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Can the Inspiration Deep Influence on the Respiratory Variables and Thoracic-Abdominal Asynchrony in Patients with Copd?

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Abstract

Objective: To determinate by the OEP the effects of deep inspiration on physiological variables and thoracic-abdominal asynchrony in patients with COPD, compared with healthy individuals matched for age.

Methods: Ten patients with COPD and 12 healthy individuals were evaluated using OEP during deep inspiration. TAA was estimated using the phase angle in a Lissajous figure for three consecutive and consistent respiratory cycles.

Results: There was significant difference ($p<0.01$) on the phase angle between the abdominal rib cage (RCa) and the abdomen (AB) in COPD patients compared to the control (-20.7°±26.3° vs -0.3°±8.8°). Greater compartmental contribution to the tidal volume was found in the pulmonary rib cage (RCp) in both the control group ($p<0.009$) and the COPD group ($p<0.003$). The degree of obstruction was not correlated with TAA between the different compartments.

Conclusion: During deep inspiration for assincroniatoracoabdominal in patients with COPD in relation to healthy, not sort of adding then to improves the respiratory pattern in this group of patients and the degree of airway obstruction of these patients correlates with the presence ATA.

Keywords: Chronic obstructive pulmonary disease; Chest wall asynchrony; Optoelectronic plethysmography; Deep breathing

Introduction

In cases of chronic obstructive pulmonary disease (COPD), airflow limitation is not completely reversible. This limitation may influence these harmonious mechanisms and cause what is known as thoraco-abdominal asynchrony (TAA) [1-3]. Thoraco-abdominal synchrony is defined by the coordinated expansion of the thoraco-abdominal compartments. This synchrony is the result of physiological mechanisms, including the coordinated action of the respiratory muscles [4,5], changes in transdiaphragmatic pressure during the respiratory cycle [3,4], and pulmonary vascular resistance and compliance [5,6]. TAA can be evaluated using different techniques. However, optoelectronic plethysmography (OEP) is currently the main tool used for the study of thoraco-abdominal movements because it is non-invasive and highly accurate.

In recent years, the treatment of COPD is based on functional exercises, inhaling oxygen and medications [10,11]. Due to pathophysiology of COPD, the functional disorder of the diaphragm muscle is considered to be an important reason the respiratory changes (acute or chronic) and it is known that [12] respiratory muscle strength can be improved by exercise [13]. But little studies using respiratory techniques, such as deep an inspiration, were performed by evaluating the improvement in asynchrony and changes in respiratory variables in this group of patients.

Thus, a hypothesis on that patients with COPD may exhibit improved asynchronous Thoracoabdominal during deep inspiration when compared to healthy individuals. The aim of this study was to verify the OEP the effects of deep inspiration on physiological variables and thoracic-abdominal asynchrony in patients with COPD, compared with healthy individuals matched for age.

Materials and Methods

Sample

Two separate groups of individuals were evaluated. The COPD group consisted of 10 patients with a diagnosis of COPD based on the criteria from the Global Initiative for Chronic Obstructive Lung Disease (GOLD) [21]. They were clinically stable and had not presented acute exacerbations of the disease in the thirty days prior to the experiment. They were also receiving regular treatment with inhaled bronchodilators. The control group was composed of 12 healthy individuals who had volunteered for the study and who were age matched. To be included in either group, individuals had to agree to participate in the study. They were informed of the objectives, and

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they signed the Free and Clear Informed Consent Form according to Brazilian Resolution No. 466, dezember 12, 2012 from the Ministry of Health. Individuals were excluded from the study if they had serious comorbidities, such as previous cardiopathies, rib cage deformities, neuromuscular diseases affecting motor skills, associated pulmonary diseases, or a history of pulmonary emphysema with bullae. They were also excluded if they did not wish to sign the Free and Clear Informed Consent Form.

Experimental Procedure

An evaluation form was used as a base. Data was collected on each patient's history and current status of the disease. A physical exam was also performed to ensure that there was no possibility of acute exacerbations in the COPD patients. All patients underwent a spirometric assessment only for the classification of the severity of airway obstruction, in which were recorded the following volumes, capacities and pulmonary flows: Slow Vital capacity (SVL), forced Vital capacity (FVC) and its derivations, such as forced Expiratory Volume in one second (FEV1) and VEF1/FVC relations. The reference values used were according to Pereira et al. in 2007 [14].

Next, respiratory mechanics were evaluated both in patients with COPD and in the healthy individuals using OEP. The evaluation was performed using a BTS OEP System® (BTS Bioengineering, Italy), which is composed of eight cameras (four cameras positions in front of the individual and four cameras positioned behind the individual). To capture the images of the thoracic and abdominal movements, 89 reflective markers were placed on the thoracic surface of each individual using double-sided adhesive tape. The individuals remained seated on a bench with no back support. Their legs were kept at 90º angles, their feet were on the ground, and they rested their arms on their legs. This procedure was performed on each individual by a technician trained for this task and following the model in the software provided by the manufacturer. The thoraco-abdominal movements were analyzed using this specific software, which is capable of transforming the images captured into three-dimensional geometric information organized into three different compartments: the pulmonary rib cage (RCp), the abdominal rib cage (RCa), and the abdomen (AB) (Figure 1).

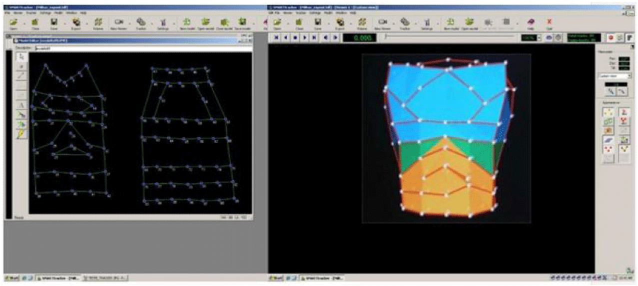

Figure 1: collect representing ETA formed automatically by the OEP System representing the pulmonary rib cage (blue), the abdominal rib cage (green), and the abdomen (orange).

Individuals were instructed, while gathering, inhale deeply and slowly through your nose and exhale through your mouth. The collection and was held for about 30 seconds in this type of breath (the number of respirations were free, according to each patient's breathing pattern).

After this step has been applied the Protocol "Quiet Breathing" present in the SPOS system. As a standard of analysis used three homogeneous respirations (maximum peaks and similar wave size) among the 30 seconds collected in each evaluation mode (Figure 2).

Absolute volumes were analyzed (in litres) of the rib cage and its three compartments separately: CTP, CTA and ABD. All these variables were present in specific report generated by the system:

Volume variables: Were analyzed the absolute volume (in litres) of the rib cage and its three compartments separately being pulmonary rib cage (RCp), the abdominal rib cage (RCa), and the abdomen (AB). The volumes to be analyzed are tidal volume (VCRCp, VRCa, VCab), the end-expiratory volume (VefRCp, VefRCa, VefCab), inspiratory volume (ViRCp, ViRCa, Viab) and the percentage of contribution from the volume of each compartment (VRCp, VRCa, Vab).

Time variables: were analyzed the variables of time, in seconds, related to the inspiratory time (IT), expiratory time (ET), total respiratory cycle time (Ttot), inspiratory time percentage in relation to total time (Ti/Ttot), respiratory rate (RR) and minute volume (MV).

The ATA was calculated using the average compartmental cycles, according to the method of phase angle. This method is based on the Lissajous figure graphically generated from the respiratory signs obtained by SPOS, forming the X and Y axes of the graph, in which the overhead compartment was placed always on the y-axis the phase angle was calculated based on the formula θsen -1 (ms), the line "m" was drawn in the Center and bounded by its interceptos with the figure and the line "s" represents the full tour of the figure on the x-axis with this method the asynchrony evaluated by θ angle varies from 0° to 180°, and 0° represents perfect timing and 180° total asynchrony. By Convention, the phase angle is positive when the upper compartment movement precedes that of the lower compartment, or is negative in otherwise [15]. This calculation was performed by a routine implemented in the MATLAB software (The Mathworks, USA).

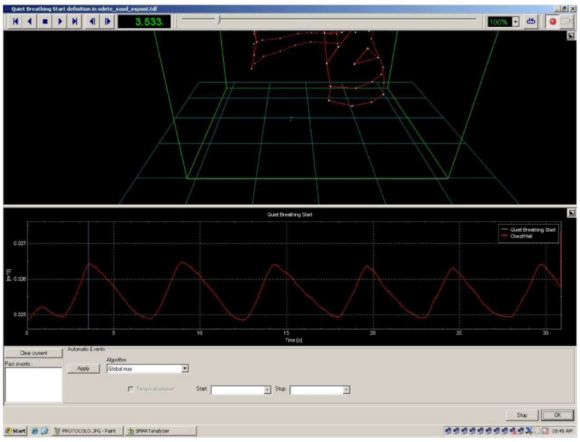

Figure 2: Application Protocol "Quiet Brieathing".

Statistical analyses

To perform the inter-group analysis was used Mann-Whitney test and correlation analysis was used the Spearman correlation. The results were considered that had a significance level of 5 ($p \le 0.05$).

Results

The anthropometric data of the individuals evaluated are detailed in Table 1. On these data, the variable age, weight, height and body mass index showed no significant difference. However, spirometric variables differed significantly between the individuals with COPD and the healthy individuals in the control group, as was expected.

	COPD (N=10)	Control (N=12)	P
age (years)	72.3 ± 10.6	70.1 ± 5.8	0.543
sexo	4 males	3 males	-
Gold	III	Normal	-
Height(m)	1.67 ± 0.07	1.62 ± 0.10	0.171
Weight(Kg)	69.0 ± 11.5	67.3 ± 20.4	0.953
BMI	24.5 ± 3.9	25.2 ± 6.4	0.731
FEV1 (%)	41.7 ± 16.5	97.27 ± 6.19	0.04*
FVC (%)	81.2 ± 20.3	96.3 ± 1.89	0.01*
FEV1/FVC (%)	66.6 ± 16.7	96.9 ± 1.65	0.02*

Table 1: Mean and standard deviations of demographic variables and the lung function measurements. BMI: Body Mass Index; FEV1: Forced Expiratory Volume in 1 second; FVC: Forced Vital Capacity.

Regarding the respiratory variables, for none of them noted statistical difference between COPD and control groups (Table 2).

	COPD	**Control**
VT	0.94 ± 0.64	0.96 ± 0.57
RR	17.4 ± 5.30	12.6 ± 2.8
VM	14.4 ± 5.20	12.2 ± 8.2
I.T	1.55 ± 0.56	2.14 ± 0.62
E.T	2.20 ± 0.73	3.35 ± 0.86

Table2: Mean and standard deviations of repiratory mensurements. VT: Tidal Volume (ml); FR: Respiratory Rate(bm); VM: Volume Minute (L); I.T: Inspiratory Time (s); E.T: Tempo Expiratório (s).

	RCp	**RCa**	**AB**
COPD	30.1 ± 11.4	13.8 ± 8.2	56.2 ±14.2*
Control	42.9 ±12.2*	16.8 ± 6.9	40.2 ± 11.1

Table 3: Mean and standard deviations of percentual contrubuition of each compartiment for de tidal volume. RCp: Pulmonary Rib Cage; RCa: Abdominal Rib Cage; AB: Abdomen.

The percent contribution of each compartment to the tidal volume was considered. In the total respiratory cycle, the RCp values were found to differ significantly between the COPD group and the control group ($p<0.009$). This contribution was greater in the control group (42.9 ± 12.2) than in the COPD group (30.1 ± 11.4). When the RCa was considered, no significant difference was found between the groups in terms of the compartment's contribution to tidal volume in the respiratory cycle ($p<0.3$). However, in the AB, a significant difference was found between the groups ($p<0.003$). The contribution was greater in the COPD group (56.2 ± 14.2) than in the control group (40.2 ± 11.1), as shown in Table 3.

	RCp vs. RCa	**RCp vs. AB**	**RCa vs. AB**
COPD	12.8 ± 21.8	-7.8 ± 11.4	-20.7± 26.3*
Control	0.8 ± 8.6	-1.0 ± 6.3	-0.3 ± 8.8

Table 4: Mean and standard deviations of phase angle betwen the compartiments RCp: Pulmonary Rib Cage; RCa: Abdominal Rib Cage; AB: Abdomen.

Thoraco-abdominal asynchrony was evaluated using the phase angle, and a significant difference was found ($p<0.01$) when the movements of the abdominal rib cage (RCa) were compared to those of the abdomen (AB) in patients from the COPD group (-20.7° ± 26.3°). This result represents an asynchrony between these two compartments. The same result did not occur in the control group (-0.3° ± 8.8°). These values represent greater synchrony in compartmental mobility (Table 4). It's important to note that, conventionally, the signal of the phase angle will be positive any time the RCp signal comes before that of the RCa, or, in other words, when the RCp signal reaches the end of inspiration and/or expiration at a moment before the RCa signal.

The degree of obstruction, which was represented by the FEV1(%), was also compared to the phase angle obtained between the compartments in COPD patients. No significant correlation was found (RCp vs. RCa with $r=-0.4$ and $p<0.19$; RCp vs. AB with $r=0.2$ and $p<0.43$; and RCa vs. AB with $r=0.6$ and $p<0.06$). This finding demonstrates that, regardless of the degree of obstruction, this factor did not influence the presence of asynchrony between the different compartments in this study.

Discussion

In healthy individuals the inspiration is the result of a coordinated movement of the thoracic compartments and the relaxation of the diaphragm muscle. Yamaguti, et al. [16] noted higher mortality in patients with COPD with low mobility of the diaphragm muscle when compared to individuals without diaphragmatic dysfunction. These results reinforce the need for targeted studies for the assessment of Thoracoabdominal mobility in this group of patients, the deep inspiration being cited in clinical studies [12], though widely used in clinical practice.

In addition, the change due to alveolar pathophysiology promotes a chronic airway closure. With deep inspiration some tension is produced and transmitted to the bronchus, preventing small peripheral Airways enter into collapse, allowing full air outlet within the lung. Thus, lung capacity and maximum breathing capacity are improved and the residual volume is reduced, thus correcting the anaerobic situation [17].

The results of this study demonstrate that patients with COPD have a higher asynchrony during inspiration deep compartment in relation to healthy. In this study, normal ranges were defined using as reference

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the AF values obtained in the control group (CG) composed of healthy individuals matched by age [15].

Although traditionally believe that movements of the rib cage during the respiratory cycle accompany changes in lung volume, this is not always the case in patients with obstructive lung disease. The compartment found [18,19] asynchrony in this study was in relation to the lower chest compartments in relation to the abdomen, suggesting a delay in the movement of the chest below in relation to other compartments (represented by the negative value obtained). This delay can be explained by altered respiratory mechanics in patients with COPD, due to a downgrading of the diaphragmatic domes, resultantede a lower abdominal pressure and, consequently, in less lower rib cage expansion leading to decreased mobility [20]. we can suggest that the asynchronicity of the CTI in patients with COPD is a stabilisation mechanism of the ring structure, more than move so uncoordinated with the other two magazines and that efficiency of the diaphragm to expand the CTI may be lower than in healthy individuals [1,7,21].

If we consider the mechanisms behind thoraco-abdominal synchrony that are explored via OEP [1,22], and which take place through the coordinated actions of the compartments, our results may provide evidence that the abdominal rib cage is what contributes the least to the total tidal volume of the respiratory cycle in patients with COPD. Our results are consistent with those reported by Calverley, et al. particularly in terms of their assertion that pulmonary hyperinflation also contributes to a structural change in the rib cage muscles because they are stretched, their strength and contraction capacity are reduced. This, in turn, reduces the mobility of the abdominal rib cage [22].

Other studies have shown that patients with COPD who presents asynchrony often contracts the abdominal muscles during expiration [24] and the relaxation of these muscles is done gradually during inspiration [7], causing the CTI tend to retract earlier inspiration and slowing its expansion in the inspiratory phase and may be then an increase in recruitment and activation of the inspiratory muscles don't diafragmáticos to compensate for this disadvantage [21,25] mechanics, which cannot be mistakenly confused by observing the abdominal compartment contrubuição increase in this population of patients.

Gorman, et al. evaluated both the zone of apposition, which was measured using ultrasonography, and ribcage diameters, which were measured using magnetometers. They observed different patterns of behavior of the abdominal rib cage in cases of dysfunctions of the diaphragm in COPD patients [26]. Similar results were found by Alliveti, et al. who used the three-dimensional OEP method for the first time. The authors reported that COPD patients who presented asynchrony of the abdominal rib cage while at rest were more prone to early-onset hyperinflation during physical exercise than those who did not present asynchrony [1]. These results corroborate with our findings, even if we have not assessed directly to lung hyperinflation of our patients, once the asynchrony was only observed in COPD group CTI and the lack of correlation of FVC with the CTI contrubuição almost presents significance, which may present greater relevacia and if the sample number was bigger.

With regard to the contribution in the total tidal volume compartment, our results showed that the upper rib cage contributes less to tidal volume in patients with COPD compared to healthy individuals. These findings, according to Bernarg, et al. can be explained by anatomical changes of respiratory muscles in these patients, such as sarcopenia and decreased contractility of this [27] muscles, which in turn can lead to a decrease in the contribution of this upper chest compartment, in the generation of tidal volume in individuals with COPD [28,29].

About the Association of obstruction of the air flow with the assincroniatoracoabdominal, there is no consensus in the literature, because, while some studies might associate the VEF1com reduction commitment of diaphragm muscle [30,31] mobility, but also of getting a relationship between diaphragmatic dysfunction and air entrapment, [32] others like Priori, et al. [15] found no correlation between the severity of the obstruction and the presence of assincroniatoracoabdominal. These data are in agreement with our findings.

In addition to these aspects, other factors that deserve more attention in the synchronic analysis of Thoracoabdominal COPD patients are respiratory muscle dysfunction and pulmonary hyperinflation [2,8]. However it is worth remembering that the inspiration for the lower rib cage is not performed for only [31] diaphragm muscle contraction.

Further studies on the behavior of the ATA in situations of exacerbation and in respiratory procedures common in clinical practice, especially of respiratory physiotherapy, could contribute to a better understanding about the improved sync and Thoracoabdominal motion in patients with COPD.

Conclusion

Based on our findings, we can conclude the deep inhalation is not able to improve the ATA and also does not promote changes in respiratory variables in patients with COPD compared to normal healthy age-matched with. Also concluded and that the severity of the disease, translated by the degree of airway obstruction, does not correlate with the presence of asynchrony ring in this population.

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