Forward Head Posture Examination and its Association to Lung Expiratory Function in Chronic Obstructive Pulmonary Disease (COPD) Patient: A Case Series

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Abstract: The expiratory function of the lung could be easily measured by using the peak flow meter, and is recorded as a peak flow rate (PFR). This function has been known to be effectively correlated with mucus clearance and effective cough. Other than general muscle weakness, COPD patients generally have altered body structures to the chronic hyperventilation condition. Structural adaptations include thoracic kyphosis with forward head posture (FHP). This study aimed to quantify the severity of FHP and observe its impacts on PFR in COPD patients. We recruited a small cohort of COPD patients in the outpatient clinic of the Medical Rehabilitation Department, Persahabatan Hospital, Jakarta. The peak flow meter will be used to measure PFR, while FHP will be measured as occiput to wall distance, measured in centimeters. Additional records such as submaximal exercise testing, peak cough flow (PCF) and COPD Assessment Test (CAT) score will be obtained as well. An independent T-test will be performed on the data to obtain the difference of PFR among severity grades of FHP. In this study, eight patients acquired, they were all above the age of 60, classified as the geriatric population. We obtained underweight median Body Mass Index (BMI) 18.29 kg/m2 (15.05-22.04), COPD GOLD A to C, limited chest expansion, and median CAT score of 14 (4-30). This study also exhibited a median OWD of 8.10 cm (6.80-9.30), PFR 227.50 ml (70-400), and PCF 255 ml (180-410). These results showed that postural changes could simply be measured and may have an impact on respiratory biomechanics, which deems comprehensive COPD care.

1 INTRODUCTION

It is a common knowledge that Chronic Obstructive Pulmonary Disease (COPD) patients are very prone to anatomical changes, owing to malnutrition and ongoing hypercarbia, reducing effective muscular metabolism. (Wada *et al.*, 2016) In the rehabilitation setting, a medical diagnosis of COPD will then lead to several functional diagnoses such as general muscle weakness, systemic endurance disorder, postural imbalance, and airway clearance disorder. Therefore nowadays, many interventions are then focused more comprehensively to address these matters.

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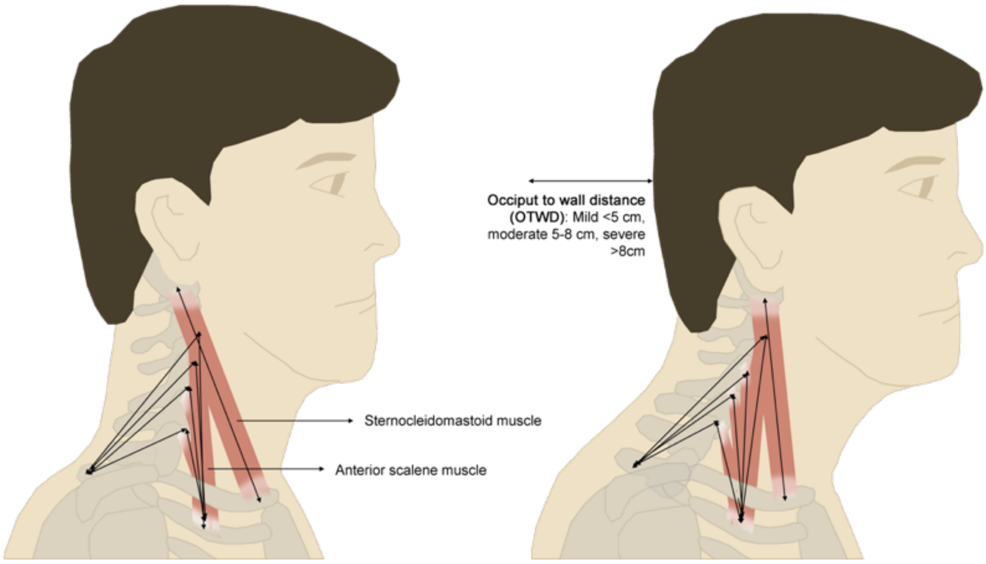

Figure 1: Forward Head Posture, changes in cervical muscles with Occiput to Wall Distance.

Among the known goals, postural correction seems to be simple, yet remained to be a goal which is rather difficult to maintain in COPD. Previous studies had shown how thoracal kyphotic structures are prevalent in COPD, and this phenomenon is generally coupled with forward head posture (FHP). (Kim et al., 2012) These anatomical changes are then expected to impact respiration and additional respiratory muscle functions as described in the "Body Function" by the Comprehensive ICF core set of COPD. Additionally, it will result in recruitments of accessory inspiratory muscles, which in turn increases energy expenditure for the tidal breathing process. Previous studies had revealed how the FHP will result in an expansion of the upper thorax, and the indrawing of the lower thorax. As it turned out, the immobility of the lower thorax could bring about several drawbacks, such as reduction of diaphragm excursion, resulting in ineffective breathing pattern. (Koseki et al., 2019)

It is interesting to know that diaphragm itself lies in the abdominal cavity, and thus movement of abdominal muscles surely would affect its effective moment arm. In that particular case, the central nervous system modulation will counteract the impulses required for effective abdominal muscle contraction, without disturbing the rhythmicity of diaphragmatic contraction. Several studies had shown that straight posture with mild FHP would correlate to better breathing mechanics, owing to the ideal thoracic cage shape, leading to ease of respiratory muscle recruitment, and effective moment arm to exhibit good length-tension relationship. (Mesquita Montes et al., 2017)

Several animal studies had shown that mucus movement correlates positively with peak expiratory flow, and the concept has been utilized in personalizing the human airway clearance technique. (McIlwaine et al., 2017; Mahajan et al., 2019) The expiratory action itself would recruit abdominal muscles during labored breathing, and it was shown that several of these core muscles have dual roles in both keeping the effective intrathoracic pressure, as well as stable erect posture; thus these biomechanics are disturbed in the presence of FHP. (Mesquita Montes et al., 2017)

With all the questions that arise regarding the impact of FHP on respiratory processes, we established our research question into: is the severity of FHP associated with pulmonary expiratory function test values in COPD patients? In response to the question, we hypothesize that patients with severe FHP will have a worse expiratory function, as FHP will cause a restrictive disorder that overlaps with the obstruction in COPD patients, resulting in an overall reduction in pulmonary function. It is our general aim to exhibit the importance of postural screening, especially in specific patient groups such as COPD.

2 METHODS

A case series observation was performed on COPD patients who routinely checks up in the Medical Rehabilitation outpatient clinic of Persahabatan General Hospital, East Jakarta.

Through consecutive sampling, all patients ≥18 years old with COPD who could ambulate independently, living in the community and clinically stable over a month were recruited. Adhering to prior study on posture, exclusion criteria include previous thoracic or abdominal surgery in the past one year, recurrent musculoskeletal injury on the upper extremity, previous mastectomy, and severe musculoskeletal, neurological, or cardiovascular disorders. (Morais, Cruz, and Marques, 2016) Additionally, we exclude patients with a tracheostomy tube or oropharyngeal disorders, which disallows patient to perform adequate mouth seal on the mouthpiece, to preserve optimal peak flow meter examination.

A comprehensive physical examination was performed by two physiatrists and discussion will be performed when there is any disagreement regarding FHP severity. This study had recorded individual FHP values which will be measured from occiput to wall distance in centimeters, by using standardized ruler and goniometer (Figure 2). FHP values below 5 cm were taken as mild, between 5 to 8 cm as moderate, and finally above 8 cm is considered severe.

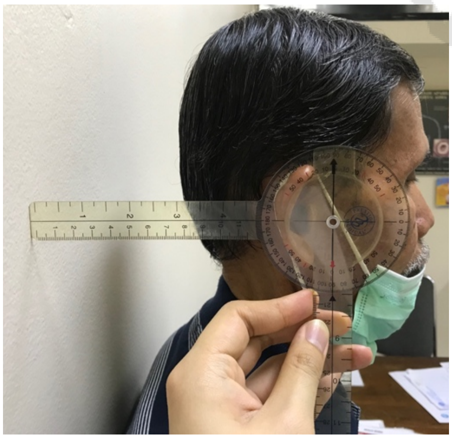

Figure 2: Measurement of occiput to wall distance.

A different examiner, blinded to the FHP severity group, measured expiratory indices by using a peak flow meter. Both peak flow rate (PFR), and peak cough flow (PCF) values were recorded as lung expiratory function values. Other physical examinations include measurement of anthropometry, vital signs, chest expansion, COPD assessment test (CAT), and submaximal exercise testing with the 6-minute walking test were all done to provide better discussion.

Each data of FHP and COPD profile are then presented and compared to each other, before grouping them each according to their FHP severity. The data are presented in a table form for better comparison between FHP severity subgroups, and charts were utilized when applicable. Statistical comparison between FHP severity groups was done with Mann Whitney U-test after identifying the normality of the samples, this includes a comparison between PFR & PCF. Graphical presentations of the data were also constructed to provide ease in comparison. All statistical tests will be considered significant when P is <0.05. with a power of 80%. The tests will be performed using SPSS (Statistical Package for the Social Sciences) for Macintosh ver. 20.0.

3 RESULTS

This study had obtained a total of 8 samples, with 4 being admitted to the moderate FHP group and 4 in the severe FHP group. Classification of the FHP profile in each of the COPD subjects was shown in Figure 2 below. It could be inferred that subject 1-4 has less than 8 cm occiput to wall distance, and thus classified in the moderate subgroup, whereas subject 5-8 are classified in the severe subgroup owing to 8 cm and above occiput to the wall distance value.

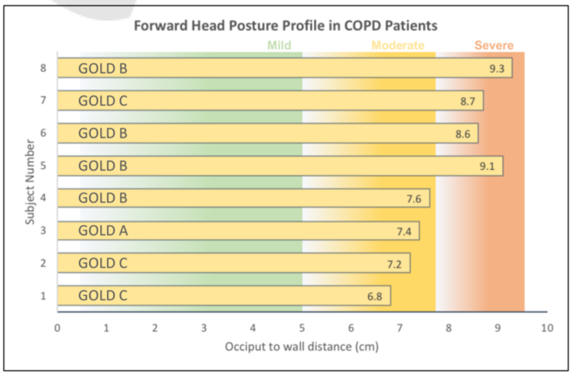

Figure 3: Forward head posture severity as measured by occiput to wall distance in the study subjects.

The descriptive values for each of these groups are shown in Table 1. It could be seen that in general, all the data are similar in both groups (p>0.05). The age group of the sample is all above 60 years old, putting them in the geriatric population. BMI values, although indifferent between the groups, moderate FHP seemed to be in the underweight category, whereas severe FHP ranges from underweight to normal. The GOLD classification ranges from A to C in moderate FHP and B to C in severe FHP. Chest expansion seemed to be similar in values in both groups, however, it could be seen that the upper chest is lower in severe FHP, as well as middle chest, and no difference could be found on the lower chest. CAT score is generally lower in moderate FHP. The patient's subjective symptoms as rated by Borg scale, are high in the effort for both groups. Oxygen saturation doesn't differ between groups, but both are lower than 99%. Submaximal exercise testing values revealed that severe FHP is seemingly better in cardiorespiratory endurance as compared to moderate FHP.

Table 1: Descriptive findings of the study subjects.

	Moderate FHP (n=4)		Severe FHP (n=4)		p[a]
Age (years)	74.50	(61-76)	75.50	(70-84)	0.486
BMI (kg/m^2)	16.87	(15.05 - 18.95)	20.96	(15.59 - 22.04)	0.200
Chest Expansion (cm)					
Upper	3.50	(3-4)	3	(2-3)	0.200
Middle	4	(2-4.50)	3.75	(3-4)	0.686
Lower	3	(2-3.50)	3	(2-3.50)	1.000
CAT Score	9.50	(4-30)	16.50	(9-29)	0.486
Borg Scale					
Effort	10	(7-11)	9	(9-11)	0.886
Dyspnea	1	(0-2)	0.75	(0-2)	0.886
Fatigue	1	(0-2)	1.25	(0-2)	1.000
Oxygen Saturation (%)	98	(93-99)	97.50	(96-98)	0.686
6 Min Walk Distance (m)	327.75	(216-453.60)	368.50	(345-390.30)	0.486
% Predicted	56.08	(37.48 - 77.44)	64.99	(57.81 - 69.22)	0.686
METs	3.89	(3.20-4.66)	4.03	(3.60-4.57)	1.000
Speed (m/s)	0.91	(0.60-1.26)	1.02	(0.96-1.08)	0.486

*All values are expressed in Median (Min-Max) unless stated

[a]ll statistical tests were done by using the Mann-Whitney U Test

The main findings of this study could be seen from the box and whisker plot depicted in Figure 3. It could be seen briefly that both PFR and PCF has a wider range for moderate FHP, while severe FHP has narrower range values. PFR could be seen higher by about 50 ml in severe subgroups, while PCF is more or less similar in the median with a value of 250 ml. Despite these differences, none of these differences have reached statistical significance.

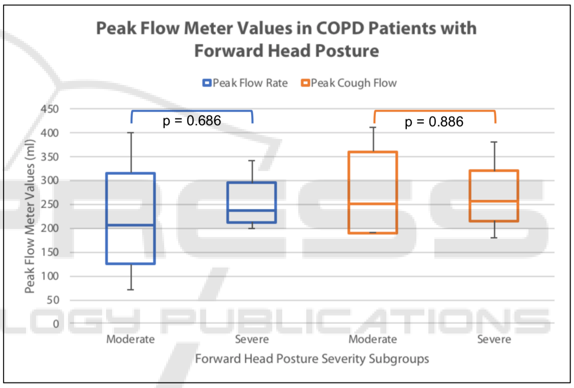

Figure 4: Comparison of expiratory indices as measured by a peak flow meter in the subjects, stratified by forward head posture severity (Mann-Whitney U Test).

4 DISCUSSIONS

All the results of this study had shown how the severity of FHP may not associate directly with the reduction of expiratory, or submaximal exercise testing values. It should also be acknowledged that this study only measured COPD severity through GOLD classification, without having any clear temporal description as to when or how long has the subject suffered from COPD. This becomes weakness of this study, that spirometry values, length of COPD and lifestyle were not measured, but may be related to the severity of FHP. However, the individual case comparison between the subjects could draw out a conclusion that FHP could be measured and classified, despite not directly associated with COPD severity. Additionally, the study also showed measurable differences within the physical examination findings, which then deems further discussion.

As the definition goes, COPD is known to be a progressive respiratory disease, which then accounts for both progressive body structure and functional decline. (Bach and Altschuler, 2010) Secondary postural changes that occur due to lung hyperinflation and higher demand in work of breathing, will eventually happen, although no study has investigated the clear timings of its occurrence in the course of COPD. (Morais, Cruz, and Marques, 2016) Studies had mentioned that the increase of thoracic kyphosis angle is the most prevalent among structural changes, ranging from 3% to 62% as compared to healthy controls. (Lee et al., 2017) Additionally, moderate COPD is observed to have higher shoulder elevation as compared to controls. (Lee et al., 2017) These coupling of these two changes will result in an overall alteration of the upper body musculoskeletal structure and thus resulted in FHP in COPD patients.

FHP itself is well known to result in other changes in the thoracic cage structure, hence even affecting much lower segments other than the cervical vertebra itself. FHP will disrupt the natural sagittal curves of the spine, thus adaptively modifying the thoracic vertebrae, these changes would then affect all the muscular attachments of the diaphragm as the primary inspiratory muscle. (Tortora and Derrickson, 2012; Koseki et al., 2019) On the other hand, since the thoracic cage dimension is altered, surely intercostal muscle length-tension relationship is disturbed, this would further cause ineffective tidal inspiration in the patients. It was also shown that upper thorax will be more expanded in FHP, whereas lower thorax will be less mobile, impairing chest expansion. (Koseki et al., 2019) Although the current study had already accounted for these changes, it is still possible that the severe group had adapted to the condition longer, and have been treated for a longer time. It is also another challenge to identify COPD in the earliest stage, as there's often delay in diagnosis due to reluctance and shame to have a medical consultation due to smoking habits. (Jagana, Bartter, and Joshi, 2015; Jonsdottir and Ingadottir, 2018) Simultaneously, Indonesia has a rising number of young smokers since the age of 10, which prevalence rises from 7.2% in 2013, up to 9.1% in 2018. (Balitbangkes, 2018) This has not been correlated directly with the incidence of COPD but should be an alarm sign towards respiratory health awareness especially in a developing country.

Even when there are no significant differences between them, this study also exhibited severe FHP to have higher BMI as compared to the moderate subgroup (median 20.96 kg/m2 vs 16.87 kg/m2 respectively), which may also be explained by longer treatment time. Another study had shown that BMI is related to COPD subtype, thus cachexia (BMI <21 kg/m2) only appear in emphysematous COPD. On the other hand, obesity (BMI >30 kg/m2) is then related to bronchitic COPD. (Voica et al., 2016) Unfortunately, almost all patients in this study had obtained patients were in the low BMI group, therefore no further analysis could be made on BMI. Future studies could then be focused on this and observing the prevalence of FHP in the higher BMI group.

Several studies had exhibited lung function tests in normal subjects with FHP, their main findings include a reduction in diaphragm contraction (with lower mobility of lower ribcage) and rib elevation. The anatomic changes would eventually lead to a reduction in pulmonary function test (spirometry) values such as vital capacity (VC), forced vital capacity (FVC), forced expiratory volume in 1 second (FEV1), PFR, and even sniff nasal inspiratory pressure (SNIP). (Dimitriadis et al., 2014; Kim, Cha, and Choi, 2017; Kang, Jeong, and Choi, 2018; Beyer et al., 2019; Koseki et al., 2019) One control comparison study with neck pain subjects, presumably due to upper cross syndrome (severe FHP with muscular manifestations of weakness and tightness) had also shown normal or increased values in FEV1/FVC within observed subjects. Therefore the summation of all these findings concluded that FHP results in restrictive lung disorder, which would manifest in a mixed lung disorder when it occurs in a COPD patient. (Dimitriadis et al., 2014) Further study recommendations would require spirometry measurements to be compared in between FHP severity, as that would be the next step after examining PFR values to identify the changes in both obstructive and restrictive lung disorder through FEV1/FVC.(Ranu, Wilde and Madden, 2011)

All in all, the thoracic kyphosis and core muscular weakness, which is caused by both FHP and COPD, would surely lead to postural control disorder. One of the ultimate manifestations of these simultaneous anatomic changes could be described as a balance disorder in COPD. A systematic review had shown how they are mainly affected by the loss of muscle strength and are generally associated with low physical activity, independence, and functional capacity level. The disorder itself expands beyond the vertebra, with a study that shows how the latency time of Achilles and patellar tendon reflex is longer in COPD patients. The nerve damage, in this case, could then be caused by secondary impairment following peripheral muscle weakness in COPD. In times where continuous oxygen supply is required, studies had shown that postural control, balance, and gait speed is worst in this group. This probably is caused by the inability of the body to recruit effective muscles and at the same time unable to extract oxygen to provide adequate muscular metabolism. (Lee et al., 2017) Despite there are no significant differences in the gait speed in our sample, this may be caused by longer treatment time in the severe FHP group, and thus gait speed or balance should be initially examined as the patient is diagnosed as COPD.

Among the progressive secondary musculoskeletal changes, FHP could be seen to be one of the earliest changes in COPD, owing to the change of thoracic cage following hyperventilation. It is then advised that further studies would be able to show how FHP to correlate to other functions, such as postural control, balance, and gait. Recently, these neuromusculoskeletal manifestations have commonly been made into achievable comprehensive goals in COPD patients. (Morais, Cruz, and Marques, 2016)

5 CONCLUSIONS

This study had shown that FHP could be measured and its severity is suggestively associated with expiratory function in COPD patients. The impairments of COPD, mainly hyperventilation, will alter the thoracic kyphotic angle, rises shoulder elevation, finally resulting in FHP. Several studies had shown that FHP will exhibit a restrictive lung disorder, which when coupled with COPD, result in a mixed lung disorder, thus worsening the clinical condition.

Longer duration of the COPD presence itself will result in other functional disorders, as such will reduce physical activity level. Musculoskeletal disorders then must not be underestimated, simple changes such as a postural correction in the cervical vertebra would be able to impact respiratory function, owing to a better length-tension relationship of the respiratory muscles.

Aside from requiring more samples to discuss the association, a further recommendation would require a temporal description of both the COPD and the treatment, to see the changes within the group, as well as their respective improvements.

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