possible Akaike Information Criterion and the higher possible Nagelneke  $R^2$ . A Receiver  
21 Operating Characteristic curve was performed to evaluate the sensitivity and the specificity of  
22 the regression model.

23 A p-value of less than 0.05 was considered statistically significant. The statistical analysis was  
24 performed using Jamovi 1.8.1.0 (The Jamovi Project).

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## RESULTS

### *PARTICIPANTS AND CHARACTERISTICS*

80 patients were consecutively included in the PARACHUTE study. Seven patients were excluded from the final analysis: four participants did not respect eligibility criteria and three did not perform the postural control assessment at baseline. Thus, a total of 73 participants were included in the analysis. The detailed characteristics of included patients are shown in the *table 1*. 43 participants presented a reduced postural control as previously defined in study's methods, 26 participants were considered having a non-reduced postural control and four participants were not classified (no normative data available for their age decade). The between group comparison (reduced postural control versus non-reduced postural control) showed significant differences in the following clinical factors: PaO<sub>2</sub> ( $P = .019$  ;  $d = .62$ ), SGRQ-total ( $P = .04$  ;  $d = -0.75$ ), SGRQ-Symptoms ( $p < .001$  ;  $d = -0.88$ ), SGRQ-Activities ( $P = .02$  ;  $d = -0.59$ ), SGRQ-Impacts ( $P = .045$  ;  $d = -0.51$ ), CAT ( $P = .040$  ;  $d = -0.52$ ) and Anxiety score of Hospital Anxiety and Depression Scale ( $P = .015$  ;  $d = -0.63$ ). The difference was not significant for BMI ( $P = .07$ ;  $d = -0.45$ ) and MIP ( $P = .09$ ;  $d = .42$ ).

### *CORRELATIONS*

The significant correlations between postural control (BBT score) and the clinical factors are represented in the *table 2*. This analysis was performed for all participants, independently of postural control status.

## 1 **LOGISTIC REGRESSION**

2 The logistic regression was performed to determine predictive factors for presenting a reduced  
 3 postural control. The best logistic regression model included the SGRQ-Symptoms (OR =1.05:  
 4 95% CI, 1.02 - 1.08,  $P = .003$ ), PaO<sub>2</sub> (OR = .93: 95% CI, .87 - .99,  $P = .020$ ), MIP (OR = .96:  
 5 95% CI, .93 - .99,  $P = .020$ ) and BMI (OR =1.15: 95% CI, 1.01 - 1.31,  $P = .034$ ). This model  
 6 was the best in accordance with the *a priori* set criteria (Akaike Information Criterion = 69.6;  
 7 Nagelneke  $R^2 = .44$ ). Setting the cut-off at 0.67, the model sensibility was 74% and specificity  
 8 was 74%, the area under the curve was 0.84 (*figure 1*).

9 The final equation is the following:

$$10 \quad \mathbf{P \text{ (Reduced postural control)}} = 2.4201 + 0.0481*\text{SGRQ-Symptoms} - 0.0771*\text{PaO}_2 -$$

$$11 \quad 0.0390*\text{MIP} + 0.1418*\text{BMI}$$

12 Where “P (reduced postural control)” is the probability of presenting a reduced postural control.

13 The estimated marginal means for each predictor are represented in the *figure 2*.

14

## 15 **DISCUSSION**

16

17 The main aim of this study was to identify clinical factors that characterized COPD patients  
 18 with reduced postural control: these patients presented significantly impaired QoL scores, lower  
 19 PaO<sub>2</sub> and higher anxiety score. Secondly, the analysis of the correlation between postural  
 20 control and clinical factors identified significant associations with QoL, PaO<sub>2</sub>, inspiratory  
 21 muscle strength, dyspnea, exercise capacity and fear of falling. Lastly, predictive clinical factors

1 of an impaired postural control were symptom-related QoL, PaO<sub>2</sub>, inspiratory muscle strength  
2 and BMI.

3 Previous research has shown that postural control impairment is frequent in COPD patients.<sup>15,16</sup>

4 In the present study, nearly six out of ten COPD patients were considered to have a reduced  
5 postural control. So, this study adds to the evidence that postural control impairment is very  
6 common in patients with COPD, and that this domain must be explored by clinicians with  
7 regard to its consequences in terms of falling<sup>44</sup> and performing daily tasks<sup>15</sup>.

8 This study identified that the QoL is significantly more impaired in COPD patients with altered  
9 postural control. QoL scores were also correlated with postural control, and the symptoms sub-  
10 score of the SGRQ was identified as the strongest predictor of the presence of a reduced postural  
11 control in these patients. The reduction of QoL in patients with impaired postural control and  
12 the significant correlation could suggest that postural control impairment has a negative impact  
13 on daily lives of people with COPD. However, the identification of the SGRQ-symptoms sub-  
14 score as one of the predictors of a reduced postural control could implicate that the relation  
15 between these parameters is bilateral: on the one hand, it seems probable that a reduction in  
16 postural control induces an impairment in quality of life. But on the other hand, symptoms (such  
17 as dyspnea) and their perceived consequences have the potential to interact negatively with  
18 postural control, as suggested by previous research<sup>9</sup>.

19 If some authors have hypothesized that hypoxemia could be an underlying mechanism of  
20 postural control impairment in COPD<sup>45</sup>, few studies on postural control included a direct  
21 measure of arterial blood pressure in oxygen. Ozalevli et al.<sup>46</sup> reported a significant correlation  
22 between PaO<sub>2</sub> and the Berg balance scale ( $r = .28$ ) in patients with COPD, which is in line with  
23 the present study. According to our results, the PaO<sub>2</sub> is also a significant predictor of the  
24 presence of a reduced postural control in COPD patients: any decrease in PaO<sub>2</sub> increases the  
25 risk of presenting a postural control impairment in the latter.

1 The results of this study suggest that inspiratory muscle strength could play a role in postural  
2 control impairment in COPD. The presence of a reduced inspiratory strength could increase the  
3 risk of presenting a postural control impairment in COPD patients. This is in line with previous  
4 clinical research<sup>47</sup> and is consistent with laboratory studies that highlighted the role of  
5 inspiratory muscles in postural control function<sup>48,49</sup>. This finding is potentially important for  
6 the management of COPD patients with decreased postural control function, as inspiratory  
7 muscle training could be a relevant intervention for them. While balance training or functional  
8 exercises are the interventions with the highest level of evidence<sup>50,51</sup>, previous studies in  
9 elderly<sup>52</sup> and in people with COPD<sup>53</sup> have shown that inspiratory muscle training could be a  
10 potential relevant intervention for postural control enhancement

11 Our results identified that the BMI is a significant predictor of postural control impairment in  
12 patients with COPD: in our analysis any raise in the BMI increases the risk of presenting a  
13 reduced postural control. Using a similar study design, Jacome et al. reported BMI as a  
14 significant predictor of reduced postural control with comparable odds ratio (OR =1.12 in  
15 Jacome study versus 1.16 here).<sup>16</sup>

16 Previous studies attempted to identify predictors of reduced postural control in COPD patients:  
17 Jacome et al.<sup>16</sup> identified BMI, number of medications, alterations in recreational activities and  
18 depression score as predictors of reduced postural control (defined by a Timed up and Go score  
19 below normative values). Liwsrisakun et al.<sup>54</sup> found that the exercise capacity (assessed by the  
20 six-minute walk test) was the only predictor of a reduced postural control (here defined using  
21 fall risk cut-off for the Timed up and Go test and the Berg Balance Scale ). The definition of  
22 “reduced postural control” differed in these studies and the clinical factors used for logistic  
23 regression were not the same and could therefore explain the differences observed.

24 Even if identified predictors are the result of a statistical analysis, it could be hypothesized that  
25 positive changes in these predictor scores could induce interesting modifications in postural

1 control of COPD patients. Future studies should investigate the impact on postural control of  
2 changes in QoL, PaO<sub>2</sub>, inspiratory muscle strength or BMI.

3

#### 4 ***LIMITATIONS***

5 Firstly, this is a secondary analysis of a study designed for a different purpose. It implicates that  
6 the sample size calculation was not tailor made for this purpose and that the number of included  
7 participants is small for this type of analysis. However, for logistic regression analysis, some  
8 authors suggested a sample size of ten participants per predictor,<sup>43</sup> which is the case here. In  
9 any case, the equation needs to be validated with a larger sample size and confirmed  
10 prospectively. The second limitation is that participants were voluntary patients participating in  
11 a pulmonary rehabilitation program. This does not represent all patients with COPD and the  
12 extrapolation to the whole COPD population should be confirmed in future research with a  
13 more representative panel.

14

#### 15 **CONCLUSION**

16 In the context of a pulmonary rehabilitation program, this study shows that COPD patients with  
17 reduced postural control present characteristics in several clinical factors that distinguish them  
18 from patients with non-impaired postural control. Symptom-related QoL, PaO<sub>2</sub>, MIP and BMI  
19 were identified as predictors of an impaired postural control in these patients.

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21

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4 collaboration on the present study.

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1 **FIGURES LEGENDS**

2 **Figure 1. The ROC curve for the logistic regression model is presented on the figure.**

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4 **Figure 2. The estimated marginal means of a reduced postural control are presented for**

5 **each identified predictor. The grey zone represents the 95% confidence interval.**

6 Abbreviations: SRGQ-S indicates Saint-George Respiratory Questionnaire-Symptoms score;

7 BMI indicates body mass index; MIP indicates maximal inspiratory pressure; PaO<sub>2</sub> indicates

8 partial arterial pressure in oxygen ; mmHg indicates millimeters of mercury ; cmH<sub>2</sub>O indicates

9 centimeters of water ; kg/m<sup>2</sup> indicates kilograms per meter squared.

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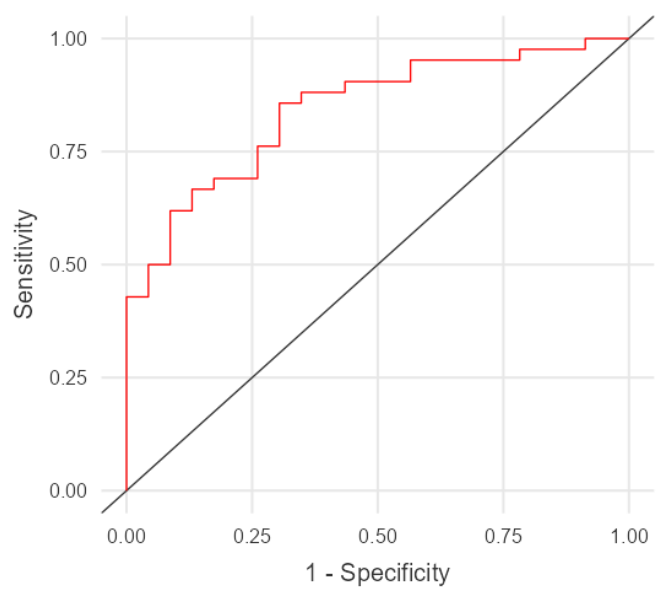
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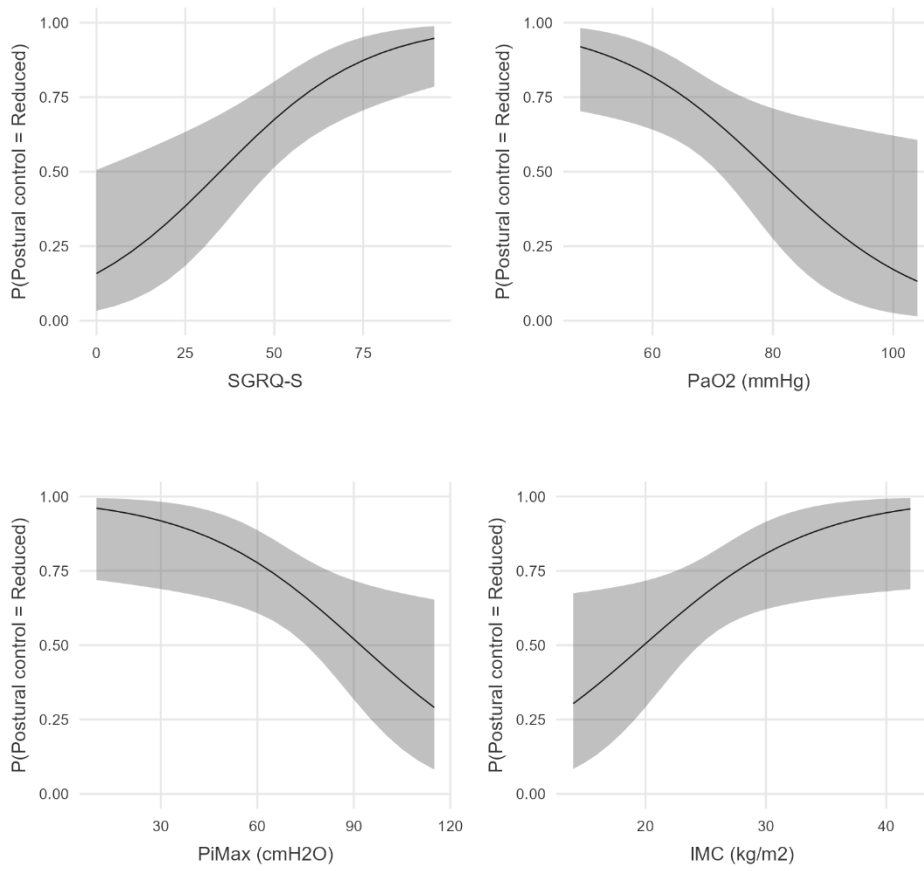
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**Figure 1**



**Figure 2**



## 1 TABLES

2 Table 1. Characteristics of participants according to postural control status

| Variables                | All participants (n=73) | Non-reduced postural control group (n=26) | Reduced postural control group (n=43) | Between-group comparison (non-reduced versus reduced postural control) |                    |
|--------------------------|-------------------------|---|---------------------------------------|--|--------------------|
|                          |                         |   |                                       | P value  | Effect size        |
| Age, yr                  | 66 (59, 70)             | 67 (62, 71)                               | 65 (27, 69.5)                         | .225 <sup>T</sup>  | .30 <sup>D</sup>   |
| BMI, kg/m <sup>2</sup>   | 26.6 ± 5.9              | 24.8 ± 6.5                                | 27.5 ± 5.5                            | .072 <sup>T</sup>  | -0.45 <sup>D</sup> |
| BBT                      | 19 (16, 20)             | 21.3 ± 1.7                                | 15.9 ± 3.2                            | < .001 <sup>M</sup>  | .88 <sup>R</sup>   |
| FEV1, %pred              | 40 (27, 55)             | 37 (27, 60.5)                             | 42 (28, 50.5)                         | .877 <sup>M</sup>  | .02 <sup>D</sup>   |
| PaO <sub>2</sub> , mmHg  | 67.5 ± 10.1             | 71.2 ± 11.2                               | 65.3 ± 8.6                            | .019 <sup>T</sup>  | .62 <sup>D</sup>   |
| PaCO <sub>2</sub> , mmHg | 42 (39, 46.8)           | 42 (39.8, 45.3)                           | 43 (39, 47.8)                         | .487 <sup>M</sup>  | .10 <sup>R</sup>   |
| MIP, cmH <sub>2</sub> O  | 70.6 ± 24.2             | 75.3 ± 24.5                               | 65.6 ± 22.2                           | .094 <sup>T</sup>  | .42 <sup>D</sup>   |
| QStrength, Nm            | 248 (174, 355)          | 193 (152, 377)                            | 263 (211, 327)                        | .233 <sup>M</sup>  | .18 <sup>R</sup>   |
| QEnd, sec                | 39.3 (28.6, 47)         | 36.5 (28.5, 46)                           | 41 (29, 48.5)                         | .383 <sup>M</sup>  | .13 <sup>R</sup>   |
| 6MWT, m                  | 395 ± 109               | 411 ± 116                                 | 380 ± 102                             | .253 <sup>T</sup>  | .28 <sup>D</sup>   |
| 1STST, reps              | 20 (17, 25.5)           | 20.7 ± 5.7                                | 21.2 ± 6.4                            | .725 <sup>T</sup>  | .08 <sup>D</sup>   |
| D12                      | 16.6 ± 8.74             | 14.5 ± 8.4                                | 17.8 ± 8.6                            | .125 <sup>T</sup>  | -0.39 <sup>D</sup> |
| MMRC                     | 2 (1, 3)                | 2 (1, 2.75)                               | 2 (1, 3)                              | .400 <sup>M</sup>  | .12 <sup>R</sup>   |
| LCADL                    | 25 (20, 35)             | 26 (20.3, 33.5)                           | 24 (20, 35)                           | .965 <sup>M</sup>  | .007 <sup>R</sup>  |
| MDP A1                   | 4 (3, 5.25)             | 4 (3, 5)                                  | 4 (3, 5.75)                           | .298 <sup>M</sup>  | .15 <sup>R</sup>   |
| MDP A2                   | 1.5 (0, 6.75)           | 1 (0, 6.5)                                | 2 (0, 6)                              | .660 <sup>M</sup>  | .07 <sup>R</sup>   |
| MDP QS                   | 9 (4, 17.8)             | 7 (2.5, 11.8)                             | 11 (5.5, 18)                          | .057 <sup>M</sup>  | .31 <sup>R</sup>   |

|            |             |                   |                   |                              |                     |
|------------|-------------|-------------------|-------------------|------------------------------|---------------------|
| SGRQ total | 51.4 ± 15.5 | 45.2 ± 16.6       | 55.9 ± 12.8       | <b>.004</b> <sup>T</sup>     | -0.75 <sup>D</sup>  |
| SGRQ-S     | 53.2 ± 21.5 | 43.3 ± 22.8       | 60.7 ± 17.6       | <b>&lt;.001</b> <sup>T</sup> | -0.88 <sup>D</sup>  |
| SGRQ-A     | 70.4 ± 18.5 | 59.9 (49.5, 79.5) | 73.0 (65.8, 86.1) | <b>.020</b> <sup>T</sup>     | -0.59 <sup>D</sup>  |
| SGRQ-I     | 40.9 ± 17.7 | 30.1 (20.8, 49.8) | 42.3 (33.9, 53.2) | <b>.045</b> <sup>T</sup>     | -0.51 <sup>D</sup>  |
| CAT        | 19.0 ± 6.78 | 17.0 ± 7.4        | 20.3 ± 5.7        | <b>.040</b> <sup>T</sup>     | -0.52 <sup>D</sup>  |
| HAD-D      | 7.12 ± 4.08 | 6.35 ± 3.77       | 7.91 ± 4.09       | .118 <sup>T</sup>            | - 0.39 <sup>D</sup> |
| HAD-A      | 8.63 ± 4.09 | 7 (4, 10)         | 9 (6.5, 13)       | <b>.015</b> <sup>T</sup>     | -0.63 <sup>D</sup>  |
| FES-I      | 23 (19, 36) | 21.5 (18, 32)     | 26 (20, 36)       | .238 <sup>M</sup>            | .17 <sup>R</sup>    |
| Falls      | 0 fall n=53 | 0 fall n=17       | 0 fall n=32       | .631 <sup>F</sup>            | NA                  |
|            | 1 fall n=13 | 1 fall n=7        | 1 fall n=6        |                              |                     |
|            | 2 falls n=2 | 2 falls n=1       | 2 falls n=1       |                              |                     |
|            | 3 falls n=2 | 3 falls n=1       | 3 falls n=1       |                              |                     |
|            | 4 falls n=1 | 4 falls n=0       | 4 falls n=1       |                              |                     |

BMI, body mass index; BBT, Brief BESTest; CAT, COPD Assessment test; D12, dyspnea-12; FES-I, Falls efficacy scale international; FEV1, forced expiratory volume in one second; HAD, Hospital anxiety and depression scale (A, anxiety score; D, depression score); LCADL, London chest activity of daily living questionnaire; MDP, multi-dimensional dyspnea profile; MIP, maximal inspiratory pressure; MMRC, modified medical research council scale; NA: not applicable; PaO<sub>2</sub>, partial arterial pressure in oxygen; PaCO<sub>2</sub>, partial arterial pressure in carbon dioxide; Qend, quadriceps endurance; Qstrength, quadriceps strength; SGRQ, Saint-George Respiratory Questionnaire (A, activity sub-score; I, Impact sub-score; S, symptoms sub-score; total, total score); 1STST, one minute sit-to-stand test; 6MWT, six minute walk-test; <sup>D</sup> Cohen effect size; <sup>F</sup> Fisher's exact test; <sup>M</sup> Mann-Whitney test; <sup>R</sup> Rank biserial correlation; <sup>T</sup> Independent Student t-test.

Data are presented as mean ± SD or median (IQR) or n. Bold indicates p values < 0.05

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1 **Table 2. Significant correlations between postural control score (BBT) and clinical**  
 2 **factors in participants (n=73)**

| <b>Variables</b> | <b>BBT</b> |
|------------------|------------|
| FES-I            | -0.30**    |
| MIP              | .34**      |
| MMRC             | -0.26*     |
| SGRQ-I           | -0.26*     |
| SGRQ-S           | -0.32**    |
| SGRQ total       | -0.31**    |
| PaO <sub>2</sub> | .26*       |
| 6MWT             | .27*       |

BBT, brief-BESTest; MIP, maximal inspiratory pressure; MMRC, modified medical research council scale; PaO<sub>2</sub>, partial arterial pressure in oxygen; SGRQ, Saint-George Respiratory Questionnaire (I, Impact sub-score ; S: symptoms sub-score); 6MWT, six-minute walk test.

All correlations reported in the table 2 were calculated using Spearman's rho. \* p < .05 ; \*\* p < .01.

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