

Inspiratory muscle training combined with pursed lip technique in women with chronic obstructive pulmonary disease: a case study

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ABSTRACT

Objective. To improve pulmonary function, exercise capacity and quality of life of two women with Chronic Obstructive Pulmonary Disease (COPD).

Material and Methods. Study of two clinical cases, both women. An intervention of 8 weeks was performed, in which the patients performed 3 weekly sessions, of which 1 was performed with supervision of the physiotherapist and 2 sessions were performed at home. The treatment sessions consisted of inspiratory muscle training with an inspiratory threshold and controlled breathing exercises with the pursed lip technique.

Results. Quality of life of both women improved at the end of the study. In the woman with severe COPD, Maximal Inspiratory Pressure (MIP) and Maximal Expiratory Pressure (MEP) increased after the intervention. The Peak Expiratory Flow (PEF) improved in both cases, but not the rest of the spirometric values. Dyspnea improved in the woman with moderate COPD but not in the case of the one with severe COPD. Finally, the distance walked in the 6MWT improved in both cases.

Conclusions. The training of the inspiratory muscles together with the pursed lip technique positively influences quality of life and exercise capacity of two women with COPD.

KEYWORDS

chronic obstructive pulmonary disease; inspiratory muscle training; pursed lip; respiratory physiotherapy

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INTRODUCTION

Chronic Obstructive Pulmonary Disease (COPD) has been defined as a preventable and treatable process, characterized by air flow limitation not completely reversible, generally progressive and associated with an abnormal inflammatory response of the lungs to particles and harmful gases, mainly those produced by smoking (Celli, MacNee, Agsuti, 2004). COPD is a major cause of morbidity and mortality worldwide, in fact, it is estimated that there are more than 200 million people with COPD, older than 45 years and 3 million of them die every year from the disease (De Torres, Casanova, 2010).

For many years, COPD has been considered a disease mainly related to men, with a higher overall prevalence in this gender than among women (Ancochea, Miravittles, Garcia-Rio, Muñoz, Sánchez, Sobradillo et al., 2013). However, in recent decades in developed countries there has been an alarming increase in respiratory diseases in women related to tobacco use (De Torres, Casanova, 2010) and in underdeveloped countries due to the biomass combustion exposure (Gan, Man, Postma, Camp, Sin, 2006) with studies showing a prevalence of COPD in women of 8.5%, although with differences between geographical areas (Buist, McBurnie, Vollmer, Gillespie, Burney, Mannino et al., 2007).

Regarding the COPD characteristics, these are mainly dyspnea, cough and expectoration, but women in particular suffer from a greater degree of dyspnea, despite having a lower smoking rate, similar cough and less expectoration than men (Varkey, 2004; Carrasco-Garrido, Miguel-Diez, Rejas-Gutierrez, 2009). Some studies have suggested that women are more susceptible to the harmful effects of tobacco and toxic environmental factors with an earlier onset and a more serious illness (Becklake, Kauffmann, 1999). It has also been observed that women have narrower airways than men, they are on average 17% smaller than of men, and therefore each cigarette means greater exposure to tobacco smoke (Becklake, Kauffmann, 1999). Women have bronchioles with thicker walls in terms of epithelial and adventitial components and a narrower lumen than men. Therefore, women and men may respond differently in regard to the location and type of lung damage related to tobacco (De Torres, Casanova, 2010; Becklake, Kauffmann, 1999; Dransfield, Washko, Foreman, Estepar, Reilly, Bailey, 2007).

The EUROSCOP study showed that women with COPD with a FEV_1/FVC ratio lower than average lost lung function faster (32 ml/year) than women with minor obstruction. (De Torres, Casanova, 2010). Also, women with COPD have been described as more symptomatic and with less functional capacity and therefore, quality of life scales present worse results (Suh, Lau, Pokras, 2008; Ferrari, Tanni, Lucheta, 2010).

Respiratory rehabilitation (RR) is an essential part in the treatment of patients with COPD, which is why some authors defend that people with this disease who continue to be limited by their symptoms even though their pharmacological treatment is correct, should be included in RR programs (Güell, Díaz Lobato, Rodríguez Trigo, Morante Véleza, San Miguel, Cejudo et al., 2014). RR has proven effective with a high level of scientific evidence, and its main goals are: decrease of symptoms, improvement of functional capacity and quality of life (Güell, Díaz Lobato, Rodríguez Trigo, Morante Véleza, San Miguel, Cejudo et al., 2014; Spruit, Singh, Garvey, ZuWallack,

Nici, Rochester et al., 2013), improvement of dyspnea and decrease of the number of exacerbations and use of health resources (De Torres, Casanova, 2010).

Alterations such as gas exchange or increased respiratory effort cause the person with COPD to try to avoid physical activity. This is why exercise or muscle training is a very important part of the RR. Regarding the respiratory muscles, it is important to highlight the training of the inspiratory muscles, which can be performed using strength techniques or resistance techniques. Larson et al. (1988) were the first to demonstrate a significant increase in inspiratory muscle strength, respiratory muscle resistance and exercise tolerance in patients with moderate or severe COPD (Larson, J., Kim, Sharp, Larson, D., 1988). Since then, inspiratory muscle training has shown improvement of muscle strength and endurance in patients with COPD. RR programs therefore usually integrate specific respiratory muscle training and peripheral musculature training, with a minimum duration of 8 weeks or 20 sessions with a frequency of 2 to 5 sessions per week (Güell, Díaz Lobato, Rodríguez Trigo, Morante Véleza, San Miguel, Cejudo et al., 2014; Spruit, Singh, Garvey, ZuWallack, Nici, Rochester et al., 2013).

Some other of the physiotherapy techniques used in RR include respiratory control techniques (controlled slow ventilation; breathing with pursed lips; thoracic mobilizations and directed ventilation), ELTGOL (Total slow exhalation with lateralized open glottis), TEF (forced expiration technique), among others (Güell, Díaz Lobato, Rodríguez Trigo, Morante Véleza, San Miguel, Cejudo et al., 2014). Respiratory exercises such as diaphragmatic breathing and pursed lips breathing have an important role in the control of dyspnea in patients with COPD. These techniques, in addition to reducing breathlessness, improve ventilation and gas exchange, optimize thoracic wall movement and decrease hyperinflation (Güell, Díaz Lobato, Rodríguez Trigo, Morante Véleza, San Miguel, Cejudo et al., 2014). However, most of the studies have researched on men with COPD, or samples with both men and women.

We hypothesised that training the inspiratory muscles along with the pursed lip breathing could improve the pulmonary function, the strength of the respiratory muscles, the exercise capacity and, ultimately, improve quality of life in women diagnosed with COPD. Therefore, the aim of this study was to implement a program with respiratory physiotherapy techniques in order to improve quality of life of women with COPD, improving values of the spirometric parameters and the strength of the inspiratory muscles.

METHODS

Participants

Participants were recruited from the “Amics de La Nau Gran de la Universitat de València” association, which includes people over 55 years old. Inclusion criteria were: women diagnosed of COPD, with no need of oxygen therapy, availability to perform treatment. Exclusion criteria were: men with COPD, need of oxygen therapy, having any muscle or skeletal illness that made unable the performance of the treatment.

Study design

An experimental case study was conducted from January 2019 to March 2019. Three women and one man were initially interested in participating in the study. The man

was discarded for not meeting the inclusion criteria; one of the women finally did not want to be included in the study because of personal reasons.

The two final participants were assessed in January and then they were treated over a period of 8 weeks, with 3 sessions per week of 45 minutes' duration each. One of the three weekly sessions was applied by a physiotherapist at the University. The other two weekly sessions were performed by the patients at home, and recorded through a follow-up file where the day that each session had been done should be marked so the physiotherapist could check.

The treatments at the faculty were applied by an experienced physiotherapist, with the necessary training and were carried out in the laboratories of the Faculty of Physical Therapy of the University of Valencia. Participants provided informed consent following an explanation of the study aims and procedures. The Ethics Review Board of our institution approved all the procedures (H1543313693557), which were performed in accordance with the principles of the Declaration of Helsinki of the World Medical Association.

Outcomes

Background data, including GOLD stages, were obtained from patients and medical records at baseline. Pulmonary function, Maximal inspiratory and expiratory pressure measurements, Exercise capacity and Quality of Life were measured at baseline and post-treatment.

Pulmonary function: it was assessed via forced spirometry of dynamic lung volumes using a portable spirometer (PONY FX, COSMED), and it included: forced vital capacity (FVC), forced expired volume at 1 second (FEV_1) and peak expiratory flow (PEF), accordance with ATS/ERS guidelines (Miller, Hankinson, Brusasco, Burgos, Casaburi, Coates et al., 2005; García-Río, Call, Burgo, Casan, del Campo, Gáldiz et al., 2013). The reliability of this instrument was reported by Lei Burton et al. (Lei Burton, LeMay, Saini, Smith, Bosnic-Anticevich, Southwell et al., 2015).

Maximal inspiratory and expiratory pressure measurements: maximal inspiratory (MIP) and expiratory pressures (MEP) were measured using an electronic pressure gauge ELKA PM-15 (Laboliser), following international regulations (Green, Road, Sieck, Similowski, 2002).

Exercise capacity: it was measured as distance walked during the six-minute walk test (6MWT). It is frequently used for measuring response to therapeutic interventions in COPD (Singh, Puhan, Andrianopoulos, Hernandez, Mitchell, Hill et al., 2014). The 6MWT was performed according to the standardized protocol (Holland, Spruit, Troosters, Puhan, Pepin, Saey et al., 2014). The dyspnea was measured by the Borg Scale which has shown to be a reliable tool for quantifying dyspnea in subjects with COPD undergoing a 6-minute walk (Belman, Brooks, Ross, Mohsenifar, 1991) and the oxygen saturation (SaO_2) was measured by an pulsioximeter (Oxym 2000) (González Mangado, Rodríguez Nieto, 2016).

Quality of Life: measured with the St George Respiratory Questionnaire which is a standardized self-administered airways disease-specific questionnaire divided into three subscales: symptoms (eight items), activity (16 items), and impacts (26 items) (Jones, Quirk, Baveystock, Littlejohns, 1992; Jones, Quirk, Baveystock, 1991). For each subscale and for the overall questionnaire, scores range from zero (no impair-

ment) to 100 (maximum impairment) (Güell, Casan, Sangenis, Morante, Belda, Guyatt, 1998).

Intervention

Intervention consisted of 8 sessions with the physiotherapist (one each week) that were repeated at home by each of the patients 2 more times per week.

Sessions 1 and 2: A brief explanation of chronic obstructive pulmonary disease was made. Then a 10 minute diaphragmatic abdominal breaths were performed: 5 minutes in supine position and 5 in sitting position, with the objective that the patients become aware of their breathing and try to perform abdominal and non-thoracic breathing. Subsequently, with participants in a sitting position they trained with the Threshold IMT® (Respironics) device with a 30% of the initial MIP of each patient, and 6 sets of 5 repetitions were performed each with 1 minute rest between sets (Barreiroa, Geaa, Marina, 2007). Later they performed the breathing exercise with pursed lips, in the supine position. During this exercise the patients had to inspire through the nose for 2 seconds and exhale with pursed lips for 4 to 6 seconds for 9 minutes, that is, 3 sets of 2 minutes of breathing with pursed lips with a minute of rest between sets (Gosselink, 2004; Mayer, Karloh, Dos Santos, de Araujo, Gulart, 2018). Finally, the inspiratory muscle training was repeated with the Threshold IMT®.

Sessions 3 and 4: The same exercises were performed as in the previous sessions, only the Threshold IMT® resistance was increased a 10%, from 30% to 40% of the MIP as suggested in previous studies (Fonseca, Cader, Dantas, Bacelar, Silva, Leal, 2010). The exercises with pursed lips in were performed, the first series in sitting and the second in standing.

Sessions 5 and 6: In both sessions the Threshold IMT® resistance was increased to 50% of the initial MIP. In the fifth session the pursed lips exercises were carried out in standing position, and in the sixth session they were performed while the patients were walking.

Sessions 7 and 8: The training resistance increased from 50% of the initial MIP in the previous sessions to 60%. In the seventh session, the patients performed pursed lips exercises as they went up and down the stairs. However, we had to discard the stairs due to dyspnea in both patients. Finally, the exercises were carried out while the patients walked in both sessions.

Statistical analysis

A descriptive analysis was conducted, with results shown as mean and percentage of the measured variables before and after the treatment for each participant, as well as the percentage change. Statistical analysis was performed using SPSS v. 19.0 (SPSS Inc., Chicago, IL, USA) licensed from the authors' institution.

RESULTS

The analysis was performed on 2 women with COPD with ages between 67 and 73 years old. Initial spirometry showed that at baseline Case 1 had a severe COPD ($30\% \leq FEV1 < 50\%$) and Case 2 had a moderate COPD ($50\% \leq FEV1 < 80\%$), according to the Global Initiative for Chronic Obstructive Lung Disease (GOLD)

(Charususin, Gosselink, Decramer, McConnell, Saey, Maltais et al., 2013) scale. Demographic and clinical characteristics of the participants by participant are depicted in Table 1.

Table 1 Demographic and clinical characteristics of the participants

	CASE 1	CASE 2
Age	73	67
Gender	Woman	Woman
Height (cm)	165	154
Weight (kg)	78.8	42.8
BMI (%)	29	18.1
CPD*	20	6
Current smoker	No	No
Marital status	Married	Divorced
Academic level	University degree	University degree
Working status	Retired	Retired
Other conditions	Atrial fibrillation Osteoporosis	Osteoporosis Arthrosis
Physical activity	Walking and Pilates (2–3 times/week)	Walking and bicycle (4–5 times/week)

* Cigarettes Smoked per Day: heavy smoking as ≥ 20 CPD and mild smoking as < 20 CPD

In relation to the pulmonary function, Case 1 showed that the FVC and the FEV_1 decreased by 2%, the FEV_1/FVC decreased 7% and PEF had a 4.8% increase. Case 2 also showed quite constant results for spirometric parameters (FEV_1 , FVC decrease 2% and FEV_1/FVC a 3%) with the only parameter with a more noticeable change being the PEF, with an increase of 6.4% at post-treatment (Table 2).

The measurements of the maximal pressures showed Case 1 improved in the strength of the respiratory muscles, with a 25% increase in the MIP and 9.4% in the MEP. However, Case 2 showed a decrease of 8.7% on the MIP and the MEP was maintained in similar results.

As for Exercise capacity, Case 1 increased by 12.12% in the walked distance (from 290 to 330 m) with similar SaO_2 and dyspnea. Case 2 increased in 90 meters the walked distance, that is a 18.75% increase.

In relation to Quality of Life the SGRQ showed that Case 1 had all items improved at post-treatment assessment, with the Activity score increasing by 12.3 points. The total score in the initial assessment was 27 and at the end of 25 this difference means that the quality of life after the intervention improved by 2 points. Case 2 had a decrease in the scores obtained, especially in the items that referred to the symptoms, which decreased by 10%. Also the Impacts of COPD on the patient's life decreased nearly a 6%. For this case, the total score of the questionnaire improved by 7%.

At the end of the treatment both cases were at the same degree of COPD according to GOLD scale, that is Case 1 had a severe COPD and Case 2 had a moderate COPD.

Table 2 Results of both cases at baseline and post-treatment

	CASE 1		CASE 2	
	Baseline	Post-treatment	Baseline	Post-treatment
Pulmonary function				
FVC (% of predictive)	50	52	60	57
FEV ₁ (% of predictive)	43	41	51	50
FEV1/FVC (% of predictive)	85	78	86	89
PEF (% of predictive)	44.5	49.3	56.7	63.1
Pressure measurements				
MIP (% of predictive)	80	105	66.7	58
MEP (% of predictive)	56.5	65.9	45.7	45.6
Exercise capacity (6MWT)				
SaO ₂ (%) (begin/end)	92/94	92/94	98/99	99/97
Dyspnea (BORG) (begin/end)	0/2	0/3	0/1	0/0
Distance (m)	290	330	390	480
Quality of Life (St George Respiratory Questionnaire)				
Symptoms	12	9	20	10
Activity	47.2	59.5	48.2	43.1
Impacts	19.7	10.6	7.3	1.6
TOTAL	27	25	22	15

DISCUSSION

The present study analysed the changes on two women with COPD regarding their pulmonary function, exercise capacity, respiratory muscle strength and quality of life after an 8-week program of respiratory physiotherapy techniques. Results showed an improvement on their quality of life at the end of the intervention, since the total score in the SGRQ decreased at post-treatment, also the walked distance in the 6MWT increased, and the MIP and MEP values improved in Case 1 (severe COPD), but not in Case 2 (moderate COPD). No changes were noticeable in the spirometric parameters.

To the best of our knowledge this is the first case study to address specifically COPD in women, given that there are no articles in this regard in the existing literature. Although there is currently a growing interest in this subject, in the last five years most of the studies include both men and women in their sample or only men.

In relation to the pulmonary function, our results did not show much change post-treatment, except the PEF that improved in both women. However, the changes of the PEF did not reach the minimal clinically significant which is 12% for obstructive patients (Karras, Sammon, Terregino, Lopez, Griswold, Arnold, 2000). Previous studies with only 3-week programs did not show any improvement in pulmonary function (Beaumont, Mialon, Le Ber-Moy, Lochon, Péran, Pichon et al., 2015). However, stud-

ies with more intensity of treatment (using muscle training 2 times a day, every day) (Wu, Guan, Zhang, Li, Yang, Guo, 2017) did show improvement.

Regarding pressure measurements, Case 1, with a more severe COPD did improve her MIP in 25% and her MEP in 9.4%, as in previous studies (Nikoleitou, Man, Mustafa, Moore, Rafferty, Grant et al., 2016; Dellweg, Reissig, Hoehn, Siemon, Haidl, 2017). Case 2 did not improve these parameters. It is conceivable that the patient with a poor baseline lung function is at risk to enter a downward spiral of dyspnea, sedentariness, demotivation, and finally deconditioning (MacIntyre, 2008) and therefore had a greater motivation in the treatment.

Inspiratory muscle training is not only beneficial for muscle strength (Belman, Brooks, Ross, Mohsenifar, 1991), but also improves inspiratory muscle endurance (Larson, J., Kim, Sharp, Larson, D., 1988), walking endurance, dyspnea and quality of life (Gosselink, De Vos, van den Heuvel, Segers, Decramer, Kwakkel, 2011). This has been observed in our results since both women have increased the walking endurance while not having a high increase in dyspnea. So, as Charususin et al. (2013) concluded in their study, inspiratory muscle training with threshold is effective and could be incorporated into evidence-based treatment recommendations for clinical practice (Charususin, Gosselink, Decramer, McConnell, Saey, Maltais et al., 2013).

As for the 6MWT, not only the walking distance was increased in Case 1 and Case 2 between 12% and 18 % respectively, but also SaO₂ was maintained steady through the test after the treatment. This is important, since change in exercise performance is still considered one of the most important and easiest outcome measures adopted to evaluate the effects of RR in COPD patients (Van Stel, Bogaard, Rijssenbeek-Nouwens, Colland, 2001).

Our results are in line with other studies (Dellweg, Reissig, Hoehn, Siemon, Haidl, 2017; Mehani, 2017). Dellweg et al. (2016) with a sample of men and women, also found an improvement on the walking distance after only 4 weeks of inspiratory muscle training with threshold. In addition, in another study conducted by Mehani (2017) with a sample of only men, the improvement of the walking distance was 25% in 6MWT for the inspiratory musculature training group.

Dyspnea was measured in the 6MWT showing Case 2 had an improvement in the dyspnea post-treatment, but not Case 1. In a previous study (Wu, Guan, Zhang, Li, Yang, Guo, 2017), which included men and women, the dyspnea degree improved after 8 weeks of inspiratory muscle training with a resistive loading device. Taking into account that women have a higher degree of dyspnea than men (Varkey, 2004; Carrasco-Garrido, Miguel-Diez, Rejas-Gutierrez, 2009) it can be explained that Case 1 with more severe COPD did not improve. Therefore, future studies with bigger samples of women could help clarify how dyspnea affects in relation to gender.

As for quality of life, both women showed an improvement. This is similar to results found in other studies with samples of men and women (Valenza, Valenza-Peña, Torres-Sánchez, González Jiménez, Conde Valero, Valenza Demet, 2014; Borgue, Marit, Omenaas, Moum, Ekman, Lein et al., 2015). Valenza et al. (2014) conducted a study in which patients had to perform breathing exercises with pursed lips twice a day for 20 minutes, the results they obtained, as in our study, were a better score for the SGRQ. Besides anxiety, depression had improved after treatment (Valenza, Valenza-Peña, Torres-Sánchez, González Jiménez, Conde Valero, Valenza Demet, 2014).

In the research conducted by Borgue et al. (2014) it was also shown that breathing exercises with pursed lips improve the quality of life of men and women with COPD (Borgue, Marit, Omenaas, Moum, Ekman, Lein et al., 2015).

Limitation in exercise capacity represents an important feature of COPD and is one of the main factors that negatively affect the quality of life in patients (Esteban, Quintana, Aburto, Moraza, Egurrola, Pérez-Izquierdo et al., 2010). Considering that in our study both cases increased the walking distance, and therefore their exercise capacity, it can be explained that quality of life also had an improvement. Reduced exercise capacity is considered to be a consequence of airflow obstruction primarily because of dynamic hyperinflation occurring during exercise (Palange, Ward, Carlsen, Casaburi, Gallagher et al., 2007). Therefore, limited physical activity of patients with COPD, although a result of the disease, at the same time promotes worsening and progression of the disease and further decline in the patient's quality of life. As stated before, quality of life scales present worse results in women (Suh, Lau, Pokras, 2008; Ferrari, Tanni, Lucheta, 2010), and the obtained results may help encourage including intervention in this area in future research.

Limitations

Some limitations of our study were first of all, the sample since only two women participated, so futures research with a bigger sample would be needed to improve the knowledge about COPD in women.

Also, a more intense treatment could be implemented, with 5 sessions per week and not 3, and with all of them being supervised by the physiotherapist.

Finally, the intervention was 8 weeks, however the benefits of pulmonary rehabilitation in women in many cases are observed at 3 months, therefore the treatment could be implemented longer.

CONCLUSION

After the study and analysis of the two cases of women with COPD, we can observe that a combination of inspiratory muscle training with purse lips technique may influence positively quality of life and exercise capacity while maintenance of pulmonary function. However, future high quality research with women samples is encouraged to be implemented.

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